R. N. E. Barton · A. Bouzouggar · S. N. Collcutt
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Cemeteries and Sedentism in the Later Stone Age of NW Africa: Excavations at Grotte des Pigeons, Taforalt, Morocco

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CEMETERIES AND SEDENTISM IN THE LATER STONE AGE OF NW AFRICA: EXCAVATIONS AT GROTTE DES PIGEONS, TAFORALT, MOROCCO

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PREFACE

Grotte des Pigeons, or Taforalt Cave, is without doubt one of the most famous yet perhaps curiously enigmatic Palaeolithic sites in North Africa. Since its discovery more than a century ago, the cave has been periodically investigated and has aroused great interest but there is still relatively little recognition of its importance as a key reference point in the prehistory of the continent. In this edited volume we aim to rectify this shortcoming by bringing together the latest results of excavation and research in a new project that began in 2003. In doing so, we draw particular attention to the fact that the cave now has one of the most detailed and well-dated cultural and environmental sequences in North Africa covering at least the last 120,000 years. It thus represents a major benchmark for all other chronostratigraphic studies in this part of Africa. At the same time, it contains a remarkably rich, continuous and varied record of human activity which includes in its later phases significant evidence for the use of the cave as a funerary site. Indeed the cave is principally known as one of the largest and oldest cemetery caves in the whole of North Africa, although paradoxically these assertions were based on questionable estimates of numbers of buried individuals and only minimal dating evidence in the original studies. Now as a result of the new project it has been possible to examine and reaffirm these claims and to establish that Taforalt provides an exceptional wealth of scientific and cultural information concerning early prehistoric hunter-gatherers in this part of the western Maghreb.

In this volume we focus on the excavation archives of the Later Stone Age (LSA) levels (known regionally as the Iberomaurusian) which run at this site from around 23,000 to 12,600 cal BP (calibrated radiocarbon years before present). Earlier phases of occupation that include the Aterian (Middle Stone Age, MSA) will be dealt with in a companion volume, now in preparation. One of the objectives of the present volume is to provide a clear description of the later stratigraphy of the site and at the same time a context for understanding the human occupation of the cave.

The main subject of our enquiry and the results of the study are presented in chapters written by each of the contributing project specialists. Following **Chapter 1** on the history of research and recent excavations, **Chapter 2** deals with the sedimentary sequences, concentrating upon the lithostratigraphy but also including discussion of site formation processes and inferences concerning human behaviour and environmental factors. **Chapter 3** contains a pilot study on the sediment micromorphology of a key sequence. The chronology of the Iberomaurusian, using various absolute dating techniques, is presented in **Chapter 4**, and this is followed by specialist reports on the Wood Charcoal (**Chapter 5**), Other Charred Plant Remains (**Chapter 6**), Phytoliths (**Chapter 7**), Land Mollusca (**Chapter 8**), Large Mammals (**Chapter 9**), Avifauna (**Chapter 10**) and other (smaller) Faunal Remains (**Chapter 11**). In each of these chapters description of the evidence is accompanied by discussion of the implications for understanding environmental and human behavioural change. This is also true of the succeeding chapters on the Lithic Artefacts (**Chapter 12**), Organic Artefacts (**Chapter 13**), and Inorganic Finds (**Chapter 14**). The next chapters focus more specifically on the human burials, from the point of view of individual interments (**Chapter 15**), the physical anthropology (**Chapter 16**) and the isotopic evidence as it relates to the human diet (**Chapter 17**). In the final part of this volume (**Chapter 18**), we offer a synthesis and interpretation in which the site and human behavioural aspects are placed within their wider regional and North African perspectives.

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THE EDITORS

1. INTRODUCTION

1.1 SETTING THE SCENE

Grotte des Pigeons or Taforalt Cave is situated in northeastern Morocco near the border with Algeria. It is a key site for the study of the Late Stone Age (LSA) culture known as the Iberomaurusian, because of the exceptional degree of finds preservation and the long stratified sequence of deposits that cover major phases of this cultural complex from around 23,000 to 12,500 cal BP (calibrated years before present). One of the immediately striking features of the cave is the common occurrence of *escargotière* lenses, distinctively white/grey ashy deposits that contain an abundance of land snails (Pond/Chapuis/Romer/Baker 1938; Lubell 2001; 2004b; Lubell/Hassan/Gautier/Ballais 1976; Fernández-López de Pablo/Gómez Puche/Martínez-Ortí 2011; Saafi/Aouadi/Dupont/Belhouchet 2013); indeed, at Taforalt, we estimate that there would have been a minimum of some 60 million shells in the upper three to four metres of deposits. Another term that has sometimes been applied is *rammadiya* (Balout 1955; Lubell 2001; Lubell/Feathers/Schwenninger 2009) from the Standard Arabic *ramad* (ash). As well as shell and ash, the thick midden-like deposits at Taforalt also contain huge numbers of charred organic remains, animal bone fragments, stone artefacts and generally burnt objects of all kinds, including masses of burnt/heated carbonate rocks. Thus the range of activities, and the dominant activity in any given location within the cave sequence, require analysis and interpretation. Similar cultural accumulations are also known from numerous open-air locations elsewhere in North Africa. Yet, despite the widespread recognition of middens in caves, often with conspicuous shell content, they have rarely received the same attention as their open-air counterparts, for example in the Capsian of Tunisia. These are generally younger in age, found in lowland open-air situations and include coastal sites. Taforalt, which lies far inland in an upland location, therefore offers a clear contrast to these later archaeological examples. An additional factor that identifies Taforalt as a site of special importance is the preservation of human burials that occur within the ashy sediments at the back of the cave. There is also a sequence of underlying deposits with occupation layers – also Iberomaurusian – that is strikingly different from the ashy deposits. The cave thus has a long and continual, in later stages potentially continuous, record of human occupation, spanning a lengthy period of the Iberomaurusian. During this time, the site arguably served a diversity of purposes, for shelter, living and storage, but also at some point it became an important burial location. Taforalt thus provides an excellent case study for examining variation in past patterns of human behaviour amongst hunter-gatherers and for investigating how these changed through time.

In the present volume, we describe our research upon the LSA levels at Taforalt; some information is already judged reliable from our latest (2017) season but other aspects of our recent work require further analysis and will therefore be reported at a later date. Of course, Taforalt is also well known for its Middle Stone Age (MSA) archaeology, occurring deeper in the stratigraphy; except where it is necessary to mention such material in the context of stratigraphic questions and the 'MSA/LSA transition' within the cave, we intend that these earlier assemblages should be the subject of a second major publication in due course.

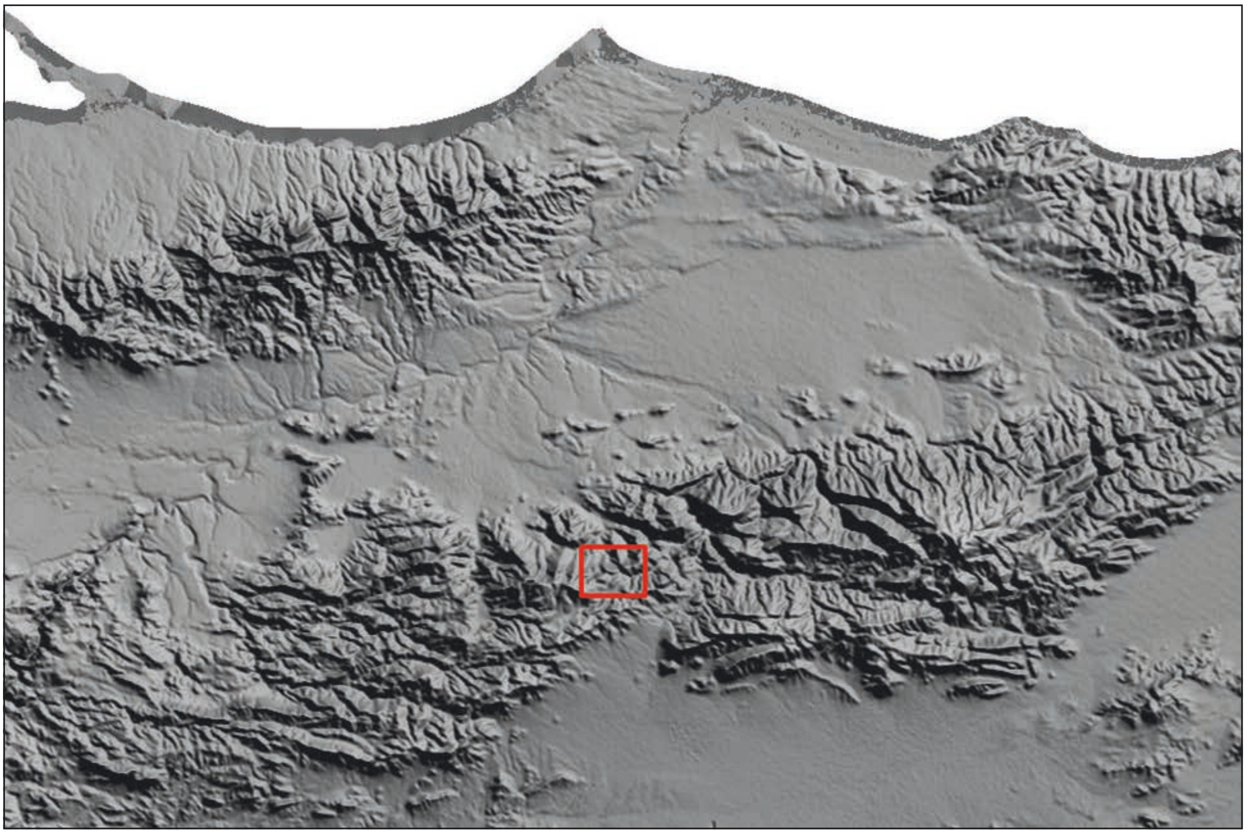


Fig. 1.1 Topographic mapping (courtesy of NASA, SRTM) (area of **fig. 1.6** boxed). – (After Tabyaoui et al. 2009).

1.2 HISTORICAL AND GEOGRAPHICAL BACKGROUND

History and geography are so often inextricably bound together, and Morocco is certainly no exception. In the present study, mention of some, relatively recent, historical aspects of the northeast of the country is necessary, even in order to understand the place names.

The site lies within the Beni Snassen mountains, geographically the eastern extremity of the Middle Atlas but now physically divided from the remainder by the Oued Moulouya, a major river running from the interior northeastwards across the coastal plain (Triffa) to the coast just west of Saïdia (**fig. 1.1**). The mountains rise to some 1500 m above mean sea level at Ras Foughal. Immediately to the south lie the Angad plains and the Oued Isly.

Many place names in the region are now given in their Arabised forms and we will usually follow this convention. However, it should be noted that the name "Beni Snassen" is derived from the Tamazight (Amazighe[1] language group, including Iznassni) for the people of the area, the *Bni Iznassen*. The groupings have related languages and related scripts, known as *Tifinagh* (and increasingly standardised for printing as Neo-Tifinagh), a set of consonantal symbols helping to accommodate regional and dialectic vowel variations.

1 The terms Amazighe (singular) and Imazighen (plural) are the correct names – albeit not as widely known as they should be – for the peoples often referred to in Europe as the "Berbers" (a distortion of the Greek '*barbaroi*').

Fig. 1.2 Cave from opposite valley side. – (TAF05_MISC_025.tif Ian R. Cartwright).

This combination of diversity and unity amongst the Imazighen proved difficult for the European powers, including France. Of particular interest in the present context, by the middle of the 19th century, the French felt obliged to pursue their interests by moving out from their bases along the coast of Algeria and penetrating into the Beni Snassen region. In October 1859, the campaign ended in the battle of the "*Col d'Aïn Taforalt*" – a phrase with a French topographical element, followed by the transliteration of an Arabic element and of the *Bni Iznassen* village name. The people of this village were at least initially displaced and the French military set up a series of camps and then a stone fort, eventually (1907) occupied by the *Légion étrangère*.

Not surprisingly, the cave which is our study site has been known under several names. It is reported that there was once a local name, given by subsequent French authors as "Kef en-nejjar" (Ruhlmann 1945a) or "Kef el-Nejjar" (Roche 1963); the first element ('cave') is a form of Arabic but the second is thought to derive from the Iznassni word for 'carpenter'. The cave was first referenced in the European literature as the cave "at Aïn Taforalt" (Pinchon 1908), from the Arabic for the local spring (see below). Following investigations at the cave in the 1940s, it rose to prominence under the names "*Grotte aux Pigeons*" (unpublished reports) and "*Grotte des Pigeons*" (a bird which was frequently hunted in the recent past, large numbers of which still nest in roof cavities) or simply "Taforalt" and this is how it is widely referred to today. However, after independence from the French Protectorate (1912-1956), the village name is now written (in Roman script) as "Tafoughalt", as it is pronounced in Amazighe.

The cave (34° 48′ 50″ N, 2° 24′ 14″ W)[2] is situated about 500 m east of, and below, the 'plateau/col' village of Tafoughalt (**figs 1.2** and **1.3**), at an altitude of around 720 m above mean sea level. Its relative position, approximately 40 km inland from the Mediterranean coast, has probably not altered much since the time it was occupied in the Iberomaurusian; even at lower sea levels, very little additional coastal shelf would have been exposed. Today, the area has a broadly Mediterranean climate (arid summers, wetter winters with peaks in late autumn and spring, but always showing high variability at various timescales and the continual possibility of influence from the Sahara [cf. Laouina 1990]), with altitude generally lowering temperatures and increasing precipitation (at least, on the northern slopes facing the sea). For instance, at Tafoughalt (810 m amsl), the mean annual temperature is 15.4°C with a mean range of 15.9°C and average monthly precipitation varies from 2 mm (summer) to 52 mm (winter, sometimes with snow), whilst Berkane (148 m amsl but only 15 km away to the northeast) has a mean annual temperature of 18.2°C with a mean range of 13.2°C and average monthly precipitation from 1 mm (summer) to 45 mm (winter)[3]. Even with the increased precipitation at higher altitude, the cave still lies in a generally arid zone; thus Laouina (1990, 36) reports that, just above Tafoughalt at an altitude of 850 m, there is an annual rainfall of 538 mm but a potential evaporation rate of 1000 mm, indicating a most significant water deficit. There is every reason to think that, at most times in the past, this general climatic pattern would have been present (albeit within differing meteorological ranges), as well as the altitudinal contrasts between mountain plateaux, valleys and the surrounding plains. It is of general interest here that Laouina (1990, 218) remarks upon the absence in the region (even higher and further south into the 'continental' zone) of geomorphological/sedimentological evidence of either cold periods (cf. lack of periglacial and nival forms) or persistently wet periods (cf. survival of ancient superficial carbonate crusts and lack of strongly weathered minerals), at any point in the Pleistocene sequences.

Taforalt is a karstic (solutional) cave formed in steeply folded dolomitic limestone (see **Chapter 2** for more detail). Most of the Beni Snassen have outcrops of various carbonate rocks, hard limestones in particular, but the northern slopes of the mountains show beds from the Palaeozoic to the Miocene, together with igneous intrusions, overall with quite a wide range of lithologies in a relatively small geographical area (see **Chapters 2** and **12** for archaeological interest). The broadly WNW-ESE principal anticlinal axis of the mountains is crossed by major near-vertical faults and thrust faults, trending dominantly NNW-to-SSE (but with secondary structures roughly at right angles and also a number of scarp-slip faults), making the outcrops even more varied and influencing the regional geomorphology and hydrology.

As has been noted, this is dominantly limestone country, and, other things being equal, water does not flow at a limestone surface but, rather, tends to descend through structural and solution features until some barrier is reached at depth. However, the combined facts that these mountains are still rising (plate margin orogeny), that they are deeply faulted and that this has probably been an area with torrential storm rainfall for much of the Quaternary, mean that the landscape is deeply incised with steep-sided valleys (cf. Laouina 1990). The principal valley immediately north of the cave now carries the "*Route de Zegzel*", the main road (agricultural and touristic) through the mountains at this point, and this valley (cf. **fig. 1.4**) is normally referred to today as the Zegzel (although it is probable that this name was first applied to a broader area of the catchment). The massif to the north of this stretch of the valley is named the Jbel Israne (reaching over 850 m amsl), that to the southeast, the Jbel Achaoun (reaching over 990 m amsl). The French (cf. Roche

2 Unfortunately, in some previous publications, we have given the position of the village of Tafoughalt in error; the co-ordinates given here are correct for the cave itself.

3 1982-2012 figures from the Climate-Data.org model.

Fig. 1.3 High view of cave and escarpment, looking south, Tafoughalt village behind. – (TAF05_MISC_029.tif Ian R. Cartwright).

1963; 1969) referred to the valley below the cave as the "Oued Trasrout" (from the village of Tghasroutte, a couple of kilometres further down-valley). This valley has certainly always been known as the Zegzel beyond the confluence with the Oueds Ferrouj and Moulay Idriss, whilst, at Berkane, it gathers further tributaries taking on the name Oued Cherraa, this, after a further 7 km, becoming a right-bank tributary of the Oued Moulouya (the Moulouya catchment overall being the second largest in North Africa).

Actual water flow is complex. From the very head of the "Trasrout" section of the valley down to a point almost directly below the cave (at c. 670 m amsl), there is now no stream at all, with water only present temporarily under conditions of torrential rain (often localised depressions penetrating from the NE). There is only one spring that is considered to be 'perennially' feeding this upper part of the catchment, the Aïn Safsaf (Dakki 2003, 10), lying (at 34° 48′ 48″ N, 2° 24′ 24″ W, at 835 m amsl, at the foot of the northern slope of the Jbel Islane which rises to 1040 m amsl) immediately SSE of the village of Tafoughalt (hence the earliest French name for the village and cave). We are not aware of any detailed research into the question but it seems likely that this resurgence is associated with impermeable / impervious beds (see **Chapter 2**); it has certainly been reported (Tabyaoui et al. 2009) how the location is associated with a local synclinal fold where it is crossed by a major fault in a set that is active in this Plio-Quaternary compression zone. The spring is thus likely to have been comparatively stable over recent geological timescales. It is known that French military engineers constructed a basin to improve the spring just before the beginning of the Protectorate; photographs then began to appear of the spectacular waterfall plunging over the cliff-top only a few tens

Fig. 1.4 View down the valley from the cave. – (TAF04-69.tif Ian R. Cartwright).

of metres southwest (up-valley) of the cave (fig. 1.5). However, during his visit in 1907 (see below), Pinchon (1908) stated that one reached the cave from the village 'by following the left bank of the *oued* formed by the spring rising just below the military camp' (then on the higher ground south of the village); this suggests that the 'natural' line of the spring water was at that time down the side valley, immediately east of the cave (which lies on the right bank of the main valley) (fig. 1.6). Indeed, today there are seeps at the head of this side valley which have recently been dammed to supply water by a pipe to facilities near the cave. Furthermore, local informants have suggested that, before the French engineering, there were 'points' with water all around the recent village (Ismail Ziani, pers. comm.). In the 1950s, the waterfall was recognised (Roche 1963) as being fed by a *seguia* (from the Arabic for an irrigation canal), thus probably an entirely artificial channel, designed to provision the new fort (almost directly above the cave) and possibly to improve agriculture immediately around the village. By the 1950s, a small amount of water was led aside from the waterfall to a minor basin (now dry) to the right of the cave mouth and then, by buried pipe, further east. In any case, once in the main valley, apart from a few pools at certain seasons, water today immediately disappears underground

Fig. 1.5 1908 postcard, showing cave and waterfall. – (Source S. N. Collcutt).

down-valley below the cave and only surfaces again (under the local name of "Oued Tafoghalt") just before the Zegzel-Ferrouj-Moulay Idriss confluence. It follows that we do not know exactly where water would have been available in the Later Stone Age but it is nevertheless reasonable to conclude that there would have been one or more persistent springs in close proximity to the cave. There is no other significant surface water for 5 km in any direction around the site and only a couple more springs even within 10 km.

One must not think that the area is (or ever was) geomorphologically inactive, however, the steep slopes and the unpredictable and extremely variable/irregular (orographic) precipitation regime occasionally combining in a spectacular manner. For instance, one may cite the case of the 10th May 1968, when rainfall equal to two-thirds of the mean annual total fell at Tafoughalt in the single day; the resulting flood along the Zegzel transported very coarse sediment and blocks that destroyed most human constructions along the route, including the bridge at Berkane (Laouina 1987). The flash flood in question was exacerbated by agricultural over-exploitation of the catchment earlier in the century but climatically-controlled periods of less dense vegetation cover in the past would probably have included similar extreme events and more common intermediate ones. It should also be noted that the Eastern Atlas is the most seismically active area in Morocco; structurally, the Beni Snassen are part of the Rif foreland, since the Rif is being compressed 'backwards' (southwards) onto the African plate.

By the end of the 19th century, much of the Beni Snassen had become deforested. Replanting at Tafoughalt, with Aleppo Pine and other tree species, started in earnest in 1942 within the col around the village. By 1999, a SIBE (*site d'intérêt biologique et écologique*) had been established across this part of the mountains, within which as many native species as possible have been encouraged. Of particular interest in the present context was the re-introduction (from surviving Atlas populations after their disappearance in the early

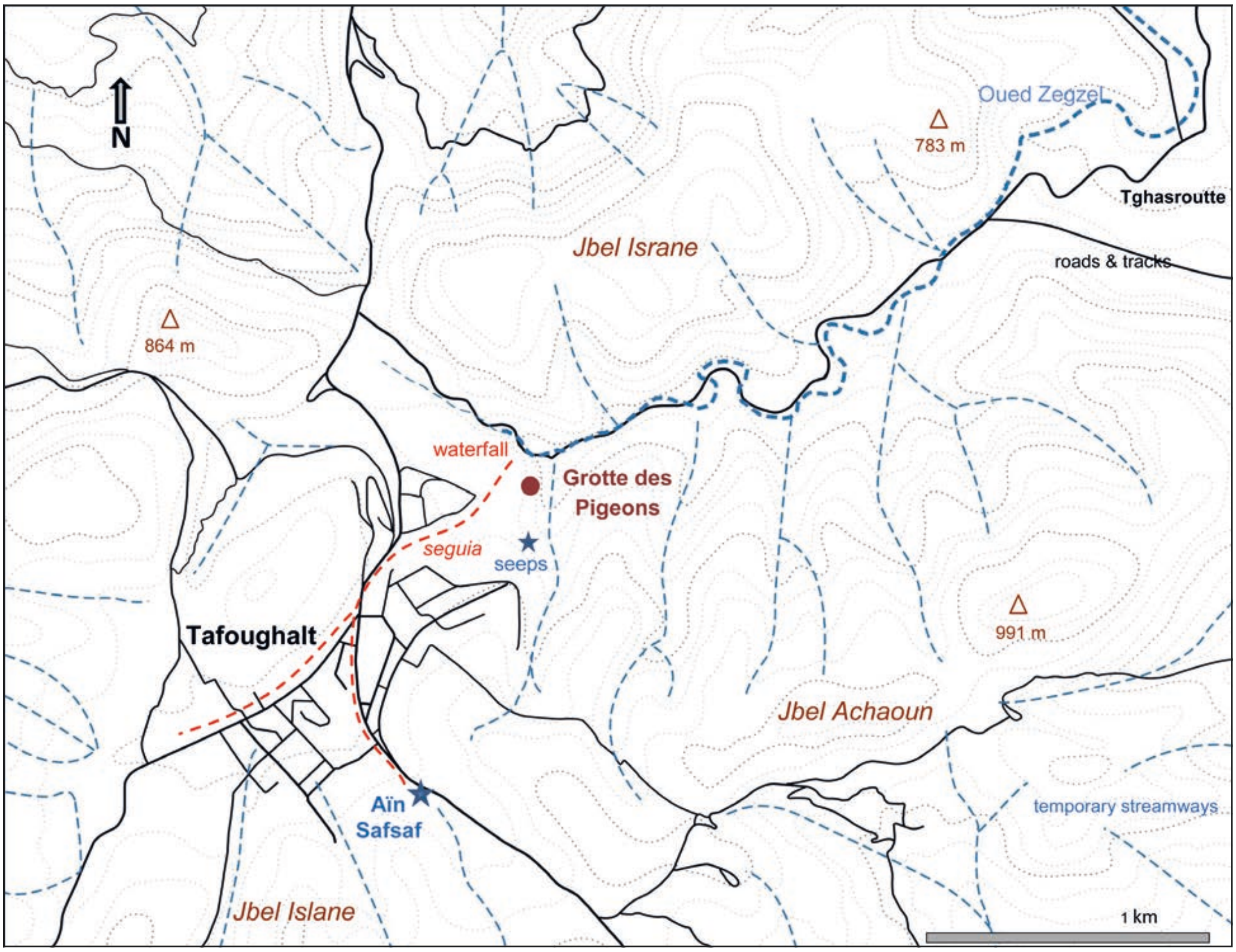


Fig. 1.6 Map of local area.

1970s from the Beni Snassen) of Barbary sheep (*Ammotragus lervia*), now regularly visible in their reserve across the valley from the mouth of the cave.

1.3 EARLIER EXCAVATIONS

Following a number of geological and archaeological surveys in Algeria and eastern Morocco in the early 20th century by Pallary and others, further reconnaissance was conducted by Dr. Pinchon[4]. During one of his trips to the Beni Snassen mountains in 1907, he found a large cave near Aïn Taforalt. In this site, he noted: "*Le sol est formé d'une terre noirâtre* […]. *A part un nucléus pyramidal trouvé à une dizaine de mètres de l'entrée, je n'ai rien pu découvrir à la surface du sol*" [The cave floor is formed of a blackish sediment […]. Apart from a pyramidal core found ten metres or so from the entrance, I discovered nothing on the ground surface] (Pinchon 1908, 435). He also discovered two nearby caves within a small side

4 Dr. D. M. Pinchon, a military medical man garrisoned for a time in Oujda; he was accompanied on his visit to the Beni Snassen by the antiquarian and botanist, Alexandre Joly; in 1909, he was listed as a member of the *Société préhistorique française*, with the address: *Direction du Service de Santé de la Division d'Oran (Algérie)*. An explanation of why Pinchon did not tarry at the cave may lie in the fact that the *Bni Iznassen*, again 'in revolt', did not submit that time until the Spring of 1908.

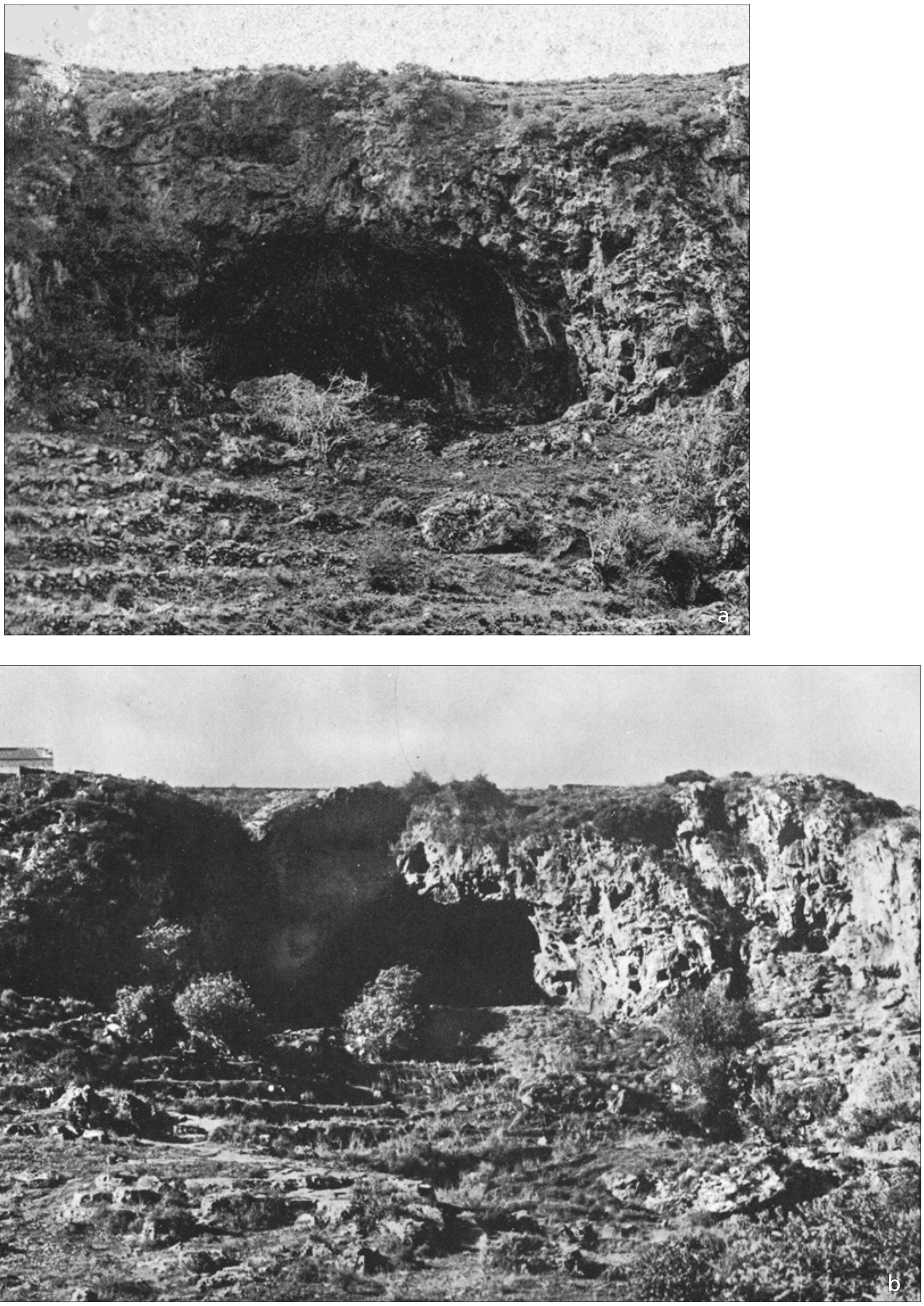


Fig. 1.7 **a** Excerpt from 1908 postcard (**fig. 1.5**); alongside **b** photo of cave mouth in the 1950s. – (b from Roche 1963).

valley (apparently further down the main valley on the left bank), where he found teeth of large carnivores but nothing to compare with the pyramidal core from the main cave. **Figure 1.5** shows the cave mouth in about 1908.

Perhaps surprisingly, given its prominent position and large size (30 m wide at the entrance and equally deep), the cave attracted little attention for another three decades and was left mostly undisturbed apart

Fig. 1.8 1951; looking southwards across the top of Ruhlmann's southern trench; Roche stands in the centre; note the start of Roche's transverse trench, which would link the two Ruhlmann ones; walls (1939 military) to form mule stalls against the south wall. – (Source Archives du Centre Camille Jullian, Aix).

from some small "*sondages*" [test pits], dug first by Bienvenu Blondeau[5] probably in 1932 (Roche 1952; 1953), then by J. Marion[6], which established the existence of Iberomaurusian finds in stratigraphic position (Ruhlmann 1945b, 81).

5 Le Révérend Père Bienvenu (André Marcel) Blondeau (1890-1965), of the Franciscan Order, arrived in Morocco in May 1931; he was in contact with the first substantial excavations, by Ruhlmann, and became the custodian of a significant portion of the latter's papers (cf. the posthumous publication in *Hésperis* 1949 by Bienvenu Blondeau of Ruhlmann's overview of fossil human remains from Morocco); he created in 1947 and (with Madame Dolorès Salvador) managed from 1948 to 1961 the *Home d'Enfants St-Joseph* (taking both French and Moroccan children) at Tafoughalt; he became a member of the *Société préhistorique française* (*Compte rendu*, 23rd November 1950, p. 494); he appears to have been the "*curé de Taforalt*" [village priest] by 1951 (Roche 1963); he rescued, with the help, amongst others, of Mme Andrée Samuel (later to become the *correspondente* for NE Morocco to Georges Souville), Jean Marion (see below) and Charles Bossler (director of the *Société des Chemins de Fer du Maroc* in Oujda and amateur archaeologist, sponsored for membership of the SPF in 1947 by Ruhlmann just before his death), endangered human remains from an unstable section in the cave in the Spring of 1952; later in 1952, he organised the visit to the cave of the participants in the Second Pan-African Congress on Prehistory, eliciting the comment: "At the Mission School near Taforalt the Father in charge allowed us to inspect a huge collection of implements from this and other sites in eastern Morocco. […]" (Cole/Clark/Davis 1952, 150); he was host to Roche during his campaigns of 1951-56 and clearly formed an important link between the campaigns of the two main excavators; he was reportedly still working in the cave in 1959. Blondeau retired to the Villa St. Thérèse, La Sèbe, Digne (France), in July 1961. In 1962, he agreed the transfer to France of his collections (lithic and bone artefacts) and also the documentation from Ruhlmann's work; with the assistance of Georges Souville and Mme Samuel, continuing even after Blondeau's death in June 1965, this material eventually reached Professor Lionel Balout in Paris, where it was distributed between the *Institut de Paléontologie humaine* and the *Musée de l'Homme*. These events are described in various correspondence held in the Georges Souville Archive (at *la Maison Méditerranéenne des Sciences de l'Homme, Centre Camille Jullian (UMR7299-CNRS) à Aix-en-Provence, Université d'Aix-Marseille*).

6 Jean Marion (1905-1976); during 1931-1957, he was a teacher of French and Latin in the *Lycée d'Oujda* [boys secondary school]; 1959-1964, *Inspecteur du Service des Antiquités du Maroc*; he was again a schoolmaster, in Digne (Provence), in 1966, when he was contacted by the Moroccan authorities concerning the Bienvenu Blondeau collection, then being held by the bishopric of Digne; he was best known for his work in later prehistory and classical studies; cf. the obituary by Souville (1978).

Fig. 1.9 1951; looking westwards, towards the cave interior; both Ruhlmann's southern and northern trenches are visible; the northern trench (right) actually burrowed underneath the wall and large rock against which the workmen are leaning; mule stalls and building (1939 military) in the background. – (Source Archives du Centre Camille Jullian, Aix).

However, in 1939 during mobilisation, the large cave came to the attention of the French military authorities as a site of strategic importance and the floor was artificially levelled to accommodate soldiers and their mules. It was during this phase that a significant volume of the grey ashy deposits ("*terre noirâtre*") must have been stripped away and dumped on the slopes outside (Roche 1963). Fortunately for later archaeologists, a capping of lime mortar was then laid inside the cave to dampen the effects of dust, thus helping to stabilise the top of later excavation trenches; even today, the ashy sediments on the south side of the cave owe their survival largely to this capping. It is assumed that this installation was abandoned in 1940 as Vichy France was forced to reduce its North African forces.

Armand Ruhlmann (1896-1948) was a career archaeologist trained in Mulhouse (Alsace). He arrived to join the *Service des Antiquités du Maroc* in 1931, at the request of Louis Chatelain, the founder and first Director (Thouvenot 1954). Although Ruhlmann worked in most periods of Moroccan archaeology (for instance, at the classical city of Volubilis), his preference was for the Palaeolithic, excavating in several now famous sites, such as Sidi Abderrahman, El Khenzira (the site upon which his doctorate was based) and Dar es-Soltan (published posthumously). After demobilisation in 1940, Ruhlmann became an *Inspecteur des Antiquités préhistoriques marocaines* and it was decided by the central administration in Rabat that he should excavate at Taforalt[7] (Ruhlmann 1945a; 1945b; see also 1947). Work continued over three seasons, each approximately one month long, in 1944, 1945 and 1947, during which two major longitudinal trenches were dug into the deposits, always to depths over 4 m and in places reaching over 7 m. Unfortunately, this

7 We do not know why but it is possible that Bienvenu Blondeau brought the site to the administration's attention.

Fig. 1.10 1951; looking northwards from a vantage point outside the cave, across the tops of both Ruhlmann's southern and northern trenches; note the dry walling intended to support the crumbling far section. – (Source Archives du Centre Camille Jullian, Aix).

work was never published and all the photographs and section drawings (recorded as having been made), detailed commentary or finds catalogues (were any such indeed compiled) seem to have disappeared, although there must be some chance that primary material survives in Paris museum collections.

The circumstances of Ruhlmann's work are not very clear. He drew on the help of local French enthusiasts and technical experts (a draftsman and a photographer) from the Oujda area but no comments were published by professional visitors (if any). The excavations were conducted quickly, even perhaps too hurriedly, but under difficult conditions – Ruhlmann complained of the constant dust and the need to smash through large limestone blocks in these narrow and deep trenches. It is only thanks to the continuing interest of Bienvenu Blondeau that the 1944-47 field notes, basic as these are[8], were later passed on[9]. Plans to continue to excavate the site were brought to a premature halt when Ruhlmann died (at the age of 52) on May 15th 1948 as a result of a fall from a section at his rock-shelter excavation at El Aïoun in Eastern Morocco[10]. All that now remains in the Taforalt cave of these early excavations are the outlines of deeper parts of the two trenches (cf. **figs 1.12-1.13** and **2.10**). Nonetheless, Ruhlmann was the first to provide an insight into the nature of the cave deposits, which he subdivided into "*terres grises*" [grey (ashy) deposits], upper units with LSA (Iberomaurusian), and "*terres jaunes*" [yellow (loamy) deposits], lower levels with traces of LSA in places and MSA (variously attributed to the 'Aterian' and 'Mousterian').

8 Termed mere "*éphémérides*" by Ruhlmann himself, bound to be tantalising yet ultimately disappointing in their lack of detail from a modern reader's viewpoint.

9 "[…] *une partie du journal de fouilles d'Armand Ruhlmann qu'avez bien voulu me communiquer le R. P. Bienvenu Blondeau*" [… a part of the excavation diary of Armand Ruhlmann which Father Bienvenu Blondeau had been good enough to communicate to me] (Souville 1973, 11). In fact, Georges Souville had a photocopy of all three years of the field notes.

10 Cf. Terrasse (1949), Lantier (1952) & Souville (1961).

Fig. 1.11 1951; looking eastwards during the clearance of the eastern end of Ruhlmann's northern trench; the workmen had still some way to go downwards before all the collapse material had been removed. – (Source Archives du Centre Camille Jullian, Aix).

Two surviving communications [11] are of interest at this point. First, there is a letter (dated the 20th November 1951) from l'Abbé Jean Roche to Maurice Antoine (who had succeeded Ruhlmann in the post of *Inspecteur des Antiquités préhistoriques* and who, in turn, would be succeeded by Roche himself in 1953), in which Roche noted his arrival at Taforalt and remarked upon the broad findings of the excavations, together with their importance – but without mentioning Ruhlmann. Then, on the 25th November, Antoine wrote to Lionel Balout at the Bardo Museum (Algiers):

> "*Grotte de Taforalt.*
> *Cette grotte très intéressante, a été fouillée par Ruhlmann. Etant donné mes anciennes relations – plus que tendues, vous avez dû en lire les échos – avec ce dernier, je me suis absolument interdit de contrôler ses fouilles. Mais l'Abbé Roche a bien voulu, à ma demande, s'y rendre* […]. […] *il y est depuis 15 jours et m'en a confirmé le gros intérêt.*"
>
> [Taforalt Cave.
> This most interesting cave has been excavated by Ruhlmann. Given my previous relations with the latter – more than strained, as you must have heard [12] – I have altogether refrained from checking on his dig. But, upon my request, l'Abbé Roche has been good enough to go there […]. […] he has been on site for a fortnight and has confirmed to me its substantial interest.]

11 Letters (the first manuscript and the second a typed copy) held in the Georges Souville Archives at *la Maison Méditerranéenne des Sciences de l'Homme, Centre Camille Jullian (UMR7299-CNRS) à Aix-en-Provence, Université d'Aix-Marseille*.

12 Deep disagreements had grown, from the later 1930s onwards, between Ruhlmann and Antoine, concerning the nature and subdivision of the Aterian. Bizarrely, the argument reached white heat in an exchange in print, (Ruhlmann 1951) and (Antoine 1952), after Ruhlmann's death, in which choice phrases (hardly needing translation here) such as "*en opposition formelle avec la réalité des faits*" and "*le caractère antiscientifique du procédé*" were traded. The 'Sidi Abderrahman affair', in which Antoine was taken to task (Neuville 1951) for blaming his predecessor for failing to push for full protection of that complex of sites from developers, also came to a head at this time.

Fig. 1.12 c. 1955-62; looking westwards, towards the cave interior, with the remaining 'study section' of the "*terres grises*" [grey (ashy) deposits] on the left and the bases of the two Ruhlmann trenches beyond, cut into the "*terres jaunes*" [yellow (loamy) deposits]. – (Source Archives du Centre Camille Jullian, Aix).

Jean Roche (1913-2008)[13] was a catholic priest who had gained his *Licence ès Lettres* [B. A.] at the Sorbonne in 1946 and then trained in prehistory and ethnology at the *Musée de l'Homme* in Paris. After early fieldwork in Portugal (which he was to pursue throughout his career), he recorded that he was invited in 1950 to Morocco by Henri Terrasse, *Directeur de l'Institut des Hautes Etudes Marocaines* [IHEM], where his first significant excavation assignment seems to have been at Taforalt.

The first season on site, in late 1951, was taken up mostly with cleaning out the Ruhlmann trenches, although a new cross-trench between the two was also started. In December, Roche submitted a short site report[14], summarising Ruhlmann's findings. A number of publications followed rapidly (Roche 1952; 1953a;

13 Cf. (Debénath 2009).

14 Typescript held in the Georges Souville Archives (at *la Maison Méditerranéenne des Sciences de l'Homme, Centre Camille Jullian (UMR7299-CNRS) à Aix-en-Provence, Université d'Aix-Marseille*).

Fig. 1.13 c. 1955-62; looking eastward, with the remaining 'study section' of the "*terres grises*" [grey (ashy) deposits] on the south (right) and the base of Ruhlmann's southern trench cut into the "*terres jaunes*" [yellow (loamy) deposits]. – (Source Archives du Centre Camille Jullian, Aix).

1953b), with quantified artefact analyses and illustrations – a most important contribution from Roche – but all based almost completely upon Ruhlmann's stratigraphic scheme and excavated collections [15], although Roche neglected to make this explicit [16].

The photographs in **figures 1.8-1.11** show the cave in 1951, with the traces of the 1939 military installations including the level floor, during cleaning of Ruhlmann's trenches.

15 The initial finds of human remains in 1951-52 being the most notable additions.

16 It was not until later (Roche 1963, 17) that he included in his 'Acknowledgements' a note: "[…] *le R. P. B. Blondeau qui m'a reçu à Taforalt et m'a remis la copie du journal de fouilles d'A. Ruhlmann,* […]" [… Father Blondeau who took me in at Taforalt and who provided me with the copy of Ruhlmann's excavation diary, …]. This 'diary' (cf. Ruhlmann 1945a-b; 1947) has never been published.

Fig. 1.14 c. 1955-62 photo montage (unrectified); looking southward, with the remaining 'study section' of the "*terres grises*" [grey (ashy) deposits] beyond the base of Ruhlmann's southern trench cut into the "*terres jaunes*" [yellow (loamy) deposits]; this montage is comparable in detail to that published, inadvertently reversed, in Roche 1963. – (Source Archives du Centre Camille Jullian, Aix).

The cave had been open and unprotected in 1951, and the sections were crumbling, but Roche provided for a fence by October 1952; we assume that the military walling inside the cave had been removed by this date. For four further field seasons in the period 1952-55, Roche continued to work under the auspices of the *Institut des Hautes Etudes Marocaines*, excavating an enormous volume of sediment from the cave, nearly exclusively from the "*terres grises*" [grey (ashy) deposits], including the area of related burials found at the back of the cave, a "*véritable ossuaire ibéromaurusien*" (Roche 1953b, 114). He later estimated (Roche 1973-1975) that the grey deposits had produced over 400,000 struck lithic artefacts. Work from the centre of the cave inwards also involved the removal of very large blocks of rock, one weighing up to 50 tonnes (Roche/Souville 1956). Roche recognised the complexity of the burial area and waited until the 1954 and 1955 seasons, when excavation of the human remains was resumed under the immediate direction of A. Jodin[17]. The photographs in **figures 1.9-1.11** show the cave at some point in the period c. 1955-62[18], after the bulk of the "*terres grises*" [grey (ashy) deposits] had been removed. It was at the beginning of this period that a stone hut was constructed outside the cave intended for a permanent guardian and a small museum (Roche/Souville 1956, 164), along with the access track, structures which remain today. Following the 1955 season, "*les travaux ayant été brusquement interrompus*" [work having been suddenly interrupted] (Roche 1963, 48), a more lasting suspension of the excavations was occasioned by the end of the French Protectorate in 1956.

Roche wrote up his research on the "Epipalaeolithic" (LSA) of Morocco, dominated by his work at Taforalt, in 1957 and submitted the work for his doctorate at *la Faculté des Lettres* in Paris, research later published in full (Roche 1963)[19]. The human remains were also described (Ferembach 1962). Charcoals collected before

17 André Jodin (1921-2003), *Service des Antiquités du Maroc*, editor of Vols 1-7 (1956-67) of the *Bulletin d'Archéologie marocaine*, best known for his later excavations in protohistoric and classical sites in Morocco and Spain but also an excavator in various Holocene cave deposits. With respect to Taforalt, see the 1954-55 excavation notebooks, plans & photographs held in the *Musée archéologique* in Rabat.

18 The photographs themselves are not marked with a date. This 'c. 1955-62' date (i. e. towards or after the end of the first phase of Roche's work) is deduced from the fact that none of the deep excavations into the "*terres jaunes*" undertaken by Roche during the second phase of his work (before 1972) have been commenced in the photographs; because nothing substantial is known to have been done in the cave during the long gap in Roche's work, it is nevertheless possible that the photographs date from as late as 1969, at the very start of the second phase. However, Plate I in Roche (1963) (which presumably dates from around 1955) shows a long section in the unstable ashy deposits that is similar in fine detail to that in **fig. 1.14** (below), suggesting that no great degree of erosion/collapse could have intervened. Furthermore, colour slides taken by Serge Kostomaroff (photographer for the *Service des Antiquités du Maroc*) and labelled "1962" (one of which is reproduced in the present volume as **fig. 15.2**) seem to show the wooden survey structure already/still in place.

19 Unfortunately, Roche's own notebooks for the 1951-55 period appear to have been lost: that covering at least the period 1952 even before c. 1959, according to a note by Roche himself (Rabat archive), all his other site notebooks having been left in Morocco after his retirement and never since coming to light (pers. comm. reported by Aoudia-Chouakri 2013, 129). Roche certainly retained his own archive of his work from 1969 onwards (mentioned in a 1982 letter to J.-P. Raynal, held in the Rabat archive) but the current whereabouts of this material are unknown. The

the interruption were submitted to Gif-sur-Yvette and provided some of the first radiocarbon dates using this technique from Morocco (Roche 1958; 1959).
Roche was able to resume excavations at Taforalt, as *Directeur de la Mission archéologique française au Maroc* in collaboration with the *Service marocain de l'Archéologie*, in 1969 (Roche 1976; Delibrias/Roche 1976).
This time, Roche worked on the "*terres jaunes*" [yellow (loamy) deposits] and deeper units, the latter proving extremely difficult to penetrate (rocks and cementation), let alone to understand. Fieldwork continued until 1976, although no detailed publication ever materialised and the whereabouts of any field notebooks are unknown; indeed, all Roche's substantive publications on the MSA material from the cave seem to have concerned the Ruhlmann collections, with occasional additions from section cleaning, despite the fact that he was certainly reporting new artefact finds in his fieldwork summaries (cf. Roche 1973-1975). Four sections were described, one longitudinal and three transversal (Roche 1973-1975); copies of the section drawings exist and are preserved in the corpus of documents held by the Archaeological Museum in Rabat. During this phase of excavation, further charcoal samples were submitted for radiocarbon dating at Gif-sur-Yvette and the results published (Delibrias/Roche 1976; Roche 1976).
In the latest stages of the Moroccan-French collaboration (1973-77), J.-P. Raynal[20] undertook a full survey of the cave in 1977 and recorded stratigraphic sections (Raynal 1980). His detailed description of the sequence in Squares M21 and N21 (towards the back of the cave), a sequence which survives largely intact today, has provided us with the main geological 'reference-section' for this part of the cave. Roche may have visited the site again in 1977 to liaise with Raynal but, due to a stratigraphic error by Roche (see Chapter 2), the MSA/LSA boundary was incorrectly located; unbeknown to him, all Raynal's work, and that derived from his sampling (probably continuing until 1982), involved MSA levels only.

1.4 HISTORY OF THE CURRENT PROJECT

The new investigations at Taforalt grew out of a collaboration between the two co-directors (Bouzouggar and Barton) that had started in 1999 and was part of a wider INSAP[21]/University of Oxford project to examine the equivalent of the Middle to Upper Palaeolithic transition in North Africa and its relationship with the early human occupation of southwest Europe (see Barton/Bouzouggar/Stringer 2001). The new project's immediate objectives were to locate and obtain high precision dating and palaeoenvironmental evidence from caves in northwest Morocco but it soon became apparent that Taforalt, with its exceptionally thick sequence of cultural and environmental deposits, offered the best potential for such work and therefore the major focus of effort was turned to this site.
When work began in 2003, the main aims were to identify and date occupation levels belonging to the Aterian (Middle Stone Age, MSA) and Iberomaurusian (Later Stone Age, LSA), and to examine deposits spanning the local transition between these two archaeological technocomplexes. If the deposits were rich enough, it was intended also to compare the way in which the different cultural groupings had utilized the cave, under diverse climatic and environmental conditions in the equivalent of the last glacial period (Marine Isotope Stages 4-2, approximately 75-10 thousand years ago). For this new phase of work, existing standing

present team wrote to Roche in March 2008, requesting an interview, but his friend and colleague, André Debénath, counselled against such a meeting given the poor state of Roche's health. Sadly, the Abbé passed away in December of that year.

20 Jean-Paul Raynal (1949-), University of Bordeaux.

21 *Institut national des Sciences de l'Archéologie et du Patrimoine*.

profiles left inside the cave by Roche and Ruhlmann were first cleaned (where safe to do so). The immediate goal was to re-describe the deposits, collect fresh dating samples and to investigate the archaeological sequence. This had previously been reported by Roche as covering a combined depth of over 10 m, and made up of rich Aterian hearth layers overlain by a 4-metre thick sequence of Iberomaurusian deposits. The latter included a major accumulation of grey deposits (which we were immediately able to confirm as related to *escargotières* and *rammadiyats* from their high content of mollusc shells and ash) and, at the back of the cave, initial clearing suggested that significant portions of the "*nécropole*" [cemetery] recognised by Roche remained intact. Except in the area of the burials, where the edges of the earlier excavations were heavily eroded, a small number of new excavation squares were arranged contiguously with the old trenches. To ease identification, each of the old sections here studied and the new areas of excavation have been designated as separate 'Sectors' within the cave (see fig. 2.10).

An early result of these studies was the publication of a first coherent set of AMS[22] radiocarbon dates for the Iberomaurusian (Barton et al. 2007). It was also possible to show that there was a much more complex sequence of sedimentary units that went well beyond the original subdivisions by Roche of the 'grey (ashy) deposits', that we have labelled the "Grey Series". Similarly, we identified a sequence relevant to the Iberomaurusian at the top of the 'yellow (loamy) deposits' that we have labelled the "Yellow Series", although this sequence is not the same as that identified by previous researchers in their publications. In the first instance, we concentrated upon a zone on the central-south side of the cave (called by us "Sector 8") which has the most complete exposure of the relevant sediments but we have subsequently been able to identify less complete exposures in other parts of the cave. Intriguingly, immediately below the levels described in detail in the present volume, we came across evidence of an older flake industry, that appeared to pre-date the Iberomaurusian but did not fit the description of any previously documented lithic industries in NW Africa. In addition, and following discovery of *in situ* human remains at the back of the cave in 2004, parallel work was begun (in the area called by us "Sector 10" in a sequence referable to part of the Grey Series), with further members of the Natural History Museum (London) joining the team and co-directing (Humphrey) excavations from 2005 onwards.

1.5 MAIN RESEARCH QUESTIONS

Linked to the research of reinvestigating the nature of the cave's stratigraphy and the chronology of the Iberomaurusian were a series of related longer term goals and objectives. These were encapsulated in two successive projects: EFCHED (Environmental Factors in Human Evolution and Dispersals in the Upper Pleistocene of the Western Mediterranean) funded by the Natural Environment and Research Council (UK) from 2003, and a second project entitled "Cemeteries and Sedentism in the Epipalaeolithic of North Africa" supported by the Leverhulme Trust from 2008. The latter was explicitly concerned with the Iberomaurusian and dealt with integrating the long occupational sequence of the cave with the human burial evidence. The Calleva Foundation have assisted in carrying the whole project forward since 2012. The research has benefitted throughout from the support of INSAP and the PROTARS project (*Programme thématique d'Appui à la Recherche scientifique*). Amongst the major research questions arising from these projects were:

22 Accelerator Mass Spectrometry (AMS).

What was the climatic and environmental background to the Iberomaurusian (23,000 to 12,500 cal BP)?

The period covered by the Iberomaurusian occupation is known in the northern hemisphere to be one of dramatic climate change characterised by sharp oscillations in temperature and precipitation. However, at the beginning of our research there were few detailed terrestrial records available from Morocco on which to test these ideas. Exceptional preservation of deposits within the cave allowed the sampling of the sequence, both Grey and Yellow Series units, for palaeontological remains including snail shell, charcoals, charred plant remains, bones of birds, larger vertebrates and small mammals, etc. One of the aims was to collect environmental evidence as proxies for climatic changes through time. For example, was it possible to detect periods of greater or lesser humidity through the analysis of environmental remains in these units?

Was there evidence of continuity of occupation or were there significant breaks in the Taforalt sequence?

One of the themes for investigation was to test whether there were any significant discontinuities in the Iberomaurusian stratigraphic sequence? What might be the nature of these temporal gaps and would it be possible to compare them (if any) with deduced changes in the rates of sedimentation? This question also interacted with our first (above), in that, if discontinuities were identified from the sediments, could these be matched by other lines of supporting evidence and did they coincide with specific regional or global shifts in the climate?

Was there evidence for cultural variability within the Iberomaurusian?

Intra-site variation in the lithic artefact assemblages between different stratigraphic units had already been noted by Roche (1963). But questions remained about the stratigraphic detail of the previous work and renewed excavations afforded the possibility of much higher precision studies thanks to systematic use of sieving and reliance on multiple AMS radiocarbon dates. The potential was also recognised for integrating the results on the bone artefact technology and adding further observations on subsistence and other cultural behaviours. If there was evidence for major variability, did this represent overall cultural changes through time or could it have been due to locally fluctuating functional objectives?

In what periods was Taforalt used for burials? What was the nature of the human burial evidence?

Lack of information concerning the chronology and context of human remains in the cave could be addressed by fresh excavations at the back of the cave, combined with direct dating of human bone from the burial layers. Questions that had arisen from the initial re-discovery in 2004 were related to whether any unexcavated burials were preserved, were they buried sequentially, what was the nature of the funerary behaviour (were the skeletons buried whole or introduced as disarticulated body parts), what age groups were represented and whether funerary behaviour varied according to age or sex of the deceased? We were also interested in cultural characteristics during life, such as the prevalence of dental evulsion (the *pre-mortem* deliberate extraction of the incisors) in the Iberomaurusian population.

What were the subsistence strategies of the Iberomaurusian humans at Taforalt?

This was the starting point of our enquiries. Our aim was to examine a variety of evidence ranging from the study of the large fauna, terrestrial molluscs and charred plant remains to anthropological analysis of the human skeletal remains. Integrated within the Leverhulme project were specific questions relating to changes in subsistence patterns through time that could be inferred from analysis of the charred plant and molluscan finds and the human dental evidence (oral health and dental modification) which all had a bearing on dietary behaviour.

Did behavioural changes in the Iberomaurusian amount to early evidence of broad-spectrum subsistence patterns, economic intensification and increased sedentism?

One of the meta-questions to emerge arose out of an increasing impression that the Iberomaurusians did not fit the traditional pattern of mobile hunter-gatherers but were more sedentary in their lifestyles. Examples from the Levant indicated that precocious development of broad spectrum behaviour and sedentism had occurred long before the advent of the Neolithic. The question here therefore was whether the evidence from Taforalt suggested a similar trajectory of development to that seen in the eastern Mediterranean (with similar causality) or whether the changes in the Iberomaurusian arose out of differing processes and sets of constraints.

2. LITHOSTRATIGRAPHIES AND SEDIMENTS

2.1 INTRODUCTION

The geological setting of the cave is not entirely clear, at least in its chronostratigraphic details. Ruhlmann (1945a) referred only to 'limestone' in respect to the bedrock of the cave. Roche (1953b, 90) noted: "[…] *le corps de la grotte est constitué par du calcaire dolomitique. Cette formation repose sur des calcaires liasiques*"; this wording would seem to suggest that the cave bedrock is dolomitic limestone and that this is younger than some Liassic limestones. He later (1963) merely implied that the cave was formed in Liassic strata of 'limestones and dolomites'. Courty (presumably following advice from Raynal, see below) suggested (Courty/Vallverdu 2001, 471) that the "cavity [is] in Plio-Pleistocene travertine on Dogger dolomitic limestone bedrock with spring-fed travertine". The present author, in earlier publications with the current team, has plumped for 'Permo-Triassic dolomitic limestones', admittedly on little more than (seemingly incorrect) hearsay evidence.

The regional geology has been reported by El Gout/Khattach/Houari 2009 (a work which contains a summary description from the unpublished Beni Snassen fieldwork of Tayub Naciri in the late 1980s and early 1990s). The Palaeozoic core of the mountains is composed principally of Devonian schists and sandstones, with a granite batholith and quartzites of the Carboniferous. Following a peneplanation surface, the "Permo-Triassic" is composed of conglomerates capped by basalts (often slightly coarser grained doloritic basalts) and interbedded with evaporitic carbonate units (including dolomites) and red claystones; there are manganese-enriched levels at the base of the Trias. The Lias (Early Jurassic) is transgressive, with the base (Hettangian) missing in this area. The first Liassic strata are probably Lotharingian (early Sinemurian) dolomites, dolomitic limestones and limestones. With deepening water, limestones with high quality cherts ('flint', 'silex') developed in the Carixian, and fine-grained 'lithographic' limestone in the Domerian. A general characteristic of the Lias in this region is that it is fossil-poor at the start and only fossil-rich towards the top, with all the difficulties of identification/correlation that this implies for the earlier stages. Carbonate deposition, increasingly marly (and with detrital beds sometimes accompanied by cherts), continued from the top of the Lias into the succeeding Dogger (Middle Jurassic), although the nearest certain major outcrops of the latter are well to the south of Taforalt, with others to the southwest and west.

Close to Taforalt, we shall rely upon the *Carte Géologique du Maroc*[23] (CGM), with geological units described below in a transect from a point southeast of the cave. The high ground (some 1.5 km from the cave) is composed of the Béni Ourimeuch Formation (Oxfordian to Kimmeridgian of the Late Jurassic), keyed as an "*alternance de grès et de marnes*" [alternations of sandstones and marls], probably largely of proximal turbidite facies (coastal platform edge facies). Of considerable significance (see below), the youngest unit of this Formation is separately shown on the CGM as a relatively thin outcrop of "*marnes vertes avec des intercalations de grès fins blanchâtres bioturbés*" [green marls with intercalations of fine whitish sandstones showing bioturbation]; Cattanéo/Gélard (1989) have suggested there are lagoonal shales at the top of this sequence. Next to the northwest lies the Mechra Klila Formation (Kimmeridgian of the Late Jurassic).

23 1:50,000 (Berkane Sheet 425) 2001 (surveyed 2000).

The earlier part is shown on the CGM as an outcrop of "*calcaires gris, partiellement dolomitisés avec des intercalations marneuses*" [grey limestones, partially dolomitised with intercalations of grey marl]. The later part is shown on the CGM as a wide outcrop (including the area of the cave itself from a boundary some 300-400 m distant and, even across a presumed fault along the valley bottom, the far hillsides) of "*dolomies massives à aspect brèchique avec des intercalations de calcaires lités*" [massive dolomites, with a brechified (thus probably syn-tectonic) appearance and intercalations of bedded limestone]. Again, much of the local Oxfordian-Kimmeridgian sequence is fossil-poor (especially so where it is dolomitic), although foraminifera and algae have been used for biostratigraphic definition in outcrops elsewhere in the region of what are taken to be the same units. No younger rocks survive in the vicinity of Taforalt until the Quaternary; the CGM shows a broad area of "*argiles de décalcification*" [clayey decalcified weathering mantle] under the village, prolonged by a zone of "*galets, blocs et argile-sableuse (éboulis)*" [pebbles, blocks and sandy clay (scree deposits)] on the plateau immediately above the cave. One may note that red beds, probably a manifestation of the deep weathering mantle, seem to be contributing to soil profiles only a few hundred metres just behind and a little above the cave.

In order to read this geological sequence on the ground, it is necessary to take note of the fact that the gross structure of the area is an anticline (slightly crescentic in plan, concave to the NNW), with the Zegzel Valley lying on the northern limb. The outcrops on the southern side of the Zegzel Valley in proximity to the cave show a very high angle dip, broadly northwards. On steep slopes (e. g. cliffs), the normal stratigraphic order may be seen, although the common faulting (along both longitudinal and transverse axes, with respect to the main anticlinal structure) may sometimes produce 'keyhole' exposures, bounded by unconformities. For example, there are outcrops of both the Palaeozoic and the Trias lower in the Zegzel Valley. However, on slopes (real or simply represented by a notional line with a significant N-S element between exposures) that are gentler than the local geological dip, the proper stratigraphic order is reversed, with older rocks tending to outcrop altitudinally higher (thus the surface outcrop transect described above is from older/higher southeast to lower/younger northwest).

As noted above, the present author has suggested a more ancient date in the past but it now seems clear that the bedrock in proximity to the cave is upper Kimmeridgian in age.

The local persistent spring (Aïn Safsaf), currently located just to the southwest of the village of Tafoughalt, was noted in Chapter 1. It has not been possible to visit the private land surrounding the spring itself but, judging from the mapping, it occurs (at the head of a significant body of 'valley-bottom' sediment shown by the CGM) at the junction between the dominantly carbonate Mechra Klila Formation and the preceding 'green marl' of the upper Béni Ourimeuch Formation. The term "*marne verte*" [green marl] is usually applied to lithologies that, due to high silica clay content, are of low permeability; a shale would certainly be impermeable. It would therefore appear that a groundwater reservoir in the older sandstones (outcropping higher to the southeast) is overflowing at this aquiclude/aquitard point, although why this should be the case at this particular point is still unclear, if probably linked to a particular fault geometry (there are currently no further springs along this geological junction, which runs east and southwest of Tafoughalt, although there are indeed secondary seep points downslope around the village, possibly more numerous in the past; cf. Chapter 1). Although the exact main point of emergence may have shifted a little, no amount of surface erosion would suffice to change the key geological geometry, such that it is reasonable to suggest that, given sufficient rainfall to fill the aquifer, the spring is very likely to have been active in the Late Pleistocene.

Returning to the cave itself, Raynal (1980, 69) gave the following summary:

> *La grotte de Pigeons est creusée dans des travertins dont l'implantation dans la vallée de l'Oued Zegzel est postérieure à la phase majeure de façonnement du relief actuel. Une karstification établie aux dépens d'une zone faillée et* [sic] *responsable d'écoulements importants et de la constitution du massif concré-*

tionné. Ces travertins se sont karstifiés pendant et après leur mis en place, à une période relativement récente du Quaternaire.

[The *Grotte des Pigeons* is formed in travertines, the insertion of which in the valley of the Oued Zegzel post-dates the main formation phase of the current relief. Karstification, taking advantage of a faulted zone, [was] responsible for major water flow and for the formation of the concreted massif. These travertines were karstified during and after their emplacement, at a relatively recent stage in the Quaternary.]

These propositions are rather difficult to follow. The present author would place them alongside his own site observations, which suggest a more complex phasing.

First, the principal bedrock of the cave (exposed over only c. 10 % of the accessible cavity) is a dense, relatively hard but largely isotropic and crushable carbonate in which very characteristic dolomite crystals (rhombs) are just visible to the naked eye (fine sand grade); the rock is massive, that is, there is very little depositional structure (save for the main dipping bedding planes) visible in the immediate outcrop and there appears to be no macroscopic fossil content. In samples degraded by either heating or weathering, dolomite rhombs dominate in the disaggregated product, with very few sand-grade silica/silicate grains. In samples decalcified in acid, the very small proportion of particulate residue lies predominantly in the clay to fine silt grades, and there would also seem to be a minor colloidal iron content. Bearing in mind the CGM mapping (above), these facts would suggest that the rock is at least a dolomitic limestone (that is, a limestone which has suffered secondary dolomitisation to settle into crystals of a stable calcium-magnesium carbonate solid solution); detailed mineralogical work would be required to rule out the possibility of an actual dolomite (dominated by magnesium carbonate).

What little macro-structure remains in the bedrock suggests that it has been steeply folded in proximity to high-angle, often now vertical, faults. These faults have been infiltrated by vein calcite, with individual veins sometimes a metre or more wide. Disaggregation of this calcite gives angular clasts, down to sharp cubes at sand grade. In passing, it may be noted that the geometry of the veins exposed within the cave (total bedrock cavity) has created a series of 'compartments', which have acted as partially separated depositional basins; however, this point is not particularly significant in the upper sediments of the cave of interest here (because the 'room walls' – the veins – have largely collapsed at this high level), so that, save for a few observations, the matter will be taken up in greater detail in the next volume (concerning the underlying MSA levels). The age of the calcite veins is unknown but it seems likely that they are of considerable antiquity (pre-Quaternary) and are the result of the deep circulation of mineralised waters within the folded and faulted bedrock, all responding to the generally orogenic structural context in the region.

This zone of weakness has indeed favoured subsequent karstification (the formation of cavities by groundwater solution). Most of the presently exposed 'rock' surfaces within the cave are, in fact, composed of ancient speleothem[24]. These may most easily be examined immediately to the northwest of the present cave mouth, where there are large bodies of well stratified but strongly convoluted material that seem eventually to have choked more or less all their original feed-cavities; the nature of this material appears speleothemic (i. e. sub-surface), the relatively dense crystal structure probably ruling out formation in exterior springs. The age (or, more probably, 'ages') of this material is again unknown but the normal mode of formation would be vadose (water flowing within an air cavity), suggesting that the watertable was dropping and that the outside valley was perhaps at least starting to function at the contemporary surface. Note that Laouina

24 The term 'speleothem' is here used to refer to a range of sub-surface (cave) precipitates, here dominated by calcium carbonate deposits. Whilst the term '*travertin*' has often been used in French to denote any hard carbonate, the terms 'travertine' and 'meteogene tufa' in English technical usage refer to dominantly sub-aqueous deposits only (often biologically mediated). The ancient speleothemic bodies at Taforalt have not been studied in detail but clearly show very wide genetic and morphological variety, certainly not restricted to true travertines.

Fig. 2.1 Ancient conglomerate hanging in the roof in the NW part of the cave, upward view. – Scale 20 cm.

(1990, 190) sees the complex cemented deposits[25] only just above the modern Zegzel valley floor, in the reach between Taforalt and Tghasroutte, as being of 'Middle Quaternary' age (now defined as the interval MIS18-6) and a product of rapid slope-stripping due to down-cutting, probably controlled by tectonic up-lift; indeed, there are even said to be 'Villafranchian' deposits in the small Tghasroutte depression itself.

Probably after the first speleothemic choke, a new significant cavity was opened, immediately to the side (south) of the last stage of the previous zone of activity but still within the overall speleothemic mass. It is not known how large this cavity might have been but it can certainly be referred to as a 'cave'. This cave was integrated into the main drainage pattern; that it carried very significant water flow is shown by small patches of coarse but rounded gravel, surviving cemented into the roof and certain deep apertures at the back of the currently accessible cavity (fig. 2.1), gravels not dissimilar in texture and lithological composition to wadi deposits in the present valley below. This conglomerate must subsequently have been undercut and

25 Probably including true spring travertines.

Fig. 2.2 Ancient conglomerate outcropping on the slopes of the valley south (N034°48.815′ W002°24.211′ ± 5 m) of the cave. – Scale 20 cm.

largely flushed, with downward and probably broadening development of the cave through time. Although there is now no observable contact with the 'normal' (largely uncemented or under-cemented) sediment sequence now physically lower in the cave, it is impossible that the latter sequence could be older than the conglomerate, since it could not possibly have survived the flow energy levels implied by that conglomerate. The contact between bedrock and conglomerate shows erosional scallops.

It is noteworthy that there are a number of other occurrences of ancient conglomerate set in carbonate matrix within former karstic cavities (usually c. 2-5 m in width), outcropping on the slopes of the small valley, south of the cave (**figs 2.2-2.3**).

At some point before the currently observable (clastic) cave fill was emplaced and probably when this section of the cave was still sufficiently deeply underground (back from the contemporary valley side) to ensure constant humidity and protection from dust, thick sheets of wall speleothem ('curtain stalagmite') formed, a zone of which still survives near the present entrance on the north side[26]. This material has not been dated but it is assumed that it is an earlier Pleistocene 'interglacial' (warm humid, with well developed soil profiles under good vegetation cover) phenomenon; collapsed clasts may occur in any of the younger cave sediments but they are truly common only in certain levels pre-dating the LSA of interest here.

26 In order to simplify descriptions of material within the site, the true orientation of the cave (cf. **fig. 2.4**) has been replaced with the following generalised notation: into the cave (west), out of the cave (east), towards left wall looking inwards (south), towards right wall looking inwards (north).

Fig. 2.3 Ancient conglomerate outcropping on the slopes of the valley south (N034°48.819′ W002°24.207′ ± 5 m) of the cave. – Scale 20 cm.

The raw materials for the lithic artefacts in the LSA are discussed in **Chapter 12**. It is nevertheless worth mentioning here that Roche (1963) reported many artefacts in limestone, at least sometimes specifically identifying 'lithographic' limestone. He also recognised this rock type as a very significant component in certain levels (not consistently specified) of the cave sediments. It is reiterated that the current cave nowhere shows an outcrop of lithographic limestone, the nearest primary outcrops of really fine-grained material (Domerian) lying well to the south and east of the cave and often at slightly, but significantly, lower altitudes; we will return to this matter below. Roche also reported common fragments of 'haematite' (redder) and 'limonite' (yellower) oxides, along with the fact that iron-bearing beds are common in the local Triassic and Palaeozoic; the latter also includes galena-bearing strata. Geothermal lead sulphides of Carixian age are also present in the region, including the Zegzel Valley itself (Bouabdellah / Boudchiche / Ouahhabi / Naciri 2008), providing a local potential for acidification of ground waters of relevance to deeper karstification. There are some fine mineralised veins in the local bedrock but nothing on a scale sufficient to explain the individual size and high frequency of iron and lead ore fragments and 'powders' that have also been recovered, especially in the zone at the back of the current cave (see **Chapter 14**). Similarly, there are often more, and a wider range of types of, quartz crystals in the archaeological layers than might be expected from 'natural' causes. Nevertheless, all stable minerals that have been encountered by Roche or the current campaign can probably be recovered relatively locally, especially in the washed deposits in the valley bottom[27]. In addition, Roche reported crystals of pyrites (again, a potential source of acidification) and gypsum (presumed to be derived from the local Jurassic and/or Triassic), although survival of such unstable minerals (which have not been noted in the recent work) in the often damp cave sediments would be surprising, possibly indicating especially ash-rich pockets of preferential preservation.

All *in situ* deposits currently observable in the main cave-fill sequence are of Pleistocene age (with material from at least as far back as MIS6 already demonstrated: Raynal 1980; Bouzouggar et al. 2007), despite the fact that it is clear that the available cavity was nowhere near filled, save in the deeper recesses, during the last cycle of deposition. It is plausible that sedimentation rate was drastically reduced in the Holocene (especially in the earlier Humid Phase), due to such factors as exterior fixing of sediments by vegetation, adjustments of feed slopes and overhangs, clogging of small feed avens and rifts through the overlying bedrock by carbonate deposition, etc. In connection with this last process, it is worth noting that the Early Holocene Humid Phase appears not to have resulted in any significant floor speleothem deposition, presumably because the main cavity was then too open and aerated, perhaps in combination with isolation from saturated drip water. Roche (1963) did mention 'superficial deposits', shallow towards the back of the cave but, with a very irregular boundary with the underlying Pleistocene levels, reaching thicknesses of as much as 2.7 m at the mouth of the cave; he interpreted this sediment as mixed/disturbed (*remanié*, *bouleversé*), containing 'historic period' artefacts. It is also necessary to take into account the 1939 military levelling of the surface (see **Chapter 1**), which Roche (1963) characterised as involving cutting at the back and redeposition at the front of the cave. Similarly, Roche reported Ruhlmann's sieving and spoil heaps from the 1940s, in the central area at the entrance. It is not clear how, or even whether, Roche was able to differentiate between all these more recent deposits and re-deposits. He did, however, comment upon the complete absence of 'Neolithic' pottery, although there is a record (Jodin 1954[28]) of heavily disturbed 'Neolithic(?) pottery' and even 'seemingly recent human bones' at the very top of the main cemetery sequence against the north wall of the cave. During the current work, a few comparatively recent artefacts have been noted only in definitely disturbed superficial contexts, especially towards the back of the cave.

2.2 EARLIER EXCAVATIONS

The earlier excavations at Taforalt were conducted according to the methods and standards of their time. There is, of course, no cause to criticise such approaches *per se* but it will nevertheless be necessary to analyse certain weaknesses and contradictions which, if ignored, would make the actual results of these important excavations less useful and might lead to misinterpretation today.

27 The Rabat archive contains comparisons of the archaeological Fe-bearing minerals from the cave with samples (probably from commercial extraction sites) from all over Morocco and even Spain but it would seem wholly unnecessary to envisage such widespread sources.

28 The excavation notebooks for the *Nécropoles* at the back of the cave (see below) are not signed but they are certainly not in Roche's well-known handwriting. Given Roche's published comment that he enlisted the help of André Jodin to excavate in these areas, it is assumed that the latter was the author of the notebooks in question. Requests to the *Fondation Nationale des Musées (Rabat)* have not yet produced the copies of other manuscript pages signed by Jodin (a long-term employee in Morocco) which would be required for comparison and certainty over the authorship of the Taforalt notebooks.

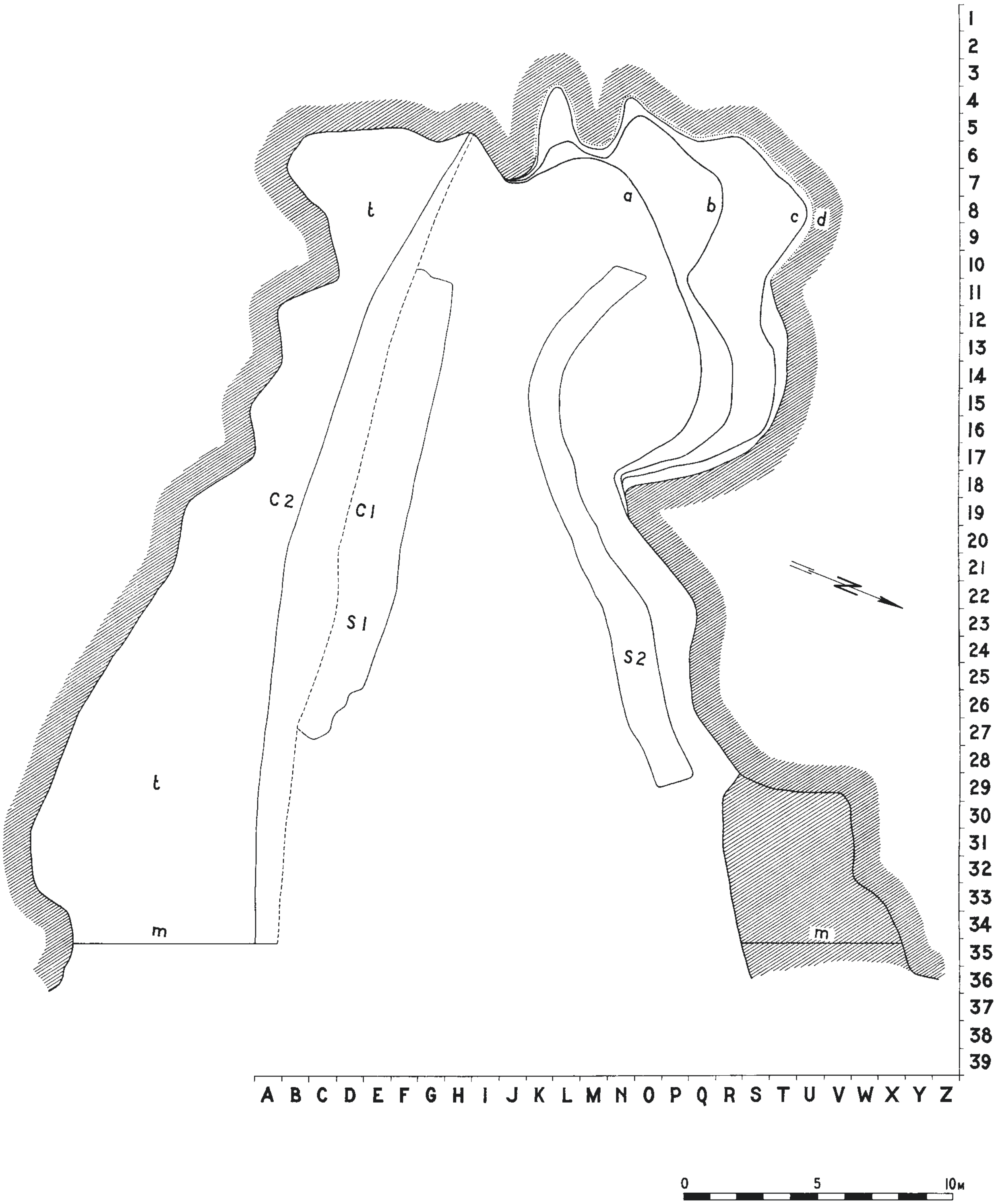


Fig. 2.4 Site plan: **a-d** successive profiles of the back cave wall, appearing as the [1950s] excavations proceeded. – **m** protective walling. – **S1, S2** Ruhlmann trenches. – **t** reference section [untouched sequence from the top of the 'grey [ashy]' series]. – **C1** edge of S1 in 1948. – **C2** edge of reference section after collapse and cleaning by 1954. – (After Roche 1963, fig. 4).

Ruhlmann 1944-47

Ruhlmann (1944-45) cut his first ('principal') trench, straight (eventually with a couple of north-side widened notches) and some 20 m long (although it was drawn at only 18 m by Roche 1963 – see **fig. 2.4** below – but described as 25 m in Roche 1953b), just south of the (longitudinal) centre of the cave; Roche later labelled this trench "*Sondage 1*" (or simply "S1") and this feature will here be called 'Ruhlmann (south trench)' where it is necessary to avoid any confusion. It is important to recognise the sheer speed with which this work was undertaken; thus, on the very first day, a trench 5.25 m long, 1.2 m wide and 1.5 m deep was cut with pick and shovel (by the local workforce). Spoil was riddled but the aperture used was not mentioned.
By the end of the 1945 season, Ruhlmann had recorded the following stratigraphy along the whole length of the trench, synthesised here as **table 2.1** from his own schematics and descriptive notes.
Ruhlmann made a first attempt to explain the origin of the 'grey [ashy]' series (the grey-shaded entries in **tab. 2.1**), suggesting (1945a, 20-21):

> *En ce qui conc. les niveaux arch ibéro-maur., il est à remarquer qu'ils reposent, chacun, sur un lit de cailloux – les traces d'autant* [de] *cours d'eau – dont bien des éléments ont subi l'action du feu. Il résulte de cette observation que les Ibéro-maurusiens se sont installés dans un habitat sous grotte à trois reprises, c'est-à-dire chaque fois après l'assèchement d'un cours d'eau. Pour les occupations I et II (dans l'ordre chronologique) il devient donc manifeste*[? uncertain reading] *qu'ils ont été chassés de leur habitat par un phénomène naturel, toujours le même, à savoir la reprise, ± subite, les eaux s'écoulant du gouffre de la grotte.*
>
> [With respect to the Iberomaurusian archaeological levels, it should be noted that each lies on a bed of stones – the signs of as many flows of water – numerous elements of which have been marked by fire. It follows that the Iberomaurusians took up residence in the cave on three occasions, that is to say, each time after the drying up of water flow. For the first and second occupations (in chronological order) it therefore becomes clear that they were forced out of their habitation by a natural phenomenon, always the same, that is to say the more or less sudden recurrence of flow from the interior of the cave system.]

Note that Ruhlmann used the term "*brèche*" [breccia] in the correct geological sense (angular stone clasts), with no implication of cementation (there is not even any point-to-point cementation in these units within the main cave, save weak diagenetic zones at the very base on occasion).
On the finding of a few Iberomaurusian lithics in the superficial interval of the 'yellow [loamy]' series towards the centre of his trench, Ruhlmann initially believed them merely to represent 'infiltration' from and through the lowest stony unit of the 'grey [ashy]' series.
Ruhlmann (1947) cut his second trench near the northern wall of the cave, eventually curving somewhat inwards and reaching a total length of some 21 m (described by Roche (1953b) as 30 m long); Roche later (1963) labelled this trench "*Sondage 2*" (or simply "S2") and this feature will here be called 'Ruhlmann (north trench)' where it is necessary to avoid any confusion.
Ruhlmann recorded the following stratigraphy, principally from the middle to outer portion of the north trench, synthesised here as **table 2.2** from his own schematics and descriptive notes.
Ruhlmann took the 'grey [ashy]' series stratigraphy (the grey-shaded entries in **tab. 2.2**) he exposed in the outer end of this north trench (thus c. 14 m laterally from the outer end of the south trench) to be more or less the same as that previously encountered, namely a triple occurrence of the pattern: stony level under ashy archaeological level (with the detail that the basal stony layer was always very thin on this side of the cave). However, presumably judging mostly from the artificial horizontality of the (military) surface, he did note that the layers stood higher towards the north cave wall, with something of a concave-up morphology (*cuvette* [trough]) presumed to occupy a line southwards, closer to the central longitudinal axis of the cave.

A	0.1 m	Modern soil: earth (humus) [note the absence of any mention of a mortar floor or other military installations].
B	0.65-0.9 m (thickening across the trench southwards, top rising), thinning longitudinally towards back of cave.	3rd **archaeological level**, ashy earth, mixed with ash and land snail shells, some hearths but flints not particularly common (Iberomaurusian).
C	0.45-0.2 m, thinning out almost completely towards back of cave.	Breccia, angular limestone, hardly rolled.
D	0.5-0.9 m, thinning inwards to 0.4 m	2nd **archaeological level**, well packed but still loose, land snail shells, mixed with ash and black earth, abundant flints (Iberomaurusian) in places but sterile in others.
E	0.8-0.9 m at front, up to 1.5 m, then thinning towards back of cave to a mere stone line.	Breccia, angular limestone, hardly rolled.
F	0.4-0.5 m	1st **archaeological level**, land snail shells, mixed with ash, abundant flints (Iberomaurusian).
G	0.1 m	Breccia, limestone clasts.
		In total, the 'grey earth' (layers B-G) were on average 3.3 m thick towards the cave exterior; across the trench, there was a general southwards dip.
H	(up to 4 m thick in total)	Yellow earth and large limestone blocks, largely sterile [of artefacts, although faunal elements appear to have been present throughout] but containing discrete archaeological levels [nearly all MSA].

Tab. 2.1 Ruhlmann (south trench) stratigraphy.

1	Up to 0.1 m	Modern surface, capped by a thick mortar floor [military].
2	0.6 m	3rd **archaeological level**, ashy earth (Iberomaurusian).
3	0.4 m	Breccia, angular limestone.
4	0.3 m	2nd **archaeological level**, ashy earth (Iberomaurusian).
5	0.4 [?] m	Breccia, angular limestone.
6	0.55 m	1st **archaeological level**, ashy earth (Iberomaurusian).
7	0.05-0.1 m	Breccia, thin stone line.
		In total, the 'grey earth' (layers 2-7) were on average 2.3 m thick towards the cave exterior.
8	(up to 3 m thick in total)	Yellow earth and large limestone blocks, largely sterile [of artefacts, although faunal elements appear to have been present throughout] but containing both dispersed artefacts and discrete archaeological levels [MSA].

Tab. 2.2 Ruhlmann (north trench) stratigraphy.

Ruhlmann recorded the visit of André Duparque, a professor of geology from the University of Lille, accompanied by another geologist from Oujda and that the three of them went over the sections in the 'principal' (south) trench. It may not be a coincidence that, three days later, Ruhlmann (1947, 4) noted:

> *Les différents lits de cailloux – trois, sépares par des couches cendreuses – retiennent toute mon attention. De l'étude des éléments qui les composent –* [*forme*]*s anguleuses de pierres – absence de* [… *sable* ?], […] *traces de* [… *feu* ?] *(c. à d. bc. de pierres dt. les surfaces portent des traces d'une calcination intense (foyers)) – prouvent qu'il ne s'agit nullement de cailloutis étalés par les eaux, possibilité envisagée au début des fouilles, mais tout au contraire, de nappes pierreuses établies par les hommes. La raison d'être de ces lits de cailloux est donc d'ordre pratique: ils ont dû servir, selon toute vraisemblance, de base à l'habitat, isolant d'une part le sol habité des couches sousjacentes, tout en rendant, d'un autre côté, – surtout au-dessus des couches cendreuses – l'habitat possible.*

[The various beds of stones – three, separated by the ashy layers – have attracted my attention. From the study of their composition – the angular forms of the stones, absence of [sands?], […] signs of [fire?] (that is, many stones with surfaces showing the effects of intense calcination [hearths]) – proves that this is certainly not a matter of stones spread by flowing water, a possibility envisaged at the beginning of the excavations, but, on the contrary, of stone spreads created by man. The reason for these beds of stone is therefore a practical one: they must have served, in all likelihood, as the base of a habitation, isolating a part of the living surface from the underlying layer and, indeed, especially above the ashy layers, making habitation possible.]

With respect to the stratigraphic range of the Iberomaurusian, Ruhlmann (1947, 4) noted:

A la surface de contact des couches – c/cendreuse III, d'une part, c/jaune de l'autre – l'industrie ib.-maurusienne persiste. Elle pénètre même de ses éléments lithiques une zone superficielle de la couche jaune qui varie entre 10 et 20 cm. Ce détail peut s'expliquer, d'une part, par le fait que les Ibéro-maurusiens se sont primitivement établis directement sur l'assise de base – c. à d. vivaient à la surface de ces sédiments – à moins, 2eme hypothèse, que les éléments se soient infiltrés à travers le lit de cailloux, peu épais ici. Personnellement, j'incline vs. la 1ère possibilité. Les outils rencontrés sont, en effet, trop nombreux pour justifier la seconde explication. Un autre argument parlant en faveur de l'interprétation que j'avance ci-dessus est la présence de restes de cuisine (ossements et dents, sv. avec traces de calcination).

[In the contact zone of the layers – ashy layer III [the lowest], on the one hand, and the yellow layer, on the other – the Iberomaurusian industry persists. This industry, in the form of its lithics, even penetrates a superficial zone of the yellow layer, to a thickness varying between 10 and 20 cm. This detail could be explained, on the one hand, had the Iberomaurusians originally established themselves directly upon the lower unit – that is, they lived upon the surface of these [yellow] sediments – unless, second hypothesis, the lithic elements have been infiltrated through the bed of stones, which is not thick at this point. Personally, I think the first possibility more likely. Indeed, the artefacts encountered are too numerous to justify the second explanation. Another argument in favour of my preferred interpretation is the presence [in the yellow layer] of cooking remains (bones and teeth, often with signs of calcination).]

Ruhlmann had therefore reached an acceptance of the dominantly anthropogenic origin of the whole 'grey [ashy]' series, in excess of 3 m in thickness, along with the realisation that there was an LSA presence already in the uppermost interval of the 'yellow [loamy]' series, at least towards the front of the cave (he recorded no further LSA material at this depth and, in contrast, recognised an 'Aterian' level almost at the very top of the 'yellow [loamy]' series deeper into the cave).

Moving always inward, Ruhlmann continued the north trench, swinging somewhat northwestwards back towards (but not reaching) the cave wall after an intervening 'alcove' (the importance of which will become apparent in due course). The excavation passed through the whole 'grey [ashy]' series (thickness not specified here but also far into the 'yellow earth' below), with Ruhlmann noting that even the two upper stony beds had been reduced to a layer of the thickness of single clasts, whilst large limestone blocks had started to appear throughout the 'grey earth' and that artefacts had become rarer. Again as will become apparent, it is of interest that, whilst numerous bone tools and various ochred objects were encountered, no human bone whatsoever was recorded in this inner reach of the north trench. Only a single human molar (described as the 'first human remains from the cave') had been found in the 3rd. archaeological level (uppermost ashy bed) in the outer part of this trench.

Roche 1951-55

Roche took up the excavations at Taforalt only four years later but, largely due to the depth and usual lack of stepping (which must have produced terrifyingly vertiginous sides), the Ruhlmann trenches had suffered considerable collapse (see **Chapter 1**). Roche's plan of the site (published only in 1963, as his fig. 4) is reproduced here as figure 2.4. The degree of collapse on the south side can be appreciated by the difference (now a sloping face) between the lines labelled C1 and C2. Indeed, Ruhlmann's north section of S2 (north trench) had also collapsed, in the outermost part of the cave leaving only the basal 'grey earth' unit between the trench and the cave wall. The tendency towards collapse of the ashy sediments also affected the inner end of the north trench, a matter to which we shall return below.

Roche (1952, 647) set out the stratigraphy as follows:

1) Sol superficiel : 0 m 10.

2) Terre cendreuse avec traces de foyer (épaisseur au fond de la grotte : 0 m 70, à l'entrée : 1 m 85) (Niveau A).

3) Lit pierreux d'épaisseur moyenne 1 m 30, en forme de cuvette, s'inclinant des bords de la grotte vers la centre ; pratiquement stérile au point de vue archéologique.

4) Terre cendreuse (épaisseur au fond de la grotte : 0 m 15, à l'entrée : 1 m 70) (Niveau B).

5) Lit pierreux (épaisseur au fond de la grotte : 0 m 10, épaisseur maximum au milieu de la grotte : 1 m)

6) Terre cendreuse se terminant en biseau sous le lit N° 5 (épaisseur au fond de la grotte : 0 m 40, épaisseur maximum : 0 m 75) (Niveau C).

7) Lit pierreux reposant directement sur les terres jaunes se terminant en biseau à l'entrée de la grotte (épaisseur au fond de la grotte : 0 m 15, épaisseur maximum : 0 m 50).

8) Terres argilo-sableuses ocres, généralement meubles, très fortement concrétionnées par places, avec gros blocs d'effondrement. Au point de vue archéologique on peut y distinguer :

a) en surface, des éléments faisant partie de l'industrie de la couche C [Ibéromaurusien] ;

b) à 11 m de l'entrée de la grotte, á 0 m 20 de profondeur, un mince lit archéologique (Niveau D) [Atérien].

(c, etc.) [Deeper levels in the *terres jaunes*].

[1) Superficial soil: 0.1 m.

2) Ashy earth with signs of hearths (thickness at the back of the cave: 0.7 m, towards the front 1.85 m) (*Niveau A*).

3) Stony bed of average thickness 1.3 m, in the form of a broad trough, with sides dipping downwards from the edges of the cave towards a low point along the cave central [longitudinal] line; practically archaeologically sterile.

4) Ashy earth (thickness at the back of the cave: 0.15 m, towards the front: 1.7 m) (*Niveau B*).

5) Stony bed (thickness at the back of the cave: 0.1 m, maximum thickness in the [longitudinal] middle of the cave: 1 m)

6) Ashy earth wedging out under [stony] bed N° 5 (thickness at the back of the cave: 0.4 m, maximum thickness: 0.75 m) (*Niveau C*).

7) Stony bed lying directly upon the yellow earth and wedging out at the front of the cave (thickness at the back of the cave: 0.15 m, maximum thickness: 0.5 m).

8) Ochre-coloured clayey sand, generally loose but very strongly concreted in places, with large bedrock-collapse blocks. From the archaeological point of view, one can distinguish:

a) at the surface, elements belonging to the industry of *Niveau C* [Iberomaurusian];

b) at 11 m from the front of the cave, at 0.2 m depth, a thin archaeological bed (*Niveau D*) [Aterian MSA].

(c, etc.) [Deeper MSA levels in the yellow earth].]

It is clear that Roche was here relying very heavily (all but exclusively) upon the description of the stratigraphy in Ruhlmann's notebooks. The specific terminology *Niveaux A-C* will be retained for the main LSA archaeological levels in the 'grey [ashy]' series, as this will enable us to follow other relevant documentation. Roche also gave two 'semi-schematic' sections, both from the 'principal' (south) trench (1952, fig. 1 the north section and fig. 2 the south section). Again, these schematics are little more than a recapitulation (without credit) of Ruhlmann's text and sketches[29]. Roche himself concentrated upon a description of what must have been, at this stage, at least dominantly the Ruhlmann archaeological collections (lithics, bone tools and other items); he also gave a faunal list, supplied by Professor Camille Arambourg. Roche did not mention Ruhlmann's north trench explicitly in this paper but he did mention human remains from two individuals, one a child and the other a young adult, said to come from *Niveau A*; a point to which we shall return below.

Roche (1953a) largely repeated the stratigraphy (along with an identical schematic section as fig. 1) noted in 1952, with the precision that the LSA artefacts penetrated into the 'yellow [loamy]' series on average by 0.15 m. He noted that there were traces of burning and even some hearth features within the stony beds and commented (p. 376): "*Les lits pierreux n^{os} 3, 5 et 7, sur lesquels reposent les trois couches cendreuses, sont vraisemblablement intentionnels. Ce sont des pierres chauffées que l'on retrouve dans bien des gisements d'Afrique du Nord.*" [The stony beds 3, 5 and 7, upon which rest the three ashy beds, appear to be intentional. These are the sort of heated stones that one finds in many North African sites.]. Here, Roche had thus moved from the more 'structural' (habitat foundation) interpretation of Ruhlmann to one implying one or more deliberate stone-heating processes.

With respect to human skeletal finds, Roche (1953a, 379) wrote:

> *Au cours de la campagne 1951, le niveau A avait fourni des fragments humain appartenant à au moins deux individus* […] *; le niveau D, un petit fragment de voute crânienne, malheureusement très incomplet. Au printemps 1952, l'effritement des coupes formées de cendres extrêmement pulvérulentes permit d'apercevoir deux squelettes assez complets dans le niveau B. Il fut décidé de fouiller cette partie de la grotte. Le décapage du niveau A permit de découvrir un véritable ossuaire ibéromaurusien. Les restes plus ou moins complets d'une dizaine d'individus furent exhumes.* […]
>
> [During the 1951 campaign, *Niveau A* produced human remains from at least two individuals […]; in *Niveau D*, a small fragment of skull, unfortunately most incomplete. In the spring of 1952, the crumbling of the sections formed by extremely powdery ash brought to light two quite complete skeletons in *Niveau B*. It was decided to excavate this part of the cave. The stripping of *Niveau A* brought about the discovery of a veritable Iberomaurusian ossuary. The remains of ten or so individuals were exhumed. […]]

The question now arises as to quite where these finds of human remains were made. Roche added some details in his next publication (1953b): the 1951 *Niveau A* finds were made close to the north wall of the cave. The position of the 1951 "*Niveau D*" find was not given until much later (Roche 1963, 47) as being Square M21 (cf. **fig. 2.4**), that is, at a point just before Ruhlmann's north trench reached the nearest point of the eastern end of the 'alcove', on the north side towards the back of the cave. Nowhere else in any of the published or unpublished documentation is there any suggestion that *Niveau D* (said to contain clear 'Aterian' artefacts) existed in Ruhlmann's north trench – it is only recorded as a thin unit, only 2 m long (E-W) in the middle (north side only) of the south trench (cf. Roche 1952; 1953a; 1953b). Furthermore, Square M21 (which would have been very blocky) lies immediately alongside the current excavations, where LSA levels

29 For the sake of scientific accuracy, it is necessary to press gently this point. Later, Roche himself (1969, 90) was perhaps, under the circumstances, less charitable than he might have been: "[…] *Il est regrettable que son journal de fouille n'ait livré aucun relevé des coupes mais seulement de rares schémas théoriques et fragmentaires qui fournissent peu de renseignements sur la localisation des niveaux archéologiques qu'il signale.*" [It is regrettable that his [Ruhlmann's unpublished] excavation journal has provided no section drawings but only rare diagrams, theoretical and fragmentary, which give little information on the location of the archaeological layers that he mentions.].

reach a depth of at least 0.4 m into the 'yellow [loamy]' series (the 'grey/yellow' boundary having already been removed at the top of the now surviving sequence). It is therefore suggested here that Roche's attribution of the parietal fragment (apparently since lost) to an MSA level was incorrect and that this probably represents a piece disturbed from the 'veritable ossuary' of LSA age, just to the northwest. The first 1952 finds of human remains were made by Blondeau's team (cf. **Chapter 1**), who noted [30] that one individual lay in the second (ashy) archaeological layer (thus, *Niveau B*), at 1.3 m from the current surface (below a clearly visible stony layer) and at 1.2 m above the 'yellow earth'; the second individual lay 0.18-0.2 m higher than the first. A 'cut-away' 3-D sketch of the find showed the cave roof swinging out southwards, low over the deposits, such that it appears likely that the location was within the 'alcove', certainly west of Square M19 or M18; Roche (1953b, 114) confirmed this impression by placing the finds in the "*coupes de l'extrémité W. de la tranchée latérale*" [in the sections of the western extremity of the lateral [northern] trench] and by later giving Square L18 as the location (1963, 47). Roche's own finds in 1952 are known [31] to come from the outer (southern) half of the 'alcove', although the deepest and most concentrated excavation was in Squares L/M/N-14/15 (Roche 1963, 47). Roche (1953b, 114) described the work as follows:

> *Il fut décidé que la campagne de fouilles 1952 porterait sur cette partie de la grotte. Il apparaissait nécessaire de retirer la couche supérieure contenant les blocs de pierre dont l'action ne pouvait qu'aggraver l'effritement de la coupe. D'autre part, la voute de la grotte s'abaisse fortement en cet endroit. L'habitat n'y était plus possible à la fin de l'occupation ibéro-maurusienne, et l'on pouvait espérer que de nombreuses inhumations avaient été faites en ce lieu.*
> *Apres décapage d'une couche épaisse de 0 m 70, atteignant ainsi la base du niveau A, je me trouvais en présence d'un véritable ossuaire ibéro-maurusien.* […]
>
> [It was decided to excavate this part of the cave during the 1952 campaign. It seemed necessary to remove the upper layer containing blocks of stone the effect of which could not fail to aggravate the crumbling of the sections. In addition, the roof of the cave drops strongly in this location. Habitation would not have been possible here at the end of the Iberomaurusian occupation and one could hope that numerous burials had been made. After the stripping of a layer 0.7 m thick, reaching thus the base of *Niveau A*, I found myself in the presence of a veritable Iberomaurusian ossuary. […]]

Looking again at **figure 2.4**, the 'alcove' in question is that north of the western end of Ruhlmann's north trench (a trench which did not contain obvious human remains and which therefore serves as a reasonable proxy for the boundary of this burial area), as far west as about Line 11 on the plan, an area that Roche would later label *Nécropole I*. These early details already give us some idea of the edge of the burial areas at Taforalt; we will return later to other stratigraphic details of these areas.

In 1953, Roche (1953b) also reported a new trench, this time a transverse one (N-S) linking the two Ruhlmann trenches and lying at 9 m from the cave entrance; the dimensions given were maximum length 6.6 m, width 3.3 m and depth 1.6 m. In Roche (1963), this transverse trench was described as having been started, with a width of 2 m (from F20/F21 to M20/21) in 1951, and taken down to the level of the second stone layer in 1953 (the location has been added to **fig. 2.4**); however, in an unpublished excavation report [32], dated December 1951, Roche stated that the dimensions of the trench had already reached a width of 3.5 m and a depth of 2.5 m. This trench, situated at the main 'pinch point' in the cave plan, was rather important in the development of the site stratigraphy, proving, as will be seen, as much a hindrance as an aid to Roche's understanding.

30 Rabat archive, unpublished typescript.
31 Rabat archive, unpublished plan.
32 Georges Souville Archive (at *la Maison Méditerranéenne des Sciences de l'Homme, Centre Camille Jullian (UMR7299-CNRS) à Aix-en-Provence, Université d'Aix-Marseille*).

With respect to the main cave area, Roche (1953b) largely repeated the stratigraphy (along with identical schematic sections as figs 1 and 2) noted in 1952. He had already (1952; 1953a) reported a lithic tool component in 'hard limestone'. He stated (1953b, 90-91) that the uppermost stony bed in the 'grey [ashy]' series was:

> […] *composé de blocs de taille sensiblement constante (à peu près le volume d'une orange), provenant généralement des calcaires liassiques que l'on trouve à l'extérieure de la grotte, plus rarement des fragments de dolomie.* […]
>
> [[…] composed of blocks of more or less constant size (about the volume of an orange), coming generally from the Liassic limestones which one finds outside the cave, more rarely fragments of dolomite. […]]

That there is a very large component of 'exterior' limestone (mostly 'lithographic' stone) in the stony beds of the 'grey [ashy]' series has been confirmed in the current work and this is an important observation in the understanding of the site formation processes (although Roche [1963] interpreted the stone-heating as being needed primarily for general warmth in a cool environment).

Roche continued excavation in his first campaign until 1955 (apparently more or less completing removal of the 'grey [ashy]' series in the main cave, beyond the burial areas, in 1954 [cf. Couvert/Roche 1978]) but there were no further publications until he mentioned (1958, 3486): "[…] *des couches cendreuses où l'on a pu discerner dix niveaux épipaléolithiques* [Iberomaurusian, LSA] *emboîtés les uns dans les autres.*" [[…] ashy beds where we have been able to make out ten [LSA] levels, interdigitating one with another]. This revised stratigraphy was also mentioned (but with no further explanation) in another publication, where Roche published a new and more detailed section (1958-1959, fig. 2), specifically in Squares A23 to A20 of the south section of the south trench. Thus, the zone of supposed interdigitation coincided with the position of the 1951-53 transverse trench (see above). It should be noted, however, that (Roche 1958-1959, 163) did comment:

> […] *la structure de cendrières épipaléolithiques offre au fouilleur des difficultés particulières : coupes très friables en raison de l'état pulvérulent des couches et surtout stratigraphie emboîtée où les repères sont toujours délicats à discerner et ne sont que localement valable.* […]
>
> [[…] the structure of Epipalaeolithic [including LSA] ashy middens presents particular difficulties for the excavator: very friable sections due to the powdery nature of the beds and, especially, the interdigitated stratigraphy in which markers are always challenging to recognise and are of only local validity. […]]

In fact, the 'new stratigraphy' for the 'grey [ashy]' series (and the immediately underlying 'yellow [loamy]' series) had been developed by Roche in his doctoral thesis, completed in 1957 and presented in 1958 but not published until later (Roche 1963). The geographical extent of these new *niveaux* (we will keep this terminology – note that the Roche layers are designated by capital Roman numerals, except in one special case) is shown in **table 2.3** and the series of plans in **figure 2.5**.

In addition to longitudinal dips for these *niveaux* (dominantly down outwards, towards the east, with the base dropping sharply at first at the back and then decreasingly so, by a total of some 3.5 m over an observed length of some 22 m in Ruhlmann's south trench), Roche also noted a number of localised cross-dips and complex internal features (described verbally for each *niveau*), but gave only a number of very small-scale cross-sections, rather lacking in detail. One can nevertheless see a general thickening southwards in these then surviving sections (base dropping increasingly faster southwards, under what appears to have been the reasonably horizontal military cross-cave truncation) of the whole 'grey [ashy]' series (at Line 13/14, 2.3 m to the north, 3.2 m to the south; at Line 20/21, 2.1 m to the north, 3.7 m to the south; at Line 22/23, 2.4 m to the north, 4.3 m to the south; at Line 26/27, 1.7 m to the north, 4.0 m to the south). Roche mentioned some 24 apparently discrete 'hearths' (with dimensions: length (n = 24) 1.30 ± 1.10 m; width (n = 8) 0.77 ± 0.41 m; thickness (n = 23) 0.36 ± 0.28 m), the sense of elongation (even when mentioned

Niveaux	Year	Locations & Comments
Superficial	1951-53	On average 0.3 m thick but reaching 2.7 m towards the front of the cave. Note also a large volume of Ruhlmann's spoil (in the rectangle G-M/28-35) which Roche later removed in bulk.
'Grey [ashy]' series.	1951+	Transverse trench across the centre of the cave (down to the second stony layer of Ruhlmann's stratigraphy in 1951 or 1952, to the 'yellow [loamy]' series by 1955).
Niveau I	1953-54	From the cave mouth back 15.6 m to Line C18-N18, wedging out (top-cut); traces of an increasingly sloping continuation onto the cave platform were heavily disturbed by the military installations.
Niveau II	1953-54	Starting 1.5 m from the back (west-central) wall of the cave and continuing eastwards, to wedge out along Line A22-K19.
Niveau III	1953-54	From the cave mouth back 12.8 m to Line B21-M21, wedging out abruptly.
Niveau IV	1953-54	Starting at the back (west-central) wall of the cave and continuing eastwards, to wedge out along Line G10-K12.
Niveau V	1953-54	Occurring in the centre of the cave, between the Lines A25-N24 and D13-K13, and wedging out both inwards and outwards.
Niveau VI	1953-54	From the cave mouth back 8.5 m to Line A26-N26, wedging out abruptly.
Niveau VII	1953-54+	A long thin lens, wedging out just at the back (west-central) wall of the cave, becoming very blocky by Line G16-K16, extending outwards by 22.5 m overall to the Line F22-M22 (or possibly further east within a very stony zone).
Niveau VIII	1953-54+	Wedging out into the cave along Line D12-K12, after an extent of 16.75-18.8 m, reaching blocks outwards, along the Line A28-K31.
Niveau IX	1953-55	A particular 'chocolate brown' level (not mentioned in earlier publications), occurring in the interior of the cave, from the line E10-G8 in the SW and thence across to the NW 'alcove'.
Niveau C	1951	A restricted survival at the base of the 'grey [ashy]' series, between the NE wall of the cave and Ruhlmann's north trench, from Q29-R29 inwards to M18-N18. Note that Roche (1963, 140) explicitly keeps Ruhlmann's original C-notation for this layer.
Niveau X	1955	The uppermost intervals of the 'yellow [loamy]' series, recognised as containing LSA artefacts in two areas, outwards in the quadrilateral O-D/22-30, and inwards in the area F-K/10-18.

Tab. 2.3 Roche 1950s stratigraphy.

only verbally) usually having been longitudinal to the cave; there were also two larger concentrations or palimpsests of hearths (both adjacent to large block piles), one covering 12 m^2 and 0.8 thick and the other 8 m^2 and 0.5 thick, broadly in the outer-central area of the cave (between approximately Lines 20 and 30). One also has the impression from the text that large numbers of very small 'burning events' were also encountered. As for the main concentrations of land-snail shells, these appear either to have occurred in bands along, or under lateral irregularities in, the cave wall/roof or, again, as larger spreads (3-4 m across) in the outer-central area of the cave. In terms of other structures, Roche did not mention any significant pits actually encountered during excavation, although he did attempt infra-red photography, identifying (1963, 40): "*dans une coupe longitudinale (B30, A31, A32) une série de fosses, à divers niveaux, qui étaient difficilement visibles à l'oeil nu*" [in the longitudinal section (B30, A31, A32) a series of pits, at various levels, which were difficult to see with the naked eye[33]]. These features were illustrated in Roche's plate IIIA, where

33 Roche's contention that it required infra-red photography to recognise these pits is perhaps over-stated, since there appear to be other 'normal' photographs of these sections in the archives in which the features also show. One could therefore hope that, had such structures been common throughout the cave, more of them would have been identified during Roche's excavation.

they would appear to be c. 0.8 m wide at the 'mouth', to have rounded bottoms and to be perhaps 0.7 m deep. The location is interesting (unfortunately now behind a stone retaining wall), being right at the front of the cave, down-slope on the overall sloping cave floor, and not well protected by the roof overhang, hardly the optimal place to store food or other perishable materials, perhaps suggesting something more along the lines of waste disposal.

Roche again noted the difficulties of excavating in such materials:

> *Ces difficultés ont été bien mises en valeur par M. Balout à propos des " fausses stratigraphies " : " les escargotières " (" Rammadyat ") capsiennes, ibéromaurusiennes ou néolithiques ne présentent généralement pas de repères trahissant une stratification naturelle. En certains points, des lits de coquilles d'Helix brisées, écrasées, indiquent un sol piétiné ; ailleurs, des couches d'escargots intacts permettent aussi de séparer avec netteté ce qui est plus ancien de ce qui est plus récent. Mais ces repères sont discontinus et les coupures stratigraphiques ainsi obtenues ne sont valables qu'au point précis où elles existent, car la Rammadiya n'est pas faite de couches régulièrement superposées, mais de tas de déchets emboités au hasard, les uns sur les autres, remaniés tout au long de l'occupation humaine, tassés, étalés, creusés pour y ensevelir les morts. Les différences des colorations des cendres sur lesquelles on a insistés sont sans valeur chronologique, car il s'agit d'altérations chimiques récentes et en tous cas postérieures au gisement.* […].
> *Un autre type de difficulté se rencontre en ce qui concerne la lecture des coupes stratigraphiques. Elles ne sont lisible que très fraîches. Composées d'éléments hétéroclites: petits cailloux, grosses pierres, coquilles d'escargot, fragments osseux liés entre eux par une cendre réduite à l'état de poussière impalpable, elles sont très instable et se dégrade continuellement. La moindre vibration du sol, le moindre souffle d'air provoquent des éboulements.* (1963, 38-39)
>
> [These difficulties have been well illustrated by *Monsieur* Balout, speaking of 'false stratigraphies': Capsian, Iberomaurusian or Neolithic shell middens (or 'ash middens') do not usually show markers indicating natural stratification. At some points, beds of Helix shells, broken, crushed, indicate a trodden surface; elsewhere, layers of intact snail shells allow precise differentiation between what is older and what is more recent. But these markers are discontinuous and the stratigraphic divisions thus obtained are only reliable at the precise point where they exist, because the 'ash midden' is not made from regularly superposed layers, but from piles of rubbish lensing at random, one above the other, reworked throughout the human occupation, piled up, spread out, dug into for the burial of the dead. The different colourations [orders of appearance] of ashes which [some authors] have thought significant are without chronological value, since this is [actually] a matter of chemical alteration that is recent or at least post-depositional. […]
> Another type of difficulty is encountered in the reading of stratigraphic sections. These are only legible when very fresh. Composed of heterogeneous elements – small stones, large blocks, snail shells, bone fragments, all bound in ash reduced to the state of an insubstantial powder – these sections are very unstable and degrade continually. The least vibration of the ground or a mere breath of air will provoke a collapse.]
>
> […] *Il faut bien avouer cependant que le problème de la fouille des cendrières n'est pas encore résolu. Dans les grands gisements comme Taforalt, le discernement des niveaux pose de sérieuses énigmes et l'on est bien oblige de recourir, par moments, à la fouille en stratigraphie artificielle.* (1963, 40)
>
> [However, one has to admit that the problem of excavating ashy middens has not yet been resolved. In large sites like Taforalt, the recognition of levels sets serious puzzles and one sometimes has no recourse but to excavate using an artificial [spit] stratigraphy.]

Despite these calls for caution from Roche, it should be remembered that the bulk excavation technique continued to be that of workmen wielding pick and shovel. **Figure 2.6** is a typical example of the unpublished photographs of the excavation[34], showing ubiquitous pick-marks; indeed, picks were even used

34 Georges Souville Archive (at *la Maison Méditerranéenne des Sciences de l'Homme, Centre Camille Jullian (UMR7299-CNRS) à Aix-en-Provence, Université d'Aix-Marseille*).

at the edges of the burial areas until each new burial grouping was encountered and isolated for treatment with finer techniques (what was described (Roche/Souville 1956, 164) as "*un patient décapage au pinceau*" [a patient stripping by means of a small brush]).

The rationalisation for the switch from the Ruhlmann three-part (*A-C*) stratigraphy to the new nine-part (*I-IX*) stratigraphy for the 'grey [ashy]' series was given by Roche (1963, 47) as follows:

> *Au cours de cette campagne* [1952]*, l'examen attentif des coupes ainsi que la stratigraphie mise à jour au cours du dégagement de la tranchée transversale me convainquirent que l'hypothèse formulée par Ruhlmann, que j'avais reprise dans mes premiers comptes rendus* [published 1951-3]*, était insuffisante.*
> *Le tracé des lits caillouteux est discontinue, les niveaux cendreux sont plus nombreux qu'on n'avait été initialement conçu et présentent une disposition complexe, emboites les uns dans les autres. Pour en suivre les méandres avec le meilleur discernement possible, on a fouillé par courtes tranchées perpendiculaires les uns par rapport aux autres, au lieu de procéder à des décapages de faible épaisseur sur de grandes longueurs.*
>
> [During this [1952] campaign, the careful examination of the sections, as well as of the stratigraphy brought to light during the cutting of the transverse trench, convinced me that the hypothesis formulated by Ruhlmann, which I had adopted in my first reports [published 1951-3], was insufficient.
> The line of the stony beds is discontinuous, the ashy layers are more numerous than one had initially supposed and present a complex disposition, one interdigitating with another. In order to follow the twists and turns with the best possible discrimination, we excavated by means of short trenches, set at right angles one to another, instead of proceeding by the stripping of shallow volumes over greater lengths.]

Whilst the underlying quandary of Roche's position here will find sympathy with anyone who has attempted to excavate such deposits as these, what Roche described (after the fact) as his applied procedure is not consistent with the details set out in unpublished documents in the Rabat archive.

Thus, in the archive, there are sheets, in Roche's hand, recording exactly the same final lithic artefact counts, in columns for each of the *Niveaux I-X*, as he published in 1963. Each column header has, not only the *Niveau* (Roman numerals) but also another annotation (which is also recapitulated later in the manuscript, were there any doubt), as shown here in **table 2.4**.

There are also cumulative typological graphs, labelled with the left-hand entries in **table 2.4**, including further lines labelled "C52" [*Niveau C* dug in 1952] and "N_1ch" ['*chocolat*' in *Nécropole 1*]. Indeed, in the archive, there are several other datasets (although all with less numerical detail), such as the mammal fauna, excavated in the *A-C* system and then later re-assigned in this same manner.

Roche most probably saw problems and had doubts during his excavation of the 'grey [ashy]' series but he nevertheless appears to have recorded all his finds (to the end of 1955) according to the original Ruhlmann stratigraphic scheme. It was probably the long and high section, at the end of this campaign[35] demanding attention all along the south side of Ruhlmann's south trench (illustrated by Roche in his 1963 plate 1 [photograph] and fig. 9 [section drawing]), that pushed Roche into trying to divide his stratigraphy further, with a crucial 'articulation zone' for all these supposed 'major interdigitations' right along that transverse trench, which, as the main excavations were being extended, had 'interrupted' the stratigraphy here as much as it exposed it. Roche's 'new' stratigraphy is simply not tenable, being both too complex and not complex enough to represent a meaningful reality. It seems much more useful to return to something simpler. Looking again at **figure 2.5**, one can appreciate three broad geographical zones within the main cave: an outer zone (from top down, *Niveaux I*, *III* and *VI*, with the basal 'grey' unit of *Niveau C* to the north side), a middle zone (from the top down, *Niveaux V* and *VIII*) and an inner zone (from top down, *Niveaux II*, *IV* and *VII*, with

35 There is a later reference to this long section, annotated in Roche's hand: "*Coupe longitudinale* (1956)", in an archive drawing dating from 1971, which suggests that Roche may even have visited the site again early in that year (1956) to draw and re-interpret the stratigraphy for his thesis.

Tab. 2.4 Roche stratigraphy: Roche headers in left column, explanation in right column.

"A52 = I"	[*Niveau A* dug in 1952 = *Niveau I*]
"A53 = II"	[*Niveau A* dug in 1953 = *Niveau II*]
"B52 = III"	[*Niveau B* dug in 1952 = *Niveau III*]
"B53 = IV"	[*Niveau B* dug in 1953 = *Niveau IV*]
"B54 = V"	[*Niveau B* dug in 1954 = *Niveau V*]
"C^{av} = VI"	[*Niveau C* dug '*en avant*' [front] = *Niveau VI*]
"C^{m} = VII"	[*Niveau C* dug in the '*milieu*' [middle] = *Niveau VII*]
"C^{f} = VIII"	[*Niveau C* dug in the '*fond*' [back] = *Niveau VIII*]
"Cch = IX"	[*Niveau C 'chocolat'* = *Niveau IX*]
"Cj = X"	[*Niveau* [interface] *C/jaune* [yellow] = *Niveau X*]

the special *Niveau IX* extending out northwards – more of which below). Using these groupings results in (a) a reasonable certainty that one actually has the coarse stratigraphy in the right order in any one of these zones, and in (b) a new and potentially interesting geographical dataset, where differences, at least in gross 'longitudinal' trends, within the cave might become apparent during further collection study[36]. The most secure examples of this possibility are obviously the closely constrained *Niveau IX* and *Niveau C*; the former lies at the base of the burial areas (it actually also continues further west than Roche reported it) and the latter (with a remarkably rich artefact assemblage, including many bone tools) occupies what would always have been the most sunlit location still under the overhang within the whole cave. Wherever it is possible from the records (published or not) to compare old assemblages from these zones and coarse stratigraphic divisions, future research is likely to benefit.

Turning to the burial areas, Roche (1963, 48) wrote:

> *En ce qui concerne les nécropoles, elles étaient isolées stratigraphiquement du reste du gisement, lorsque j'entrepris leur fouille, d'une part par un énorme bloc d'éboulis tombé à la fin de l'occupation atérienne et, d'autre part, par la tranchée d'exploration S2. La rareté des lits caillouteux, leur raccord difficile avec ceux existant dans la partie centrale du gisement, les fosses d'inhumation ont, en plus, complique la tâche.*
> *En fait, elles forment un monde à part. On a distingué six niveaux différents que l'on tachera de raccorder, dans un autre travail, avec ceux du gisement proprement dit.*
>
> [When I undertook their excavation, the burial areas [*Nécropoles I & II*] were stratigraphically isolated from the rest of the site, on the one hand, by an enormous block fallen at the end of the Aterian [MSA] occupation and, on the other, by [Ruhlmann's north trench]. Furthermore, the rarity of stony beds, their poor linkage with those existing in the central part of the site and the burial cuts, all complicated the task. In fact, [these areas] constitute a world unto themselves. We distinguished six different levels which we will attempt to link, in a future publication, with those of the main site.]

The 'six' levels mentioned by Roche are *Niveau IX* ('*chocolat*') at the base, plus five more, numbered (in Arabic numerals) 1-5 (top downwards) and shown, with no further explanation, demarcated by simple dashes against the side of Ruhlmann's north trench in Roche (1963, fig. 14). Roche never returned to this topic in print and there are no surviving documents to help us understand what these 'five' levels might have been[37]. The removal, from Squares L13-N17, of the 50 tonne block in 1953 required the aid of *La Compag-*

36 In fact, there remains one significant uncertainty in this scheme. In his publication (1963), Roche described and illustrated his *Niveau VII* as stretching right to the back of the cave, whilst *Niveau VIII* was shown in the middle of the cave (cf. **fig. 2.5**). However, the reverse is implied by the written archive notes summarised here in **tab. 2.4**. It is therefore possible that Roche inadvertently switched the two find assemblages as reported in 1963.

37 One could speculate that, since the basal stony layer of the typical 'grey [ashy]' series was missing in these areas, the five remaining units might just have been the *Niveau A-C* system (with their two intervening stony units) – but speculation this must remain.

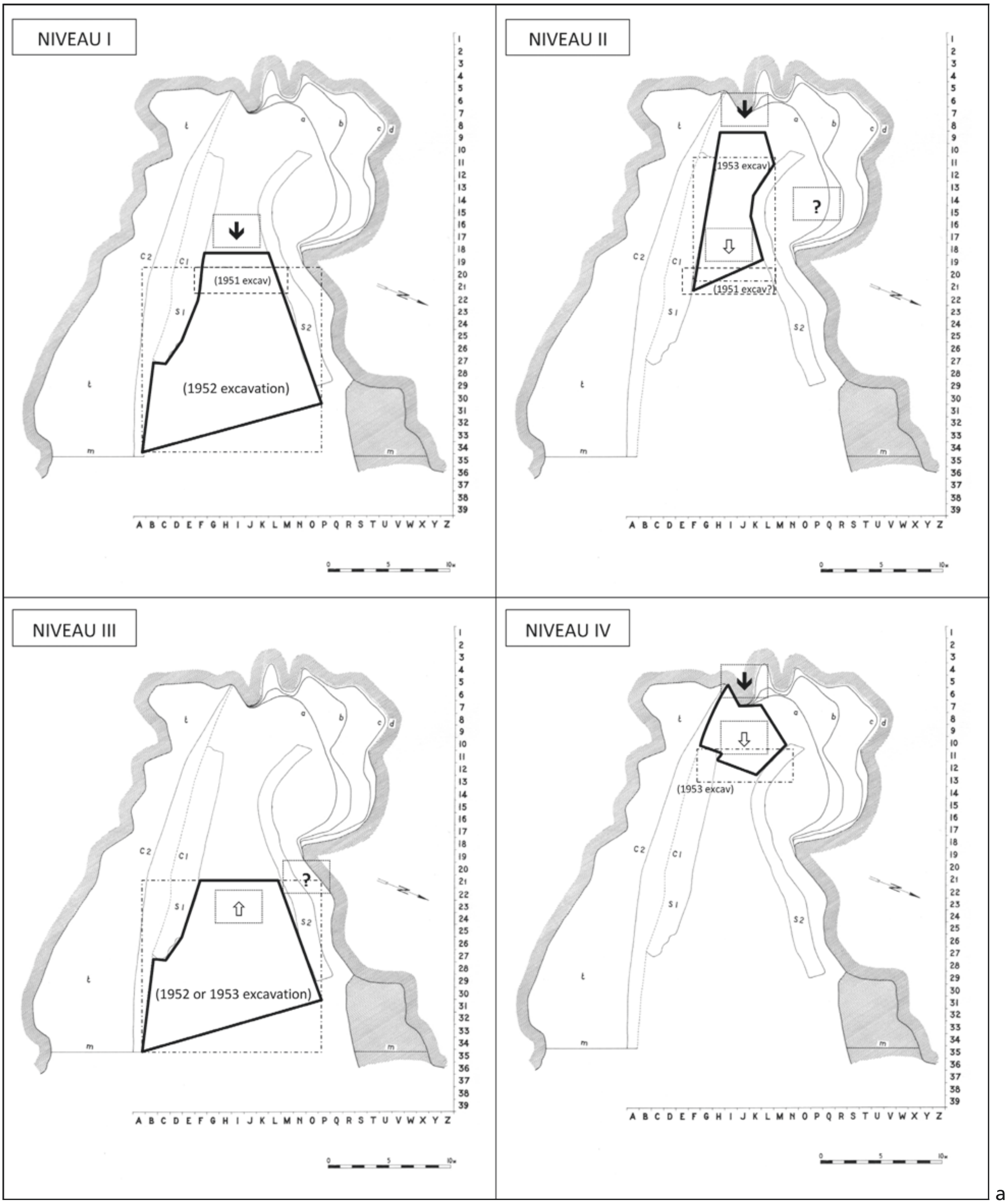


Fig. 2.5 a-c Estimated/approximate plan extent of Roche's *Niveaux*. – (After site plan, Roche 1963, fig. 4 and text).

nie Royale Asturienne des Mines and thus may well have involved explosives (Roche/Souville 1956; Roche 1963).

However, it should be noted that the Rabat archive contains unpublished texts, plans and photographs (all contemporary with the actual excavations in 1951-55), together with finds lists, that, if taken carefully at

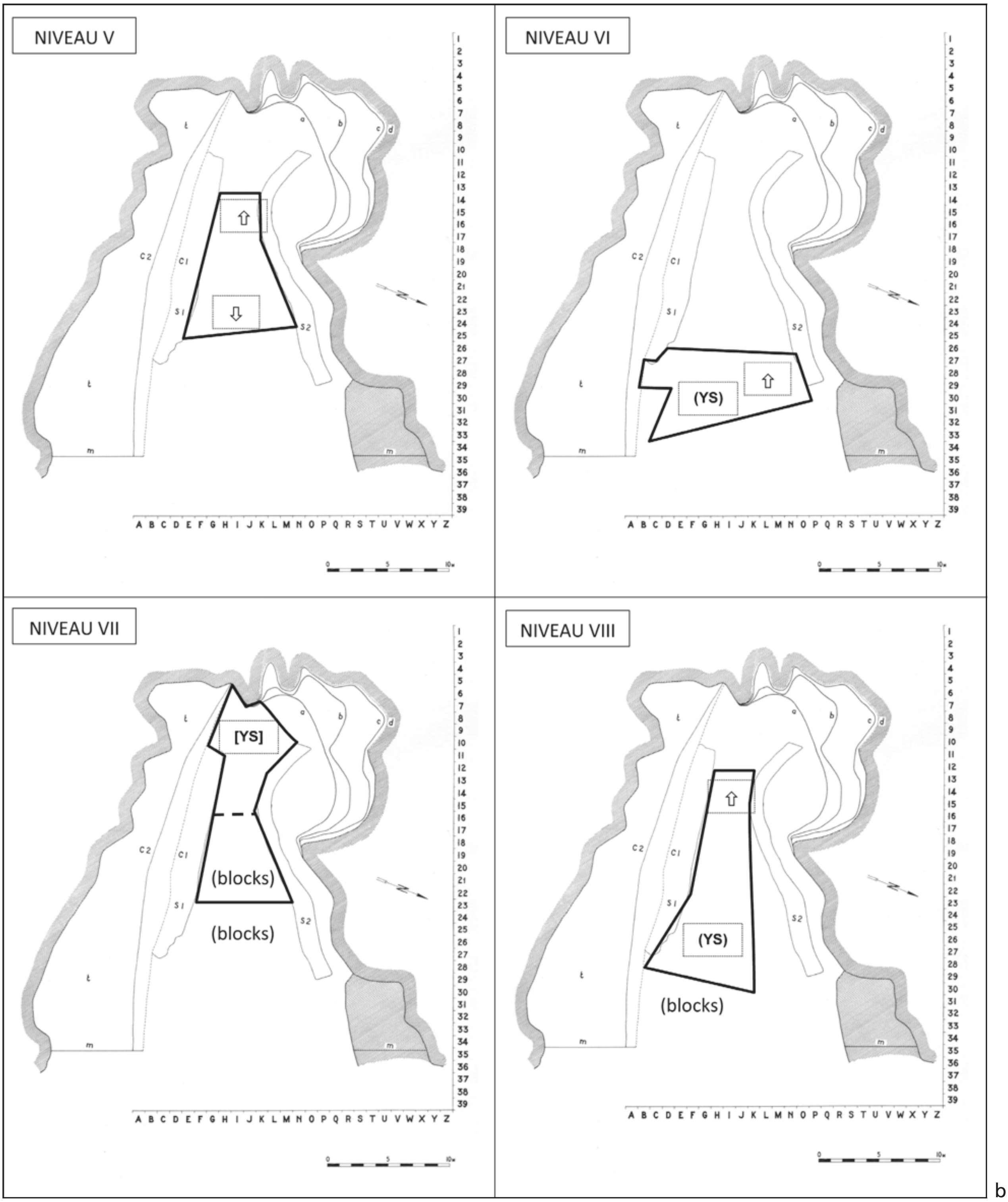
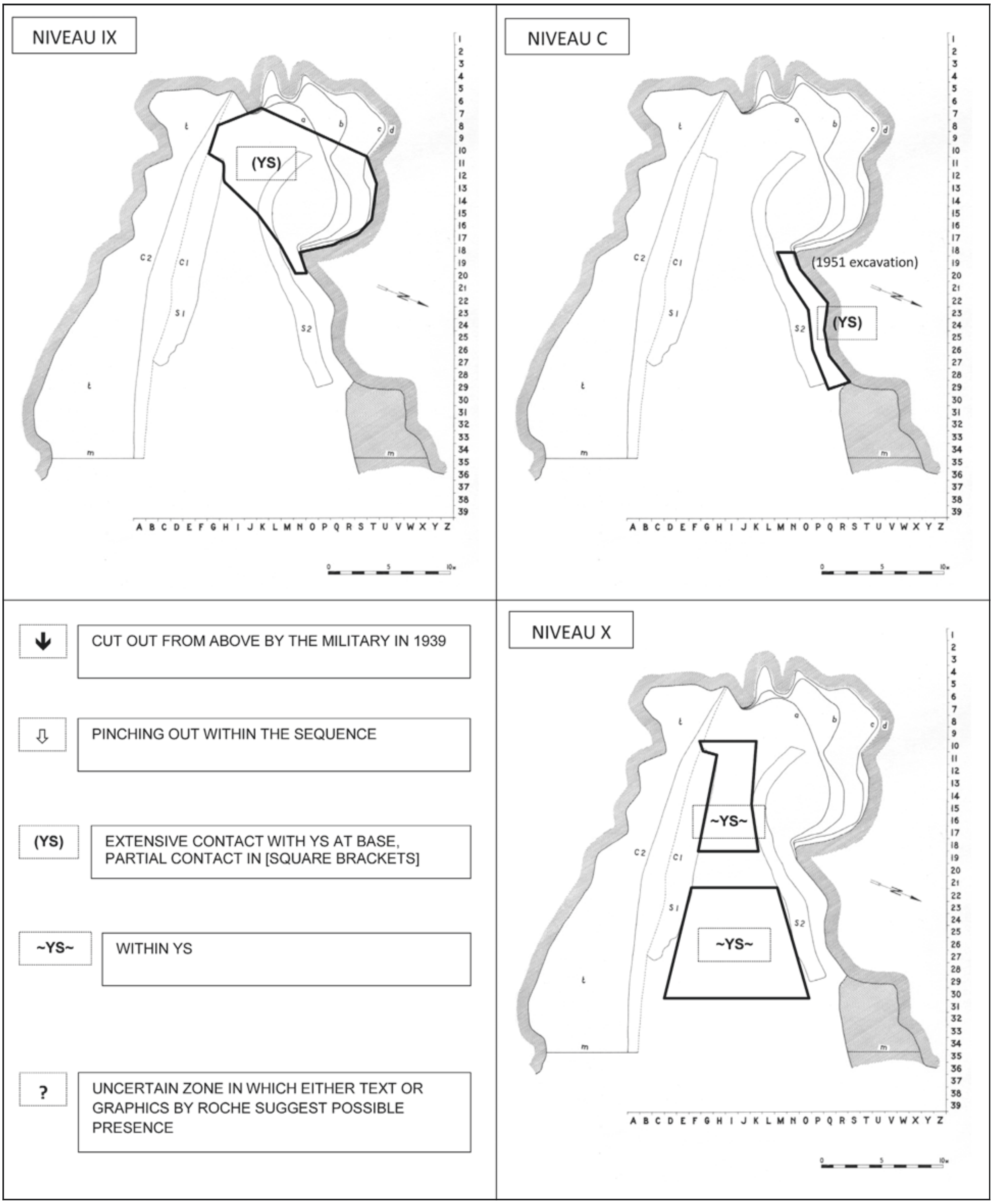


Fig. 2.5 (continued)

a microstratigraphic level, should allow an interesting degree of assemblage grouping and a reliable relative chronology to be recognised in the old finds; this work is in train, being led, as is appropriate, by the physical anthropology specialisation (the best available measure of true microstratigraphic association under these circumstances). Hopefully, more radiocarbon dates can be gathered directly on human bone and bone



c

Fig. 2.5 (continued)

Fig. 2.6 Baulk showing pick-marks, c. 1953. – Scale ?50 cm.

artefacts[38]. This having been said, it is necessary to make some comments here on what were recorded as 'sedimentary' aspects of the stratigraphy of the burial areas.

After the initial discoveries of Roche (noted above), Jodin (1954) took over recording the work in the main 'alcove', *Nécropole I*. Just as elsewhere, the *Niveau A-C* system was used for all recording (albeit that Roche's instinct that the presumed stratigraphic links with the main cave were suspect was probably well founded). Jodin reported that there was considerable disturbance of the upper levels of *Niveau A*, possibly including some intrusive Holocene or even historical period activity; no mortar layer was ever mentioned in this area. There were quite a number of dispersed stones and blocks at this level but, approaching the actual north wall, the sediment (in which there were seemingly arbitrary objects, such as lithics and animal bones) became black, damp and plastic, with an organic feel[39]. Lower down, the sediments became better structured (with some small hearths and shelly lenses, as well as the actual burial groups) and Jodin thought it appropriate to call this *Niveau* A_2 (as distinct from A_1 for the upper part). Note that specific burial groupings[40] were designated by "*S.*" or "*Sép.*" (for *sépulture[s]*, grave[s]) together with a capital Roman numeral; wider

38 Roche organised a radiocarbon date on charcoals but the taphonomy of such small and mobile objects requires extreme caution at the sampling point within this type of deposit. Thus, Roche later reported (1959, 729) that the determination (Lamont 399E) was made on 100 g of charcoal grouped (presumably after sieving) from a 0.5 m thick volume over an area of 4 m² in *Nécropole I*. The stratigraphic reliability of such samples must be doubtful. Furthermore, it is unlikely that the pretreatment procedures of the 1950s could have dealt adequately with the fact that this area had been capped by a strongly organic deposit, probably including Holocene material (Jodin 1954).

39 In passing, one may note that one would expect continual animal burrowing to have been a significant factor in such a 'wall-adjacent' context.

40 See **Chapter 15** for discussion of these groupings.

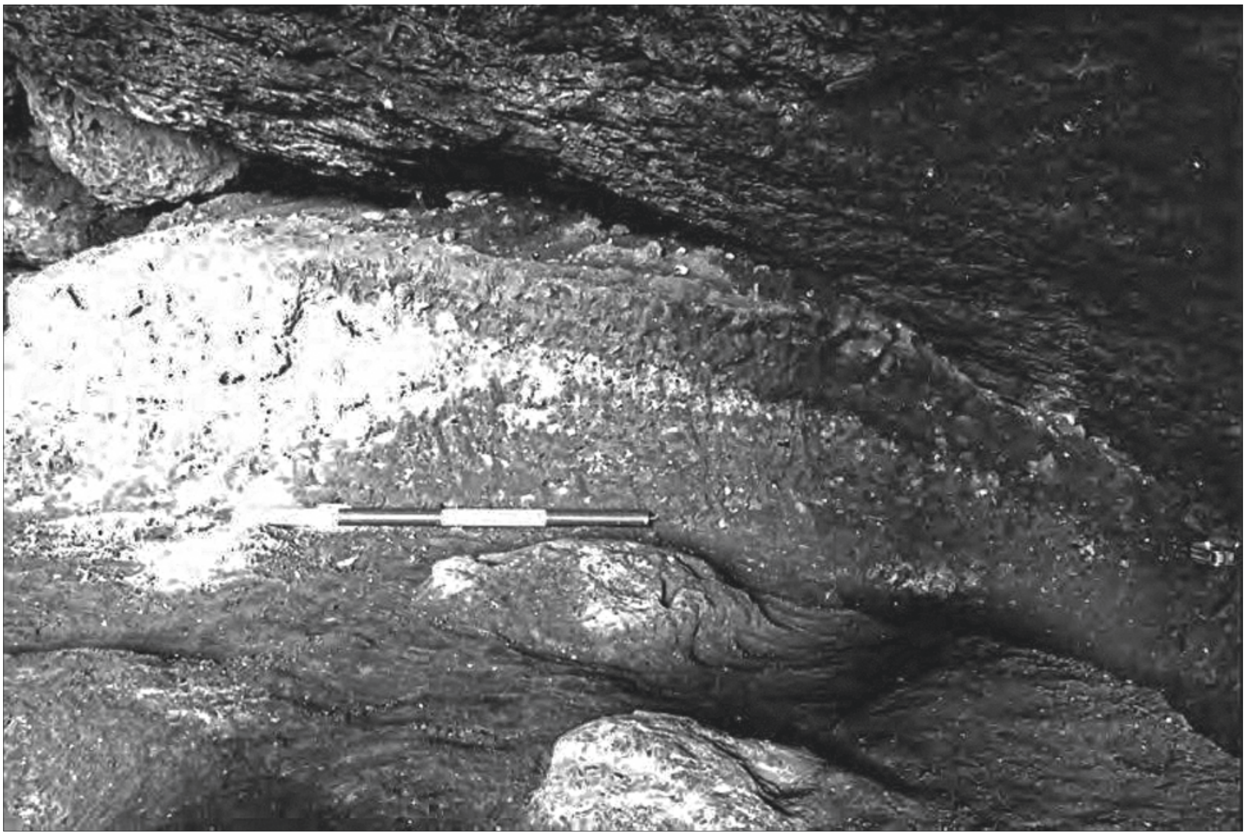


Fig. 2.7 1955, W end (S-N section) in *Nécropole I*. – Scale ?40 cm.

labels, e.g. "*Sép-A*", were sometimes used (during the excavation and for finds documentation) as an alternative label for all or part of *Niveau A* in *Nécropole I* (i.e. not a specific burial group).

As work progressed, Jodin felt that a *Niveau B*, "*une couche terreuse*" [an earthy layer], could be discerned. He noted (1954, 46) that, at the eastern end of *Nécropole I*, "*le sol est constitué d'une terre brunâtre, légèrement humide, beaucoup moins pulvérulente que les cendres de surface. Des éléments organiques nombreux, inhumations ou dépôts de nourriture se sont mêlés aux foyers pour former cette terre.*" [[…] the ground is made up of a brownish earth, slightly humid, much less powdery than the ashes [of the upper levels]. Numerous organic elements, burials [or, perhaps, simply disarticulated human remains] or food deposits are mixed with hearths to form this earth.]. It would seem that, as work progressed westwards, this earthy *Niveau B* could not be readily distinguished from the damp, dark zone immediately under the now very strongly sloping cave roof, as seen, for instance, at the top of the reference section in figure 2.7. At least in the outer and eastern parts of *Nécropole I*, there seems to have been a 6-8 cm thick lens of stones (with some small hearths and shelly spreads), separating *Niveau B* from *C* below, itself ashy again, with some larger blocks included and perhaps a very small hearth feature or two. One may also note certain passing references to calcite encrustations on bone, as well as dark brown stains, as spots or wider discoloration; such features are common in damp and heterogeneous cave sediments, the brown colour probably showing a strong manganese component (naturally present in the groundwater and further locally mobilised by any decaying organic matter; cf. Marín Arroyo et al. 2008; Barton et al. 2009).

Jodin (1955) also examined the top and outer part of *Nécropole II*, in the western recesses of the cave. The angle of *Niveau B* (already observed dipping strongly down northwards – up to 30° in places under the roof – and thus, presumably, upwards southwards), together with the discovery of underlying 'yellow earth',

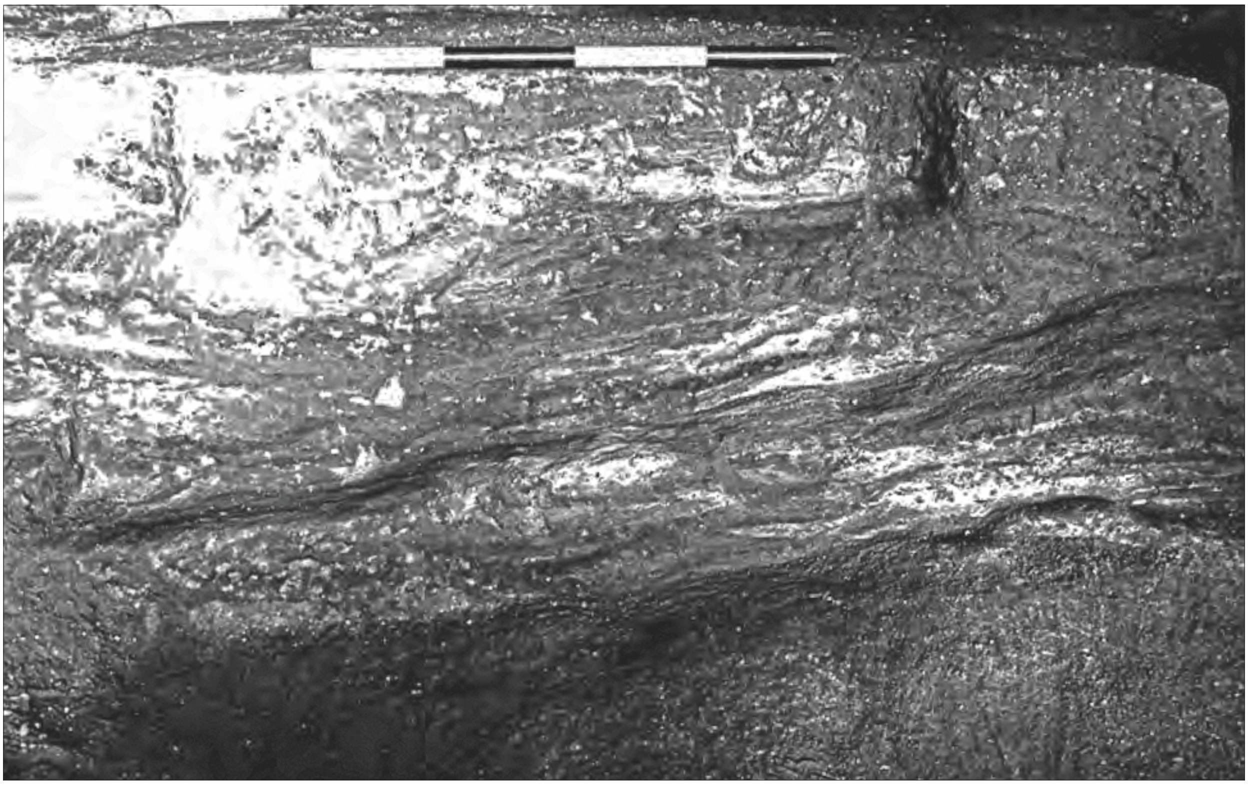


Fig. 2.8 1955, S-N section (ultra-violet light) in *Nécropole II*. – Scale ?40 cm.

are probably the reasons that the bulk of material excavated in *Nécropole II* was attributed to *Niveau C*. However, there is nothing explicit in the site notes to confirm that a dark earthy *Niveau B* had been physically traced across the western recesses of the cave. One may note that Roche (1963, 43) did say that the details of the rockforms here were originally "*entièrement masqués par les remplissages supérieures de cendres*" [completely masked by the upper ashy fills], plausibly higher still than any *Niveau B* level.

We have already noted Roche's *Niveau IX* ('*chocolat*'), mapped as passing under both *Nécropoles* and separating *Niveau C* from the underlying 'yellow [loamy]' series. Jodin (1955) noted a gradual 'browning' at the base of *Niveau C* in the main burial area but this basal level seems to have become a more discrete unit towards the west. Roche (1963, 129) first stated that he did not think this to be a true stratigraphic unit, suggesting rather an alteration of the ashy deposit against the damper underlying 'yellow [loamy]' series, but then went straight on to note that the contents of this unit certainly constituted a particular (discrete) association with chronostratigraphic significance. He offered (1963) a photograph of the basal section in *Nécropole II*, taken in ultra-violet light; another shot from the Rabat archives of this aspect is included here in figure 2.8. Below what Roche took to be the base of a grave cut, this technique brought out very well the characteristics typical of 'made-ground' (fine boundaries that are sharp, accidented/convoluted, laterally restricted and often relatively high-angle) in what was explicitly (Roche/Souville 1956, 164) identified as "*la terre brune qui est à la base des niveaux ibéromaurusiens*" [the brown earth at the base of the LSA levels], albeit a 'brown' that, upon exposure, was usually masked in grey dust. Roche (1963) also noted specifically that there were no hearths, stone lines or shell lenses actually within *Niveau IX*.

To recapitulate therefore, within relatively restricted zones, the *A-C* notation (together with the underlying *Niveau IX 'chocolat'*) does give a very basic idea of stratigraphic order within the burial areas (with all the necessary caveats over the possibility of reworking), an idea which may prove useful in the future for consideration of any finds which cannot be reliably associated with specific grave groupings. Because of the basic logistics which would have applied in this part of the cave geometry, it is very tempting to suggest (as did Roche himself, without further elaboration) that there may well have been a significant 'lateral' or 'lateral-oblique' component to the stratigraphy, with older features (including burials) deeper inwards and younger ones then building outwards towards the main cave. However, this proposition does not yet benefit from any direct proof and more detailed work on the whole burial area archive must now be undertaken to test the possibility.

Before leaving the 1950s campaign, one may note that, whilst Roche (1963) only reported LSA material in the uppermost 'yellow [loamy]' series (in his *Niveau X*) in the centre of the cave as far west as Line 10, there are archive notes of backed bladelets and other tell-tale lithics from immediately below *Nécropole II*, suggesting at least shallow or patchy LSA survivals above or alongside the underlying MSA units.

Roche 1969-76

Roche's second campaign is, unfortunately, extremely poorly documented. The excavations began again in October 1969. Roche commented (1969, 90): "*Deux sondages furent creusés au centre de la grotte dans les terres jaunes. Ils permirent d'observer une belle succession de niveaux épipaléolithiques surmontant des couches brècheuses qui ont livré des industries paléolithiques*." [Two exploration trenches were dug in the centre of the cave into the 'yellow [loamy]' series. These allowed the recognition of a good succession of [LSA] levels, overlying stony [and here explicitly cemented] beds which have produced [MSA] industries.]. Again, one may note the apparent facility with which different prehistoric groupings were linked with different sediment types.

Progress to 1972 was next reported (Roche 1973-1975), this time with a plan (reproduced here as **fig. 2.9**) to locate four sections. Roche had reversed the longitudinal co-ordinates (with respect to those published in 1963). Thus, letters were still used across the cave in the same direction, from A on the south side, but numbers now increased from the east inwards (the inversion point between the two systems being at approximately the 17 Line). The text description of the sections did not always match the plan (or the relevant void surviving today), in either dimensions or even orientation; in **figure 2.9**, those sections for which there are indeed surviving drawings are marked.

Roche (1973-1975, 149) added the following short statement:

> *Dans la partie supérieure des formations jaunes-grises, noires, on trouve des industries appartenant à un Epipaléolithique ancien. On se doutait depuis longtemps de l'existence au Maghreb d'industries épipaléolithiques sous les formations cendreuses mais, pour diverses raisons, elles n'avaient jamais été isolées. A Taforalt, huit occupations principales appartenant à cette période ont été mises en évidence. Elles se subdivisent localement en séries complexes (foyers rubannés, lentilles ...) : Niveaux 10 à 17. Si l'on ajoute les observations antérieurement faites sur les couches cendreuses, on constate que la grotte a connu en tout 17 occupations épipaléolithiques, ce qui est remarquable.*
>
> [In the upper part of the yellow-grey formation [the 'yellow [loamy]' series], [which here contains] black [archaeological subunits], one finds industries belonging to the 'Early LSA'. It has long been suspected that 'Epipalaeolithic' industries existed in the Maghreb below the ashy formations [middens] but, for a variety of reasons, these had never been isolated. At Taforalt, eight main occupations belonging to this period have been proven. These are subdivided locally within a complex set (hearth bands, lenses, etc.) as *Niveaux 10-17*. If one adds the previous observations made within the ashy layers, one concludes that the cave has known 17 LSA occupations, a remarkable total.]

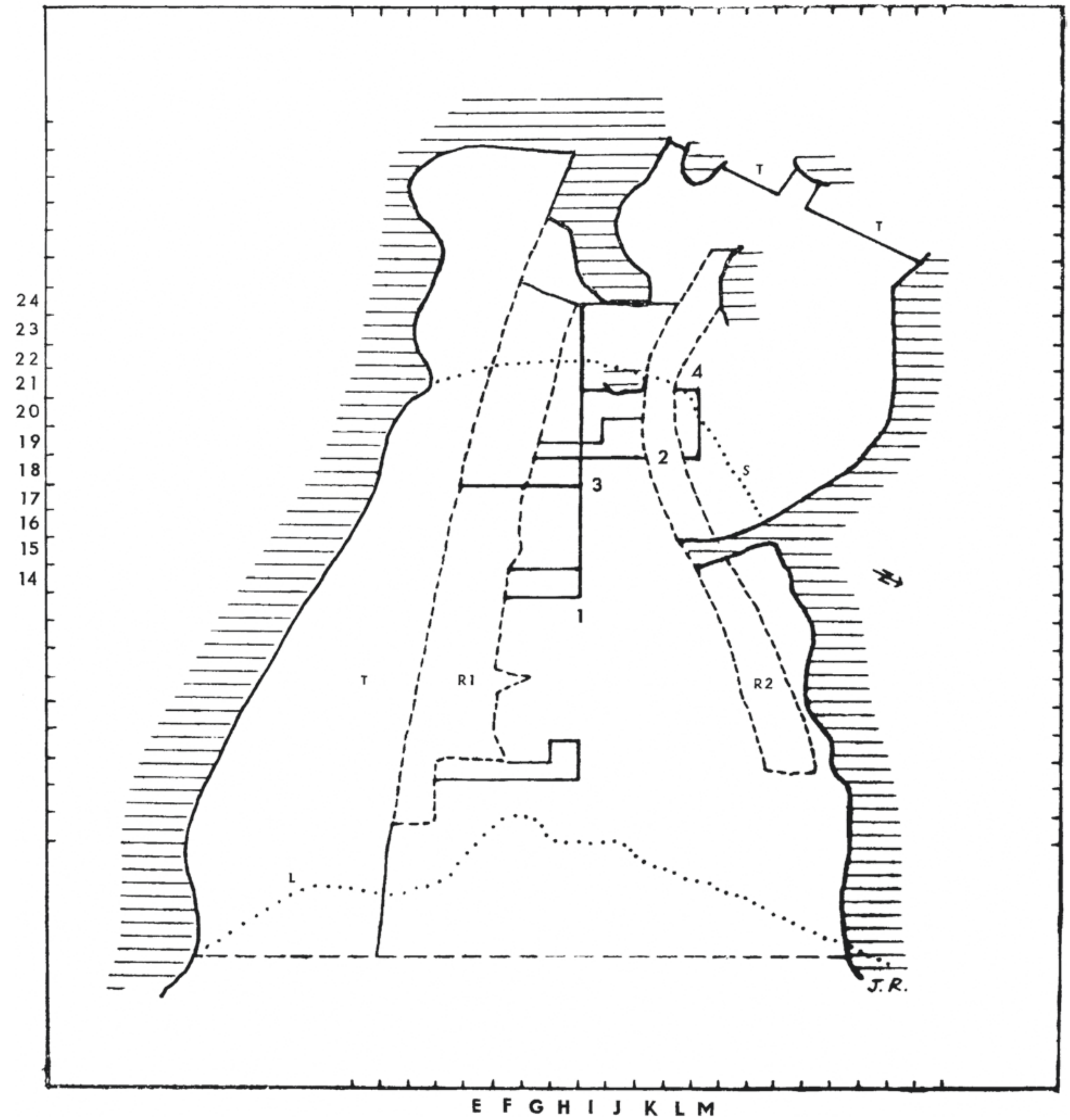


Fig. 2.9 Roche site plan of 1970s YS sections.

Note that Roche had here switched to using Arabic numerals for his layers (although Roman numerals sometimes appear again in places) but that the sequence was considered to be continuous (thus, *Niveau X* of earlier publications was strictly the same thing as *Niveau 10* in the 1970s).

Roche gave a description of his *Niveaux 10-17* (Roche 1976), details which are repeated in full in **Appendix 2** in the present text, since, fortunately, it is possible to match, more or less exactly, the section in question (via the drawing H/I 18-17 published in Delibrias/Roche 1976[41]) with that surviving in Sector 3 of the

41 Noting only that this section drawing was wholly 'notional' in its upper part, since the whole 'grey [ashy]' series was there shown, sediments which, in fact, had long been excavated away.

current excavations (see fig. 2.14 below). Roche showed a number of blackish 'charcoal trains', sometimes with some greyer ashes, as bifurcating and/or merging in this sequence, over 0.95 m thick in total, whilst a slightly more straightforward sequence, with relatively thin archaeological levels lying within a generally well-stratified (laminated) set of dominantly natural deposits, has been recognised during the present campaign.
The question therefore arises as to what Roche meant by "*un Epipaléolithique ancien*" [an Early LSA], remembering that his most obvious contribution up to this point had been in the detailed analysis of the lithic industries of the 'grey [ashy]' series (as well as in the analyses of MSA lithics from deeper in the stratigraphy). However, we now hit a complete blank – there is no published (or archival) description of this material, not even a passing comment. In fact, in addition to these stratigraphic details, the 1976 publications concentrated exclusively upon the matter of radiocarbon dates. There must be a strong suspicion that it was the numerical values of these dates[42] which allowed the development of an 'easy assumption' that the LSA/MSA boundary fell at the *Niveaux 17/18* level. The assumption is definitely incorrect in the centre of Roche's 'type section' (Sector 3 in the system used during the current campaign), where the LSA/MSA transition actually occurs, without any doubt, after a thickness of only c. 0.45 m of the 'yellow [loamy]' series, at approximately the base of Roche *Niveau 13*; all the beds (and the boundary in question) are dipping outwards to the east, with at least a slight local thickening in most of the component subunits in that direction but, commensurately, an increasing thinning westwards, into the cave.
It was noted above that other 'yellow [loamy]' series (and below) section drawings survive in the archives (with plan alignments as shown in fig. 2.9). In Roche Section 4, the labelled *Niveaux 10-17* set were laterally interrupted by very large amorphous zones (in the complete thickness of over 1 m and in a width of 1-1.5 m), showing an unexplained ornamentation (not stone blocks but possibly large burrows or perhaps strong carbonate cementation, the latter being the most likely, judging from the study of the surviving deposits in this area); whatever the cause, there is no plausible stratigraphic continuity across these zones (we have recovered no LSA material at all in this area, the current Sector 1). Similarly, in Roche Section 1, the stratigraphy was completely cut by very large limestone blocks (of dimensions well over 1 m), immediately west of the published section H/I 18-17. And again, Roche Section 2 (isolated at each end by the Ruhlmann trenches) showed a complex laminated set, interrupted in the centre by what is now interpreted as a large drip-pocket (cementation, down-warping, etc.); the current excavations here (Sector 6) have recovered LSA material only in the top 0.35 m (at most), whilst the Roche drawing showed the 'Aterian/Epipalaeolithic' boundary (explicitly as a red line) almost a metre lower.
By 1975 (Hassar-Benslimane 1976), Roche appears to have been working only at increasing depth in the MSA levels.

Raynal 1977-82

Towards the end of his fieldwork in Morocco, Roche established links with the prehistory department at Bordeaux University, where he entered into a collaboration concerning Taforalt with the geoarchaeologist, Jean-Paul Raynal. The only substantive primary publication from this collaboration was Raynal (1980), reporting work in 1977-78. Here, Raynal presented a narrow transverse section drawing, from "M-N

42 There are several factual reasons to query these early determinations (bulk sampling of charcoals, even described in a few instances simply as *terre charbonneuse* [black earth]); even when a 'numerical value' appears to be plausible (in the light of modern dating work), it cannot now be disproven that such a 'value' may well have been a simple coincidence.

21/20" [43], covering all the 'yellow [loamy]' series and more below; this drawing was most accurate and represented a very legible section which still survives, such that it has been adopted as the 'type-section' in this part of the cave. Raynal allocated Arabic numerals to the layers he recognised; during the present work, an 'R' has been added to all Raynal's numbers, in an attempt to keep on top of the growing complexity of the lithostratigraphic recording systems.

> *Une coupe détaillée a été relevée à cheval sur les carres M21 et N21 (figure 11). Elle a fait l'objet d'un échantillonnage serré en vue d'une étude sédimentologie fine : 42 prélèvements ont été effectués.*
> *Elle permet les observations suivantes :*
> *- 30 niveaux ont été individualisés, certains se subdivisant en plusieurs sous-niveaux sur des critères anthropiques (succession de foyers par exemple, succession de zones rubéfiées).*
> *- Les niveaux 1 à 11 sont sablo-limoneux fins, de colorations jaunâtre mais le plus souvent grise à noire (foyers). Ils renferment tous de l'Epipaléolithique.*
> *- Les niveaux 14 à 18 correspondent à la couche 17 de J. Roche ; ce sont des sédiments sablo-limoneux, comportant des blocs (anthropiques ?) et surtout plusieurs zones superposées de concrétionnement (genre de croûtes carbonatées rosâtres). C'est la zone de transition entre Atérien et Epipaléolithique. En d'autres points du gisement (fouille de J. Roche en K18) la transition n'est pas non plus marquée par un changement de texture du sédiment, mais les phénomènes de concrétionnement ne semblent affecter que les niveaux atériens.*
>
> [A detailed section has been recorded across the divide between Squares M21 and N21 (figure 11). This section has been tightly sampled (at 42 points) with a view to a precise sedimentological study.
> The section recording allows the following observations:
> - 30 layers [R-layers, Raynal-layers] have been singled out, some calling for division into several sub-layers on anthropogenic criteria (successions of hearths or rubified zones, for example).
> - Layers R1 to R11 [what Raynal also called "*Ensemble I*" or 'Group I'] are of fine sandy silt, of a yellowish colour but often grey to black (hearths). These layers all contain Epipalaeolithic material [LSA].
> - Layers R14 to R18 correspond to *Niveau 17* of J. Roche; these are sandy silt sediments, containing blocs (placed by man?) and, in particular, several superposed zones of concretion (of the type: pinkish carbonate crusts). This is the zone of transition between the Aterian [MSA] and the Epipalaeolithic [LSA]. At other points within the site (excavation by J. Roche in Square K18 [c. K16 of the original Roche system]) the transition is no longer marked by a change in sediment texture, although the concretionary phenomena only appear to affect the Aterian layers.]

Raynal here seems to have fallen foul of the complexity of the stratigraphic labelling systems already in use at that time. On his section (which has flanking annotations on stratigraphy and sampling), Raynal included R1-R11 in his 'Group I' (as noted in the above text); this Group was specifically correlated with Roche's *Niveaux 10-15*. However, the description that Raynal gave (above) in text for 'R14-R18' fits (in terms of the ornamentation on the drawing, checked against the still surviving sediments themselves) much better his R12-R13 [what he also called "*Ensemble II*" or 'Group II'], which, on the diagram, he specifically correlated with Roche's *Niveau 17*. One may also note that 'Group II' contained samples 14-18 (which probably explains the slip).

It must be stressed that the present author cannot accept Roche's wide-ranging correlation (right across the centre of the main cave) of his *Niveaux 10-17* within the 'yellow [loamy]' series. Nevertheless, looking at Roche's Section 4 and Raynal's more detailed section, it is plausible to allow, very locally, that Roche and Raynal were talking about more or less the same set of units. It is not now known what Raynal may have meant by the idea of 'Group II' being archaeologically 'transitional' (and, in passing, the idea that the contained carbonate blocks were likely placed by man must be rejected). It is reiterated that, in reality, there are now no LSA levels at all in the deposits of this area, although it is vaguely possible that such material

43 Note that Raynal was using Roche's 'reversed' (1969-76) square number notation, such that these would be squares 'M-N 13/14' in the 1963 system (although survey during the current campaign would put this section in L-M 14/15 at the base, sloping back 'westwards' into square 14 upwards).

was still present in, say, R1 or R2 (units which now survive only as tiny remnants[44]) – from the current work, Raynal's 'Group I' demonstrably contains, more or less at the top, a non-Levallois flake industry and then clear MSA material below (all with appropriate date determinations). It may also be noted, in passing, that the north end of Roche's 1971 Section 2 was later annotated "*Fouilles JPR/JR 1977*", suggesting that the collaborators actually dug a small 'notch' down through the sediments in Square K18 (K16 in the old notation; see the comment by Raynal above). Oddly enough, the red line, annotated as the LSA/MSA boundary, was drawn at the top of *Niveau 19* in that square, with two units above (together at least 0.35 m thick), labelled "*18?*" and "*18*", before *Niveau 17*. As already noted, LSA material has been confirmed during the current campaign in this part of the cave (Sector 6[N]) only very much higher still.

The Roche-Raynal collaboration therefore left us with increased geological precision in at least one area but did not reverse the misconception over dating and, in particular, over the boundary between the LSA and MSA.

Courty 1980s

Indeed, the misconception was to deepen yet further. Coherent samples were taken, apparently in 1982, by either Raynal or by Marie-Agnès Courty herself, for micromorphological analysis by the latter. There are two publications covering this work. Courty (1989, fig. 11.2[a]) first offered a simplified version of the Raynal ("M-N 21/22") section but she explicitly placed the "Aterian/Epipalaeolithic transition" at the base of Raynal's 'Group III' (that is, at the base of R23, equivalent to the base of Roche *Niveau 19*). Then Courty offered a photograph (1989, fig. 11.2[b]) of this same area, in the key of which she noted: "transition between the Epipaleolithic sequence (down to sample 18 […]) and the Aterian sequence (up to [and including] sample 19 […])". The entities actually shown by numbered labels in this photograph were not "samples", they were R-layers (still readily identifiable today). In her own drawn section (1989, fig. 11.3), Courty then showed part of Roche Section 2 (Sector 6 in the system used during the current campaign), with the LSA/MSA transition marked on the south side at the Roche *Niveau 17/18* level. Courty later developed (Courty & Vallverdu 2001) yet another stratigraphic system (units with capital Roman numerals), covering the supposed "MSA/LSA transition"; it is actually possible to relate much of this detail back to the earlier (Raynal and Roche) stratigraphies (judging by what seem to be Raynal's sample numbers, it would appear that Raynal 'Groups III and II', layers R23-R12, were involved) but this task will be left until a future volume covering the earlier deposits at Taforalt. Throughout her work, Courty was using entirely the wrong chronological and palaeoclimatic paradigm (all stemming from the cumulative stratigraphic confusion), such that her constrained interpretations must be separated as carefully as possible from her (still most valuable) primary micromorphological observations (as will be the case in the forthcoming volume on the earlier levels of this cave).

The only point at which Courty (1989, 225) appears to have been commenting upon a true interval of 'LSA time' was as follows:

> *It is only in the upper part of the Epipalaeolithic sequence in the thick layered ash units at the base of the necropolis that calcium carbonate ash crystals become abundant (Figure 11.4e)* [caption: *"Mildly disturbed calcitic ashes forming thick accumulations in the upper part of the Epipalaeolithic sequence"*]. *There they form an essential constituent, associated with abundant, highly burnt sheep droppings and fire-cracked exploded travertine fragments.*

[44] That no great physical interval between the base of the 'grey [ashy]' series and the top of the 'yellow [loamy]' series is missing in this area is suggested by the fact that layers R1-2 still have small to very small burrow-forms containing almost pure ash, unlike anything in the immediately surrounding 'yellow' sediments.

Unfortunately, the exact location of this sample is unclear (remembering that most of the 'grey [ashy]' series had long been removed); either Courty had access to a sample from *Nécropole II* or the sample simply came from the surviving units somewhere along the south side of the main cave. Both Raynal and Courty used the term 'travertine' to refer to many different materials, including the cave bedrock (see above). As for "sheep droppings" [45], the present author remains highly sceptical (the actual published micrograph shows many dark opaque particles but these are all smaller than 50 microns in diameter). The present author has never observed macroscopic coprolites or dung, whether or not burnt, although alkali-soluble organic matter is ubiquitous in the 'ashy' units and is thus probably present at least as coatings, if not amorphous concentrations (see also **Chapter 3**). Also, extremely low (small- and very small-scale) bioturbation levels and absence of shrinkage-cracking have been noted, even during 'air-jet' excavation (see below), features which one would have expected in abundance, had there originally been significant 'dung lenses' within the ashy sequence (cf. Collcutt 2012).

2.3 THE CURRENT CAMPAIGN

The excavations since 2003 have involved works in various parts of the cave. The rock walls show a complex morphology and even the early excavation trenches had further degraded in many places, so that re-establishing the exact geography of the site was not straightforward. However, there were certain 'hard points', including apparent survey points, which have been located. Whilst finds and other spatial data from the current excavations have been recorded by total station in a standard three-dimensional co-ordinate system (to 1 cm precision), it is believed that it has been possible to approximate to a sufficient accuracy the grid squares of the Roche (1963) report, a simple notation which will be used in the present volume where appropriate. Note that any z co-ordinates reported here (cf. **Appendix 2**) are measured downwards from the current arbitrary (high) Site Datum; other data are given measured downwards from a local zero at the top of the sequence in question.

Since the locations of earlier works and observations were not always immediately clear, different parts of the cave have been designated as numbered 'Sectors' (sometimes abbreviated as 'S8', 'S10', etc.). The locations involved are shown in **figure 2.10**, with a high level view over the site in **figure 2.11**. There are currently twelve sectors but only some of these contain deposits of relevance to the Later Stone Age period (see below).

In the LSA deposits (where no very large rocks were encountered), the normal excavation technique during the current campaign has always involved the use of small to very small hand-tools (sometimes assisted by air-jetting), with total dry-sieving (2 mm mesh). However, the objectives of the present campaign have been to apply a wide range of technical analyses (as reported in previous publications and in the various chapters of the present text), most of which are heavily reliant upon stratigraphic control and vertical development through time. Thus, quite significant proportions of the small total volume that has been excavated during the present campaign have been extracted as samples at a wide range of scales. Sometimes these samples have been totally 'excavated out', in order to avoid contamination from bioturbation or other intrusive structures, but, in other cases, samples sequences have been taken as slots, columns, boxes or peels; **figures 2.12**, **2.13** and **2.14** each show a typical result – not a thing of beauty but illustrative of the control

45 See **Chapter 9** on the lack of evidence for any proximal manipulation (e. g. 'forced penning') of *Ammotragus* at Taforalt.

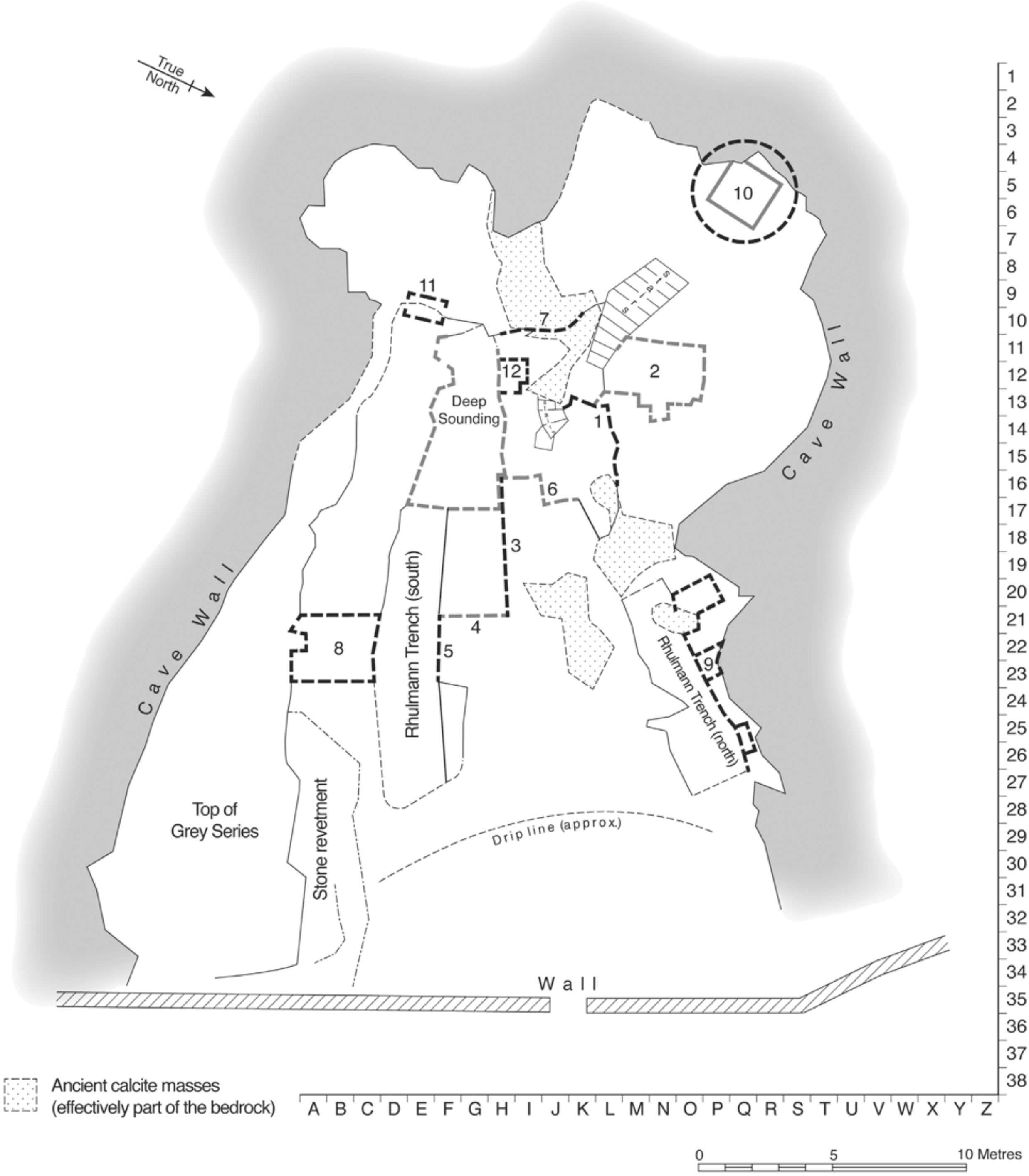


Fig. 2.10 Site plan, current campaign, showing sectors.

which has been exercised. Following selection for current analyses, an archive of further samples has been established.

It is reiterated that the critical discussion above of the earlier excavations is aimed primarily at trying to bring out the real and enduring value of those works. The current campaign at Taforalt (2003 onwards) in the

Fig. 2.11 Surveying from the top of the Grey Series. – (AD5891.tif Ian R. Cartwright).

Grey and Yellow Series[46] has delivered a great increase in precision and accuracy but this work has been concentrated upon only a relatively tiny volume of the 'grey earths' (Grey Series[47]) and still a considerably smaller volume of the 'yellow earths' (upper Yellow Series, LSA levels[48]) than that excavated by Ruhlmann and Roche. Thus, the current findings must include uncertainty over the degree to which they are representative of the whole geography (and, in some zones, even the chronostratigraphy) of the site. Whilst this uncertainty cannot now be removed, researchers in all disciplines should not hesitate to check back over the earlier results, through the necessary adjustment identified in the modern critique, for any wider insights that might be found there. Nonetheless, we would respectfully point out that the level of uncertainty concerning stratigraphic control and correlation now achieved at Taforalt has been greatly over-stated by

46 The 'Grey Series' and 'Yellow Series' terminology (abbreviated where appropriate to 'GS' and 'YS') was adopted in Barton et al. 2007 and Bouzouggar et al. 2008 and continues in use; in Bouzouggar et al. 2007, the Grey Series was labelled as "group A", whilst the "Upper Laminated group B&C" included the Yellow Series.

47 It is estimated that, by the 1940s, the Grey Series occupied a volume at the very least of 1350 m³, with every indication that, prior to the earlier military works, that volume would have totalled at least 1750 m³. Hopefully, as much as 400 m³ survive in the remaining southern 'reference section'. The current work to date in the S8 Grey Series has amounted to under 3 m³ (with a further small volume in S10, as noted in **Chapter 15**).

48 The Ruhlmann and Roche excavations removed (wittingly or not) up to 70 m³ of the LSA Yellow Series (with the proviso that it is now difficult to be sure of where the LSA/MSA boundary fell in many cases). As a very rough estimation of the probably still surviving LSA Yellow Series, the present author would suggest a volume of perhaps 200 m³, thickening towards the front of the cave but possibly still present in a few restricted patches towards the back. The work up to and including 2017 of the current campaign in the S3/S8/S9 LSA Yellow Series has amounted to just over 4 m³.

Fig. 2.12 Intensive sampling in Grey Series in Sector 8, E-W orientation.

Klasen et al. (2018); the reader is invited to examine the source data in Barton et al. (2013; 2016), as well as those in this and other chapters of the present work (see especially Appendix 2).

2.4 LITHOSTRATIGRAPHIES

The deposits at Taforalt of LSA relevance present a number of stratigraphic challenges: they may be extremely lenticular and discontinuous, unstable (with exposures shifting between excavation seasons) and/or very repetitive and cyclical. For this reason, detailed stratigraphic descriptions have been recorded by several colleagues (during excavation and sampling) and by the present author, each time a major study has been

Fig. 2.13 Intensive sampling in Yellow Series in Sector 8, SE view. – Scale 1 m.

conducted in any given Sector. These descriptions are included in **Appendix 2**, which also contains (at the end) schematic sections of the main exposures, with direct (i.e. physically traceable) correlations indicated (by grey dashed lines) wherever possible. More distant correlations between sectors across the cave often require confirmation by other data sets (especially ^{14}C determinations; see **Chapter 4**).

Sectors 1 & 2

In Bouzouggar et al. (2007), the present author suggested that the junction between the B and C groups of sediments (as there defined) could be traced across the cave, principally between Sectors 1 & 2 and Sector 8. This turned out to be an error, caused by over-reliance upon a sedimentary motif (reddish clayey

Fig. 2.14 Intensive sampling in Yellow Series in Sector 3, W-E section. – Scale 20 cm.

material and white carbonate powder caught in minor plastic deformation structures) that is now known to occur in different places within the cave at different stratigraphic levels. As already noted in **Section 2.2** above, no LSA material has be recovered during the present campaign in Sectors 1 & 2, all surviving deposits being older than this.

Sector 8

This sector is the only one in which the Grey Series and the Yellow Series have been observed during the present campaign in the fullest stratigraphic continuity (**fig. 2.15**). It may therefore be thought of as containing the Taforalt 'type' sequence for the LSA period. However, it should be remembered that this sector is truncated at the top and probably lacks an interval covering latest LSA time. There may also be a degree of loss at the 'erosive' GS-YS boundary (see below), although ^{14}C dating suggests that this is unlikely to have involved a really significant interval.

Sectors 3, 4 & 5

These three sectors are in lateral continuity (see **fig. 2.10**) and the Yellow Series stratigraphy can be followed throughout, with units usually dipping markedly (4-10°) and often thickening eastwards, out of the cave. These sectors are also close to Sector 8 (across Ruhlmann's south trench) and certain key units can plausibly

Fig. 2.15 Sector 8 and inward extension, E-W; cf. **fig. 1.14**. – (Photo Ian R. Cartwright). – Scale with 50cm units.

be traced across the gap (in particular Unit Y5, just below the LSA deposits). These cross-trench correlations suggest that there is also a general southwards dip of up to 6° (a dip which can actually be seen in Sector 4). There is no surviving Grey Series sediment at the top of S3 (the exposure being already some 0.5m above the altitude of the GS/YS boundary in S8[49]); indeed, the S3 sequence appears to start within the correlate of S8-Y2. If the section in Delibrias/Roche (1976, fig.1) is correct in showing the (former) presence of *Niveau VIII* (GS) above *Niveaux X* and *XI* (top YS), this would suggest a stronger erosive gap (top of YS missing) nearer the middle (longitudinal) line of the cave.

Sector 9

This sector is also now missing any trace of GS sediment[50]. Whilst a slight eastwards (outwards) dip is still present in units at the western (inner) end of Sector 9, by the time the currently exposed eastern end of this sector has been reached (approximately but not fully the outer end of Ruhlmann's north trench), the dip has reversed, suggesting the presence of the inner slope of an entrance talus. It is also of interest that, judging from the best correlations currently available, whilst Sector 1 (lacking LSA-period sediments) shows little

49 The cross-sections in Roche (1963) also show the GS/YS boundary dipping southwards, at an increasing angle at points nearer the cave mouth.

50 The cross-section in Roche (1963) shows the GS/YS boundary quite high on this side of the cave, dipping southwards (right across the cave).

Fig. 2.16 Sector 10, base of the 'Brown Layer', above lighter well stratified material with hearth traces, W-E section. – Scale 10 cm.

or no appreciable dip eastwards (outwards), moving further eastwards and passing over the intervening massive ancient speleothem boulders and possible *in situ* calcite vein (see **fig. 2.10**), there appears to be a relatively abrupt drop of up to 1.5 m in equivalent levels (that is, in the levels of the youngest pre-LSA interval in S9), demonstrating well the concept of separate depositional 'compartments' mentioned in **Section 2.1**. Probably the most significant element in the Sector 9 stratigraphy is the well-developed interval between the LSA (the earliest yet encountered in the cave) and the MSA, an interval in which strong silt units appear (see below), an input which could only be suspected in the equivalent (but greatly condensed) interval in Sector 8 (within Unit Y4, centred at S8-Y4spit3).

Sector 10

The ashy matrix of Sector 10, in which burials have been made (see **Chapter 15**), is very similar in bulk composition (barring, of course, the important addition of human bone and associated objects) to the Grey Series in Sector 8, although the S10 material has a completely different structure and, at least in places, a different stone content (see below). The basal deposit, the 'Brown Layer', which appears to be the same unit as recorded by Roche (1963) as *Niveau IX ('chocolat')*, is not the 'typical' ashy sediment (**fig. 2.16**) but is similar enough to be included in the same group, namely the Grey Series. The surviving Sector 10 deposits have been truncated at the top by previous excavation. The deposits below the 'Brown Layer' have not been examined in any detail or to any great depth. These usually comprise yellowish fine sand, but often have a strong small stone content and common carbonate (sometimes as a diffuse cement); signs of human occupation are present and a very few finds of both LSA and MSA lithic material have been made. It seems likely that the 'main' (pre-GS) sequence is here extremely condensed and, possibly, made even more complex by human disturbance.

Other Traces

Sector 6 is capped by a shallow LSA-relevant interval (investigated on the north side as S6[N]). Erosive phenomena (including units showing plastic deformation) are here cutting out underlying material increasingly northwards; the oldest deposit plausibly within LSA time lies some 0.35 m above the equivalent level in Sector 3.

The southern section of the Deep Sounding (see **fig. 2.10**) can be thought of as a western continuation of Sector 8, towards the west end of Ruhlmann's south trench; it contains a condensed YS sequence, together with the GS above. The principal interest is the GS/YS boundary (here falling approximately a metre higher than the same level in S8), around which several ^{14}C determinations have been made (see **Chapter 4**).

Sector 11, containing material relatively high in the GS, was investigated by air-jetting to test for the survival state of charred composites (see below).

2.5 DEPOSITION RATES

All radiocarbon dating results are presented in **Chapter 4**. Early in the present campaign, it became apparent that it would be possible to develop a detailed stratigraphic understanding of Sector 8 (and its inward, more westerly, extension), where the cumulative excavations had left a tall and wide (longitudinal) section. Sample material for radiocarbon dating was steadily collected over the years. A first attempt to model deposition against time was published in Barton et al. (2013), both in terms of Bayesian modelling and (for the Yellow Series) more basic plotting of radiocarbon dates against sedimentary processes. More determinations have since been made and the 2013 suggestions should be considered as superseded by the analyses in the present volume. The data of relevance are shown in **table 4.1**.

In order to analyse deposition in this part of the cave, the radiocarbon dating must be matched with 'nominal depths', the best estimates available, given that the samples to be included in the analysis as a whole come from different locations (geographically/laterally) in sloping and variable-thickness stratigraphic units (even discontinuous lenses) within Sector 8 and its westward (inward) extension. What has been done (as a continuation of the process begun for the 2013 paper) is that samples have been related to a 'notional' single vertical, attempting, as much as is possible, to maintain relative order (where known) and relative intervals and respecting sedimentary structure and the information provided by sedimentary discontinuities. Each dated sample is therefore associated with a 'nominal depth', expressed as a central value with an 'uncertainty bracket', the latter being an expression of subjective professional judgement by the present author.

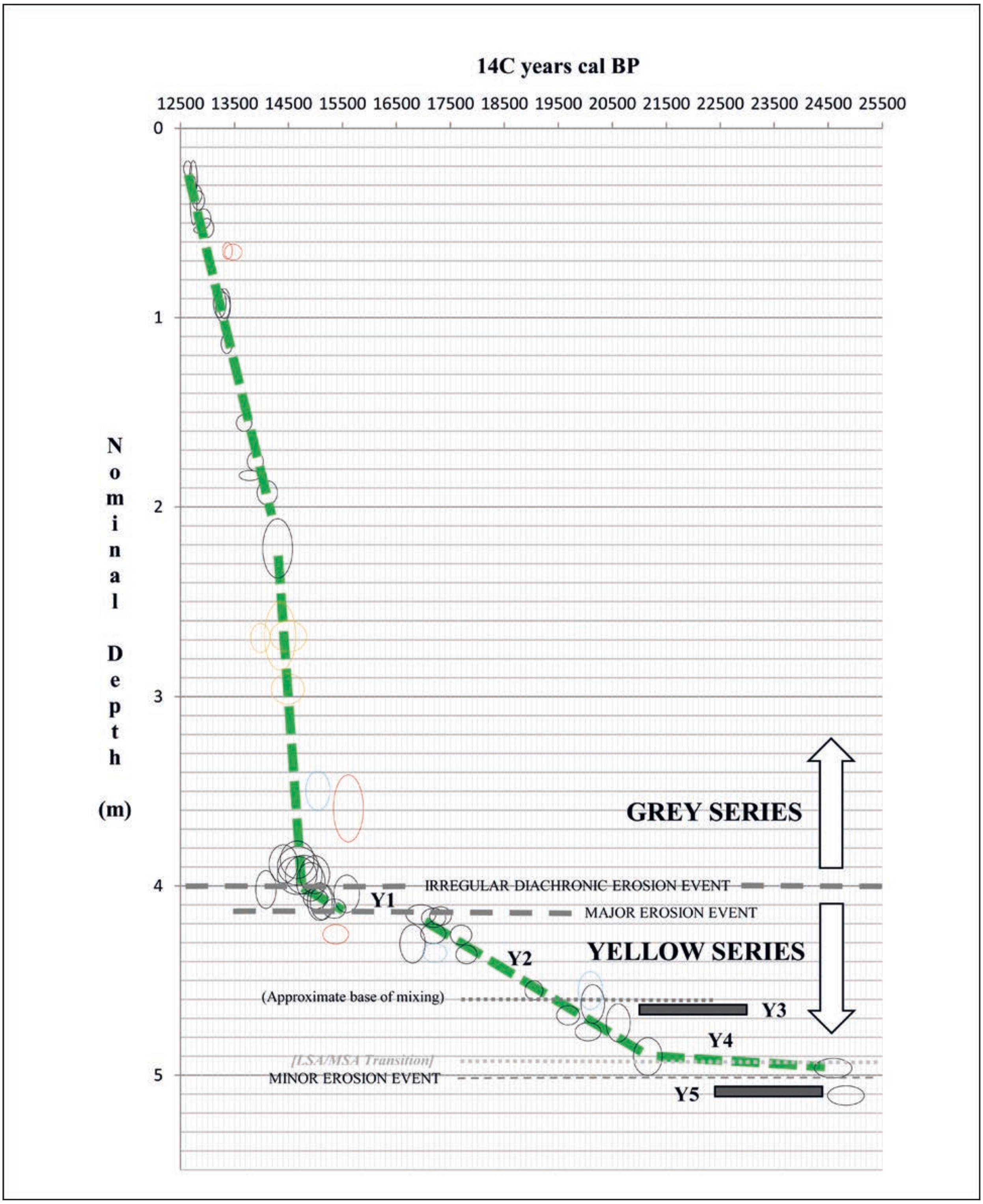


Fig. 2.17 Sector 8 deposition diagram.

A basic 'deposition diagram' (fig. 2.17) has been constructed with 'nominal depths' (and the main discontinuities contributing to the understanding of the lithostratigraphy) on the vertical axis but unmodelled ^{14}C years cal BP on the horizontal axis (incorporating the 2-sigma range). The advantage of this approach is that real sedimentological/lithostratigraphic information can be included and the overall presentation allows the

reader to examine some of the professional judgements underlying the conclusions which can be drawn. The main disadvantage of this diagram is that the manner of portraying individual dated objects (by ovals, in order to avoid the visual confusion that would result from the use of rectangles or crosses) obscures the fact that the radiocarbon determinations (probability densities) are usually significantly asymmetrical. Whilst the estimation of sedimentation rates could be undertaken mathematically (within selected relevant sections of the diagram), the present author feels that the 'best fit by eye' method used here (the dashed green line sections) is adequate for present purposes.
This diagram (**fig. 2.17**) will be used below in this chapter as a basis for the discussion of sedimentation rates. The same dataset will be subjected to Bayesian modelling in **Chapter 4**, where there will also be a combined discussion of the various factors bearing upon the understanding the temporal characteristics of this sequence.

2.6 LITHOGENESIS

The sedimentation modes and sources apparent in the two main divisions of relevance to LSA time at Taforalt, the Yellow Series and the Grey Series, are markedly different, the former being dominated by geogenic and the latter by anthropogenic processes.

Geogenic Sedimentation

The exterior Quaternary deposits in the immediate vicinity have not been studied in any detail. Laouina (1990) has produced the most useful compendium covering the whole region and certain salient points from his work are summarised here. He noted (p. 218) the absence of periglacial or nival forms, even at higher altitudes and further to the south (more continental conditions) in any of the Pleistocene deposits he studied; he also suggested that the common survival of ancient carbonate crusts (a repetitive motif in most of the sedimentary cycles studied, of various ages) indicated a lack of truly wet Quaternary (including Holocene) periods in this area. He reported (pp. 374-375. 407) that the red soils caught in surface micro-karst contained material originating from the local bedrock, dominantly a strongly clayey silt, usually with only a small (< 10 %) fine sand component, becoming increasingly clayey deeper into solution hollows (clays derived from the bedrock); sand content could reach c. 13 % at the very top of red soils (*terra rossa*) but, in any case, the profiles remained poorly sorted. However, he did note dolomite rhomb sand as a weathering product in some pockets. Laouina recorded deposits – especially the matrix of stony deposits in mountainous and foothill slopes (pp. 414-415) or in otherwise clearly fluvial deposits (pp. 416-419) – with coarser silts (low in clay and sand, some coarse-tail, others fine-tail skewed) but he assumed they were colluvial or fluvial, derived from local soils and did not consider an aeolian origin. He did mention (in a recent terrace of the Moulouya) an aeolian bed (p. 440), with mica quartz and very little carbonate, but this was a sand.
Within the cave, the Yellow Series is typically composed of quite laterally persistent units, always with a strong mode in the fine sand grades and a finer 'tail' (mostly silts but with some clays), poorly sorted overall. In more protected areas and, especially, deeper into the cave, nearly all these sediments are finely structured (laminated or wide thin-lenticular bedding) and, even eastwards, show a marked oblique dip to the 'south-east' (thus, outwards and southwards across the cave). Such structure is the result of intermittent wash, at various energies but never strong enough to show clear current structures (for instance, there are no cut-

Fig. 2.18 Small-scale bioturbation in the Yellow Series of Sector 3, S-N section. – Scale 10 cm.

and-fill structures or consistent obstacle marks, let alone channelling, although tiny mud-balls do occur at some levels) (see also **Chapter 3**). The geometry requires that the water source would have been from and through the cave roof; drip structures are common towards the back of the cave at all stratigraphic levels and there are plenty of fine fissures and small karstic tubes (now often clogged with speleothem) in the roof. The consistent bedding dip must have resulted from an unobstructed 'drainage exit' on the south side of the cave mouth (not an area currently available to us). The bulk of the actual sediment must also have been transported from or through the karstic system and it is this aspect which probably explains why the typical YS sediments are somewhat coarser than the normal surface deposits (see Laouina 1990, summarised above); finer materials (mixed clayey silts) are more difficult to erode in the first place than sandier materials (including dolomitic decomposition sands) and any finest fraction can be more easily separated (and deposited elsewhere) during staged transport underground. There are grit particles and larger stones (all of carbonate 'bedrock') floating in this sequence but there are never lenses of clast-support or true 'scree'.

Fig. 2.19 N-S section in Sector 8 (D22), showing the sequence (slightly furred by small-scale bioturbation) Y1 to the top of Y4. – Scale 20 cm.

On the northeast side of the cave, in Sector 9, these units are generally stonier (mostly local ancient speleothem clasts) and have less well developed fine-scale bedding (weak laminations showing only in restricted patches/intervals); these characteristics fit with the facts that this area is physically higher than equivalent levels across the cave to the south (probably due to the fact that this higher insolation zone is more open to variation in temperature/humidity, which will have caused greater rock weathering and a slightly faster natural build-up of coarser sediment) and that there is here a gentle back-slope (inwards), indicating a low talus on this north side of the entrance. One may also note that, in some parts of the cave (especially towards the centre and with increasing intensity outwards), there are significant levels of small scale bioturbation (markedly post-depositional for the most part, possibly dominantly Holocene, but apparently with some penecontemporaneous activity at many levels, in-faunal traces being the most common with a much weaker contribution from plant-rooting), which 'fur' the stratigraphy and necessitate care in sampling of small objects (cf. **figs 2.18** and **2.19**; see also **Chapter 3**).

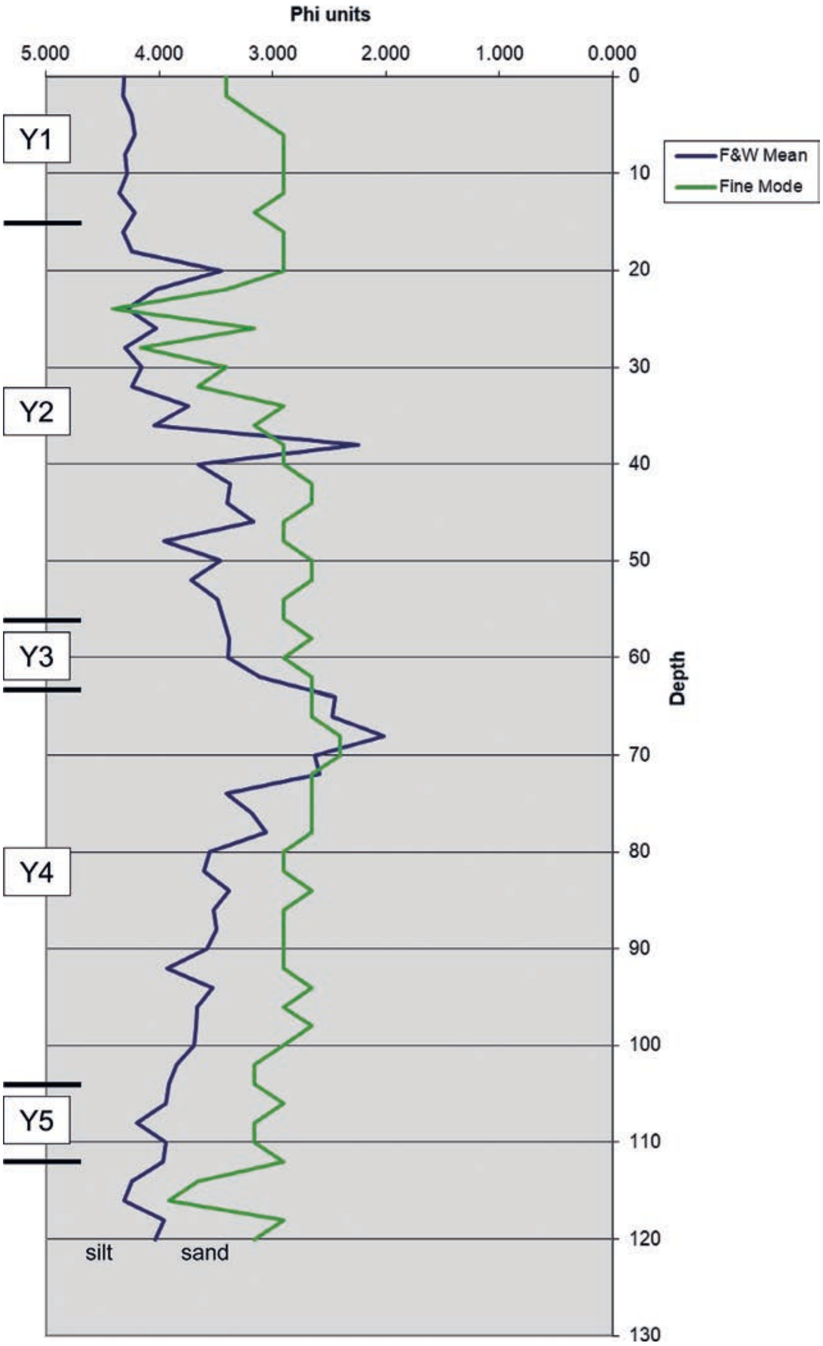


Fig. 2.20 Sector 8 Yellow Series Particle Size (decarbonated): Central Tendencies.

Oh (2011) measured the carbonate content and carried out (decalcified) particle size analyses on samples of the Yellow Series sediments[51]. Her data for Sector 8[52] have been used to produce **figures 2.20-2.24** here. **Figure 2.20** shows the central tendencies in particle size (any material above 4 mm in diameter, i.e. 'stones', having first been removed), down-section (local zero at the top). The first five main units, Y1-Y5, also are shown, noting that the lowest LSA material in this section falls within Y4, at a depth of c. 86 cm.

51 Particle size range (0.388 to 4000 microns, 11.36 to -2 phi): after HCl-treatment, measured with Mastersizer 2000 particle size analyser and Hydro 2000 MU sample dispersion unit. Reported carbonate content is the HCl-soluble portion. Analysis using Gradistat v.6 2008 (developed by Dr. Simon J. Blott, Kenneth Pye Associates Ltd.). The phi-scale is a logarithmic function (the negative value of the logarithm to the base-2 of the particle diameter) used in standard granulometry better to represent the natural tendency towards exponentially increasing numbers of sedimentary particles as diameter decreases.

52 Raw data for column S8A1, Run 3 (courtesy of Y. A. Oh).

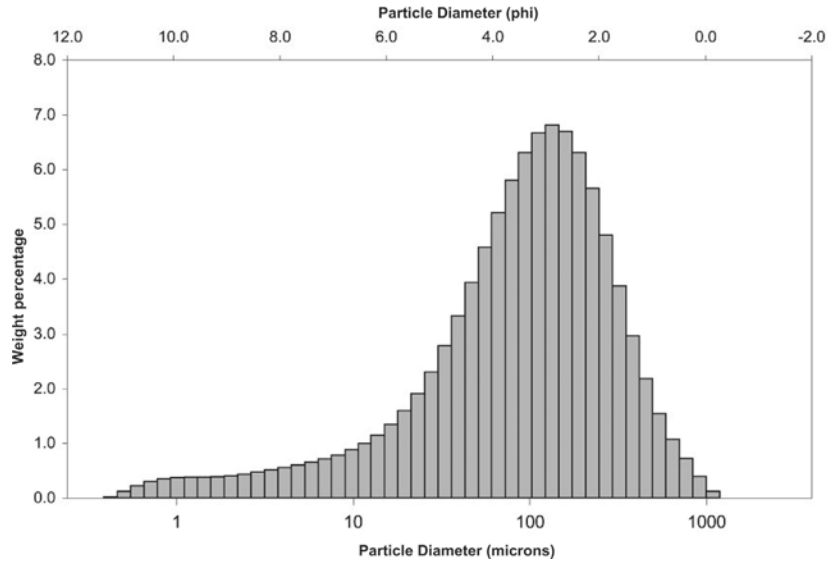


Fig. 2.21 Sector 8 Yellow Series Particle Size (decalcified): logarithmic distribution at Depth 54 (lower Y2).

The fact that the main mode tends to fall at a coarser level than the mean at most depths implies that (for a uni-modal sediment) the distribution is positively (fine) skewed, meaning that there is usually a fine-tail. **Figure 2.21** shows a distribution (remembering that silts fall in the 9-4 phi unit (2-63 micron) interval, with clays/colloids below and sands above) which is typical of this particular Yellow Series sequence, with just such a tail. **Figure 2.22** shows the standard distribution descriptors: sorting (which is poor to very poor), kurtosis (usually peaked, reflecting that persistent fine sand mode) and skewness (normally positive, confirming the fine-tail). In **figure 2.23**, the fine sand, coarse silt and total silt are shown separately, with an interesting result to which we shall return below. **Figure 2.24** shows coarse sand and carbonate. Remembering that the former is non-carbonate sand, it is interesting to note quite a strong degree of correlation in the form of these two traces; this suggests that, in the raw samples, small carbonate fragments were also common in the coarse sand grade.

Approximate sedimentation rates may be estimated (**fig. 2.17**). Setting known discontinuities and unusual situations aside for the moment, the 'normal' background rate would appear to be around 0.17 m/ky, a moderately high figure, given the dominantly fine texture, which would suggest ample sediment supply.

Turning now to those discontinuities and unusual situations in the S8-YS sequence, the first point to note is that Unit Y3 is defined by a strong anthropogenic input (lithics, bones, charcoal, etc.). The overall sedimentation rate in this unit is markedly faster than the 'normal' rate; the figure is difficult to estimate (we have not attempted to show the 'kink' in **fig. 2.17**), since this is only a relatively short pulse, but a figure of 2-3 times background would seem likely. This temporary increase is also seen in Units Y5 and Y7, similarly anthropogenic intervals pre-dating the LSA. Indeed, this is a general motif, found at most levels in the cave: a human presence increases gross sedimentation rates. Even where there is debris from human activity, the YS sediments are still usually affected by wash, with charcoal spreads often size-sorted or finely laminated and unassociated with ash or other traces of *in situ* burning. Actual surviving anthropogenic structures are rare but not wholly absent; for instance, **figure 2.25** shows a small hearth surviving in the lower part of S8-Y2.

Various erosion events (involving angular unconformities) are present in this sequence, the most marked also being shown in **figure 2.17**. The one of particular interest in the LSA context is that at the top of Unit Y2. The erosion surface is a little irregular but it seems likely that significant time has (locally) been lost during this event, probably a thousand years or more. Directly below this surface in Sector 8, the upper part of Unit Y2 shows weak plastic deformation structures, although much stronger deformation, accompanied

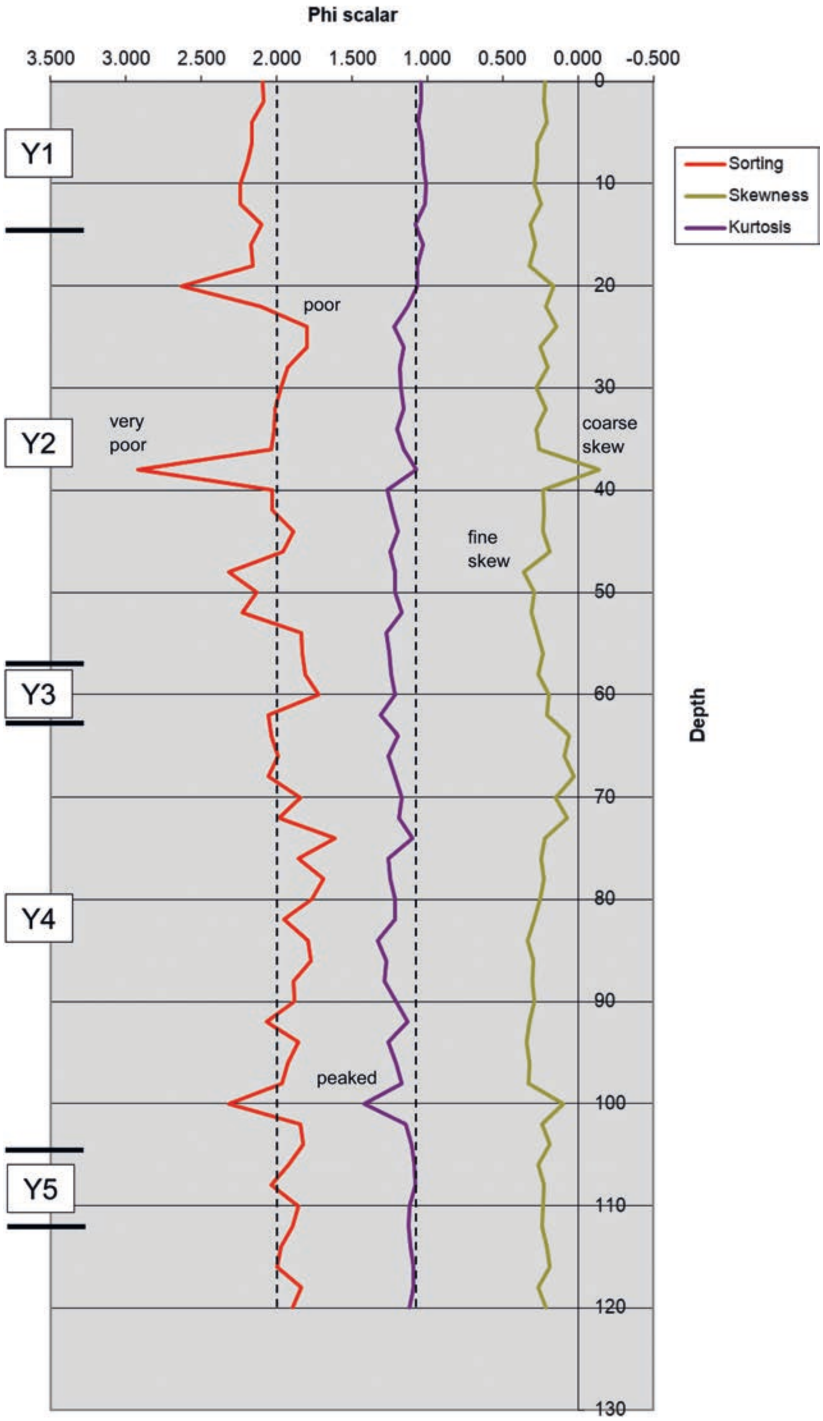
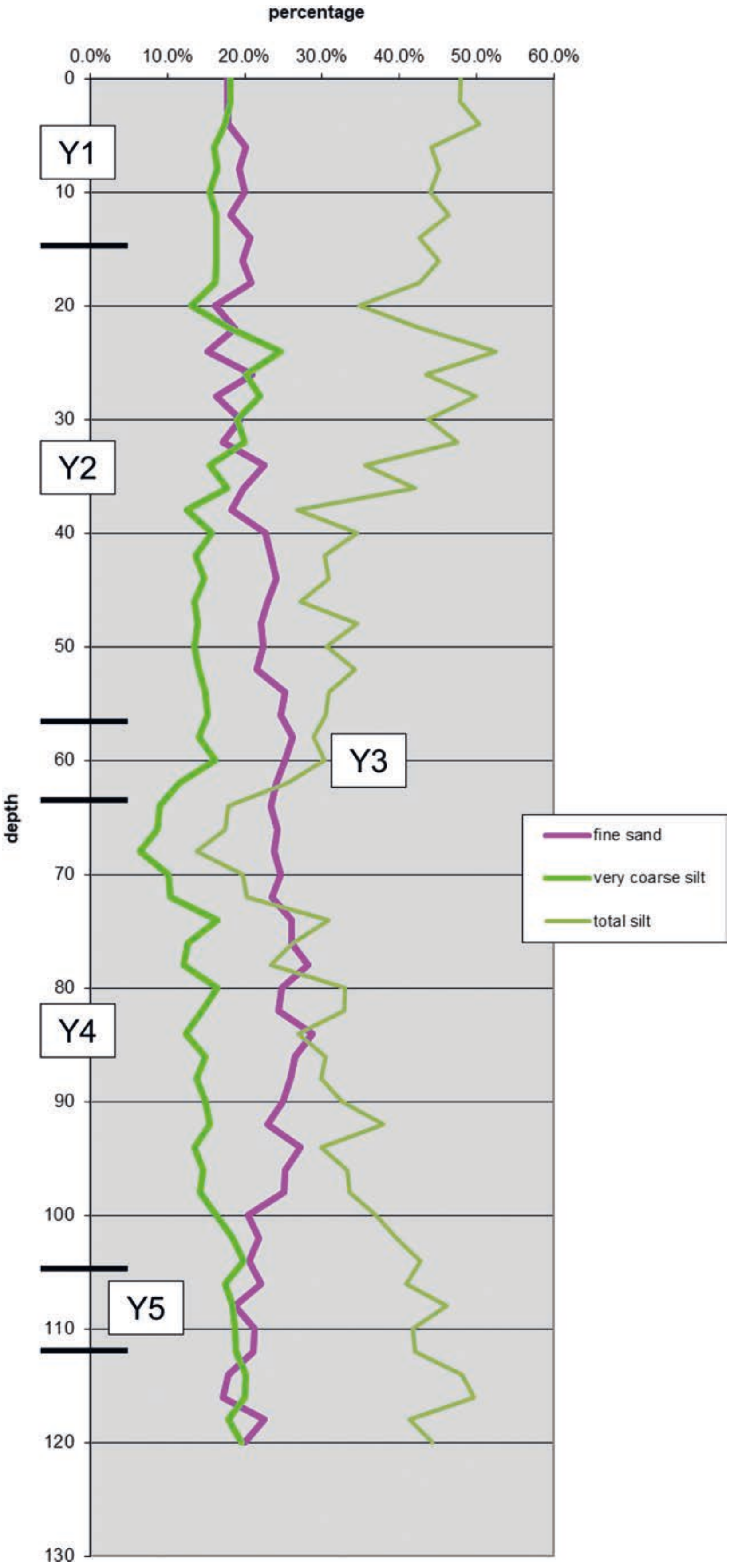


Fig. 2.22 Sector 8 Yellow Series Particle Size (decarbonated): Folk/Ward (1957) Logarithmic Distribution Statistics.

by a probable major drip structure (fig. 2.26), appears to originate from this level at the top of the surviving sequence in Sector 6[53]. The deformation reaches right through the Y2-equivalent in Sector 3, even warping the top of the Unit Y3-correlate (fig. 2.27). Caught up in the deformation in all areas there are bodies of light-coloured carbonate-rich silt and reddish slightly clayey silts, both showing traces of original (now contorted) lamination. It is noteworthy that the clay minerals involved include kaolinite (FTIR [mid-infrared] analysis by Dan Cabanes 2006, reported in Ward 2007). There are also zones, especially lower in the de-

53 Courty (1989, fig. 11.3) had already noted this structure.

Fig. 2.23 Sector 8 Yellow Series Particle Size (decarbonated): Fine Sand (2-3 phi, 250-125 micron) and Very Coarse Silt (4-5 phi, 63-31 micron).



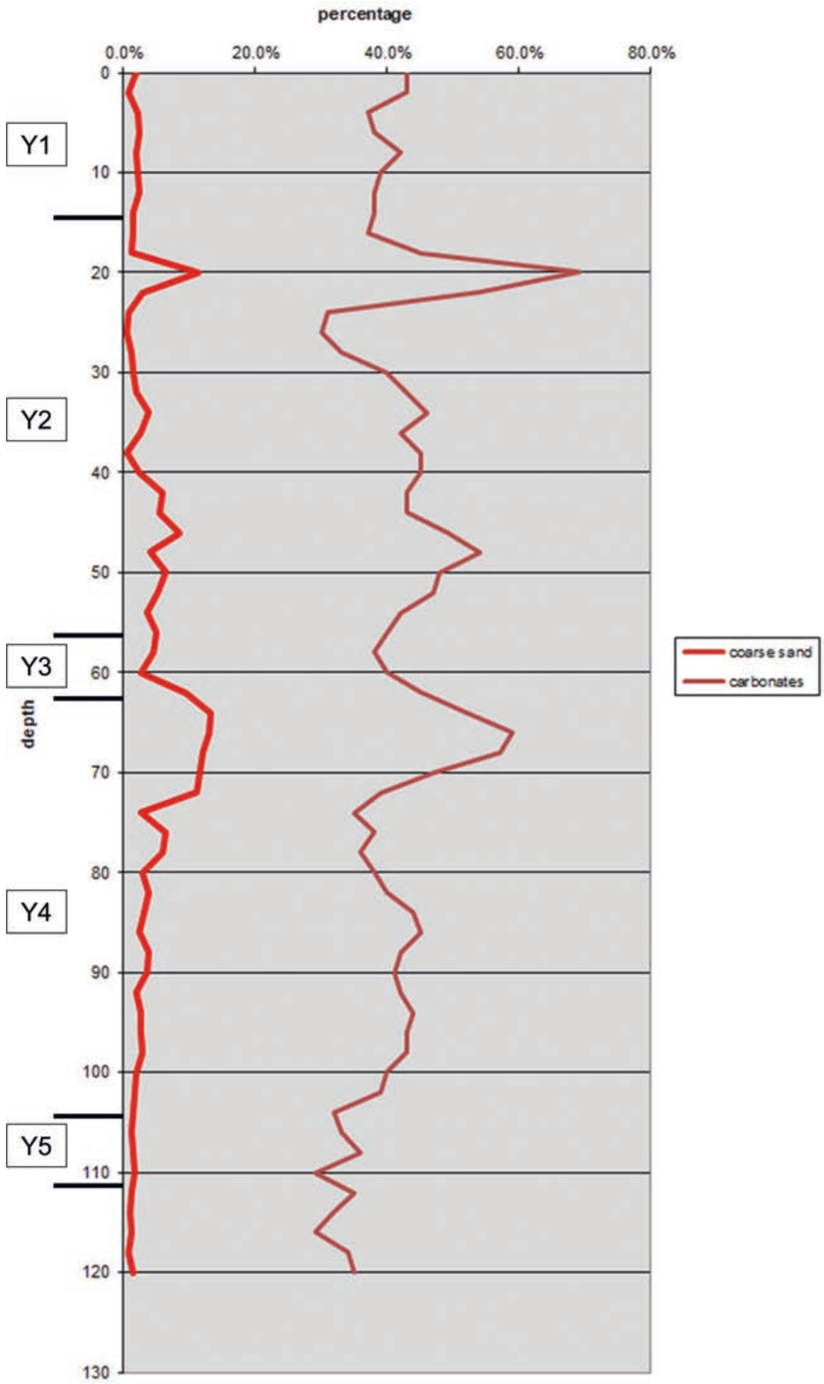


Fig. 2.24 Sector 8 Yellow Series Particle Size: Coarse Sand (decarbonated) (0-1 phi, 1000-500 micron) and carbonates.

formed interval, with segregated coarser material (small stones and even lithic artefacts). Looking through the sedimentological data for this deformed zone in upper Y2 of S8 (**fig. 2.28**), one can see a number of interesting characteristics. The fine mode often drops towards, and even below, the mean, into the silt grades (**fig. 2.20**); silt content overall is very important, with coarse silt contributing approximately a half of the total (**fig. 2.23**). The sorting can become very poor, once even with a negative (coarse-tail) skew (**fig. 2.22**). Towards the top, there is a very strong carbonate content (**fig. 2.24**), higher than could be explained simply by a bedrock grit component, supporting the field observation that carbonate silts are included. Unit Y2 therefore began under relatively 'normal' conditions but very significant silt, both carbonate and non-carbonate, became increasingly common in the wash input, possibly also with pulses of coarser material and

Fig. 2.25 Small hearth (in plan, south-up), lower part of Y2 in Sector 8 (C22). – Scale 20 cm.

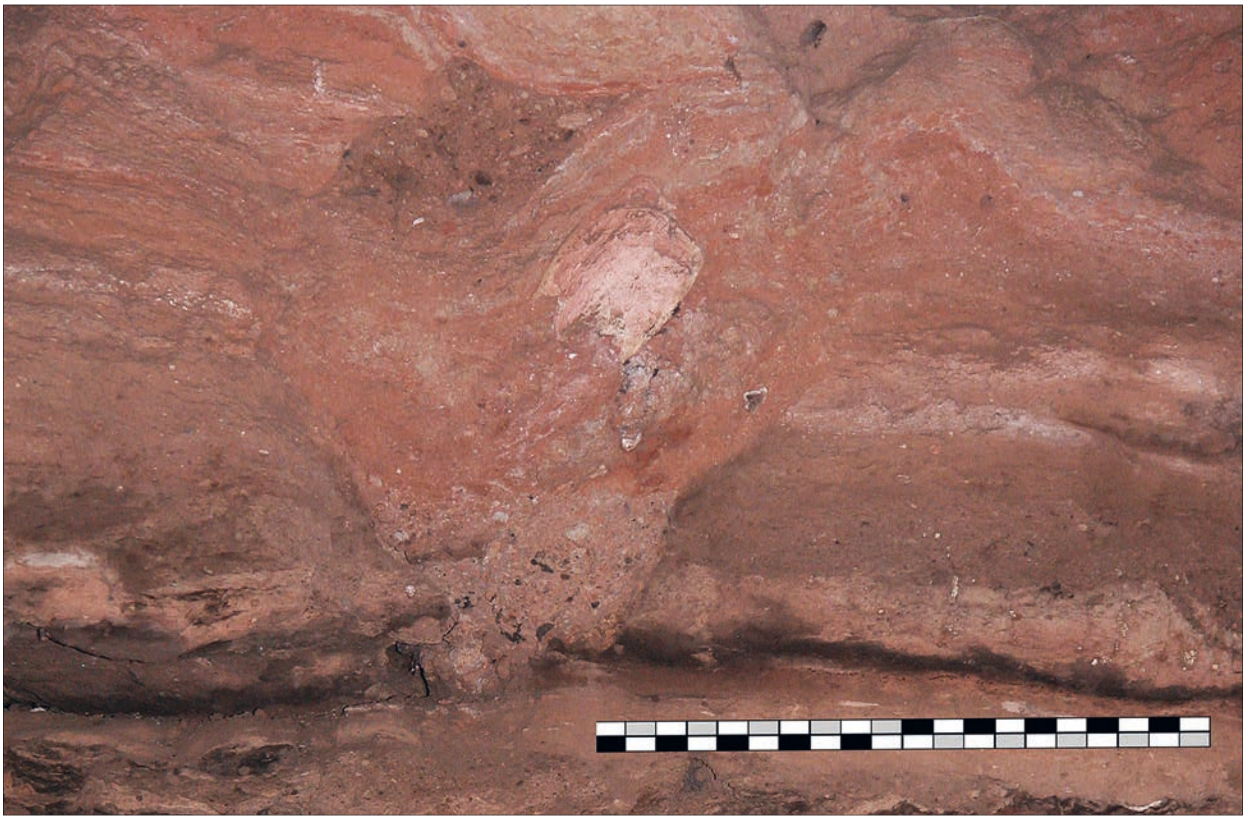


Fig. 2.26 Plastic deformation and drip structure in Sector 6, probably stratigraphically equivalent to the phenomena in the upper part of S8-Y2, N-S section. – Scale 20 cm.

Fig. 2.27 Surviving sequence in Sector 3, with warping affecting the deposits down (to a depth of 20 in the S3 log) to the top of the Y3-correlate, W-E section. – Scale 20 cm.

Fig. 2.28 Upper YS in Sector 8 (C22), top scale in the upper (deformed) part of Y2, N-S section; note also irregular and erosive base of GS. – Scale 20 cm.

Fig. 2.29 Sector 9, Units S9(E)-CTX3 to S9(E)-CTX17, W-E section. – Scale 20 cm.

some clays (including kaolinite) (see also **Chapter 3** concerning the lower part of S8-Y2spit1). The top of the unit (at least) then became sufficiently wet to allow widespread plastic deformation, with some localised erosion and segregation. Finally, conditions became wet enough to allow significant general erosion from the top; no concentrated current features (channels) have been observed to date so that it is assumed that sheet erosion was the main process involved.

Lower in the Yellow Series sequence in Sector 8, Y4 presents some anomalies, becoming most noticeable at and just below the centre of this unit (in S8-Y4spit3). The sedimentation rate slows markedly (**fig. 2.17**), eventually dropping to no more than 0.05 m/ky, possibly as low as 0.02 m/ky. The interval involved here (in S8) is very narrow and rather furred by small-scale bioturbation, such that no obvious traces survive of associated primary sedimentary structure. In the field, one may appreciate (upon the closest examination) a peak in silt but this does not show very strongly in the laboratory results, although total silt was recorded as outweighing coarse sand from this point downwards in the sample sequence (**fig. 2.23**). It again seems likely that some of these silts are carbonates, since carbonate coarse sand cannot be an explanation (**fig. 2.24**). Similarly, kaolinite is again present (FTIR analysis by Dan Cabanes 2006, reported in Ward 2007). The sediment here is dense, massive and shows good matrix-support; compared to units both above and

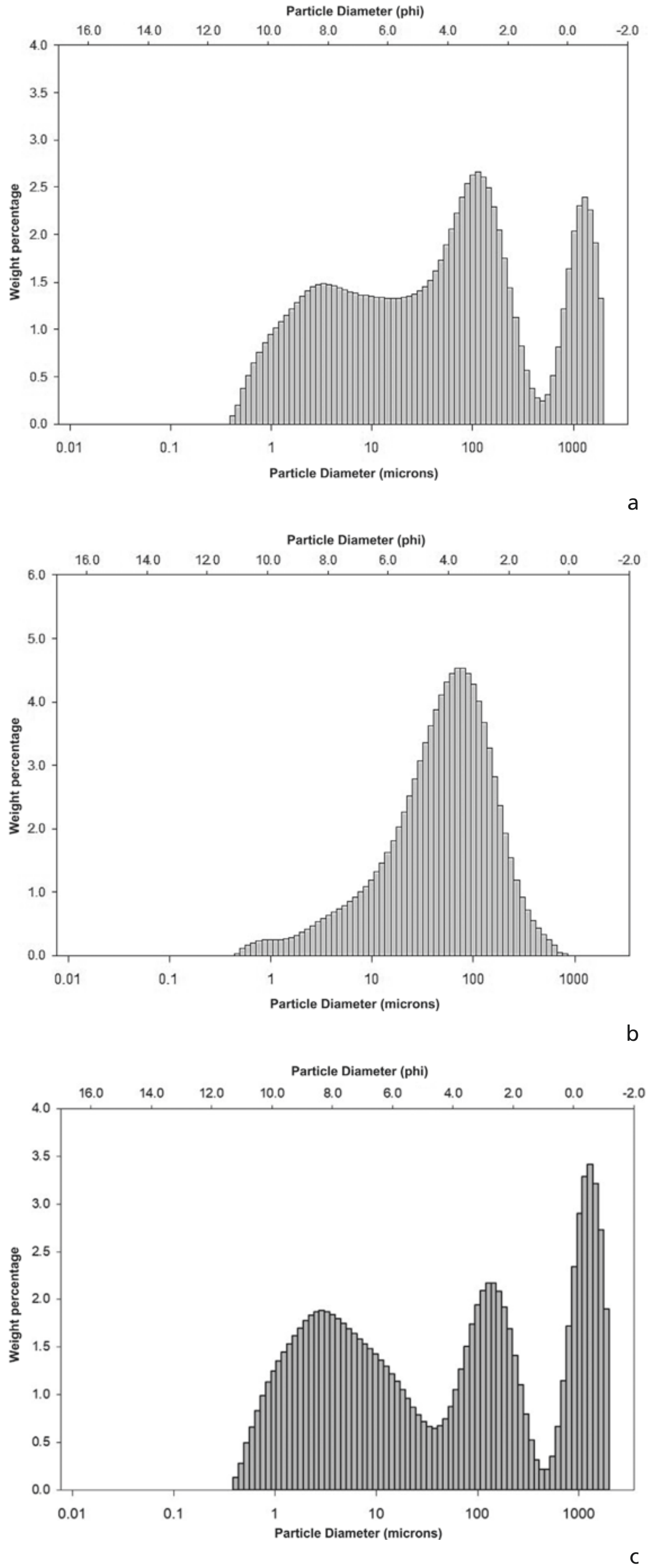
Fig. 2.30 Sector 9, close-up across the dark (anthropogenic) S9(E)-CTX12, sandwiched between silty units, W-E section. – Scale 20 cm.

below, there would seem to be a significant bulk reduction in bioturbation structures, with no definitely syn-depositional forms recognised.

The S8-Y4spit3 interval is obviously minimally represented (extremely condensed) but, moving across the cave to Sector 9 (**fig. 2.10**), several clear and discrete silt-dominated beds (firmly time-correlated to Sector 8 by ^{14}C determinations and other finds assemblages) appear in the interval from S9(E)-CTX11 to S9(E)-CTX16 (see **figs 2.29-2.30**, where the dark, strongly archaeological layer[54] S9(E)-CTX12 is sandwiched between two light-coloured, very silty units). Despite some small- to medium-scale bioturbation (usually significantly post-depositional), the silt (or siltier) units are usually well bedded, sometimes showing true laminations (within silt-dominated sediment) or very fine lenticular inter-bedding with sharp bedrock grit lenses.

54 This archaeological material, indeed, all the lithics within the CTX 11-16 interval in S9, belong to a non-Levallois flake industry with large core-tools ('adzes'); pending full analysis, this material is referred to as "intermediate" given its consistent stratigraphic position lying between classic LSA and MSA assemblages (cf. Barton et al. 2016).

Fig. 2.31 Sector 9(E) Yellow Series Particle Size: distribution in CTX 11. – **a** whole sediment; **b** non-carbonate; **c** carbonate.



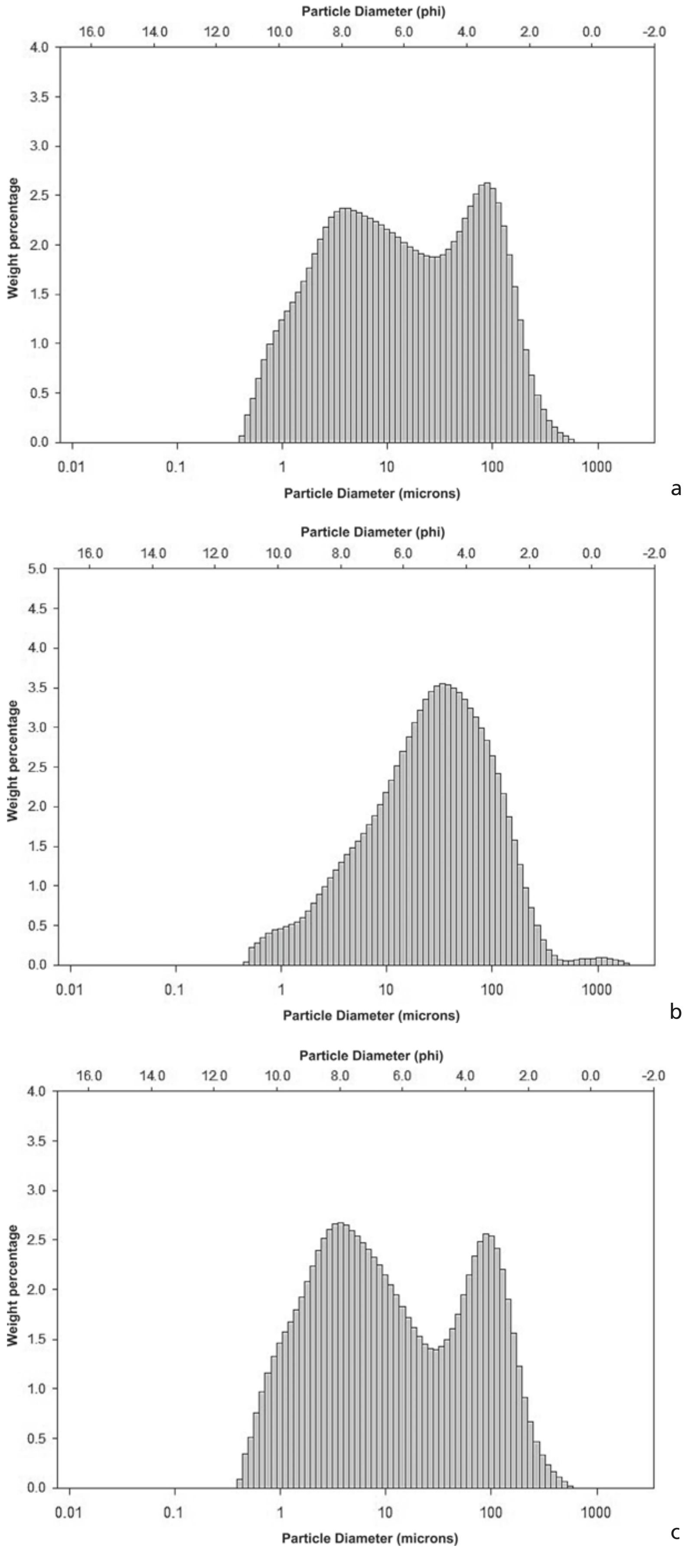


Fig. 2.32 Sector 9(E) Yellow Series Particle Size: distribution in CTX 13. – **a** whole sediment; **b** non-carbonate; **c** carbonate.

Analyses of the particle size distribution in S9(E)-CTX11 and S9(E)-CTX13, the two cleanest silty units, are shown in **figure 2.31** and **figure 2.32** respectively [55]; in each case, distribution (a) whole sediment and (b) decalcified sediment was directly measured, with distribution (c) carbonates calculated from the previous results and bulk carbonate content. The results of these analyses show interesting peaks, characterised in the figure captions by their modal values. It is reiterated that these units here show a gentle dip westwards, into the cave. Insufficient work has so far been done to allow exact modelling but enough radiocarbon dates are available to suggest an estimated sedimentation rate of around 0.10 m/ky for the silty units (abstracting the strongly archaeological interstratified units which probably show faster sedimentation), that is, more than twice as fast as the rate for the equivalent stratigraphic interval in S8, although still markedly slower than that for the laminated fine sand which forms the most common facies in the Yellow Series, here in S9 as elsewhere.

A preliminary and merely qualitative microscopic examination has also been made on samples of S9(E)-CTX11 and S9(E)-CTX13 [56]. As expected, under the binocular microscope, there are traces of a human presence (micro-debitage, charcoal dust, ash, tiny bone fragments, burnt grains) within a matrix dominantly structured by diagenetic, possibly often markedly post-depositional, effects (fine bioturbation cavities, secondary carbonate and/or gypsum deposition and cracking and pseudo-lamination during shrinkage-swelling cycles due to moisture fluctuation). The finer matrix of both samples was then examined by SEM-EDA (scanning electron microscopy – energy dispersive analysis) to collect morphological data and elemental chemistry. Fine inclusions are predominantly quartz with much smaller amounts of potassium feldspar and rare calcium amphibole. Secondary natural inclusions are mainly calcite, either as fibrous forms (with rhombohedral cleaves on terminations) or as soft white microspheres. High phosphate levels in conjunction with elevated magnesium values are consistent with a significant ash component. Probably the most noteworthy observation is that both samples appear to be dominated by clay mineral of the smectite group, with a smaller component of illite; these clays are often part of silt-grade aggregates, some of which may even pre-date deposition in the cave (see below).

One may note in passing that, unfortunately, the surviving Sector 9 sequence does not continue up to the time interval equivalent to S8-Y2. There are slightly silty intervals at the S8-Y4spit3-equivalent level in Sector 3 but nothing as marked as in Sector 8 and certainly no discrete units as (earlier) in Sector 9.

Anthropogenic Sedimentation and Effects

General Characteristics

Whilst there are some lenses of material with strong signs of anthropogenic effects (especially burning, together with lithic and bone debris) within the Yellow Series, the main occurrence of such effects at Taforalt is in the Grey Series, typically represented within Sector 8. The GS composition comprises burnt stone (from blocks to powder), ash, charcoal and other charred remains, lithic artefacts and debris, land mollusca, and bone debris, in such huge quantities as to mask geogenic input almost completely (cf. **figs 2.33-2.34**). For

55 Analyses kindly conducted by Dr. Joshua Allin, Department of Geography and Environment, University of Oxford. Initial sodium hexametaphosphate and ultrasonic treatment for disaggregation. Particle size range (0.345 to 2000 microns, 11.5 to -1 phi): whole sediment, then after HCl-treatment, measured with Mastersizer 2000 particle size analyser and Hydro 2000 MU sample dispersion unit. Reported carbonate content is the HCl-soluble portion. Analysis using Gradistat v.8 2010 (developed by Dr Simon J. Blott, Kenneth Pye Associates Ltd.).

56 Observations and commentary kindly provided by Dr. Chris Doherty, RLAHA, Institute of Archaeology, University of Oxford.

Fig. 2.33 Sector 8, Unit L5, varied and unsorted composition (stone, ash, charcoal, mollusca, animal bone, lithic artefacts, etc.), E-W section. – Scale 10 cm.

Fig. 2.34 Sector 8, Unit G95-2, varied and unsorted composition (stone, ash, charcoal, mollusca, animal bone, lithic artefacts, etc.), E-W section. – Scale 20 cm.

instance, in Sector 8, Ward (2007) estimated more than a ten-fold increase in charcoal in the GS, compared with the richest units in the YS. A 'natural' component is probably still present (presumed similar to that characteristic of the Yellow Series below) but it is never recognisable as differentiated units, just occasional patches of slightly 'browner'/'earthier' colour against the normal 'greys' (see below). There are no obvious drip pools or floor speleothem. Sedimentation rates in the S8 Grey Series are estimated at 4.00 m/ky in the lower (more obviously stonier) part and 1.11 m/ky in upper part, S8-L20 (and equivalents) and above; this gives an overall average of 1.82 m/ky (thus, a thickness of about 4 m persistently accumulated over some 2,200 years), a bulk rate over ten times faster than the 'background' geogenic (wash) deposits of the Yellow Series.

This having been said, it must be stressed that it is the content of carbonate stone (and burnt derivatives) which is actually dominant by volume throughout the GS[57]. There are no slopes or conduits along which quantities of stones could be fed into the cave by 'natural' processes; in any case, the manifestly non-natural structure of these deposits would not allow such an interpretation (cf. **figs 2.35-2.37**). Whilst some stone will have fallen after weakening of roof/walls by repeated fires, there is simply too much stone, by several orders of magnitude, to be explained by mere 'secondary' processes. No convincing evidence that stones were used by people to construct major features/boundaries have yet been observed, and the principal cause, in the main chamber of the cave (but see below concerning the special case of Sector 10), is therefore interpreted to be various processes associated with the deliberate transfer of heat via stones, pyrolithic processes, a topic that will be examined in detail in the following section.

57 See **Chapter 8** for relative counts of other categories of fine debris; **Chapter 3** for micromorphological features; charred floral remains (**Chapters 5 & 6**); burnt bone, only c. 8 % of larger (anatomically and/or taxonomically determinable) bones burnt (cf. **Chapter 9**) but some 65 % of smaller fragments (cf. **Chapter 8**); perhaps 60 % of mollusc shells show some contact with heat (cf. **Chapter 8**); significant traces of burning on lithic artefacts, reaching over 80 % in the upper part of the GS (Layers 27-2, G96-88) (cf. **Chapter 12**).

Fig. 2.35 Sector 8, sqA23, MMC1 to MMC23, S-N section. – Scale 20 cm.

Fig. 2.36 Sector 8, sqA24, mid-GS, Units G94 to G96-1, E-W section. – Scale 20 cm.

The structure of the Grey Series is essentially localised, with most strata being of lenticular or otherwise discontinuous form, often on lateral scales of only a few tens of centimetres. The immediate implication for the present is that it has not been possible to follow many stratigraphic units or boundaries very far, especially given the restricted, columnar (almost two-dimensional) exposures that the present research design has necessitated in Sector 8.

There are no obvious signs of widespread 'natural' surface reworking (e. g. by wash), although there are small-scale microlaminated zones, often at relatively high angles (**figs 2.38-2.40**). The sediments of the GS are likely to have been able to absorb even quite large amounts of drip water, with only the occasional surface 'puddle'; even today, one may observe high permeability and very rapid hydraulic transmission. There are only rare signs of bioturbation (other than anthropogenic); certainly only a very few burrows have been identified macroscopically, probably because these sediments have always constituted a hostile environment: sharp, dusty, caustic, collapse-prone and subject to common human physical and chemical activity. Nevertheless, there is a risk of long-term displacement of the smallest objects, downwards through common clast-supported zones (potentially originally 'airhole scree' in places, cf. **fig. 2.41**), assisted by continual infiltration of water; note that the present abundance of fines even within some of the most completely clast-supported zones implies a significant degree of secondary filling. Many of the more soluble components seem to be accumulating as a very weakly concreted zone at or near the GS/YS boundary; this might suggest down-sequence mobility of radio-isotopes (such as potassium) with resultant difficulties in estimating environmental dose rate for luminescence dating.

Fig. 2.37 Sector 8, 2003 sampling, Units G88 to G96-3, E-W section; note recent military mortar floor at summit and modern retaining dry-stone wall at bottom-left. – Scale 1 m.

Apart from the very common sediment interfaces themselves, there are few more complex anthropogenic structures in the available exposures. *In situ* hearths are not common and all quite small (see **figs 2.42** and **2.43**), with only very rare survival of reddened basal sediment lenses and the identification as hearths being based more commonly on superposition of ash over a charcoal lens (cf. Goldberg/Miller/Mentzer 2017) and observably stronger traces of burning on the 'inward faces' of peripheral stones; in the areas investigated in detail during the current campaign, burning events appear to have been very frequent but of relatively small-scale. Even in the wide longitudinal exposure on the south side of the cave (including Sectors 8 and 11), there are no obvious 'preferred locations', with more concentrated structure or special composition (e.g. no obvious 'bonfires' or organised hearth pits, and no strongly preferential disposal *loci*). This is not to say, of course, that zones more central to the main cave chamber or tending towards the exterior might not once have contained such evidence; indeed, Roche does appear to have recognised some more strongly structured areas during his work (see above).

Carbonate Stone and Pyrolithic Processes

It has been noted how Ruhlmann suggested that the stone content in the Grey Series served a primarily structural purpose, as a solid foundation for occupation, whilst Roche, noting the highly burnt nature of most of the stone, deduced a response to a need for heating in a 'cool' environment. Roche also noticed

Fig. 2.38 Sector 8, Unit L6, consistent wash structure, E-W section. – Scale 20 cm.

that the stones tended to have a preferred size (that of an 'orange') and that many of them were composed of a dense ('lithographic') limestone (which will simply be called 'limestone' here) that was not the bedrock of the cave, although there are also stones of the true stratal bedrock type as well, somewhere along the continuum between dolomitic limestone to dolomite (a type which will simply be called 'dolostone' here), as well as of the dominant carbonate actually outcropping in the immediate cave walls, roof and exterior cliff (which will be called 'speleothem' here). The original volume of 'imported' stone cannot now be calculated with any accuracy. However, judging from analyses of samples from the surviving Grey Series deposits (see below), the limestone component (that is, the wholly 'exotic' material) of stone content is seen in the range c. 2-95 %, on average above c. 40 %. If as an extremely conservative estimate, one assumes only about half of the Grey Series sediment is actual stone (and derivatives), one could suggest that perhaps 20 % is composed of 'imported' limestone. If this were repeated all around the cave (and such limestone is indeed present all along the surviving south section in the Grey Series, from Sector 8 to Sector 11), there would have resulted a need to import c. 350 m³ or 910 tonnes of limestone (over some 2,200 years, thus just over 400 kilos a year at a steady 'average' rate). Turning now to the dolostone, one notes it has very poor accessibility in the immediate area of the cave. The current analyses show that the dolostone content lies in the range c. 1-52 % on average over 30 %. With the same assumptions as before, but adding the extremely conservative proposition that only half of the dolostone had to be gathered from outside the cave, there

Fig. 2.39 Sector 8, Unit L12, wash lenses with small local disturbance features, E-W section. – Scale 5 cm.

would have resulted a need to for additional import of c. 130 m^3 or 340 tonnes of dolostone (over some 2,200 years, thus just over 150 kilos a year at a steady 'average' rate). The LSA occupants would hardly have gone to such pains without very good reasons[58].

We cannot actually calculate the full effort involved, because the real sources of the imported stone are not known, although it is reasonable to assume that, at the most arduous, access in the form of 'ready-made' clasts was sought (e. g. in scree slopes) rather than any form of 'mining'. The purest 'lithographic' limestone in the area, the Domerian, only outcrops over five kilometres down-valley; whilst detailed petrographic study would be necessary to confirm the point, it seems most unlikely that this was the normal source of fined-grained limestone. Dolostone scree from the local bedrock was probably available within about 100 m of the cave entrance. However, it is noteworthy that many stones in the Grey Series that have not been so modified by fire as to render their source unidentifiable show rounded forms, consistent with high-energy

58 In **Chapter 12**, it is reported that the use of limestone for lithic artefact manufacture increased steadily to over five-fold (by number proportion within the full range of raw materials) in the upper Grey Series (compared to the Yellow Series). There was therefore a wide interest in this rock type (and one may note that there might have been a significant improvement in flaking characteristics had controlled heat-treatment been applied) but the large total volumes involved must surely reflect the predominance of pyrolithic objectives.

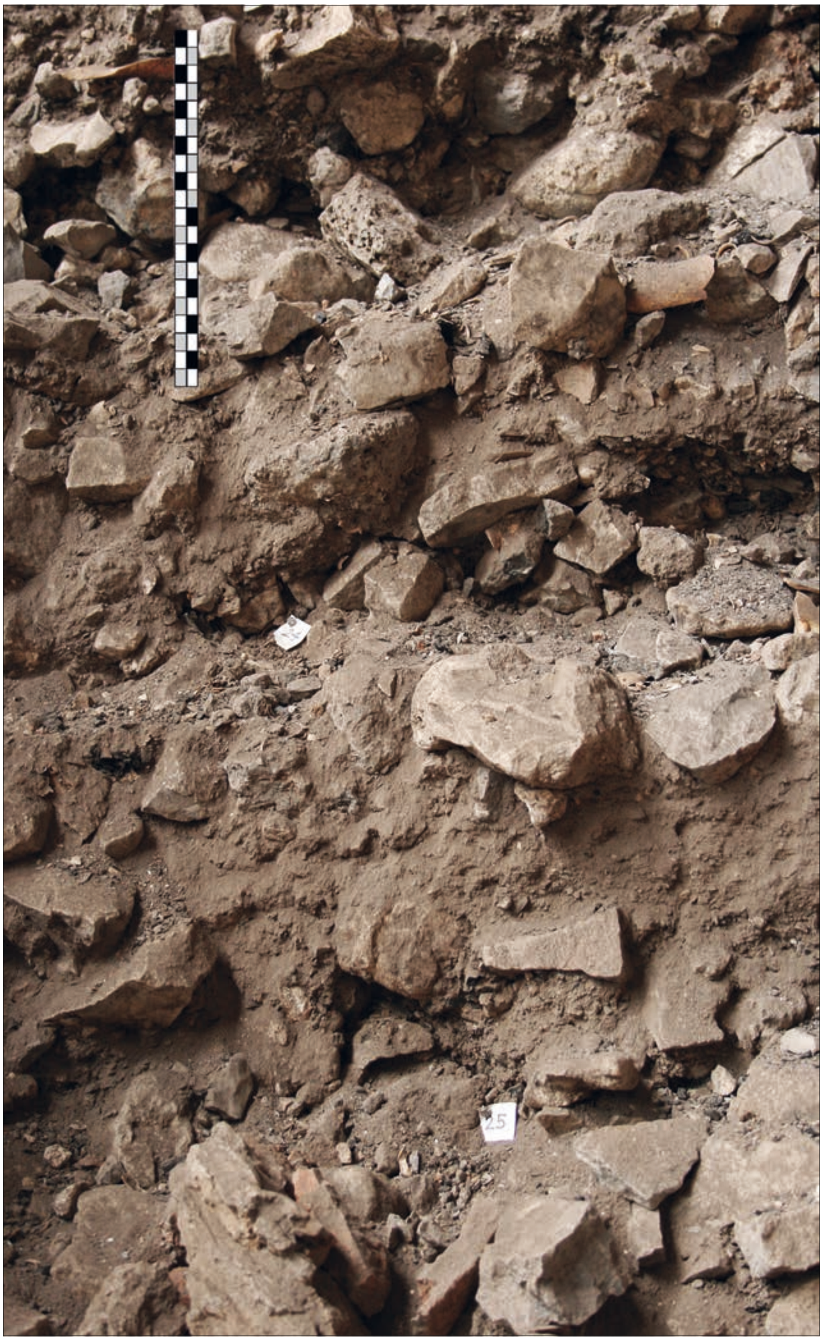
Fig. 2.40 Sector 8, Units L20 to L21, localised wash, E-W section. – Scale 10 cm.

water transport. They might have been gathered from the wadi bottom but this would have involved a considerable climb back up to the cave. However, today (and presumably in the past), on the slopes of the side valley, southeast of the cave and running back southwestwards (towards the modern village of Tafoughalt), there are relatively common outcrops of ancient karstic tubes carrying water-worn fine-grained limestone and dolostone clasts (the nearest identified so far being about 73 m 'around the corner' from the cave entrance), tubes which are similar to the aperture noted above (cf. **fig. 2.1**), intersecting with the back of the current cave. Exposed in the open, the fill of these tubes tends to lose some of its carbonate cement, such that limestone and dolostone of sufficient size can be collected, if rather slowly, without heavy tools (**figs 2.2-2.3**). It therefore seems likely that at least some of the burden of harvesting appropriate stone from primary outcrops or wadi bottom could have been reduced through more local 'scavenging'. Since there are no occurrences of Domerian limestone in a geometric position to be traversed by the observed karstic tubes, the observation of fine-grained limestone in the fills of the latter implies that such limestone occurs somewhere amongst the immediately 'up-stream' lithologies, perhaps in the Mechra Klila Formation. Cattanéo/Gélard (1989) indeed noted sometimes micritised lagoonal calcareous mudstones in this sequence, a lithology which should behave very similarly to 'lithographic' calc-limestone (e.g. where reasonably isotropic, it could show a pseudo-conchoidal fracture) and which could well be difficult to differentiate from the Domerian in hand specimens without petrographic study.

Since limestone, dolostone and speleothem clasts in the Grey Series all show relatively high levels of burning, one suspects that there must be some difference between them which prompted selection, perhaps durability and response to specific heat-transfer requirement.

The thermal properties of carbonate rocks are complex and depend very much upon the chemical and structural characteristics of the actual types. Nevertheless, there are certain trends observed in most cases, from which one may generalise with caution (cf. Robertson 1988; Eppelbaum/Kutasov/Pilchin 2014; Chaalal/Islam/Zekri 2017). The interest here is in two quite markedly different purer carbonates: a 'lithographic' limestone (that is, a limestone dominated by $CaCO_3$, with a fine, low-porosity structure) and a dolostone (in this case, at least a dolomitic limestone, composed of $CaMg(CO_3)_2$; the relevant broad characteristics are set out in **table 2.5**. The properties of speleothem, especially the composite types usually present at Taforalt, cannot be readily predicted, so that reliance upon direct experimental results (reported

Fig. 2.41 Sector 8, subunits in L24 to L26, E-W section. – Scale 20 cm.



below) will need to suffice. In passing, one may note that carbonate rocks tend to have much lower thermal expansion than siliceous rocks, the latter tending to be more susceptible to 'explosive' rupture during heating and/or (rapid) cooling.

Heating a carbonate rock may bring about changes under five broad headings: (a) sintering; (b) calcination; (c) thermal shock effects; (d) differential heating/cooling effects; (e) ancillary mineral changes.

Sintering is the fusing of materials (without actual liquefaction), especially in the presence of water vapour or CO_2, usually occurring only at high temperatures (optimally over 1000°C) and with significant heating duration. Thus, in the present context, sintering would only be plausible in a very restricted (grain- or microfissure-scale) context.

Fig. 2.42 Small hearth in Sector 8, sqA24, Unit L2, looking SE (2009). – Scale 20 cm.

Fig. 2.43 Small hearth in Sector 8, sqA24, Unit L6, looking SW. – Scale 20 cm.

During calcination, a pure limestone loses about 44 % of its weight, whilst a pure dolomite loses 48 %, in each case by out-gassing of CO_2, to leave pure oxides or 'quicklimes'. Calcination (an endothermic reaction, thus favoured by higher temperatures) is technically measurable from about 500°C but decomposition pressures for limestone do not rise above an atmosphere until 900°C; pure limestones do not shrink greatly during calcination (thus, their porosity increases and their bulk density decreases, perhaps by a half at full calcination). However, magnesite (pure magnesium carbonate) calcination will occur in the range 400 to 550°C, implying that many dolomitic rocks will calcine at significantly lower temperatures than calc-limestones; indeed, most reports of experimental results suggest that advanced calcination of dolostone will occur by 770-800°C, even lower temperatures in the presence of other metallic catalysts (such as iron

	Limestone	Dolostone	Comment
Specific Heat Capacity	Usually requires less heating to reach a given temperature (often c. 5.0-7.5 % lower SHC than in dolostones).	Usually requires more heating (higher SHC).	
Thermal Conductivity	Less rapid energy transfer (TC usually between two-thirds and half that of dolostones).	More rapid energy transfer (high TC; a dolostone may have the same TC at 600°C as a limestone of similar porosity at 300°C, remembering that TC in carbonates is strongly inversely proportional to temperature).	A higher quartz content in any carbonate will raise the TC; increased porosity will lower the TC.
Bulk Density	Lighter (c. 4-8 % lower BD than dolostones).	Heavier (higher BD).	
Thermal Diffusivity	Lower TD (i.e. rate of heat transfer within the material).	TD (similar to that of quartzite) usually well over twice that of limestones.	TD = TC/(BD.SHC)
Thermal Inertia	Lower TI (broadly equivalent to lower resistance to cooling).	TI usually about two-thirds higher than in limestones.	TI = $\sqrt{}$(TC.BD.SHC)
Volumetric Thermal Expansion	Calcite crystals show lower VTE (depending upon crystal axis orientation, 5.0-1.2 times lower than that of dolomite crystals).	Higher VTE (in crystals, which expand in all axes, and in dolostones overall, where the parameter may be 10-12 % higher than in limestones).	

Tab. 2.5 Thermal properties of limestones and dolostones.

oxides). In the current context, temperatures as high as 900°C will not often be reached (unforced open hearths usually being capable of reaching only 500-600°C, although sustained 'bonfires' can reach at least 850°C) and it is unlikely that large volumes of limestone will have become wholly 'calcined'; calcination should be preferentially located at outer surfaces and internal grain interfaces (along penetrating porosity or microfissures) and be markedly more likely in dolostone. Even partial calcination will result in notable loss in strength and grain-coherence, usually with the production of some quantity of 'fines' (often at sand- or powder-grades). Some crystal-structural features (such as distribution of purer sparites) will tend to increase disaggregation potential. Adding water to strongly heated dolostone can cause marked hydration expansion (and thus disaggregation pressure) at any point where there had been free 'lime'; the same is true of limestone but the process will be less significant in originally less porous rock. Note that the slaking of 'quicklimes' to a hydroxide is an exothermic reaction, which, if occurring in macroscopic volumes, can cause direct as well as steam-mediated damage to neighbouring materials such as bone[59]; the subsequent 'setting' of slaked lime will produce cementation (inadvertent 'lime mortar'), an effect that may often occur locally within vegetable ashes (even without input from mineral carbonates, biogenic calcium oxalate monohydrate will give calcium carbonate pseudomorphs or 'quick' calcium oxide, depending up temperature range, with potassium carbonate also usually present[60]).

Whilst calcination can indeed cause the bulk fragmentation of carbonate rocks, it is the effect of thermal shock which is perhaps more likely to have such an effect. Very low level shocks can occur within the natural diurnal range (eventually causing 'weathering' through cumulative strain). However, the concern here is with the extremely rapid cooling caused when heated rocks and water (or similar fluids) come into contact ('quenching'). Thermal shock will begin at low temperatures (measurable damage would normally be

59 No obvious quicklime damage has yet been noted on bone from the Grey Series at Taforalt (E. Turner, pers. comm.).

60 In 2006, Dan Cabanes (in the context of phytolith preservation) carried out FTIR (mid-infrared) work on sample TAF03-221 of Unit S8-G95-1, finding a calcite peak which Ward (2007) has interpreted as due to ashes.

shown in a rock at c. 150°C having being immersed in c. 25°C water) and, in limestones, is known to begin to collapse natural porosity. Once there are already some fractures in the limestone, shock at 200°C tends to increase the apparent porosity (i. e. to spread microfractures); increasing the temperature increases the resulting permeability (fracturing) and will eventually lead to gross fragmentation. The interplay between surface crazing, partial penetration and 'through & through' rupture will probably depend upon quite a large set of parameters at play in any real situation. With repetition of heating (or heating/cooling) cycles, even at low temperatures (c. 150°C), cumulative thermal shock tends to reduce the fracture pressure subsequently required (i. e. the strength of the rock) by a factor of about 4 (with higher permeability rocks being weaker even before but especially after shocking).

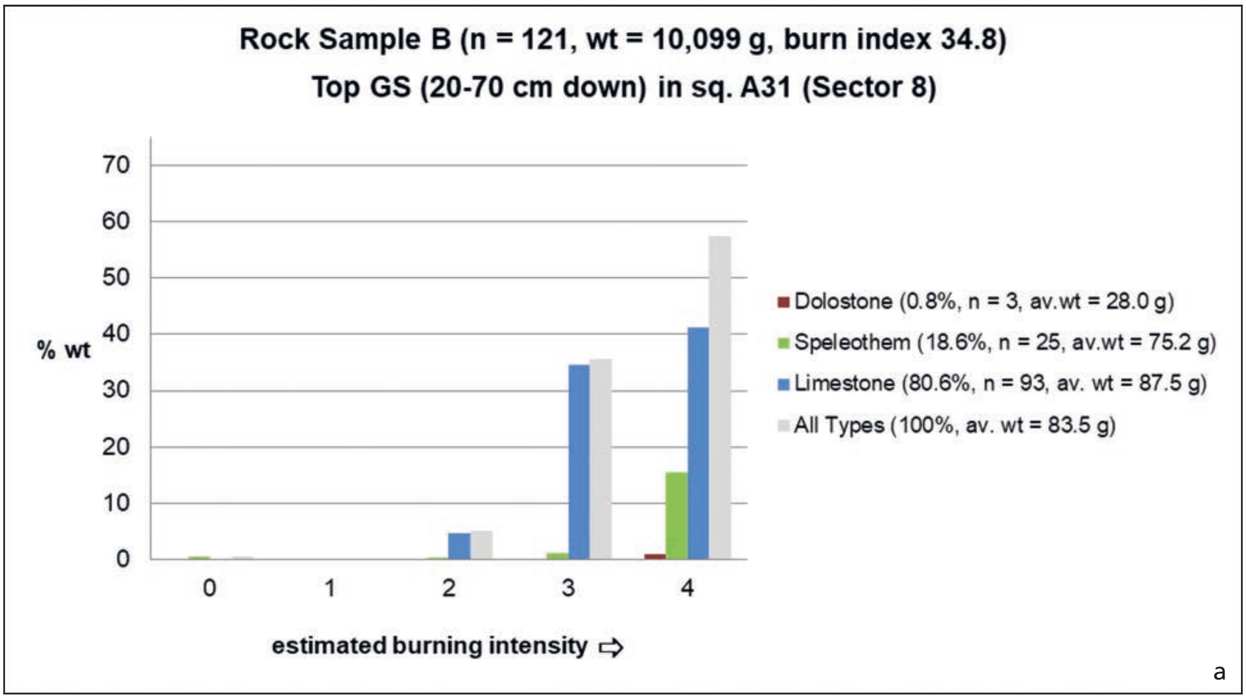
If heating does not reaches temperatures capable of inducing calcination and no rapid temperature changes are forced (i. e. no thermal shock), both limestones and dolostones may show apparent increased porosity due to anisotropic thermal deformation of calcite, magnesite and dolomite crystals. Even gentle heating and cooling cycles (say to 200°C) will eventually cause some rupture.

With respect to ancillary mineral changes, surface-reddening of stones may suggest the concentration of Fe-compounds in an oxidising atmosphere. Pure calcite and magnesite are diamagnetic but, if the iron content of stones is sufficient, 'unnatural' magnetic susceptibility (possibly showing frequency-dependence) may appear (from perhaps 100°C) and rise thereafter, with bulk magnetic realignment above c. 500°C. Heated materials may start to display paramagnetism (in the presence of a magnetic field) or ferrimagnetism (sustained even after the removal of a field), most easily noticed in the behaviour of fine-grained sediment in the presence of a magnet. In the current case, all fine sediments within the Grey Series are at least paramagnetic (strongly attracted to a weak magnet) and it is assumed that some heat-generated maghaemite is present. Magnetic analyses of Taforalt sediments in the future may assist, especially in the more detailed understanding of firing regimes, remembering that background soil magnetic susceptibility may well be raised already, across this region.

There are therefore good theoretical reasons to suppose that more can be learnt from the burnt limestone and dolostone (as well as the speleothem) in the Grey Series at Taforalt. Using this theory, and also with an eye on other publications concerning archaeological pyrolithic processes (the principal ones being referenced below in the 'Discussion' section of this chapter), two sets of data have been collected.

The first dataset comprises observation of a number of reasonably large stone samples, collected from the main (accessible) standing sections within the cave. For each sample, each stone was recorded for composition (limestone, dolostone, speleothem, presence of vein iron oxides), weight[61], form (cobble or irregular clast) and intensity of burning. This last parameter was estimated, on a 5-degree scale (0 = unburnt to 4 = heavily burnt), based upon professional judgement of the combination of the following visual characteristics: surface whitening; sandy/grainy surface texture; powdery surface and even sub-surface texture; deeply cracked; surface crazed; blocky fractures; curved fractures; sharpness of protuberances (fine scale); angularity (coarse scale); rounded surfaces; vugginess (induced porosity); surface cupules/pitting/spalling; surface reddening. From recent experimental results (see below), it was known that the three different stone types respond slightly differently to heating (thus, surface graininess and rounding occur due to heating mostly on dolostone, never on limestone, for instance) but this did not prevent consistent (and demonstrably repeatable) results in allocation of a given example (no matter of which stone type) to a burning degree, over the c. 1600 stones analysed in this way. In each sample, the percentages for each of the burning intensities (across all three stone types) were then weighted (by multiplication with the burning degree) and the

61 Another estimate of size, 'equivalent square aperture passed', was also recorded; this parameter was used in selection of stones for all samples only in the interval 10-64 mm but has not been used further in the results reported here.



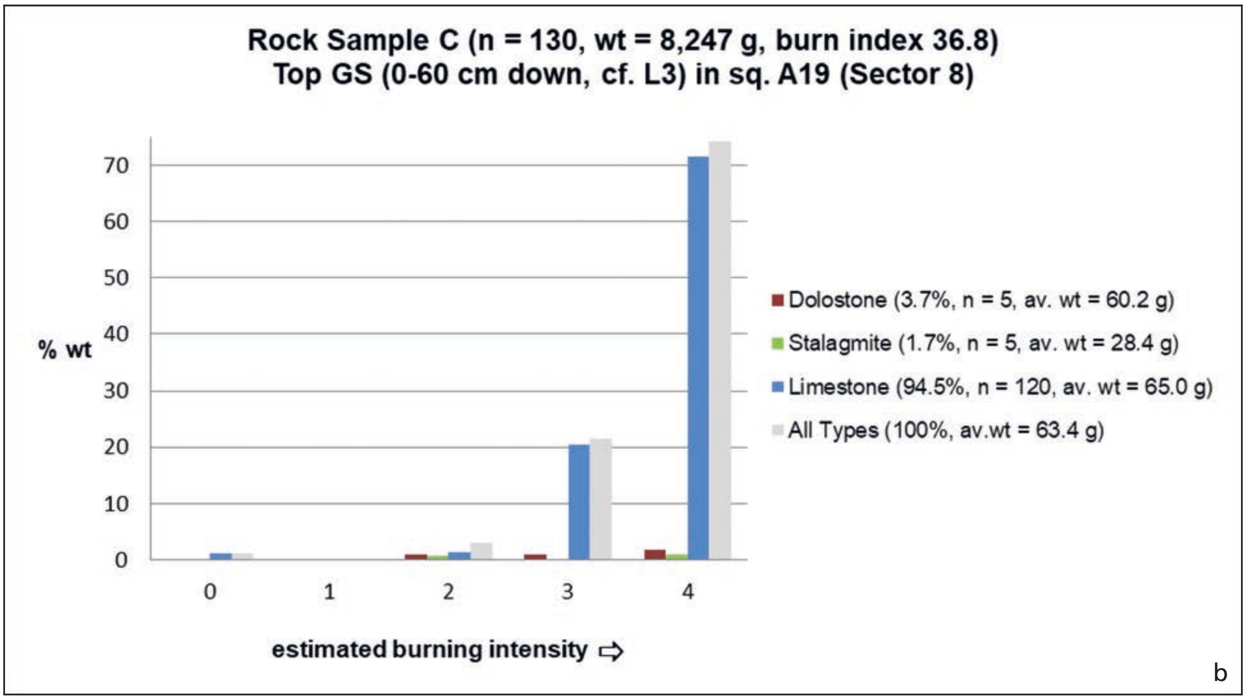
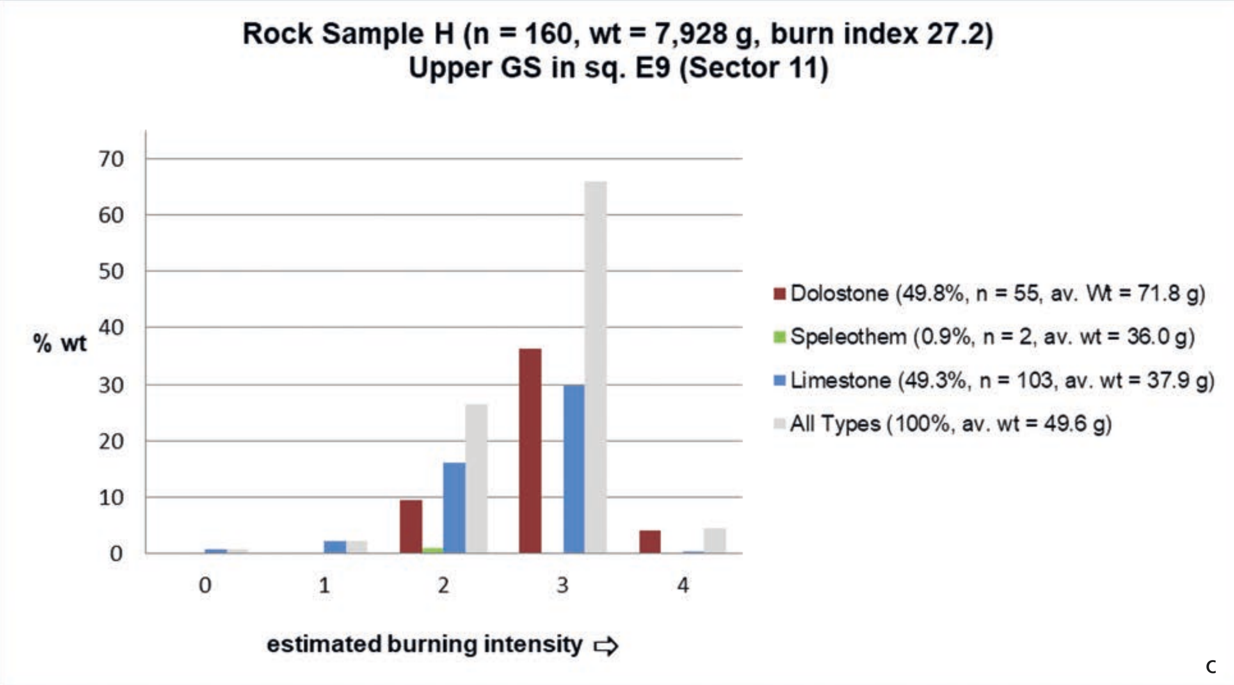


Fig. 2.44 **a-i** Cave samples of stones (archaeological burning), graphic analysis.

total was divided by 10 to give a 'burn index', in the range 0 for totally unburnt, 20 for evenly distributed burning across at least the central degrees and 40 for totally heavily burnt. Selected results from the Taforalt sampling (also with samples from Sector 10 and a representative one from the Yellow Series for comparison) appear in figure 2.44 (a-i).

The second dataset comprises observations made during field heating experiments on initially unheated stones (collected from the slopes outside the cave). In order to maintain close control, a small fire (some



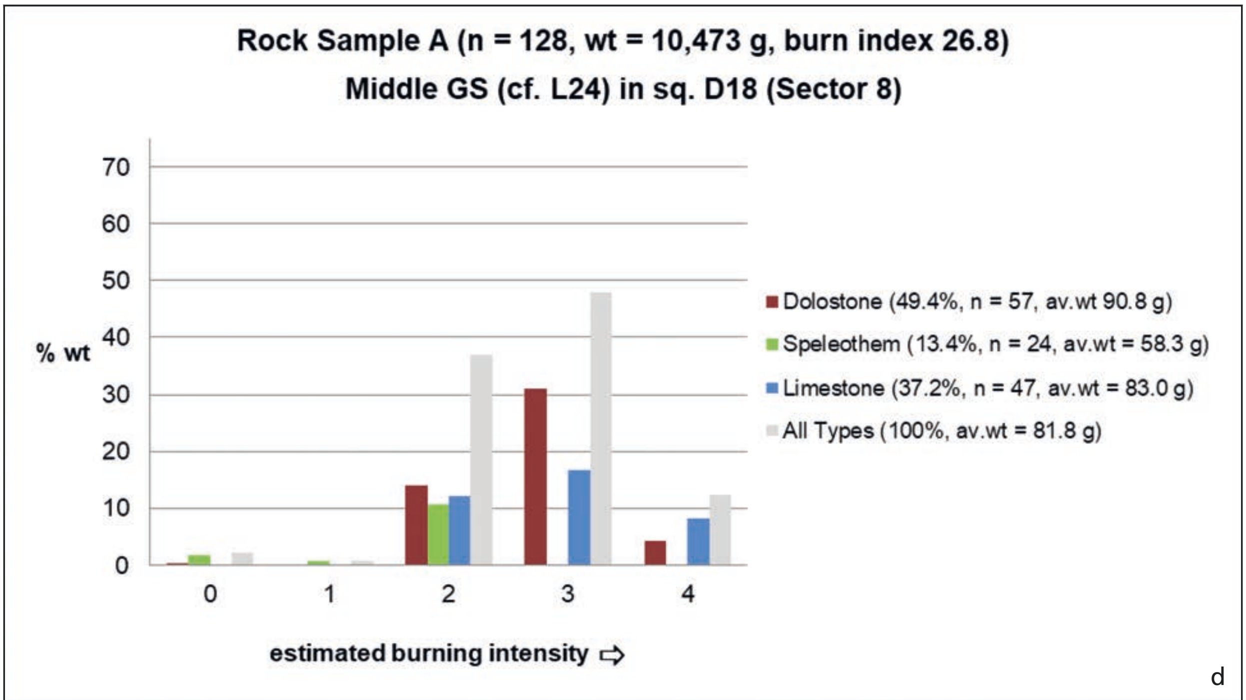
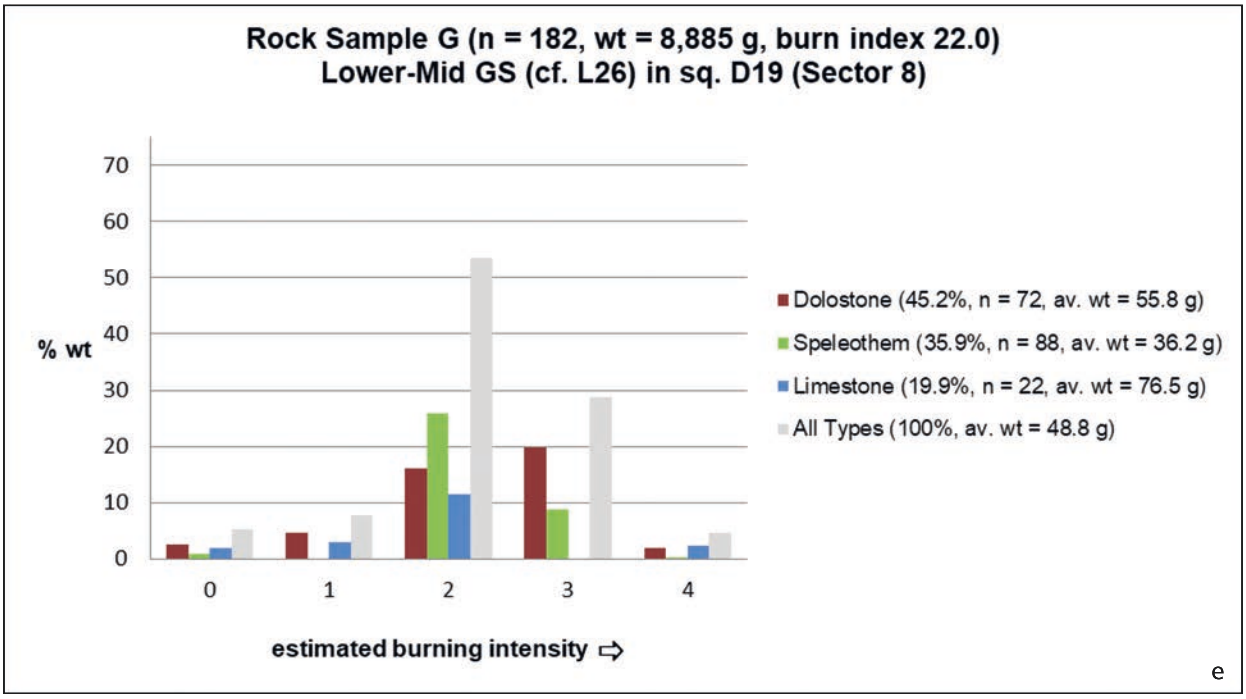


Fig. 2.44 (continued)

40-50 cm across) of charcoal was used (with pine cones as 'lighters/accelerant' as needed), without structural support (no fire-pit or boundary stones) and without any air-forcing (**fig. 2.45**). Temperatures in the fire and at stone surfaces were monitored using an infra-red laser pyrometer; all firings reached a maximum within the range 500-600°C. Weight loss was measured using an electronic microbalance to 0.1 gm precision (thus, in excess of one part in 1000 for all sample stones, and mostly 2-3 times this precision). Selected results appear in **figure 2.46 (a-b)**; other experimental parameters are marked on the diagrams. One may also note at a qualitative level that the dolostone (which has a typical unweathered dry colour of



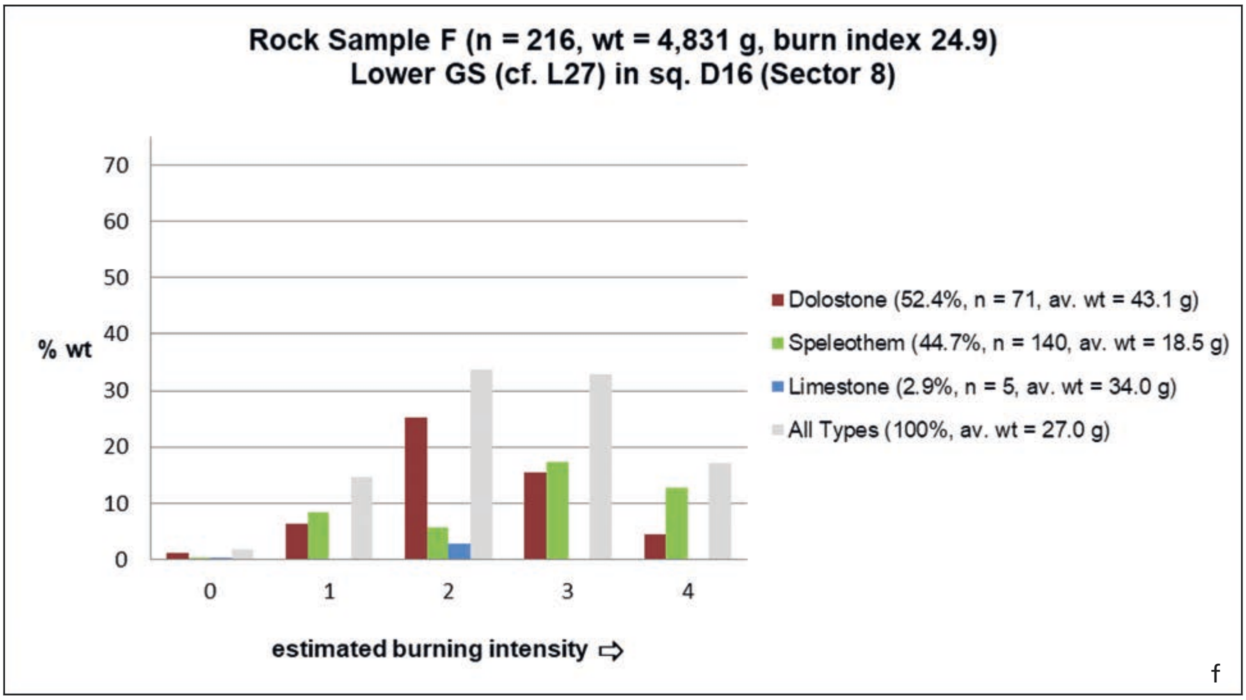
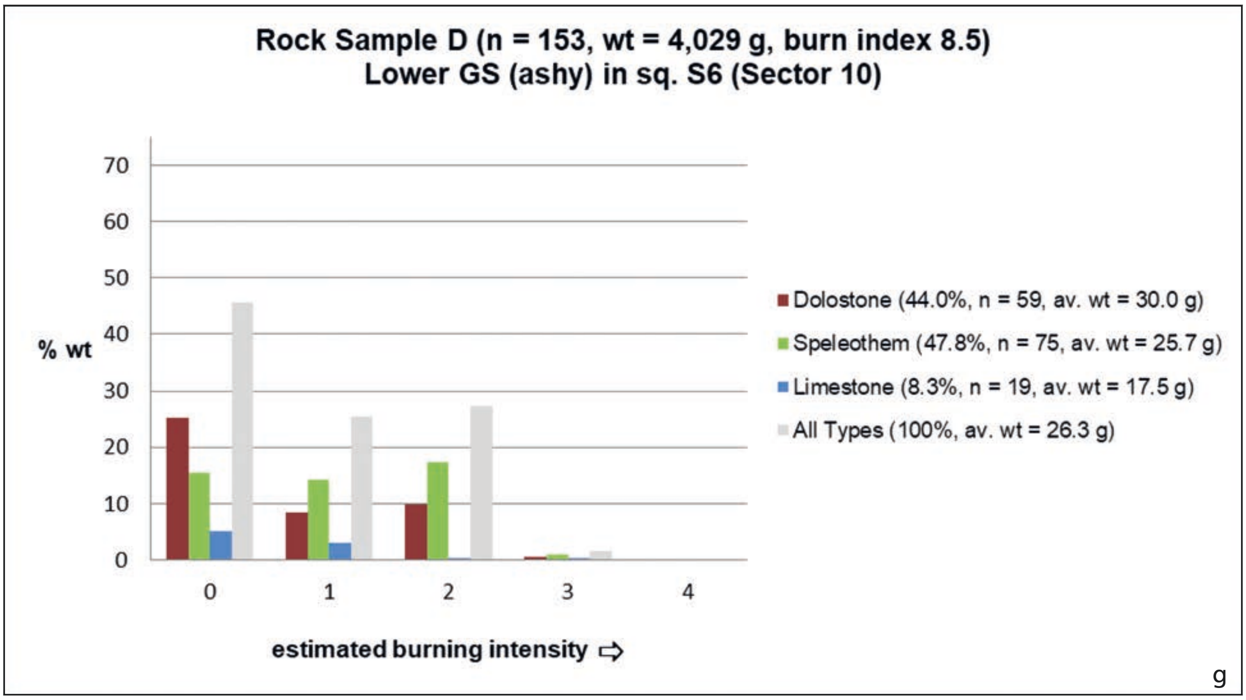


Fig. 2.44 (continued)

7.5Y 6-7/2-3 when natural but usually 'whiter' than 2.5Y 8/1 when burnt, or tending to 'brick-red' if containing significant Fe-compounds) gives a rather weak HCl-reaction when unburnt but a strong one when well burnt, suggesting preferential removal (calcination) of magnesium carbonate. The limestone (typically 10YR 5-6/2 when unweathered natural and also 'whitening' markedly when burnt) gives a very strong HCl-reaction in any condition, whether heated or not; the speleothem usually gives a strong reaction, as well. In addition, it was noted that all stone types show decreased bulk density with increased heating duration,



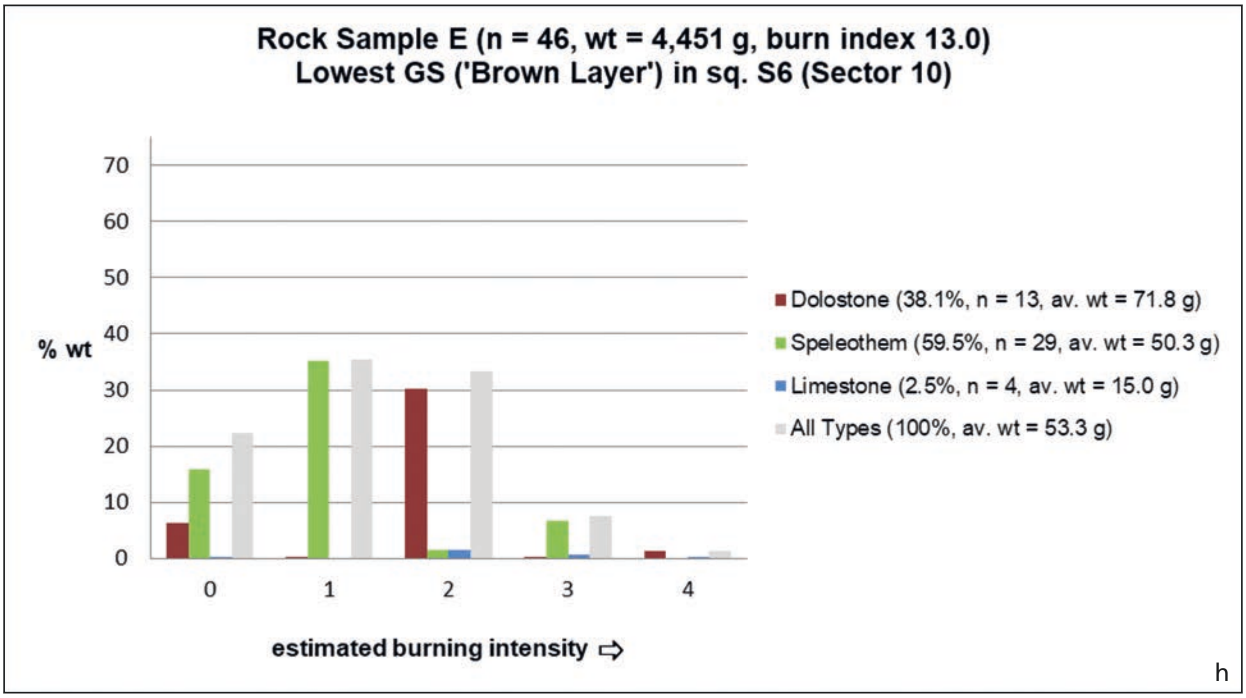


Fig. 2.44 (continued)

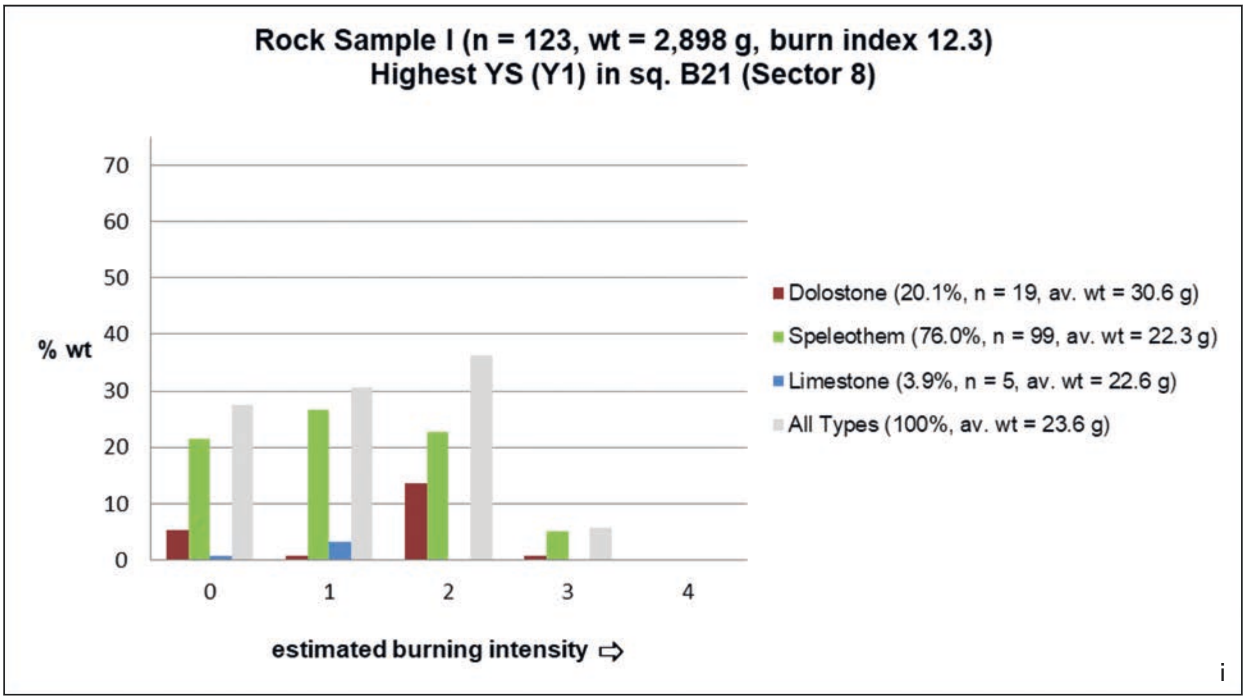


Fig. 2.44 (continued)

Fig. 2.45 Small experimental charcoal hearth.

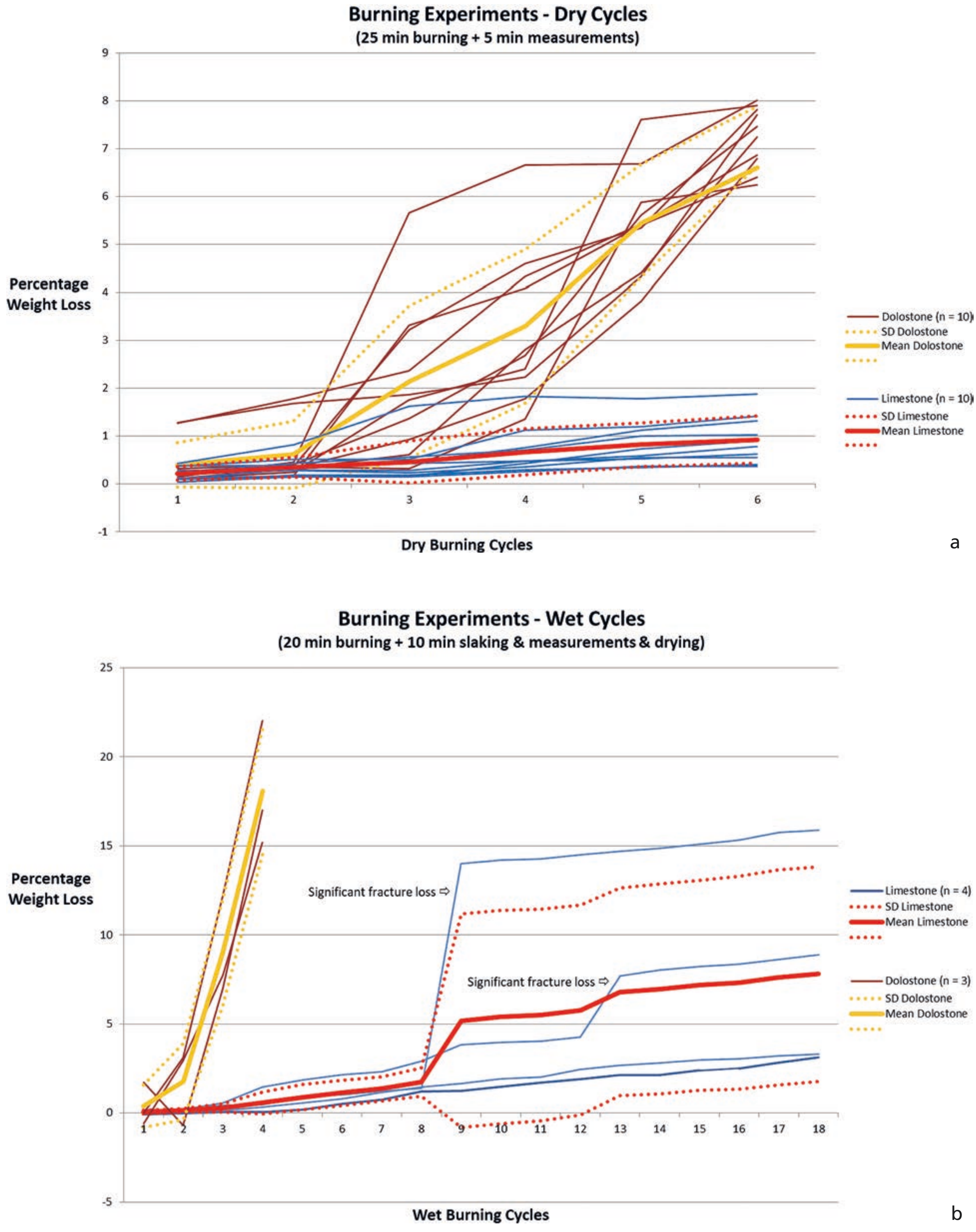


Fig. 2.46 a-b Experimental samples of stones (dry & wet burning cycles), graphic analysis.

although this proved to be too difficult a characteristic to measure consistently on larger samples. The acidity/alkalinity of the water used (and always replaced clean at pH 7) after a quenching in wet burning cycles was tested occasionally with litmus paper capable of registering 0.5 pH unit differences.

2.7 DISCUSSION

The Yellow Series

The fine lamination sometimes surviving in the Yellow Series is interpreted as due to sheetwash. The facts that bedding angle may often be relatively high and that normal grading is not macroscopically obvious in any observed laminae would suggest sediment pulses, quite quickly draining into underlying dry deposits. This merely implies event-based occasional and/or seasonal water availability, acting upon less consolidated source sediments, on the exterior land surfaces and within the karstic system. An artificial (and extreme) example of what can happen today (in a climatic context considered to be relatively 'dry') is shown in **figure 2.47**; these sediments built up in the eastern end of Ruhlmann's south trench over only a two-year period, during which no excavations took place and old barrier spoil (the unconsolidated sediment source) was breached during rain storms, the wash from which directly reached the outer part of the cave. Indeed, laminated sediment intervals can be considered as the norm for cave sediments under a range of seasonal climates with a sufficiently marked dry season, including the current 'Mediterranean' one. It seems unlikely that mid-range temperature variations would produce any easily discernible signal in such a context. One may note the absence of desiccation cracking (whether caused by heat or cold) and of the bulk cementation (and certainly not stalagmitic crusts) that one might expect under warmer, more humid conditions. Similarly, as a general rule, the small-scale bioturbation structures present do not show preferential origins at particular stratigraphic levels.

There appear to be two main 'excursions' from the normal sedimentation motif in that part of the Yellow Series of interest here, in S8-Y4spit3 (correlated with S9(E)-CTX11 to S9(E)-CTX16) and S8-Y2, each of which involved increased silt content. The details of the particle distribution of this silt are difficult to observe, as they are masked by the fine-tail of the main fine sand mode, more so in Sector 8 than in Sector 9. Silts do, of course, occur as alteration products of many of the local rock types (including the limestones) but they normally co-occur with clays, rendering them resistant to mobilisation. Purer silts are not particularly common, away from any obvious primary source, and usually imply a competent sorting current, either of water or of air. The highland context of Taforalt makes an aqueous current less likely; although remobilisation of something like an ancient lacustrine sediment, previously available to, or trapped further back in, the karstic system, is not impossible, there is no corroborating evidence for such an origin. Alternatively, the Sahara is the world's largest dust source and is known to have produced wind-borne sediment for hundreds of thousands, indeed millions, of years. Unlike sand (which moves in wind by saltating across the surface), silt is actually carried aloft in the air, with, as a general rule, finer particles travelling further (and higher) than coarser ones. Nevertheless, it is commonly observed that aeolian material tends to fall into two modes, 'large dust' which is the main constituent of true loess with modes within the c. 50-60 micron grades (but often with a tail – or even modes, in more source-distant locations – down to 20 micron), and 'small dust', a common example of which is the far-travelled material that may be seen, for instance, in marine cores, concentrated within the c. 2-8 micron grades (cf. Goudie/Middleton 2001; 2006; Smalley et al. 2005). All these particles are small enough for their erosion (initial mobilisation) to be very strongly inhibited by moisture

Fig. 2.47 Modern wash (rain storm) laminations in Ruhlmann's south trench. – Scale 20 cm.

in the source area and, therefore, the best sources are deserts, with the scope of regional dust production increasing whenever there is more general climatic aridity. One may note in passing that 'small dust' (and more rarely even 'large dust') may also contain clay agglomerates (of the same 'particle' sizes in aggregate) but that the formation of such material relies heavily upon desiccation of the deposits (with crazing and surface clay-curl production) from shallow water bodies. Deposition of dust usually occurs when a moister air mass is encountered (with the dust particles encouraging condensation) and terrestrial dust accumulation is best achieved by a vegetation cover (which provides a dead air layer and, eventually, stabilises the dust by incorporation due to the rooting systems and accompanying pedogenic organisation). Alternatively, before stabilisation, dust can be washed, or even blown, straight into a karstic system. Dust can be deposited on, can 'blanket', any type of terrain, including highlands. Orographic forcing (air streams having to rise over highland areas) tends to cause more deposition but often of slightly finer particles; Zielhofer et al. (2017) report multiple dust sources producing deposits (dating from c. 11,000 cal BP onwards, with a suggestion of an earlier dust flux event at the very base of this core) at a Moroccan Middle Atlas lake site (altitude 2080 m a. s. l.) with modes at 45.7, 13.2 and 6.6 microns. Naturally, if the vegetation cover that tends to hold the accumulated dust in place should begin to fail, any silty materials may be remobilised, especially in terrain with higher slopes.

Turning to the Taforalt silty episodes, there is circumstantial support for an aeolian origin.

Laouina (1990) reported that illites are the main clay mineral in the Jurassic sequence of the Beni Snassen, although there is some kaolinite in the basal Triassic and traces in superficial (calcreted) Quaternary deposits (such as piedmont cones); illites and chlorites (with some palygorskite and smectites in calcretes) are most typical of the external Quaternary deposits. Most western Mediterranean and proximal Atlantic research (e.g. Martínez-Ruiz et al. 2015) indicates that palygorskite ought to be the most diagnostic clay mineral (even though it is usually far from being the dominant type) in regional aeolian sediments from the western Sahara, although studies of dust flux across the eastern Sahara (e.g. Ehrmann / Schmiedl / Beuscher / Krüger 2017) show kaolinite associated with drying phases. As has been noted above, FTIR analyses have recognised kaolinite in the two silty intervals of interest in Sector 8 at Taforalt. However, palygorskite is not easily recognised using FTIR (XRD and NIR analyses would be more determinative); pure palygorskite is characterised by multiple FTIR bands but these wave numbers can be rather variable in the presence of accessory elements and smaller amounts can be masked by neighbouring peaks (especially since there are several low peaks from structurally-bound water / hydroxyl that any heating can easily collapse). Thus, palygorskite might be present but, so far, concealed at Taforalt.

In Sector 9 on the north side of the cave, qualitative analysis of the two most silty intervals (S9(E)-CTX11 and S9(E)-CTX13), both correlating with lower (S8-Y4spit3) occurrence on the south side, shows them to be dominated by clay mineral of the smectite group, with a smaller component of illite; these clays are often part of silt-grade aggregates, some of which may even pre-date deposition in the cave (see above). It should also be remembered that, judging from the persistent bedding (and micro-bedding) angles, the two sides of the cave differ in this part of the Yellow Series, in that, to the south, sediment was transported towards the cave mouth and probably largely originated from material that had been collected by the local karstic system, whilst, to the north, the sediment was transported inwards from the cave mouth, either directly by air-flow or by very local back-wash down the interior slope of an entrance talus. The smectite-dominated clay mineral suite in Sector 9 appears less weathered than the more varied and kaolinite-including suite in Sector 8, an observation that would be consistent with a more direct aeolian input including some 'immature' sediment to Sector 9. One may also recall that, having to rely upon sufficient water to bring silts through the karst, Sector 8 sedimentation was very slow during this period, whilst, benefitting from a more direct route into the cave, the Sector 9 silts were able to accumulate significantly faster. Further work on the silt-grade and clay mineralogy of theses silty deposits is envisaged in the future. For the moment, a general observation is of interest, that both palygorskite and kaolinite are formed by weathering during wet periods but are commonly eroded during dry ones.

No correlate of the S8-Y2 interval survives in Sector 9, the latter having been truncated by earlier excavations. The general nature of the upper part of the S8-Y2 material has been noted above: significant silt input, some of which being carbonate, followed by plastic deformation and eventual sheet erosion. The much more discrete Sector 9 silts (correlating with the lower, S8-Y4spit3, interval) provide an opportunity for better granulometric characterisation. In CTX-11 (**fig. 2.31**), the mode in the siliceous fines remains just within the fine sand grade (at 3.6 phi) but is still quite significantly finer than the average seen in most of the 'wash sands' in Sector 8; there is also a strong fine 'tail' through the silts and into the colloids. Looking at the much more common carbonate component, there are coarser modes (probably resulting from bedrock disaggregation and stronger wash) but also a very strong one in the fine silts (at 8.4 phi). Although still not fully determinative, this result is consistent with a strong aeolian input, probably with quite a proximal source for the siliceous material as well as for the carbonate 'small dust'. In CTX-13 (**fig. 2.32**), the siliceous mode is now firmly in the medium silts (at 4.9 phi / 33.6 microns), again with a positive skew, and the carbonate 'small dust' is dominant, an overall distribution suggestive of a strong aeolian input.

The final set of circumstantial evidence, quite strong in its own right, derives from the comparison of the age of the Taforalt silty intervals with the regional climate succession. Using the radiocarbon dates for Sector 8 (see **Chapter 4** for full discussion; shown in summary for S8 in **fig. 2.17**), it can be seen that the silty intervals correspond reasonably well with the dating of Heinrich Events 2 and 1; such events are said to be marked by the incursion of cold polar surface waters into the Mediterranean (cf. Moreno et al. 2005 analysing the interval 50-28 ky). For the earlier, just pre-LSA silty interval, the available radiocarbon dates from Sector 9 (see **Chapter 4**) are compatible with a very broadly 'Last Glacial Maximum' (LGM) age, including Heinrich Event 2.

Heinrich Events (and the later, Younger Dryas appears to have included a comparable episode) have been associated with phases of greater aridity in Iberia and northwest Africa, as documented in pollen sequences from the Alboran Sea cores (Combourieu Nebout et al. 2002; Sánchez Goñi 2006; Jiménez-Espejo et al. 2007; Fletcher / Sánchez Goñi 2008) and increased input of windborne dust from the Sahara (Moreno et al. 2002; Moreno 2012). Bout-Roumazeilles et al. (2007) report good clay mineral peaks from the intervals they have interpreted as 'HE2', 'HE1' and 'YD', correlating well with other cold proxies, from ODP Site 976. Jiménez-Espejo et al. (2008) note that coinciding Si and Zr peaks from dust seen in Alboran cores are very well correlated with proxies for 'HE1' cold conditions, implying fresh water from Atlantic iceberg melting. In the Mediterranean cores extending back to beyond 20 ka discussed by Martínez-Ruiz et al. (2015), there are elemental proxies for clay minerals (palygorskite and smectite) from the western Sahara, arriving in the Alboran Sea, with aeolian dust inputs commonly judged by Zr, Si, Ti (from zircon, quartz, rutile, sphene and ilmenite) ratios against Al; for instance, in Alboran Core 293, dust (in the fine silt grades) is apparent in the 'HE1' correlate (especially) and in the 'YD' correlate. There are similar dust flux peaks in cores off the Atlantic coast of Morocco (Bradtmiller et al. 2016) and off Mauretania (McGee et al. 2013), interpreted as dating from 'HE1' (estimated by these authors as 16-16.5 cal ka) and 'YD' (12.5-13.5 cal ka). Climate modelling also suggests that annual rainfall may have fallen below 100 mm per year during certain 'Heinrich Event' correlates (Sepulchre et al. 2007). In contrast, the periods following 'Heinrich Event' correlates appear to have been relatively warmer and more humid, as for example that part of the 'Last Glacial Maximum' phase probably within Greenland Stadial 2 after 'HE2' (Penaud et al. 2010) and the phase of significant warming at the beginning of Greenland Interstadial 1e, the latter recognised as responsible for a rise in sea surface temperatures and the diversion westward of moisture-bearing winds bringing higher precipitation to the Maghreb (Moreno et al. 2005; Rodrigo-Gámiz et al. 2011). The difficulties of correlating global, regional and local climate-based stratigraphies are further discussed in **Chapter 18**.

One may note briefly that potentially aeolian silts have been noted at some other cave sites in Morocco within the general time range of interest here, although never yet with much stratigraphic or chronological precision. For instance, on the Atlantic coast at Grotte des Contrebandiers, Aldeias / Goldberg / Dibble / El-Hajraoui (2014) have noted a probable aeolian input within the earlier LSA time-range but the deposits have been demonstrated to be reworked. Similarly, at Ifri n'Ammar (some 56 km to the west of Taforalt), Klasen et al. (2018) have noted likely aeolian silt input within Unit B (upper "*couche rouge*"), containing the earliest LSA at that site, but, save for the very base, this thick Unit is said to be highly bioturbated and lacking in fine stratification.

To recapitulate, the raised silt contents at Taforalt in S8-Y4spit3 and the upper part of S8-Y2 (and their respective 'south side' correlates) would therefore suggest that wash input was capturing aeolian dust from the exterior surroundings, mostly via the local karstic system. Prior to pedogenic incorporation, newly deposited aeolian silts are extremely vulnerable to remobilisation by water, so that there is no reason to suspect any great time lapse between the generating cool / dry climate phase and final deposition within the cave. It is likely that the better expression of the earlier phase in Sector 9 actually reflects a more direct route on the 'north side', by very local wash down the back-slope of an entrance talus, where silts may have been concentrated due to the effects of the cliffs above and the ionised air boundary at the cave mouth. In the later phase at Taforalt (supposed 'HE1' correlate), conditions certainly became increasingly damper within the cave, possibly even with transient superficial freezing (which would have increased deformation pres-

sures), although there are no unequivocal signs of ground-ice (either macroscopically or microscopically, cf. Chapter 3). The deformation within Unit S8-Y2 is mirrored in the apparently mixed nature of some of its contained materials. Radiocarbon dates from this unit show less coherence and steady ordering than in any other unit (see Chapter 4). The lithic artefact collection may be interpreted (see Chapter 12) as a physical mixture of two assemblages, although the artefacts likely to belong to the younger of the two seem to be present in sufficient numbers to suggest that the actual cultural (archaeological) change occurred within the upper Y2 timescale itself (rather than at the beginning of Y1 time, after the erosion event capping Y2).
In the earlier phase at Taforalt (supposed 'HE2/LGM' correlate), there are no indications of climatic instability, with sedimentation rate either very slow (Sector 8) or faster extremely locally but with no subsequent deformation or significant erosion (Sector 9).
It would therefore appear that, at Taforalt, a relatively 'highland' site, the earliest LSA archaeology appeared more or less directly after – not during – intervals (including the supposed 'HE2/LGM') of significant silt deposition, probably due to aeolian transport in a generally dry, possibly cooler, climate. It is possible from currently available data that LSA industries appeared slightly earlier in relatively 'lowland' (currently coastal) sites (cf. Chapter 12). These observations beg the question of the importance of climatic determinism – a question that cannot be answered without a sustained regional analysis of all relevant sites, of early LSA, late MSA and, indeed, 'Intermediate' types. At Taforalt, LSA people were certainly able to cope with the subsequent conditions during the probable 'HE1' and 'YD' correlates.

The Grey Series

General Characteristics

Overall, the term 'midden' has often been used for such material as the Grey Series, at Taforalt and at other similar (if usually smaller-scale) sites. However, one wonders whether some extension of this idea, perhaps a term such as 'macro-midden' or even 'hyper-midden', might be more appropriate for this immense composite accumulation. Since the anthropogenic component is so dominant, no direct 'climatic/environmental' signal is recoverable at the macroscopic level from the sediments themselves.
The huge increase in sedimentation rate in the Grey Series has already been noted and the gross geometry of these deposits is also of considerable interest. Roche's observations, backed up by the pre-1908 postcard (figs 1.5 and 1.7a), show that the cross-cave dip was sequentially reversed during GS deposition, which must imply that human activity swamped the natural sedimentation pattern (there being no evidence for a 'natural' cause for such a switch, especially in the absence of some sort of catastrophic modification, such as major channelling, which would have left a massive angular unconformity). The interesting question here is why such swamping should have been stronger on the south side. The LSA occupants would hardly have systematically 'carted' all their waste over to the south side – much too great an effort. It follows that they must have been engaged in activities generating bulk more on the south side (which itself would have caused the roof weathering input to drift southwards, when one factors in such things as abundance of hearths and other heated features). So, the occupants in GS-time appear actively to have favoured the south side for these activities, the one that was more poorly lit. Did they prefer less sunlight (perhaps it was actually hot in the summer) or were there other weather aspects (perhaps wind direction) which made the south side more attractive? In fact, the most important factor was likely to have been that fires would probably work best on the south side to give the greatest smoke clearance (note these were comparatively recent time, when one can assume that the cave shape was not grossly different). In respect of this 'smoke evacua-

Fig. 2.48 Sector 8, anthropogenic cut at base of Unit L12, S-N section. – Scale 20 cm.

tion' mechanism, there would have been positive feedback, with the roof weathering upwards as fires were lit on the south side, which would reinforce the effect by improving the 'roof chimney groove' sloping up-outwards to the east. This certainly does not mean that the north side would have been ignored – perhaps activities requiring good lighting were favoured in an area with lower relief in debris piles (and fewer active pyrolithic processes, see below), activities such as making fine bone tools and using them in basketry or mounting microliths into composite tools.

Apart from burial features in Sector 10, only rare, small scale anthropogenic cut features (cf. **figs 2.48-2.49**) are presently visible but the geometry of lenses and component bedding (generally undulating but with high-angle sets locally, dipping in any direction) suggests common small-scale reorganisation of 'piles' of material at accreting surfaces and possibly some 'grubbing' for recycling purposes. The lack, or at least rarity (see above), of large cut features has possible implications for storage, with baskets/bags perhaps used more often than pits.

However, it cannot be stressed too strongly that out sampling design, with its vertical emphasis, will not have favoured the recovery of man-made structures. In this context, one may note the instructive work of Mulazzani et al. 2009 in a large open-air Holocene *rammadiya*. These authors first confirmed that structures on most scales, and certainly actual habitation structures, have not usually been observed in such sites; their own initial approach, using a cross-trench and its sections, produced a similar level of stratigraphic understanding as that which has been achieved so far at Taforalt. However, once Mulazzani et al. switched their technique to painstaking single-context (three-dimensional) open-area excavation, a whole range of small negative and positive features (cuts, fill differentiation, stone lines, post- and stake-holes, etc.) were

Fig. 2.49 Sector 8, Units MMC32 to MMC35, irregular cut base, N-S section. – Scale 20 cm.

identified, some groupings being interpretable (after analysis of the discrete datasets thus collected) in terms of activity areas and habitation structures.

At Taforalt, the 'patchiness' in vertical sections may be expressed not just in terms of composition but also of differential compaction and fragmentation (e.g. shell), suggesting varying degrees of treadage/trampling (**fig. 2.50**; see also **Chapter 3**); such a characteristic seen in three dimensions might allow the identification of persistent 'pathways' across a cave floor. The reverse phenomenon may be seen in some zones of under- or uncompacted ash; for instance, in Units S8-G90 and S8-L28, the present author has observed micro-structures, sometimes in spicular or cylindrical bundles, that may represent undisturbed burnt plant fragments (possible partially supported by structural silica).

Fragile structures will be destroyed by sieving/flotation, and would even be difficult to capture in thin section. A particularly tempting target in the context of the Grey Series would be fragments of charred organic

Fig. 2.50 Sector 8, Unit L3, possible treadage zone, E-W section. – Scale 10 cm.

composite (woven/platted) artefacts (baskets, mats, ropes, cords, etc.). Desiccated examples of such material are known from Holocene hunter/gatherer sites towards the desert margins in the Maghreb (cf. di Lernia/Massamba N'siala/Mercuri 2012) but Taforalt has certainly not been dry enough for such primary organic preservation. The chances of survival of recognisable charred composites (single fragments of charred rhizomes indeed being known from this site, see **Chapter 6**) is extremely low, depending first upon effective 'smothering' or 'wetting' of the burning fragment at the cusp, in that critical interval after it had thoroughly charred but before it turned to ash, and then upon permanent protection from crushing and even natural sediment compaction, perhaps within a stony matrix.

At Taforalt, a particular micro-excavation technique was therefore devised, involving the removal of c. 2 mm thick spits, using only a small soft brush and a rubber-bulb air blower. Three blocks (15 × 40 × 40 cm; 15 × 40 × 40 cm; 25 × 30 × 30 cm) in Sector 8 Unit L28, another block (15 × 40 × 40 cm) in Unit L25, and a further block (15 × 40 × 40 cm) in Sector 11 from high in the GS sequence (approximately equivalent to L6-L11 in Sector 8) were treated in this way. This work was laborious (0.1185 m³ excavated in approximately 30 hours) and, perhaps not unsurprisingly, no charred composites were encountered. However, *in situ* phytolith packets were observed on two occasions, showing that extremely fragile associations can indeed be recovered (cf. **Chapter 7**). On balance (taking into account, on the one hand, the toll upon sanity and the

Fig. 2.51 Sector 8, MMC91, burnt clay fragments, N-S section. – Scale 5 cm.

dust exposure but, on the other, the very high reward that any success would have represented), the present author thinks the effort worthwhile and would encourage others to repeat the trial.

An additional component of the GS sediments at many levels comprises the quite common clasts or aggregates, some tiny but most under 1 cm in diameter, of 'burnt clay' (**fig. 2.51**), which, given that clay would not have been available naturally on the cave floor, might represent the disturbed lining of (former) depressions or even the 'caulking' of baskets. Further examples of apparently fired clay objects are discussed in **Chapter 14**, whilst small to microscopic aggregates of 'wetland' and heated clay are noted in **Chapter 3**.

Untreated, the generally dry occupation surface of the cave in the GS period would have been very 'dusty/ashy', with possible implications for behaviour: matting and/or floor-skins might have been used in current 'living' areas, whilst 'untreated' areas might have had repercussions for sanitation/infestation, perhaps involving the suppression of micromammal, reptile, insect and other vermin. The ground would also have been locally (away from stone piles) 'softer' than most purely mineral surfaces, again with possible implications for behaviour, with the form easily adapted to current needs (e. g. for stabilising irregular or rounded objects, sleeping hollows, etc.).

We have not yet taken the opportunity to examine actual hearths in detail (cf. **Chapter 8**) but it is clear that geochemical and micromorphological examination could prove useful in the future (cf. Homsey/Capo 2006; Mentzer 2014). The examination of burnt stone at Taforalt has, however, permitted an initial understanding of the possible range of pyrolithic processes, as set out in the next section.

Pyrolithic Processes

The use of heated stones by hunter-gatherers has been considered in some detail by Thoms (2009), with particular attention to heat-retention, fuel-sparing (rendering heat more usable, by 'energy down-stepping' from fast-burning to slow heating), water-boiling and steam-generation. Most studies have concentrated

Fig. 2.52 Experimental speleothem; gentle placing (not dropping) into water was followed by almost immediate boiling, persisting for over 2 minutes. – Bowl diameter 22 cm.

upon the structures formed during pyrolithic process; for instance, Black/Thoms (2014) have considered earth ovens, amongst other categories of 'hearth' and associated cooking structures.

Studies of the heated stones in their own right have been rarer, although they often include intriguing details that will help to structure future research. For instance, Gao et al. (2014) report burnt stone from the Late Palaeolithic site of Shuidonggou 12 (Ningxia Hui Autonomous Region, northern CHN), almost entirely quartz sandstone and dolomite (with the former more common than the latter); (calc-)limestone, the most common lithology in that region, was not found amongst the burnt stones. Various shapes, mostly irregular polyhedrons, are included, with no sign of percussive shaping or other 'form-processing'. Stone sizes vary, with most between 12 and 280 g (60 % 20-50 g, 18 % 50-100 g, 5 % 100-150 g, and only 1.5 % >150 g); the diameters of 55 % of the stones are in the range 2.5-5.0 cm. Approximately 98 % of the stones are fragmented after being burnt, with cracks on the surface and light grey and grey-brown colouration taken to be a result of high temperatures, a colouration apparently different from the rocks' original internal colour beyond any weathering rind. A small number of fire cracked rocks are still intact but display irregular cracked surfaces. Approximately 40 % of the fire cracked stones retain their original 'cortices' (weathering rinds), suggesting the direct use of natural clasts as heating stones. In the case of the Late Paleoindian to Middle Archaic levels at Dust Cave (Alabama, USA), Homsey (2009) has been able to demonstrate a preference for more massive limestone (tolerance to thermal stress) over other types of limestone (such as more finely bedded types) which disaggregated more readily.

It has been noted above that, at Taforalt, three different types of carbonate stone have been used in pyrolithic processes (the local categories being termed simply 'speleothem', 'dolostone' and 'limestone') and that these types (in the order given) would probably have involved increasing effort in procurement.

Fig. 2.53 Unburnt dolostone, a typical weathered clast from hillslopes. – Scale 5cm.

Results from the heating experiments have not been graphed for the speleothem category, simply because it was found that the great majority of such stones showed very heavy damage upon one heating only and all more or less disintegrated if a second, third and certainly if a fourth, heating was attempted. Heated stones were inevitably very 'dirty' and left considerable amounts of debris (fine stone, ash, charcoal fragments), even just in a dry state but especially when they were used to heat water. This effect is a direct result of the fact that speleothem fragments are always very porous or 'vuggy', a characteristic that also allowed a high surface contact with water, the resulting heat transfer causing more rapid and sustained boiling than with any other stone type (**fig. 2.52**).

The analysed results of the heating experiments, with either dry or wet (full quenching) cycles, for dolostone and limestone are shown in **figure 2.46 (a-b)**. With dry cycles, dolostone showed itself to be the more

Fig. 2.54 Experimental dolostone: after 4 wet burning cycles; major effects, including crazing and curvilinear cracking, deep loss of volume, increased porosity, rounding, discoloration and surface granularity. – Scales 5 cm.

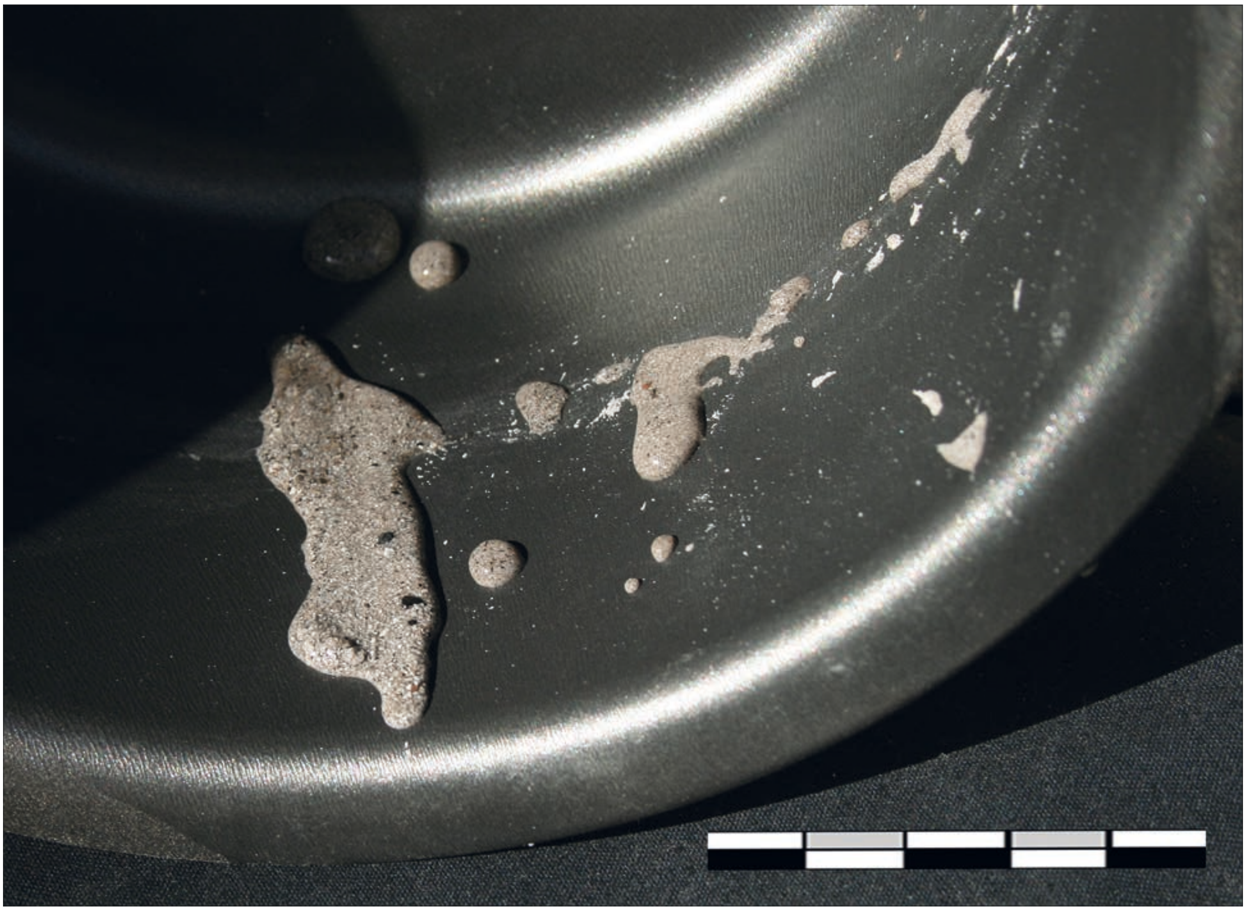


Fig. 2.55 Coarser particulate residue (after decantation of 'milky' water) from dolostone after a first wet burning cycle. – Scale 5 cm.

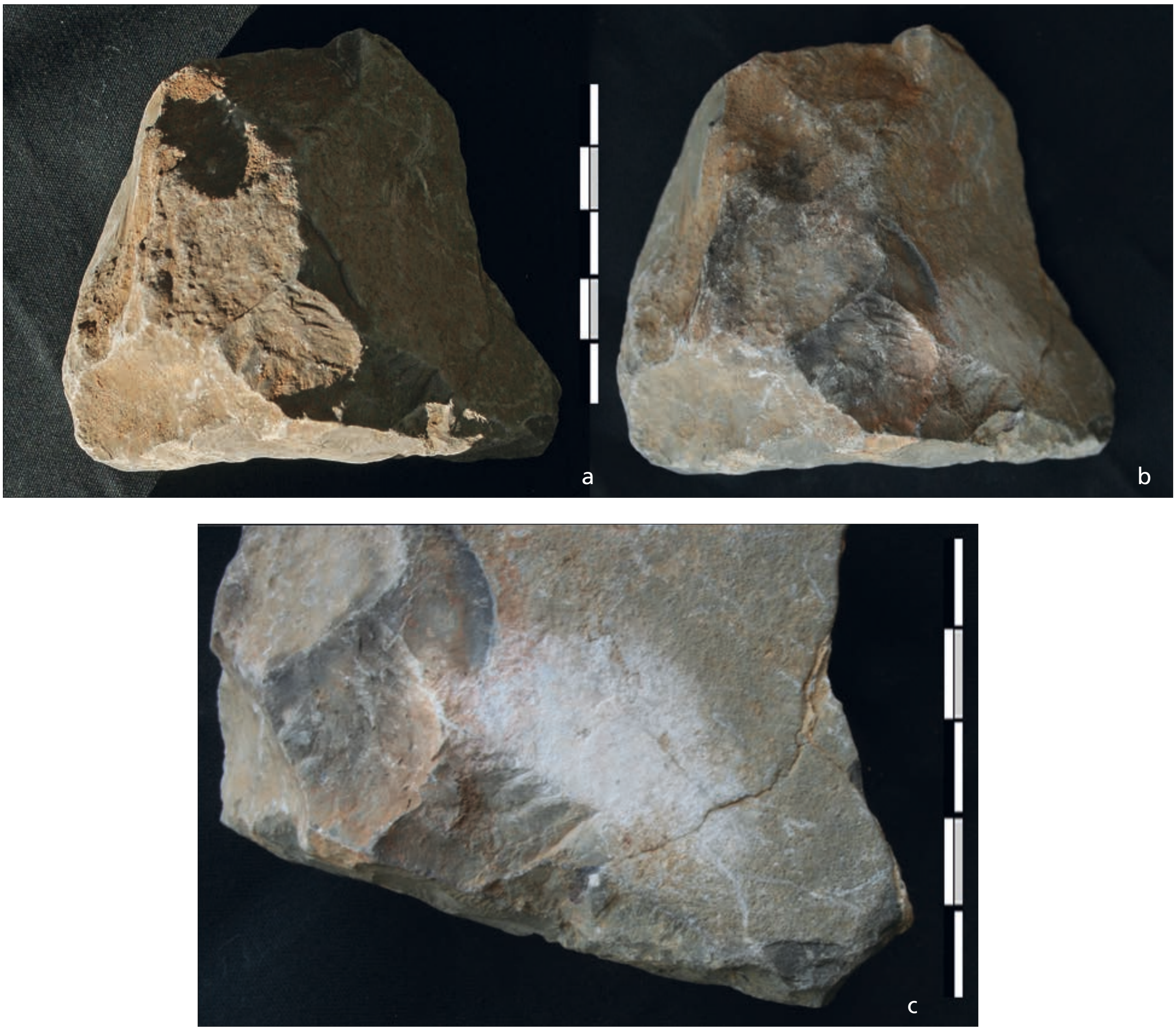


Fig. 2.56 Experimental limestone: before burning (**a**); after 18 wet burning cycles (**b**, with slightly reoriented detail **c**); only minor effects, including some surface powdering and discoloration. – Scales 5 cm.

susceptible, losing on average c. 6.5 % of its weight after 6 cycles; the loss probably includes both micro-spalling from the surface and some calcination. The limestone was much more robust, losing only c. 1 % of its weight after 6 cycles. This dry cycle experiment was continued 'in the background', without measurements, to 18 cycles, with the result that the dolostone had become superficially very porous and crazed, with some larger fractures (i. e. loss from the 'core stone'), whilst the limestone barely showed any change. It was noted informally (but quite painfully) that dolostone tends to remain warmer than limestone for longer, probably due to more distributed warming throughout the stone mass in the first place.

Turning to wet cycles, the difference between the two rock types became extreme. Dolostone lost on average c. 18 % of its weight after only 4 cycles (cf. **fig. 2.54**, with unburnt dolostone in **fig. 2.53** for comparison); stone debris of all grades was produced and larger fragments often showed increased porosity, interpreted as due to loss of soluble 'quick lime' after calcination. Whilst it was very difficult to separate the chemical effects of superficial ash from those of calcination of the stone, a rise of c. 0.5 pH units was produced reasonably consistently with dolostone in the 'standard water bowl volume' used here (see **fig. 2.55**). Limestone, in comparison, was still much more robust (cf. **fig. 2.56**), losing on average c. 7.5 %

of its weight after 18 cycles; most of this loss was by simple fracture (the sharp 'steps' in the graph), leaving all fragments (particularly the surviving 'core stone') perfectly capable of re-use (note the continued gentle gradient, between 'steps', in fig. 2.46b, suggesting lack of deep penetration of thermal decomposition effects). It was also much easier to keep water clean of fine debris with limestone. Water boiled more quickly with limestone than with dolostone, an effect which may well be due to the retention of heat near the surface with limestone, as opposed to the better distributed heat transfer in dolostone (apparently not compensated for by the increasing porosity). This same characteristic, together with the more continuous structure in the fine-grained limestone, probably explain why the limestone was more likely to suffer deep fracture, the strain being taken up more readily at the grain- and microstructural levels in the other rock types.

All these experiments could be repeated with much greater control under laboratory conditions. Nevertheless, the differential effects were strong enough in the field trials for it to be possible here to state with some confidence that the three specific categories of stone from Taforalt (which, it should be recalled, may not behave identically to all types of stone from these same general categories[62]) can be summarily characterised as follows:

- Speleothem: single-use; very polluting; moderate dry heat retention; very rapid boiling/steam-generation.
- Dolostone: low-to-moderate cycling; somewhat polluting; good dry heat retention; messy water heating but with slightly increased water alkalinity.
- Limestone: by far the greatest potential for multiple cycling; non-polluting; moderate dry heat retention; moderately fast to rapid boiling/steam-generation.

If these simple field experiments have allowed such clear conclusions, the same observations would have been readily made by LSA people.

Turning now to the ancient deposits in the cave, the results of stone sample observation may be considered. The 'background' level for these purposes may be taken as the uppermost Yellow Series, deposits where human activity (including burning) is clearly present but at moderate levels, within what is dominantly a geogenic sequence. A sample from Unit S8-Y1 (fig. 2.44i) is typical. The burn index is 12.3 (remembering that this is a linear 40-point scale, with 40 denoting totally burnt). Most of the stone is speleothem (cf. fig. 2.57), that is, the immediately enclosing carbonate of the cave walls and roof, and of the proximal exterior cliff face; there is only a small proportion of dolostone and a relatively tiny proportion of the 'exotic' limestone. These results are entirely consistent with *a priori* expectations.

Leaving the 'special cases' from Sector 10 aside for the moment (see below), the Grey Series from the main cave chamber shows rather different results. In the lowest levels (see fig. 2.44f), the burn index rises to above the half-way mark on the scale; speleothem is still strongly present but now dolostone has become important, in quantities much too great to have been easily available actually within the cave. Moving up the sequence, to the lower-mid GS (see fig. 2.44e), the burn index is not significantly different; however, whilst speleothem is present and dolostone is important (cf. fig. 2.58), the proportion of 'exotic' limestone climbs well above the mere background level. In the middle GS (see fig. 2.44d), the burn index is perhaps creeping up; speleothem has become much less common, with limestone (showing a raised type-specific degree of burning) catching up with dolostone. In the upper GS, in Sector 11 further back in the main chamber (see fig. 2.44c), the burn index continues to be quite high; speleothem has all but disappeared, whilst the 'exotic' limestone proportion in now equal to the dolostone (at this point in the cave with the greatest availability, near to the true bedrock outcrop of dolomitic limestone). Moving forward in the cave,

62 Gao et al. (2014) report significantly different effects in their simulation experiments; it is clear that local rock sources should be tested for each archaeological site and that over-reliance should not be placed upon theories of 'standard' rock responses.

Fig. 2.57 Archaeological sample of burnt speleothem. – Scale 10 cm.

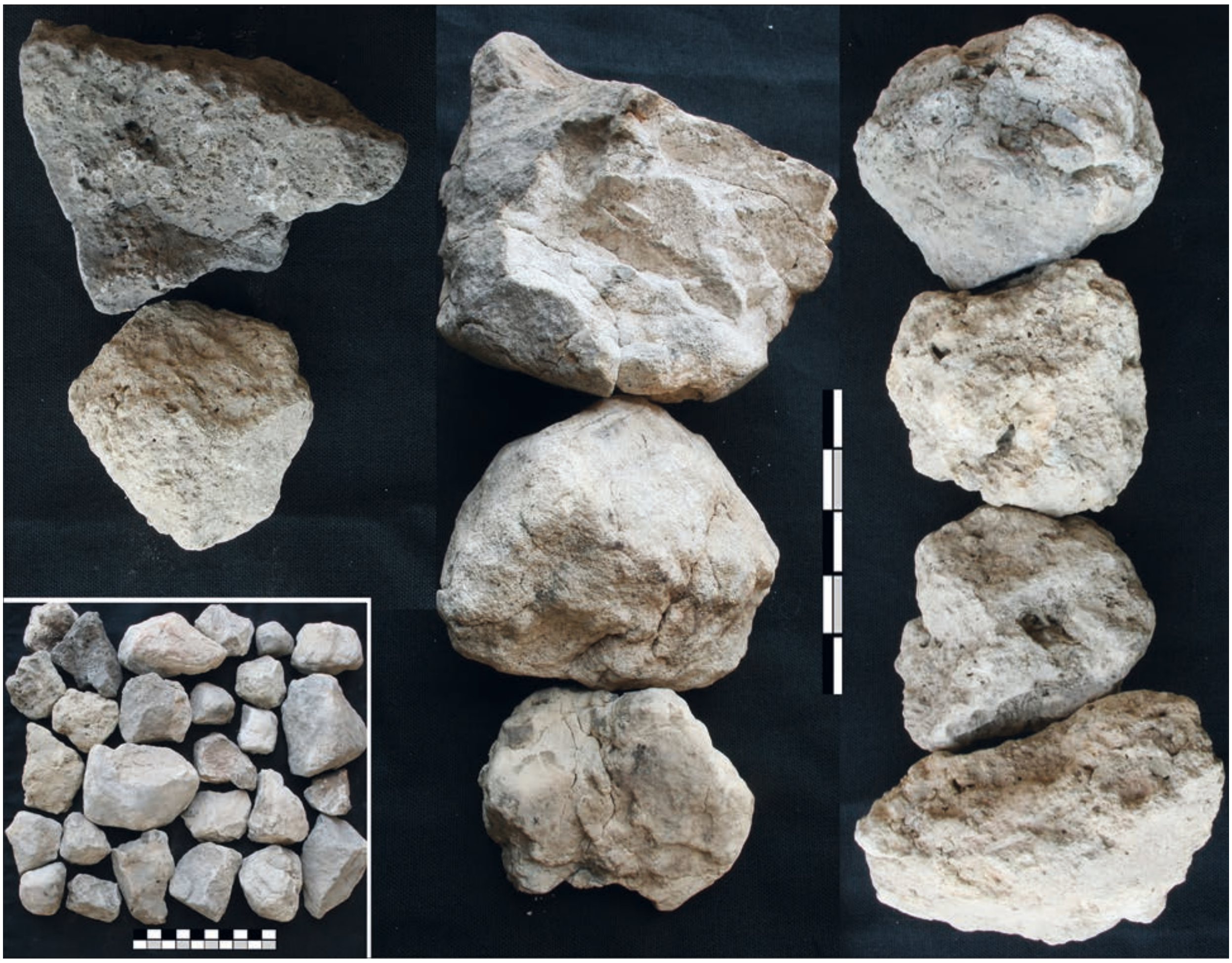


Fig. 2.58 Archaeological sample of burnt dolostone; most common effects include vugginess and increased porosity, crazing and curvilinear cracking, deep loss of volume, rounding and surface granularity. – Scales in cm units.

to the top of the GS surviving in Sector 8 (see fig. 2.44b), burning is almost at its maximum – nearly every stone is burnt and they are nearly all 'exotic' limestone (see fig. 2.59); many of these limestone fragments have originated in relatively large, >10 cm diameter, cobbles, with rounded outer surfaces. It should be noted that it is not uncommon at this level to encounter limestone that has been so strongly heated that it has become powdery and calcined and, in a few cases, even slightly sintered, implying temperatures of at least 800°C (in turn suggesting that some simple means of airflow forcing might have been employed), levels never reached in the recent experiments. Yet further forward in the cave at the top of the GS (see fig. 2.44a), the burning index remains very high, and limestone is still dominant, but a significant proportion of speleothem again appears, in this area where the latter would have been increasingly available as the cave roof sweeps and steps upwards to meet the exterior cliff above. The observed relative slowing sedimentation in the upper part of the GS seems to have been in large part due to greater 're-use' of limestone, with a diminishing need to import large quantities of more fragile stone for pyrolithic processes.

The exact objective or objectives (whether involving down-stepping from hot/fast calorific generation to prolonged warmth retention, or calorific transfer to water or steam, or direct heating/cooking), will need consideration across the different research disciplines. Here it will simply be noted that there is an incontestable case to recognise a sustained increase, and plausible ramification, in pyrolithic processes in general – the deliberate transfer of heat via fired stones on a most impressive scale.

Fig. 2.59 Archaeological sample of burnt limestone; most common effects include deep fracturing and surface powdering. – Scales in cm units.

Before leaving the discussion of heating/burning, further consideration may also be given to the data presented in **Chapter 8**, together with additional details kindly provided by Victoria Taylor (pers. comm.). In terms of MMC units, the GS can be divided into three broad intervals: the lower part MMC105-96 (MMC106 being known to be a mixed unit), the middle part MMC95-80 (which contains many stones, including much coarse clastic material >50 mm) and the upper part MMC50-2 (MMC1 being known to be a disturbed unit). The MMC units in the YS can be treated here as a single interval.

Looking at the two columns to the right of **figure 8.5** (% particles >0.5 mm and weight of particles >4 mm), the graphed traces within the YS interval show almost perfect correlation. This reflects the general continuity in particle size distribution to be expected in the majority of dominantly natural sediments (including scree bodies), a continuity approximating more or less closely to log-normal unimodality. This characteristic, although weakening slightly, can still be recognised upwards into the lower and middle intervals of the GS, suggesting that these sediments have not been too strongly affected by man. However, in the upper GS, the two traces are more or less decoupled – basically, these upper sediments are deficient in medium-sized stones. It is suggested that this is a sign of major alteration (remembering that the sedimentation rate had

	>4 mm	4-2 mm	2-1 mm	1-0.5 mm	Totals
MMC2-50	*16.50 % of total* 22.97 % burnt [b 164 : unb 550]	*25.03 % of total* 48.32 % burnt [b 533 : unb 550]	*44.08 % of total* 83.57 % burnt [b 1577 : unb 330]	*14.38 % of total* 92.28 % burnt [b 574 : unb 48]	*4326* 65.83 % burnt [b 2848 : unb 1478]
MMC80-95	*41.24 % of total* 4.90 % burnt [b 15 : unb 291]	*22.24 % of total* 20.61 % burnt [b 34 : unb 131]	*23.58 % of total* 49.14 % burnt [b 86 : unb 89]	*12.94 % of total* 64.58 % burnt [b 62 : unb 34]	*742* 26.55 % burnt [b 197 : unb 545]
MMC96-105	*30.89 % of total* 5.26 % burnt [b 2 : 36 unb]	*21.95 % of total* 40.74 % burnt [b 11 : unb 16]	*32.52 % of total* 40.00 % burnt [b 16 : unb 24]	*14.63 % of total* 66.67 % burnt [b 12 : 6 unb]	*123* 33.33 % burnt [b 41 : unb 82]

Tab. 2.6 Distribution of burnt and unburnt mollusc fragments in the GS. – (Data courtesy of V. Taylor).

slowed somewhat), principally due to repeated firing but probably also to other inadvertent human ablation activities, both chemical and physical.

Moving from one of the more robust components of the GS (stones) to one of the more fragile, it is interesting to compare the distribution (by counts) of size fractions and of burnt and unburnt fragments of mollusc shell in the three intervals defined here[63]. The figures are shown in **table 2.6**. Looking first at the size distributions, there are modes in both the >4 mm and the 2-1 mm fractions. However, the coarser mode is best developed in the middle GS, where fragments would have been captured and best protected within the open stony framework, and not present at all in the upper GS. Conversely, the 2-1 mm fraction is best developed in the upper GS and least developed in the middle GS. The lower GS shows broadly 'intermediate' characteristics. In the percentage of burnt fragments, there is now only one mode at each level, in the 1-0.5 mm fraction. The lower and middle GS are quite similar, with just a little more burning in most grades in the lower interval. It is the upper GS which shows by far the highest levels of burning, especially in the smaller fractions. Therefore, comminution of mollusca[64], accompanied by burning of the shells, follows broadly the pattern of marked increase in activity in the upper GS seen in many other characteristics of this anthropogenic interval.

The Special Case of Sector 10

Work in Sector 10 has necessarily prioritised the recovery of the complex suite of human remains and associated objects. At the 'bulk' level, the S10 fill is much more similar to the 'normal' Grey Series than to any

63 For the present purposes, it is not necessary to adjust the figures to reflect sample numbers or sedimentation rate, since the parameters of interest are within-sample variables.

64 Greater fragmentation still is reported in the YS in **Chapter 8**, which one assumes is the result of the vulnerability of shells under markedly slower sedimentation rates.

other deposit in the cave. However, if 'normal GS activities' were taking place actually in S10, such activities should have left traces (such as more or less ubiquitous signs of originally *in situ* burning/heating) and there should have been significant organisation of deposits ('stratification') – in fact, there are no such traces. On the other hand, the degree to which subsequent burials could have dispersed 'structured' remains/associations is not yet clear.

At this stage, one can only speculate, within the known parameters, and then attempt to identify further lines of enquiry that might lead to a better understanding. The nature of the Sector 10 sediments and the geometry of the depocentre (remembering that there was at least one very large limestone block in the 'approach' to S10 before removal by Roche) are such that it is extremely unlikely that the accumulation is merely due to natural transfer (by air, water or gravity alone) back from the main chamber of the cave. One might suggest simple 'dumping', with the principal objective of just getting rid of general 'waste', but this sits uncomfortably with the obviously very careful burial use of the area. The present author believes that there is enough to suggest, at least as a real possibility, the 'import' of sediment as a deliberate adjunct to the burial practices. One wonders whether 'grave cutting' (cf. survival of some basal cuts and disturbance of existing burials) and 'grave filling' (piling up loose ashy material, easily imported, over the top of new burials, with or without the formation of low and temporary mounds) might both have been techniques used. Imported material might have been more 'desirable' in phases where it had become difficult to dig new graves without encountering masses of existing bones (and/or when there was an increasing frequency of burials for some reason). Ashy sediment would help to desiccate bodies more quickly and thus control decomposition; on the other hand, early decomposition, or renewed decomposition due to wetting, would react with the surrounding ashes, possibly generating temporary voids and potential for subsequent displacements. Even the idea of constructing a new 'bank' of deposit, ready for new grave cuts, seems plausible (and might result in significant zones without burials, as have indeed been encountered in our excavations, if not used 'to capacity'), although the more 'organised' such activity became, the greater the chance of common stratigraphic boundaries that might survive to be found, boundaries which, in fact, are not apparent. In the present author's view, the idea of importing, say, basketfuls/hidefuls of GS sediment to S10 seems much more likely than accumulation due to 'ordinary habitation activity' between burial events, given the tight physical constraints towards the back of the cave.

Going back to first principles, therefore, if the S10 matrix is just 'dump' or the result of 'normal GS activities' actually in S10, then it should contain the full range of 'normal objects' (i.e. those robust categories which should have survived any amount of disturbance during the burials) in broadly similar proportions. Clearly, 'unusual objects' could have been added during burials but 'normal objects' are not likely to have been removed in significant numbers. If, on the other hand, the S10 matrix was more carefully selected from some contemporary activity areas located further out in the cave chamber, then the range of surviving objects may not include the full range of 'normal GS objects'.

All categories of finds from Sector 10 should be considered in this light in the future. One contribution to the discussion can already be provided from the 10-64 mm equivalent square aperture component of the stone content of S10 (**fig. 2.44g**). The stone type mix, with speleothem a little more common than dolostone but limestone very rare, compares well with samples from the early part of the typical Grey Series. Whilst the base of the grey material in S10 is somewhat 'earthy' (inclusion of mineral sediment), the main part of this unit is much more loose (than the base and than the chronologically equivalent units in Sector 8), with plenty of ash, fine burnt stone derivatives and crushed charcoal in the matrix (and there is strong paramagnetism). However, the 'burn index' of stones in S10 is the lowest of any sample yet examined from the cave, including samples from the 'normal' Yellow Series (that is, deposits from reasonably accessible areas, carrying significant traces of human occupation), an interesting anomaly possibly associated with fill selection for S10.

Fig. 2.60 Yellow Series/Grey Series Boundary in Sector 8, sqC24, E-W section, base of lithics column; slot is 1 m wide.

The the 'Brown Layer' below the ashy deposits in Sector 10 is a 'special case of a special case' (see figs 2.16 and 2.44h). It has been allocated (at the 'group' level) to the Grey Series because its structure points to an anthropogenic origin, this time, only disturbed by the base of burial cuts in a few obvious places and otherwise often with an interstratified (alternating lenses) upward transition zone. The fine detail of the structure (including zones with high-angle 'tip lines') suggests relatively rapid formation. In terms of sediment composition (as opposed to structure) it is somewhat 'intermediate' between more typical GS and YS material. It does contain some ash and finer charcoal dispersed through the generally more 'earthy' (mineral) matrix. A small sample of stones shows similarities, in both types (dominant speleothem) and burn index, to typical Yellow Series material. Many types of object are rather corroded and, noting also the strong sesquioxide content (especially manganese, which gives most of the brown colour), one suspects that the sediment originally contained significant soft organic matter. As with the ashy deposits above, it will be necessary to analyse all the components of this unit before the intent of its creators becomes clear.

The Transition between the Yellow Series and the Grey Series

Excavators in Sector 8 (particularly in respect of the L-series of units in the column excavated principally for lithic artefacts [cf. Chapter 12] and the MMC-series of units excavated principally for mollusc remains [cf. Chapter 8]) recognised sedimentary characteristics which they described as "transitional", at or just above the boundary between the YS and the GS (cf. Appendix 2). It is important that the geometric, structural, compositional and chronological characteristics of the sediments across this interval be understood as fully as possible, since there is a *prima facie* case to suspect significant cultural change. Both the 'typical' YS and GS have already been described and, as shorthand, it will be useful here to refer (with no great precision

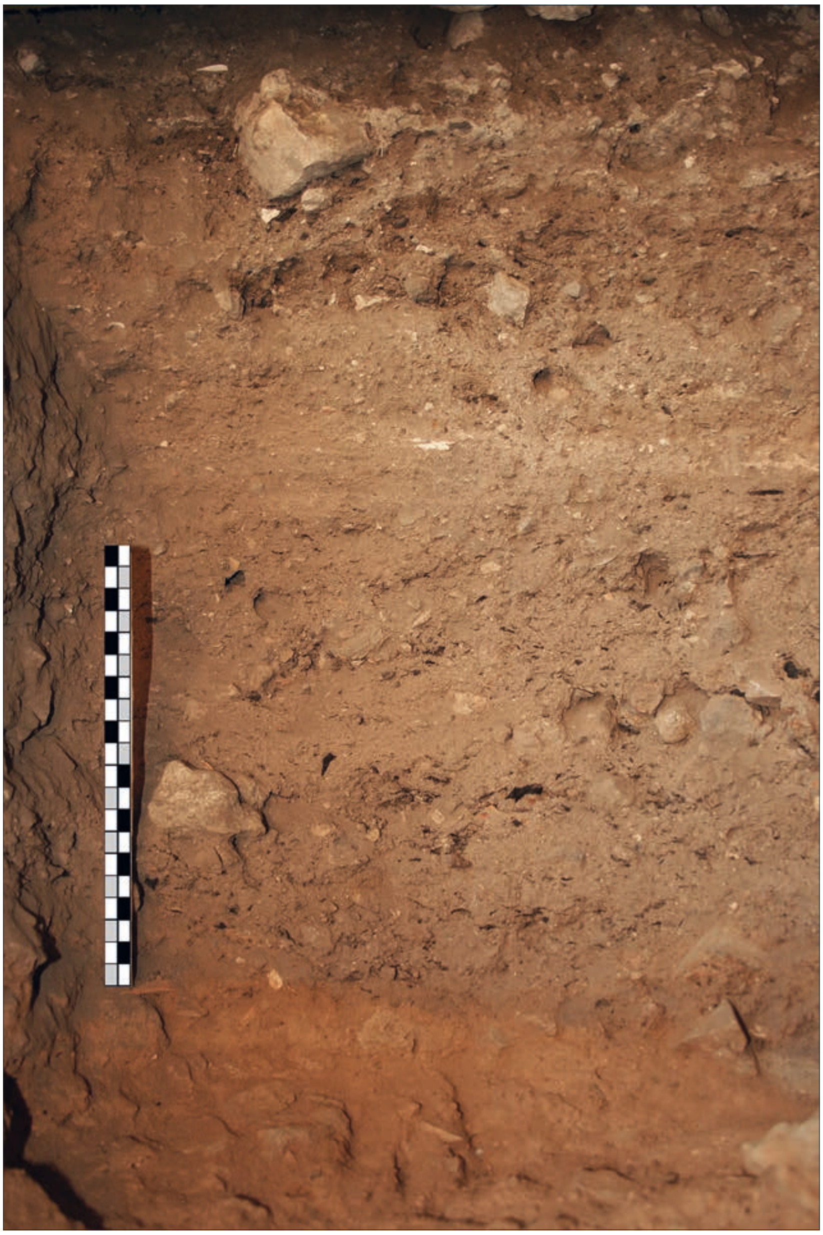


Fig. 2.61 Yellow Series/Grey Series Boundary in Sector 8, sqC23, E-W section, base of 'mollusc column' at base of scale. – Scale 20 cm.

or specificity intended) to the 'YS behavioural suite' and the 'GS behavioural suite' (including the massive increase in burning/heating and the bulk collection and processing of various foodstuffs) as those human causes contributing to these two sedimentation patterns.

In addition to earlier observations, the present author made a particular study of the boundary between the Grey and Yellow Series in 2016, wherever safe access was available, broadly in the vicinity of Sector 8. The bases of the lithics column (**fig. 2.60**) and the mollusc column were cleared (**fig. 2.61**). An earlier section, a little further into the cave, is shown in **figure 2.62**. Two new cuts were then made, one on each side of the latter (thus, on the east side, including the small 'baulk' before the lithics column), using the brush & air blower techniques (see above).

Here as in all other exposures, the GS/YS boundary is always sharp and erosive. The basal interval of the GS never contains discrete, naturally deposited lenses of YS-like material but it does contain (a) small heavily disturbed and contorted patches/blotches/smears and (b) a noticeable 'earthy' component mixed in more or less uniformly with the ashy component more typical of (most) higher units in the GS. As an

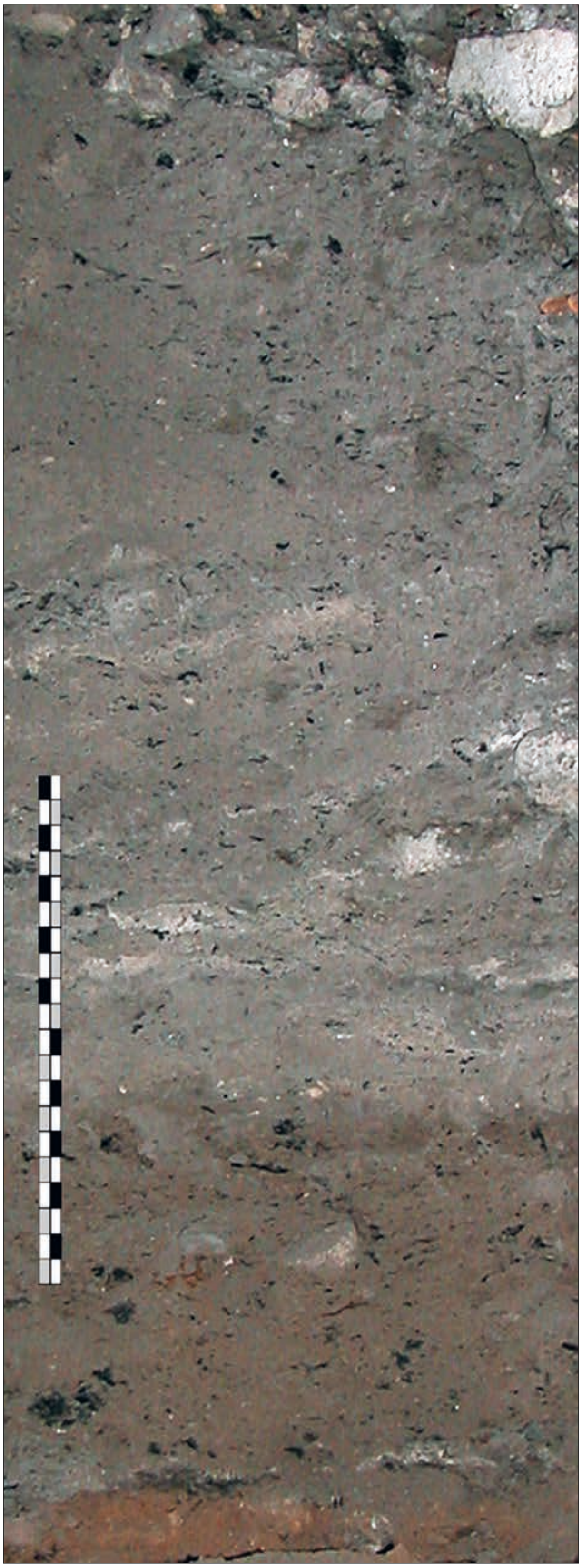


Fig. 2.62 Sector 8, sqB21, Units G96-6 to Y1, E-W section. – Scale 20 cm.

example of the (probably local maximum) degree of 'unconformity' between the two Series, **figure 2.62** shows the boundary only just over 1 m 'west' (into the cave) of the mollusc column, on a transverse line across the cave; the 20 cm scale is standing in a 'scrape' at the base of the GS, with the whole extent of the boundary shown cutting across the here more or less horizontal bedding in the underlying YS. A similarly irregular transverse boundary can be seen in **figure 2.28**.

The available evidence would suggest that the 'GS behaviour suite' was established quite quickly but, obviously, this would not happen right across the cave in the first instance – a finite time would have been needed to render the YS sediments 'inaccessible' to normal shallow disturbance activity. There does not appear to be any evidence to suggest that the 'GS behaviour suite' was initially 'occasional', with significant periods of site abandonment or reversion to 'non-GS behaviour' (remembering that the evidence for human presence in Y1 is itself strong). The fact that there do not appear to be any true 'alternations' between GS-like and YS-like sediments favours the interpretation that 'GS behaviour' spread out from one, or only a small number of *loci*, rather than being dotted randomly around the cave floor in the initial period. The 'GS behaviour suite' seems to have been adopted 'abruptly' at Taforalt (perhaps suggesting that the origin(s) of the behaviour(s) lay elsewhere) and to have continued more or less uninterrupted for well over two thousand years. This having been said, the question of actual 'intensity' arises.

The radiocarbon dates are not conclusive in this context within Sector 8 but there may be some evidence that some of the basal interval of the GS (equivalent to much of Unit L28, L29 at the very base being somewhat more chaotic) built up a little more gradually than much of the material immediately above, possibly even with a tempo increasing steadily from the initial 'switch'. Even the admixture of natural 'earthy' sediment (whether disturbed from the YS or, rather less likely, added by contemporary wash sedimentation) in the first c. 50 cm of GS suggests that it took some time for such material to be truly swamped by ash and burnt stone, etc. It may therefore be arguable that the intensity of 'GS behaviour' increased steadily from the rather abrupt starting point in Sector 8. Note that, whilst this is a real possibility, no attempt has been made, on the radiocarbon determinations alone, to show a separate sedimentation rate gradient for this initial GS interval in figure 2.17.

Looking at the dating evidence actually across the YS/GS boundary, especially paired, large individual charcoal samples (see Chapter 4) were collected (as close laterally as possible, aiming at the optimum of a vertical pair), from S8 proper, in sqC22, and from sqD17 (some 5-6 m westwards further into the cave, over the Deep Sounding), with the specific objective of trying to understand the irregular diachronic erosion event that separated the Grey Series from the Yellow Series.

In sqD17, pairs of samples were taken on the west (Pair A, GS OxA-22902 & YS OxA-22786) and east (Pair B, GS OxA-22784+duplicateOxA-22785 & YS OxA-22903) sides of the exposure; the boundary is here irregular and the YS laminations are dipping locally westwards, into the cave. In the case of Pair A, the highest YS material (demonstrably the stratigraphically highest YS in this area) may be slightly younger than the lowest GS material, consistent with the small observed anthropogenic 'digging' structures, cut downward in places from the GS, and with dip of the YS laminations, younging westwards. In the nearby case of Pair B, there is no temporal overlap across the boundary, suggesting a slight erosive gap at this point; the local inward dip probably also contributes to the greater age of the youngest YS on the eastern (outer) side of the square, especially when combined with the absolutely falling-eastwards (outwards) of the GS/YS boundary itself at this point in the cave.

In sqC22, pairs of samples were taken on the west (Pair C, GS OxA-22904 & YS OxA-22905) and east (Pair D, GS OxA-22787 & YS OxA-22788) sides of the exposure; the boundary is here reasonably straight (in the E-W plane) but the internal YS laminations are dipping very locally southwestwards, into the cave. In the case of Pair C, there is major overlap in the dates across the boundary, whilst, in the case of Pair D, there is no overlap; such variation plausibly results in part from non-uniform 'digging' activities at the base of the GS. The GS/YS boundary is reasonably horizontal (in the sample plane across this square in S8) but the very local back-dip in the highest surviving YS material may explain the poor overlap laterally, between the YS dates in Pairs C and D.

The above discussion is based upon only eight charcoal samples and, whilst the largest available fragments were collected to minimise the chances of redeposition, one simply cannot be sure that they are giving a full picture. On the other hand, the pattern of dates is entirely consistent with the sedimentological observations and interpretation. The dating model presented in Barton et al. (2013) suggested that the boundary between the Yellow and Grey Series occurred in the range of 15,190-14,830 cal BP (95.4 % probability). The current dataset (see fig. 2.17 and Chapter 4) suggests that this range might be very slightly too early but it cannot be far off – as an estimate for Sector 8. However, looking at this 360 year range, one must also remember that a calculation has been made that this would represent only a thickness of some 6 cm of YS sediment deposition. Both the observed obvious anthropogenic disturbance features and the more planar oblique local unconformities have a 'relief' in exposure of several times such a small thickness. Every effort has been made to pick the most representative points but what of the huge area of the GS/YS boundary that was removed by earlier excavations – did the boundary drift slightly higher or lower in different parts of the cave? One can only return to the observation that, in the long section of the cave (aligned with Sector 8) available to us, zones of interstratified GS/YS sediments do not occur, a situation which would be more and more improbable the greater the real diachronism across the cave geography in the shift to the GS behavioural suite. There is certainly no evidence in the available radiocarbon data to suggest that GS behaviour began markedly earlier in, say, the outer or the middle or the deeper parts of the main cave. That there may be, or have been, zones with greater erosional gaps (i. e. missing the top of the Yellow Series deposits) is a more realistic possibility.

Fig. 2.63 Yellow Series/Grey Series Boundary in Sector 8, sqD21, S-N section; boundary at base of scale. – Scale 20 cm.

When it comes to interpreting apparent change across the YS/GS boundary, it is difficult to see how any impression of continuity could be caused by upward-mixing from the YS, given the much lower density of most types of archaeologically significant 'finds' in the latter; this is, of course, a probabilistic conclusion, since individual 'finds' might indeed have been displaced. On the other hand, any impression of discontinuity could be affected (augmented) by the degree of truncation and mixing.

R. I. MACPHAIL

3. SEDIMENT MICROMORPHOLOGY

3.1 INTRODUCTION

Grotte des Pigeons at Taforalt, Morocco, has a long history of geoarchaeological investigation, including the use of soil micromorphology (Barton et al., 2013; Courty/Goldberg/Macphail 1989, 216-227). This current study involves the analysis of seven large (max 100 × 60 mm) thin sections from the 2009 excavation of the Grey and underlying Yellow Series in Sector 8. The samples were taken by Peter Ditchfield and supplied to the present author by Nick Barton, Institute of Archaeology, University of Oxford. The slides had been made at Reading University and were partly studied for an MSc dissertation (Jones 2013).

3.2 METHODS

The thin sections (**tab. 3.1**) were analysed using a petrological microscope under plane polarised light (PPL), crossed polarised light (XPL), oblique incident light (OIL) and using fluorescence microscopy (blue light – BL), at magnifications ranging from x1 to x200/400. Thin sections, which sample between 0-70 mm and 0-100 mm depth of sediment, were described with a relative zero at the top of each slide. Sediments were ascribed soil microfabric types (SMTs) and microfacies types (MFTs) (see **tabs 3.1-3.2**), and counted according to established methods (Bullock et al. 1985; Courty 2001; Courty/Goldberg/Macphail 1989; Goldberg/Macphail 2006; Karkanas/Goldberg 2018; Macphail/Goldberg 2018a; Nicosia/Stoops 2017; Stoops 2003; Stoops/Marcelino/Mees 2018). Previous studies of the lower (pre-LSA) levels at Grotte des Pigeons (Courty/Goldberg/Macphail 1989, 216-227) and relatively nearby and similarly dated Gibraltar, e.g. Vanguard Cave (Macphail/Goldberg/Barton 2012), also proved useful.

3.3 RESULTS AND INTERPRETATION

Soil micromorphology results are presented in detail in **tables 3.1-3.2**, and illustrated in **figures 3.1-3.48**. Twenty-four characteristics and micro-inclusions were identified and counted from the 9 intervals in the 7 thin sections analysed, as measured from a relative zero at the top of each slide.

Thin section	Exact Lithological Unit(s)	Relative depth	MFT	SMT	Voids	Gravel	Shell	Burnt shell
S8-10-MM2	S8-09/10-L13	0-95 mm	D1	3a, 3b	35 %	*-ff-fff	ffff	aaaa
S8-10-MM3	S8-09/10-L28 (upper)	0-100 mm	C3	3b, 3a	20 %-45 %	ff-fff	*	aaa-a*
S8-09-MM6	S8-09/10-L28 (lower)	0-70 mm	C2	3b	35 %	fff	f	aa
S8-09-MM7	S8-L29 [base of Grey Series]	0-60(70) mm	C1	3a(1c)	45 %	fff	f	
S8-09-MM7	S8-L30 [top of Yellow Series]	60(70)-80 mm	A3	1c	40 %	ffff	*	
S8-09-MM8	S8-Yell08[2-12] [equivalent to the middle part of S8-Y1]	0-75 mm	A2	1b	40 %	fff	*	
S8-09-MM9	Unit S8-Yell08[16-18] and part of Unit [12-16] [equivalent to the upper part of S8-Y2spit1]	0-25 mm	B2	FS-2a-1a	35-40 %		*	
S8-09-MM9	upper part of Unit S8-Yell08[18-23] [equivalent to the middle part of S8-Y2spit1]	25-75 mm	B1	FS,1b/1b2a,2b,FS	40 %	*	*	
S8-09-MM10	centred on S8-Yell08[33-38] [equivalent to part of S8-Y2spit2]	0-70 mm	A1	1a	35 %	ff	f	

Thin section	Root residues	Charcoal	Bone	Burnt bone	Fish bone	$CaCO_3$	Burnt chert	Wetland? clay	Coprolite (hyaena?)	CaP guano?	Poss omniv cop	Burnt soil	Burnt lime/spel
S8-10-MM2		aaaaa	a	aaaa		aaaa		a*				a*	a*
S8-10-MM3	a*	aaaaa		aaa	?	aaaaa		a*				a(aaa)	aaaaa
S8-09-MM6	a(a)	aaaaa		aaaa		aaaaa		a(burnt)				a(aaa)	aaaaa
S8-09-MM7		aaaaa	a	aaa		aaaa	a-1	aa				a	aaa
S8-09-MM7	a*	aaa	aaa	a*					aaa	?			
S8-09-MM8		aaaa	aaaaa	a	a*?				aaaaa	a*	a*	(a*)	
S8-09-MM9		a*											
S8-09-MM9		a	a*						a*				
S8-09-MM10		aaa	aaa	a			a-1			aaa		a-1	

Thin section	Matrix infills	2ndary $CaCO_3$	$CaCO^3$	Neoform speleothem	Thin burrows	Broad burrows	V. thin organo-min. excr.	Thin organo-min. excr.	Broad organo-min. excr.
S8-10-MM2					aaaaa	aaaa	aaaaa	aaa	
S8-10-MM3		aa			aaaa	aaaaa	aaa	aaaaa(tot)	
S8-09-MM6		aa	a*		aaaaa	aaaaa	aaaaa	aaaa	
S8-09-MM7					aaaaa	aaa	aaaaa	aaaa	
S8-09-MM7		a-1	a-1		aaaaa	aa	aaaaa	aaa	

Thin section	Matrix infills	2ndary $CaCO_3$	$CaCO^3$	Neoform speleothem	Thin burrows	Broad burrows	V. thin organo-min. excr.	Thin organo-min. excr.	Broad organo-min. excr.
S8-09-MM8	a				aaaaa	aaaaa	aaaaa	aaaa	aaa(tot)
S8-09-MM9	(aa)	aa	a	aa	aa	a	aaa	a	
S8-09-MM9	aa	aaaa	aaa	aaa	aaaa	aaaaa	aaaaa	aa	
S8-09-MM10	aaaa	a			aaa	aaaa	a	aaa	aaaaa(tot)

Tab. 3.1 Taforalt Cave, Morocco: soil micromorphology samples and counts. – * = very few 0-5 %; f = few 5-15 %; ff = frequent 15-30 %; fff = common 30-50 %; ffff = dominant 50-70 %; fffff = very dominant >70 %; a = rare <2 % (a*1 %; a-1; single occurrence); aa = occasional 2-5 %; aaa = many 5-10 %; aaaa = abundant 10-20 %; aaaaa = very abundant >20 %.

Microfacies type (MFT)/Soil micro-fabric type (SMT)	Sample No.	Depth (relative depth) Soil Micromorphology (SM)	Summary and Comments
MFT D1/SMT 3a, 3b	S8-10-MM2	0-95 mm SM: very dominant very shell-rich calcitic grey and darkish grey ash residues (SMT 3a), with common sub-horizontally oriented shell, and frequent burrow fills of more charcoal-rich ashy sands (SMT 3b); *Microstructure*: massive with both sloping broad layering and sub-horizontal diffuse fine layering, and pellety, 35 % voids, complex packing voids, open sub-horizontal fissures; *Coarse Mineral*: as SMT 3a and 3b, with for example layers of very few gravel (30-60 mm depth), common gravel-size material (c. 60-80 mm depth; max 5 mm, burnt soil; with coarse bone, 12 mm), and frequent gravel at 15-30 mm depth (max 9 mm, limestone); *Organic and Anthropogenic*: abundant fine to coarse charcoal throughout, with bands (max 9 mm) of very abundant and associated calcitic crystals and ash *sensu lato* which is patchily abundant throughout, very abundant shell with abundant burnt shell, often showing sub-horizontal orientation, and with broken fragments, abundant mainly fine bone with coarse examples (max 13 mm), very dominantly rubefied, some of possible coprolitic origin, rare trace of clay clasts and unburnt reddish soil, fine burnt soil (max 5 mm) and burnt limestone and other minerogenic material and a possible 2 mm size chert flake(?); *Fine Fabric*: as SMT 3a and 3b; *Pedofeatures*: *Fabric*: very abundant thin and abundant broad burrows; *Excrements*: very abundant very thin and many thin organo-mineral excrements, with loose total excremental microfabric.	S8-09/10-L13 The uppermost sample of the Grey Series is made up of very dominant, very shell-rich calcitic grey and darkish grey ash residues, with common sub-horizontally oriented shell (**figs 3.43-3.46**), and frequent burrow fills of more charcoal-rich ashy sands, with for example layers within the thin section of the following materials: very few gravels at 30-60 mm depth; common gravel-size material at c. 60-80 mm depth (max 5 mm, burnt soil; with coarse bone, 12 mm); and frequent gravel at 15-30 mm depth (max 9 mm, limestone). There are abundant fine to coarse charcoals throughout, with bands (max 9 mm) of very abundant and associated calcitic crystals and ash *sensu lato* which is patchily abundant throughout, very abundant shell with abundant burnt shell, often showing sub-horizontal orientation, and with broken fragments, abundant mainly fine bone with coarse examples (max 13 mm), very dominantly rubefied but some of possible coprolitic origin, rare trace of clay clasts and unburnt reddish soil, fine burnt soil (max 5 mm) and burnt limestone and other minerogenic material, and a possible 2 mm size chert flake(?) (**figs 3.47-3.48**). Very abundant thin and abundant broad burrows, and very abundant very thin and many thin organo-mineral excrements, with loose total excremental microfabric.

Tab. 3.2 Taforalt Cave, Morocco: soil micromorphology descriptions and preliminary comments.

Microfacies type (MFT)/Soil micro-fabric type (SMT)	Sample No.	Depth (relative depth) Soil Micromorphology (SM)	Summary and Comments
MFT C2/SMT 3b, 3a	S8-10-MM3	0-100 mm SM: broadly and diffusely layered and broadly burrowed composed of dominant dark brownish grey fine charcoal-rich calcitic ash residues (SMT 3b) fine charcoal-rich dusty calcitic grey silty sands (SMT 3a); *Microstructure*: massive, with open 45 % voids (complex packing voids mainly) in broad burrows and compact 20 % voids (fine channels) throughout generally; *Coarse Mineral*: as SMT 3a and 3b, with common gravel and small stones (e.g. burnt limestone – max 19 mm) in broad burrowed areas, and frequent gravel (max 6 mm) in compact deposits; *Organic and Anthropogenic*: abundant fine and coarse charcoal (max 7 mm), many rubefied bone (max > 11 mm), very abundant burnt limestone and speleothem and abundant ash residues in broad burrows, and generally very abundant fine and coarse charcoal (max 9 mm), abundant rubefied fine bone (max c. 2 mm), many burnt soil and fine minerogenic inclusions, very abundant burnt limestone and speleothem and very abundant ash and semi-cemented ash, with embedded very fine charcoal, rare shell (max 5 mm) and many burnt shell including bivalve material (max 5 mm), often with charcoal sometimes showing sub-horizontal orientation, and with 5 mm example of clay, with trace of very fine fibrous roots; *Fine Fabric*: *Pedofeatures*: *Depletion*: examples of included partially decalcified speleothem; *Crystalline*: occasional recalcifications and example of partial micritisation of burnt bone; *Fabric*: abundant thin and very abundant broad burrows; *Excrements*: many very thin and very abundant thin organo-mineral excrements, with compacted total excremental microfabric.	S8-09/10-L28 (upper) This upper part of L28 is broadly and diffusely layered and broadly burrowed (**fig. 3.36**). It is composed of dominant dark brownish grey fine charcoal-rich calcitic ash residues fine charcoal-rich dusty calcitic grey silty sands. Common gravel and small stones (e.g. burnt limestone, max 19 mm) in broad burrowed areas, and frequent gravel (max 6 mm) in compact deposits. Abundant fine and coarse charcoal (max 7 mm), many rubefied bone (max > 11 mm), very abundant burnt limestone and speleothem and abundant ash residues were found in broad burrows, while generally very abundant fine and coarse charcoal (max 9 mm), abundant rubefied fine bone (max c. 2 mm), many burnt soil and fine minerogenic inclusions, very abundant burnt limestone and speleothem and very abundant ash and semi-cemented ash, with embedded very fine charcoal, rare shell (max 5 mm) and many burnt shell including bivalve material (max 5 mm), often with charcoal sometimes showing sub-horizontal orientation, and with 5 mm example of clay, with trace of very fine fibrous roots (**figs 3.36-3.42**). Occasional recalcifications and an example of partial micritisation of burnt bone, abundant thin and very abundant broad burrows, and many very thin and very abundant thin organo-mineral excrements, with compacted total excremental microfabric.

Microfacies type (MFT)/Soil micro-fabric type (SMT)	Sample No.	Depth (relative depth) Soil Micromorphology (SM)	Summary and Comments
MFT C2/SMT 3b	S8-09-MM6	SM: very dominant dark brownish grey calcitic ash residues (SMT 3b) with patches and broad burrow fills of fine charcoal-rich dusty calcitic grey silty sands (SMT 3a); *Microstructure*: massive, pellety and channel, 35 % voids, complex packing voids, chambers and channels; *Coarse Mineral*: C:F=65:35, moderately poorly sorted with quartz and feldspar sand, and with sand-size probably burnt limestone, speleothem and fused calcitic ash clasts; also present are common gravel-size clasts of limestone, burnt limestone and speleothem variants (max 8 mm); *Organic and Anthropogenic*: very abundant fine to coarse charcoal (max 9 mm), including several examples of sub-horizontally oriented material, very abundant ash residues (examples of plant tissue remains) and blackened and fissured burnt limestone and speleothem throughout, many shell (including much burnt shell, many bivalve and gastropod examples), abundant bone, mainly weakly to strongly rubefied burnt bone (max 15 mm), rare burnt red silt loam soil (max 3.5 mm) and possible 'wetland clay' (max 6 mm), occasional very fine to fine root remains, some fibrous (max 1.5 mm), some earlier calcitic pseudomorphs; *Fine Fabric*: SMT 3b: cloudy dark brownish grey (PPL), moderately high to high interference colours (compact intergrain aggregate to loose open porphyric, crystallitic b-fabric, XPL), pale brownish grey (OIL), with weak iron stained amorphous organic matter staining and occasional very fine charcoal; *Pedofeatures*: *Depletion*: many areas of partial decalcification of microfabric, with many partially decalcified inclusions (speleothem fragments); *Crystalline*: occasional micritic calcite infilling and void coatings, and root pseudomorphs, with possible layer cementation; *Fabric*: very abundant thin and broad burrows; *Excrements*: very abundant very thin and abundant thin organo-mineral excrements.	S8-09/10-L28 (lower) Very dominant dark brownish grey calcitic ash residues with patches and broad burrow fills of fine charcoal-rich dusty calcitic grey silty sands, with common gravel-size clasts of limestone, burnt limestone and speleothem variants (max 8 mm) (**figs 3.32-3.35**). Very abundant fine to coarse charcoal (max 9 mm), including several examples of sub-horizontally oriented material, very abundant ash residues (examples of plant tissue remains) and blackened and fissured burnt limestone and speleothem throughout, many shell fragments, including much burnt shell, and many bivalve and gastropod examples (**figs 3.32-3.35**). As found below, there is abundant bone, which is mainly weakly to strongly rubefied burnt bone (max 15 mm), rare burnt red silt loam soil (max 3.5 mm) and possible 'wetland clay' (max 6 mm). Occasional very fine to fine root remains (some fibrous. max 1.5 mm) and some earlier-formed calcitic pseudomorphs. Occasional micritic calcite infilling and void coatings, and root pseudomorphs, with possible layer cementation, very abundant thin and broad burrows, and very abundant very thin and abundant thin organo-mineral excrements.

Tab. 3.2 (continued)

Microfacies type (MFT)/Soil micro-fabric type (SMT)	Sample No.	Depth (relative depth) Soil Micromorphology (SM)	Summary and Comments
MFT C1/SMT 3a (1c)	S8-09-MM7	0-60(70) mm SM: Very dominant fine charcoal-rich dusty calcitic grey silty sands (SMT 3a), with few patches of greyish reddish brown weakly calcitic clay loam (SMT 1c); *Microstructure*: massive, diffusely layered, with occasional sub-horizontal orientation of coarse inclusions, 45 % voids, channels, chambers and complex packing voids; *Coarse Mineral*: C:F=70:30, poorly sorted with silt, fine sand (quartz, feldspars, calcite), with medium and coarse sand (limestone, sandstone, speleothem), and common gravel to stone size clasts (shell, speleothem, limestone: max >25 mm); *Organic and Anthropogenic*: example of possible fire-cracked siliceous rock (9 mm), occasional fine clay clasts with example of 8 mm long flattish pale brown and very weakly humic clay fragment (phytoliths and spore/pollen and fine channel microstructure present – wetland clay?), with associated very fine red-burnt(?) mineral material, with rare examples of burnt(?) 'clay' (max 3.5 mm: soil clasts with relict root channels), many likely burnt(?) limestone with attached speleothem (cracked and blackened), very abundant bone, including many burnt bone (max 13 mm – both strongly rubefied to weakly calcined), very abundant fine to coarse charcoal, including 10 mm long sub-horizontally oriented material, with abundant ash residues throughout and a rare trace of isotropic (hyaena?) coprolite (at the very base of this mixed layer); *Fine Fabric*: SMT 3a: dusty and dotted cloudy grey (PPL), patchy high interference colours (intergrain aggregate, linked grain and porphyric, crystallitic b-fabric, XPL), very pale brownish grey (OIL), abundant very fine charcoal and charred organic matter, with phytoliths and probable calcitic ash present; *Pedofeatures*: *Depletion*: probable many areas of partial decalcification of microfabric, with partially decalcified inclusions (speleothem fragments); *Fabric*: very abundant thin and many broad burrows; *Excrements*: very abundant very thin and abundant thin organo-mineral excrements.	*S8-L29 [base of Grey Series]* The upper part of this slide (L29) shows a marked change to very dominant fine charcoal-rich dusty calcitic grey silty sands, with a few patches of greyish reddish brown weakly calcitic clay loam, diffusely layered, with occasional sub-horizontal orientation of coarse inclusions (**fig. 3.20**). Common gravel to stone-size clasts (shell, speleothem, limestone: max >25 mm), an example of possible fire-cracked siliceous rock (9 mm), occasional fine clay clasts with an example of an 8 mm long flattish pale brown and very weakly humic clay fragment. The clay embeds phytoliths and spores/pollen and has a fine channel microstructure, which together suggest that it is wetland clay sediment. The deposit also includes very fine red-burnt(?) mineral material, with rare examples of burnt(?) 'clay', some examples (max 3.5 mm) being soil clasts with relict root channels. In addition, many likely burnt(?) limestone clasts with attached speleothem that are cracked and blackened, very abundant bone, including many burnt strongly rubefied to weakly calcined bone (max 13 mm), and very abundant fine to coarse charcoal, including 10 mm long sub-horizontally oriented material. There are abundant ash residues throughout but only a rare trace of isotropic (hyaena?) coprolite was identified at the very base of this mixed unit) (**figs 3.24-3.31**). Many areas of partial probable decalcification of microfabric, with partially decalcified inclusions (speleothem fragments), very abundant thin and many broad burrows, and very abundant very thin and abundant thin organo-mineral excrements. There is a diffuse boundary to L30 below.

Microfacies type (MFT)/Soil micro-fabric type (SMT)	Sample No.	Depth (relative depth) Soil Micromorphology (SM)	Summary and Comments
MFT A3/SMT 1c	S8-09-MM7	Diffuse boundary 60(70)-80 mm SM: Very dominant pale greyish reddish brown weakly calcitic gravelly clay loam (SMT 1c); *Microstructure*: massive, pellety, 40 % voids, complex packing voids and channels; *Coarse Mineral*: as SMT 1a, with dominant gravel and small stone-size clasts (max 12 mm, mainly partially decalcified speleothem and attached limestone, with (hyaena?) coprolites; *Organic and Anthropogenic*: many fine charcoal (max 1 mm), fine bone (max 1 mm, with heated bone examples) and (hyaena?) coprolites (max c. 2.5 mm), with probable recent root material within 5 mm wide rhizolith – calcitic void hypocoating; *Fine Fabric*: SMT 1c: cloudy pale greyish reddish brown (PPL), moderate interference colours (intergrain aggregate and porphyric, crystallitic b-fabric, XPL), pale greyish orange (OIL), occasional very fine amorphous organic matter and charred OM; *Pedofeatures*: *Depletion*: very abundant partially decalcified inclusions (speleothem fragments); *Crystalline*: example of 5 mm-size calcitic root channel hypocoating; *Fabric*: very abundant thin and occasional broad burrows; *Excrements*: very abundant very thin and many thin organo-mineral excrements, with partial total excremental microfabric.	S8-L30 [top of Yellow Series] The lower part (L30) of this thin section sample is composed of a very dominant pale greyish reddish brown weakly calcitic gravelly clay loam, with dominant gravel and small stone-size clasts (max 12 mm, mainly partially decalcified speleothem and attached limestone, with (hyaena?) coprolites (**figs 3.20-3.23**)). Present are: many fine charcoal (max 1 mm), fine bone (max 1 mm with heated bone examples) and (hyaena?) coprolites (max c. 2.5 mm), with probable recent root material within 5 mm wide rhizoliths (calcitic void hypocoating). The interval is characterised by very abundant partially decalcified inclusions (speleothem fragments), an example of a 5 mm-size calcitic root channel hypocoating (**figs 3.21-3.23**), very abundant thin and occasional broad burrows and very abundant very thin and many thin organo-mineral excrements, with partial total excremental microfabric.

Tab. 3.2 (continued)

Microfacies type (MFT)/Soil micro-fabric type (SMT)	Sample No.	Depth (relative depth) Soil Micromorphology (SM)	Summary and Comments
MFT A2/SMT 1b	S8-09-MM8	0-75 mm SM: homogeneous poorly to moderately calcitic darkish reddish brown clay loam and sandy loam variants (SMT 1b); *Microstructure*: massive, pellety, channel, 40 % voids, channels, chambers and complex packing voids; *Coarse Mineral*: as SMT 1a, poorly sorted silts and fine sands, with medium and coarse sands, and common gravel size clasts of speleothem (max 7 mm) and limestone, with bone and coprolites for example; *Organic and Anthropogenic*: very abundant grey, isotropic BL autofluorescent coprolites (max 4 mm; likely hyena with embedded silt, and examples with channel pseudomorphs of hair/fur), <1 mm size orange brown coprolites – one with embedded charred organic matter and red-burnt(?) mineral matter (possibly omnivore – possibly human??), very abundant fine to coarse bone (max 7.5 mm; including very poorly preserved examples [coprolitic – example embedded in phosphatised sediment], rare probably burnt bone, possible bird and fish bones material), abundant fine to coarse wood charcoal (max 8 mm), and rare trace of guano and very fine red-burnt(?) mineral matter; *Fine Fabric*: as SMT 1a, darkish cloudy and finely speckled reddish brown (PPL), XPL as SMT 1a, orange to darkish orange (OIL), abundant very fine organic traces and charred organic matter; *Pedofeatures*: *Textural*: rare matrix infills; *Depletion*: rare trace of decalcified inclusions; *Fabric*: very abundant thin and broad burrows; *Excrements*: very abundant very thin, abundant thin and many broad organo-mineral excrements, with partial total excremental microfabric.	*S8-Yell08[2-12] [equivalent to the middle part of S8-Y1]* Homogeneous poorly to moderately calcitic darkish reddish brown clay loam and sandy loam variants, composed of poorly sorted silts and fine sands, with medium and coarse sands, and common gravel size clasts of speleothem (max 7 mm) and limestone, together with coarse bone and coprolites (**fig. 3.13**). The last include very abundant grey, isotropic BL autofluorescent coprolites (max 4 mm; likely hyena with embedded silt. Other <1 mm size orange brown coprolites were observed, one with embedded charred organic matter and red-burnt(?) mineral matter, which is possibly from an omnivore (human?), and which is moderately to moderately strongly autofluorescent under BL and contains fine spores/pollen (<~50 µm). Also, very abundant fine to coarse bone (max 7.5 mm; including very poorly preserved examples (coprolitic – example embedded in phosphatised sediment), rare probably burnt bone, possible bird and fish bones material), abundant fine to coarse wood charcoal (max 8 mm), and rare traces of guano and very fine red-burnt(?) mineral matter (**figs 3.13-3.19**). Rare matrix infills, a rare trace of decalcified inclusions, very abundant thin and broad burrows, and very abundant very thin, abundant thin and many broad organo-mineral excrements, with partial total excremental microfabric.

Microfacies type (MFT)/Soil micro-fabric type (SMT)	Sample No.	Depth (relative depth) Soil Micromorphology (SM)	Summary and Comments
MFT B2/SMT FS over 2a over 1a	S8-09-MM9	0-25 mm Somewhat fragmented, but with: SM: layers of fine to medium sands (SMT FS) over strongly calcareous grey fine sandy loam (SMT 2a), and over laminated moderately calcitic reddish brown clay loam and loamy sand types (SMT 1a); *Microstructure*: massive, layered, 35-40 % voids, channels, simple packing voids upwards; *Coarse Mineral*: silts and fine sands, with upper layer of moderately well sorted fine to medium sands; *Organic and Anthropogenic*: trace of fine charcoal; *Fine Fabric*: as SMT 1a, 2a and FS; *Pedofeatures*: *Textural*: very abundant essentially decalcified clayey laminae (panning) at c. 16-22 mm depth with occasional matrix intercalations; *Depletion*: nothing evident; *Crystalline*: occasional mainly micritic microlaminated speleothem growths and rare root channel hypocoatings and rare root pseudomorphs; *Fabric*: occasional thin and rare broad burrows; *Excrements*: many very thin and rare thin organo-mineral excrements at c. 12-16 mm.	*Unit S8-Yell08[16-18] and part of Unit [12-16] [equivalent to the upper part of S8-Y2spit1]* Somewhat fragmented in this upper part of the slide, but with clear layers of fine to medium sands over strongly calcareous grey fine sandy loam; below these are laminated moderately calcitic reddish brown clay loam and loamy sand types (**figs 3.6, 3.11-3.12**). A trace of fine charcoal. Very abundant essentially decalcified clayey laminae (panning) at c. 16-22 mm depth with occasional matrix intercalations, occasional mainly micritic microlaminated speleothem growths and rare root channel hypocoatings and rare root pseudomorphs, occasional thin and rare broad burrows, and many very thin and rare thin organo-mineral excrements at c. 12-16 mm.

Tab. 3.2 (continued)

Microfacies type (MFT)/Soil micro-fabric type (SMT)	Sample No.	Depth (relative depth) Soil Micromorphology (SM)	Summary and Comments
MFT B1/SMT FS, 1b over SMT 1b, 2a, 2b, FS	S8-09-MM9	35-75 mm SM: heterogeneous with dominant (broad and thin burrow-mixed) reddish grey moderately calcareous fine sandy clay loam (SMT 1b), strongly calcareous grey fine sandy loam (SMT 2a) and loamy fine sands (SMT 2b), with increasingly common fine sand concentrations (SMT FS) upwards (c. 25-40 mm); *Microstructure*: massive, with relict layering, pellety and channel, 40 % voids, simple and complex packing voids, chambers and channels; *Coarse Mineral*: C:F – 2a=70:30, 2b=90:10, moderately well sorted silts and fine sands, with very few medium, and coarse sands, and gravel (max 8 mm – speleothem/limestone clast); mineralogy as below with only examples of shell; *Organic and Anthropogenic*: rare wood charcoal (max 4 mm), an example of CaP coprolite (1.5 mm; fine channels possibly pseudomorphic of hair – hyaena?) and trace of fine bone (< 1 mm; possible hollow bird bone example), and example of eggshell (c. 1 mm); *Fine Fabric*: SMT 1b: grey red (PPL), moderately high interference colours (XPL as SMT 1a), pale orange (OIL), rare very fine charcoal; SMT 2a and 2b: pale reddish grey (PPL), high interference colours (XPL as SMT 1a), grey (OIL), minerogenic; *Pedofeatures*: *Textural*: occasional clayey infills (panning); *Depletion*: nothing evident; *Crystalline*: many mainly micritic microlaminated speleothem growths and many root channel hypocoatings and rare root pseudomorphs; *Fabric*: abundant thin and very abundant broad burrows (including mixing reddish clay downwards); *Excrements*: very abundant very thin, and occasional organo-mineral excrements.	*Upper part of Unit S8-Yell08[18-23] [equivalent to the middle part of S8-Y2spit1]* Heterogeneous with dominant (including a mix of broad and thin burrows) reddish grey moderately calcareous fine sandy clay loam, strongly calcareous grey fine sandy loam and loamy fine sands, with increasingly common fine sand concentrations upwards (c. 35-40 mm; **figs 3.6-3.8**). Moderately well sorted silts and fine sands, with very few medium and coarse sands, and gravel (max 8 mm – speleothem/limestone clast) (cf. Vanguard Cave: Macphail/Goldberg/Barton 2012). Rare wood charcoal (max 4 mm), examples of CaP coprolites (max 1.5 mm; vesicles formed by 'trapped gas' and fine channels possibly pseudomorphic of hair – hyaena?; see MM8, **figs 3.13-3.14**) (Horwitz/Goldberg 1989; Karkanas/Goldberg 2018, 68-71; Larkin/Alexander/Lewis 2000; Macphail/Goldberg 2012). Trace amounts of fine bone (< 1 mm; including possible hollow bird bone example) and example of eggshell (c. 1 mm). Cave soil is characterised by occasional clayey infills (panning), no evident decalcification, many mainly micritic microlaminated speleothem growths and many root channel hypocoatings and rare root pseudomorphs (**figs 3.9-3.10**) (Durand/Monger/Canti 2010; Gillieson 1996), abundant thin and very abundant broad burrows (including mixing of reddish clay downwards), very abundant very thin, and occasional thin organo-mineral excrements.

Microfacies type (MFT)/Soil microfabric type (SMT)	Sample No.	Depth (relative depth) Soil Micromorphology (SM)	Summary and Comments
MFT A1/SMT 1a	S8-09-MM10	0-70 mm SM: essentially homogeneous moderately to strongly calcitic reddish brown clay loam and sandy loam variants (SMT 1a); *Microstructure*: massive, with areas of diffuse layering, and with current channel and chamber, 35 % voids, channels, chambers, and with relict fine vughs; *Coarse Mineral*: C:F (Coarse:Fine ratio limit at ~10 µm) – 70:30 to 85:15; unsorted coarse silts and fine sands, and with medium and coarse sands (quartz, feldspar, calcite, shell, limestone), and frequent gravel to small stones (max 17 mm; shell, speleothem, examples of cave soil clasts, bone, coprolite and flint – see below); *Organic and Anthropogenic*: many fine and coarse wood charcoal (max 6 mm), probable example of 13 mm-size angular fire cracked flint, many fine bone, including variously preserved/coprolitic and with heated to burnt examples (rubefied to strongly blackened; max 3.5 mm), according to PPL colour and autofluorescence under BL; occasional fine shell (max 4 mm), and many phosphatic nodules (~CaP), some of diffusely layered probable guano origin; and possible example of blackened (burnt/) humic cave soil clast (1.5 mm); *Fine Fabric*: SMT 1a: dusty and cloudy reddish brown (PPL), moderate to moderately high interference colours (open to close porphyric, crystallitic b-fabric, XPL), orange (OIL), many to abundant very fine blackened and sometimes charred organic matter; *Pedofeatures*: *Textural*: abundant relict diffuse layering (panning), and broad void infills of matrix material (decalcified clay); *Depletion*: partial decalcification has affected calcite and speleothem clasts; *Crystalline*: rare sparitic calcite void infills; *Fabric*: many thin and abundant broad burrows; *Excrements*: rare very thin, many thin and very abundant broad organo-mineral excrements and areas of total excremental fabric.	*Centred on S8-Yell08[33-38] [equivalent to part of S8-Y2spit2]* Essentially homogeneous moderately to strongly calcitic reddish brown clay loam and sandy loam variants, composed of unsorted coarse silts and fine sands, and with medium and coarse sands (quartz, feldspar, calcite, shell), and frequent gravel to small stones (max 17 mm; shell, speleothem, examples of cave soil clasts, bone, coprolite and flint – see below) (**fig. 3.1**). There are many fine and coarse wood charcoal (max 6 mm), probable example of 13 mm-size angular fire cracked chert (**figs 3.1-3.2**), many fine bone, including variously preserved/coprolitic and with heated to burnt examples (rubefied to strongly blackened; max 3.5 mm; **fig. 3.3**); this is according to PPL colour and autofluorescence under BL. Occasional fine shell (max 4 mm), and many phosphatic nodules (~CaP), some being of probable hyaena coprolite origin (see main text), some of diffusely layered probable guano origin (Karkanas/Goldberg 2018, 68-71; Karkanas et al. 2002; Shahack-Gross/Berna/Karkanas/Weiner 2004) (cf. Vanguard Cave: Macphail/Goldberg/Barton 2012) (**fig. 3.4**); and possible example of blackened (burnt/) humic cave soil clast (1.5 mm), probably linked to a combustion zone, where cave soil had become incorporated. Abundant relict diffuse layering (panning), and broad void infills of matrix material (decalcified clay; **fig. 3.5**)), partial decalcification affecting some calcite and speleothem clasts, rare sparitic calcite void infills, many thin and abundant broad to very broad (1-5 mm) burrows; and rare very thin, many thin and very abundant broad organo-mineral excrements and areas of total excremental fabric.

Tab. 3.2 (continued)

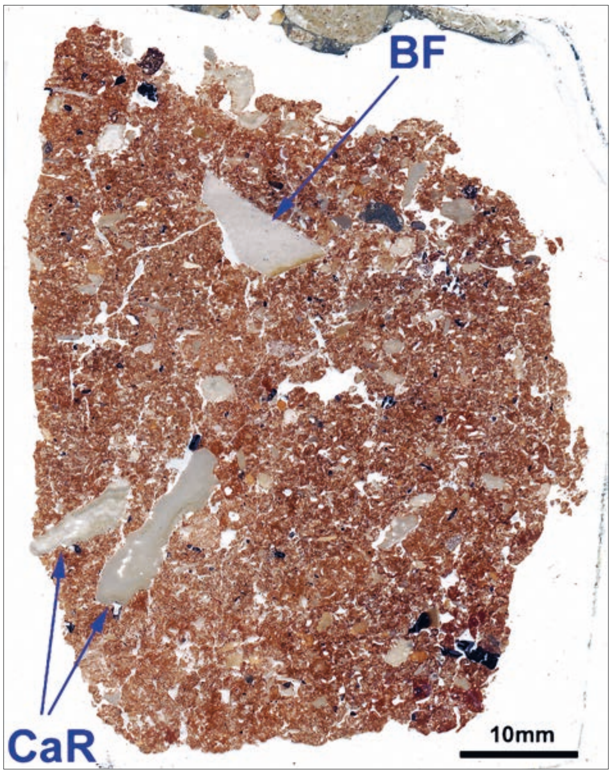


Fig. 3.1 Scan of S8-09-MM10 (centred on S8-Yell08[33-38]; equivalent to part of S8-Y2spit2); calcitic reddish brown clay loam and sandy clay loam variants, with coarse calcareous rock (**CaR**), an example of possibly burnt siliceous chert-like material (**BF**; cf. **fig. 3.2**) and charcoal. – Scale bar 10 mm.

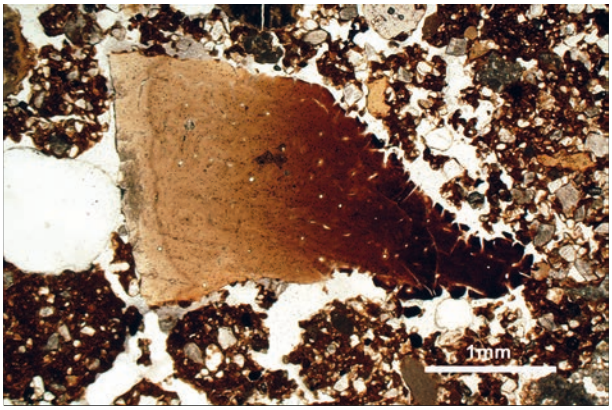


Fig. 3.3 MM10 (as **fig. 3.2**), moderately strongly to weakly burnt bone showing degrees of blackening to weak rubefication; plane polarised light (PPL). – Scale bar 1 mm.

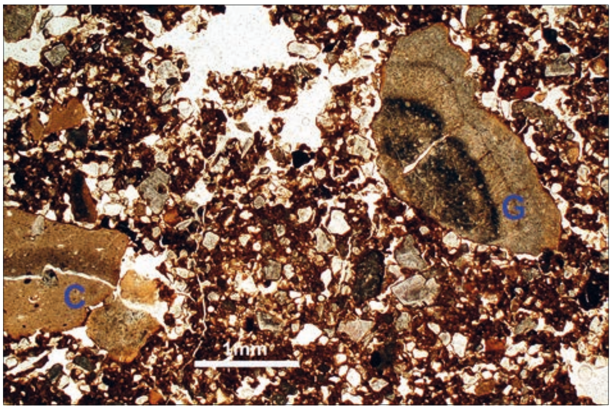


Fig. 3.4 MM10 (as **fig. 3.2**), coarse phosphatic fragments (isotropic under crossed polarised light, and autofluorescent under blue light); coprolite (**C**) and layered example of probable mineralised guano (**G**); PPL. – Scale bar 1 mm.

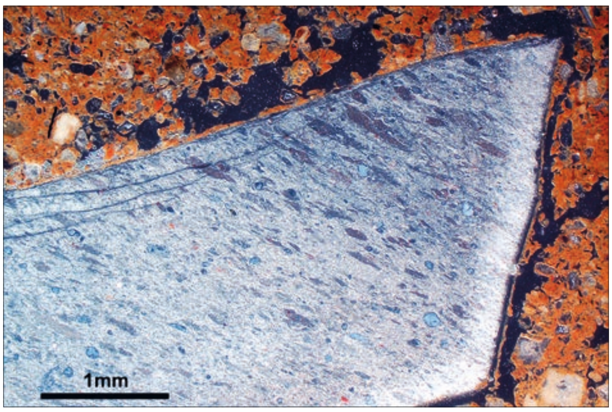


Fig. 3.2 Photomicrograph of S8-09-MM10 (centred on S8-Yell08 [33-38]; equivalent to part of S8-Y2spit2); reddish cave earth embeds possible fire cracked rock (cf. **fig. 3.1**); oblique incident light (OIL). – Scale bar 1 mm.

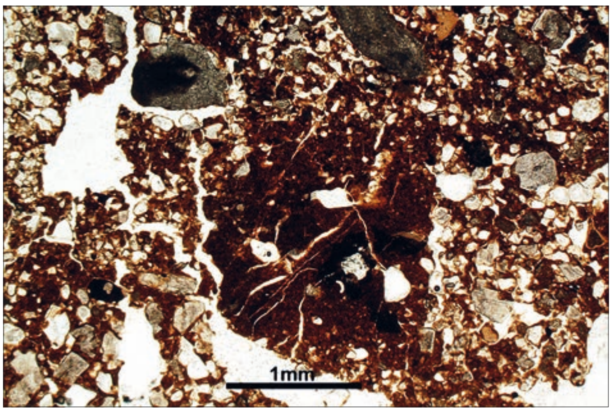


Fig. 3.5 MM10 (as **fig. 3.2**), decalcified reddish clay inwash from accumulating and overlying colluvial deposition; PPL. – Scale bar 1 mm.

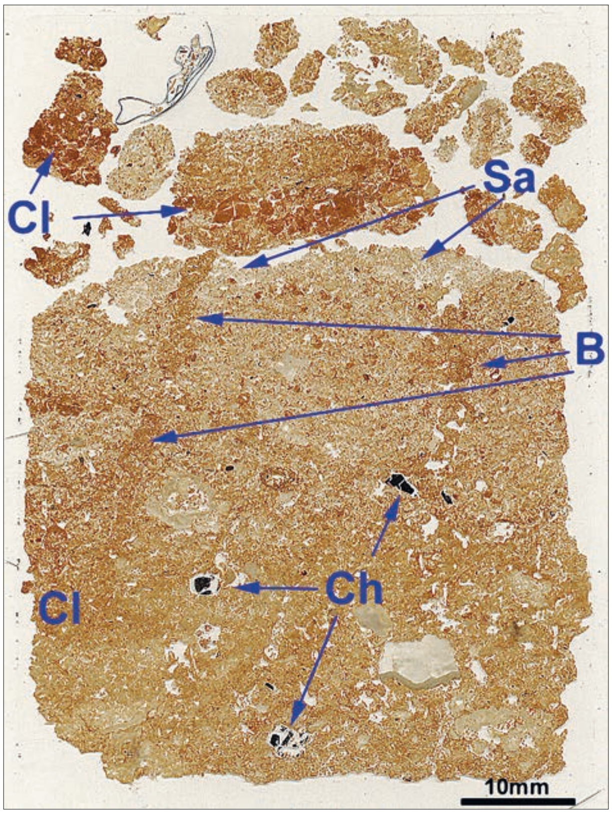


Fig. 3.6 Scan of S8-09-MM9 (Units S8-Yell08[16-23] and part of [12-16]; equivalent to the middle and upper parts of S8-Y2spit1)); calcareous fine sandy loam with burrow fills and areas of reddish grey calcareous sandy loam/clay loam (**Cl**), with upper interval of semi-intact fragments with major decalcified clay layers and pans (**Cl**); the lower interval, which includes charcoal (**Ch**) is markedly affected by burrowing (**B**); upwards, there is a fine sand layer (**Sa**) with burrows through it (**B**; cf. figs 3.7-3.8). – Scale bar 10 mm.

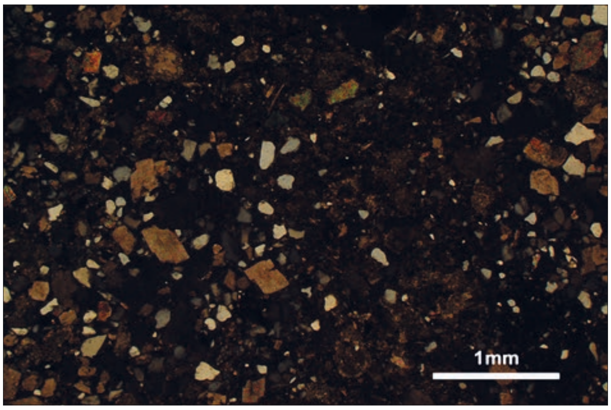


Fig. 3.8 MM9 (as fig. 3.7), under crossed polarised light (XPL), showing quartz-feldspar fine sands and fine sand size calcite. – Scale bar 1 mm.

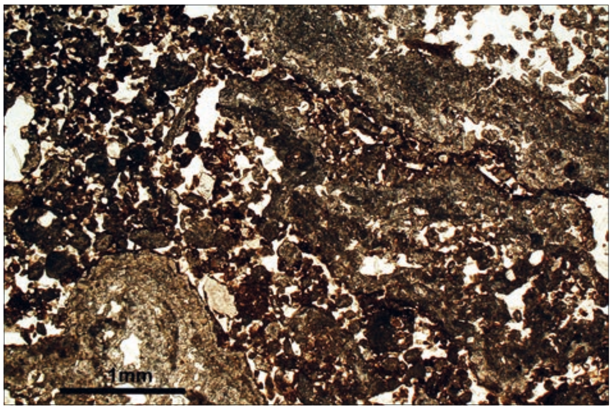


Fig. 3.9 MM9 (as fig. 3.7), calcitic fine sands and micritic calcite speleothem growths; PPL. – Scale bar 1 mm.

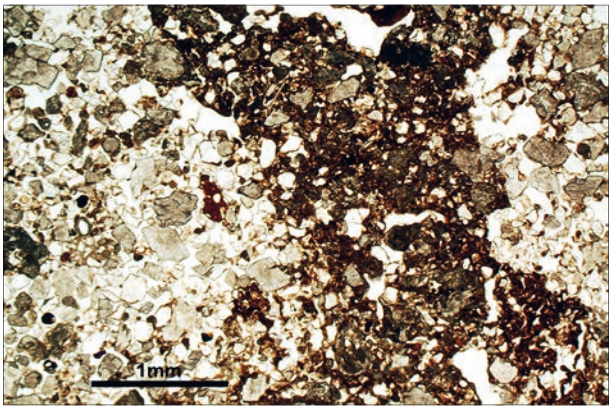


Fig. 3.7 Photomicrograph of S8-09-MM9 (Units S8-Yell08[16-23] and part of [12-16]; equivalent to the middle and upper parts of S8-Y2spit1); clayey burrow fill through fine sandy layer; PPL. – Scale bar 1 mm.

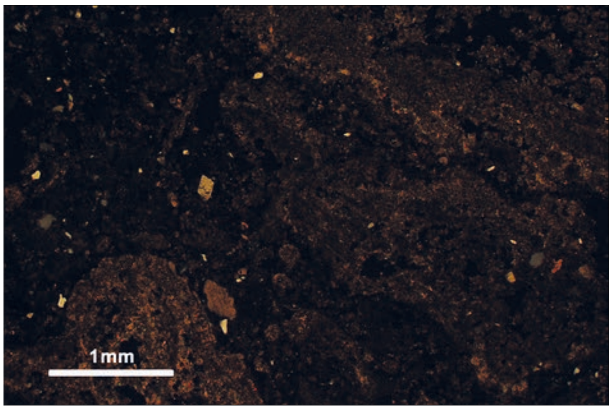


Fig. 3.10 MM9 (as fig. 3.9), under XPL. – Scale bar 1 mm.

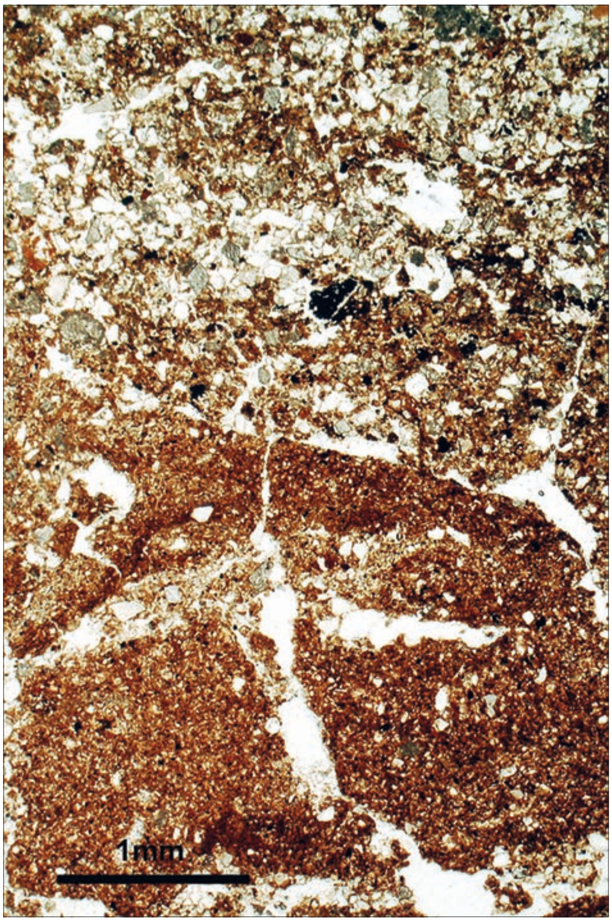


Fig. 3.11 Photomicrograph of S8-09-MM9 (Unit S8-Yell08[16-18] and part of Unit [12-16]; equivalent to the upper part of S8-Y2spit1); Upper unit in **fig. 3.6**; muddy clay layer below more fine sandy loamy fine sand; PPL. – Scale bar 1 mm.

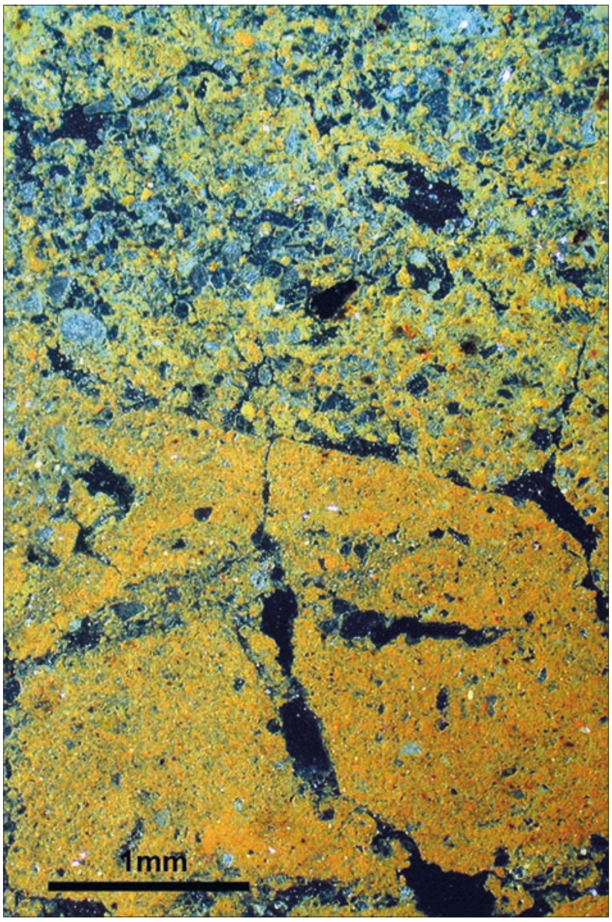
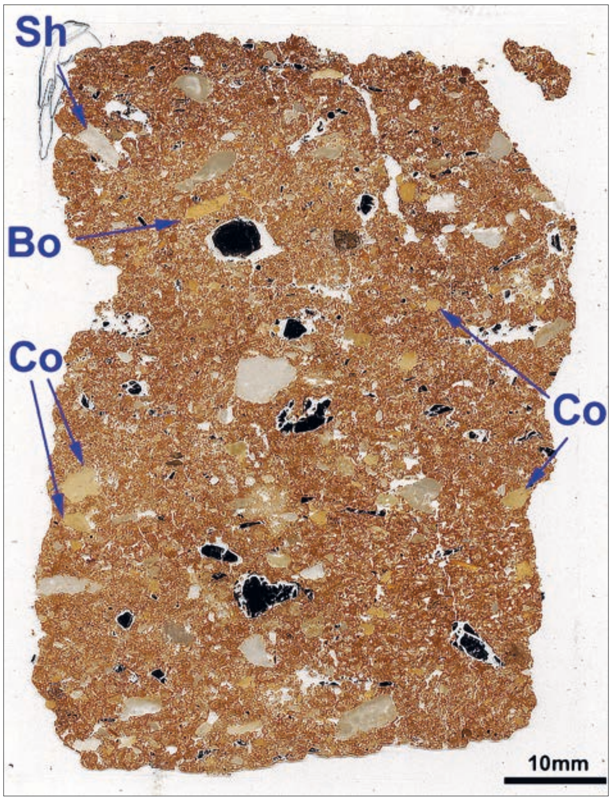


Fig. 3.12 MM9 (as **fig. 3.11**), under OIL; muddy colluvial clayey wash occurs below fine sands of windblown origin; note thin burrow mixing of the two microfacies. – Scale bar 1 mm.



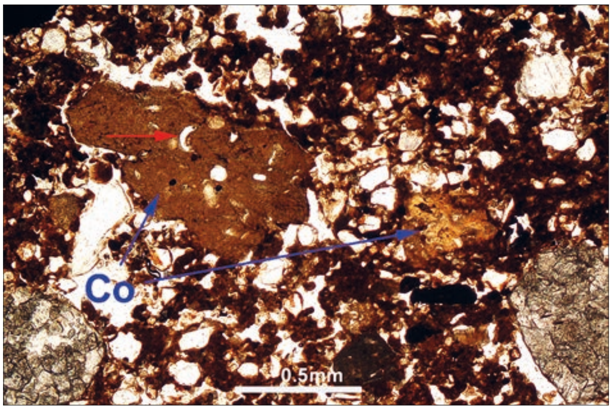


Fig. 3.14 MM8 (as **fig. 3.13**), reddish grey calcareous clay loam, with coprolitic inclusions, which are isotropic under XPL and autofluorescent under BL (blue light); note vesicles (from 'trapped gas') and fine channel probably pseudomorphic of ingested hair/fur by a carnivore such as a hyaena; PPL. – Scale bar 0.5 mm.

Fig. 3.13 Scan of S8-09-MM8 (S8-Yell08[2-12]; equivalent to the middle part of S8-Y1); reddish cave earth loam, with whitish calcareous rock inclusions, black fine and coarse charcoal, bone (**Bo**), shell (**Sh**) and very abundant coprolite fragments (**Co**; cf. **figs 3.14-3.15**). – Scale bar 10 mm.

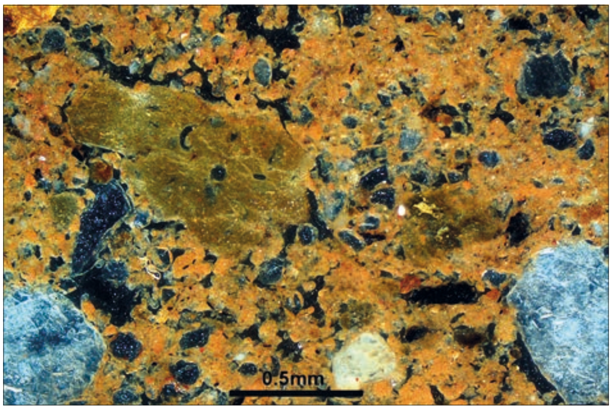


Fig. 3.15 MM8 (as fig. 3.14), under OIL; the cave earth is typically orange while the coprolites are a dull yellow. – Scale bar 0.5 mm.

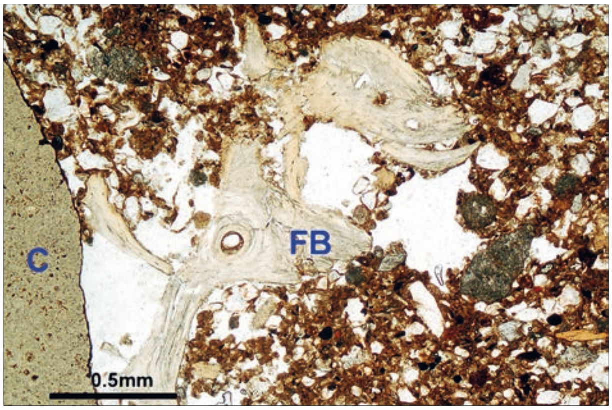


Fig. 3.16 MM8 (as fig. 3.14); leached white probable fish bone (**FB**) next to dusty grey (hyaena?) coprolite (**C**); PPL. – Scale bar 0.5 mm.

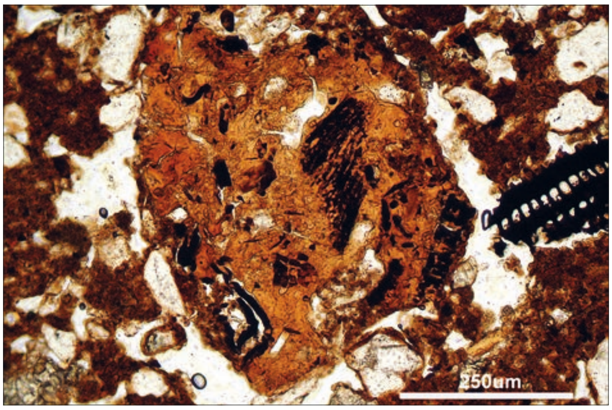


Fig. 3.17 MM8 (as fig. 3.14); orange brown omnivore (human?) coprolite embedding fine charcoal; PPL. – Scale bar 250 µm.

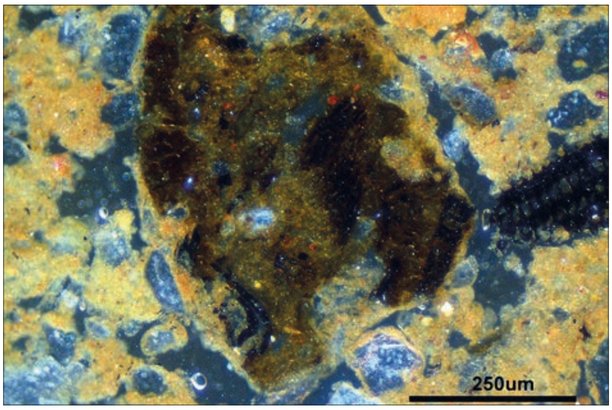


Fig. 3.18 MM8 (as fig. 3.17), under OIL (coprolite is isotropic under XPL, and moderately to strongly autofluorescent under BL); staining is from an organic content; note very fine red burnt minerogenic inclusions. – Scale bar 250 µm.

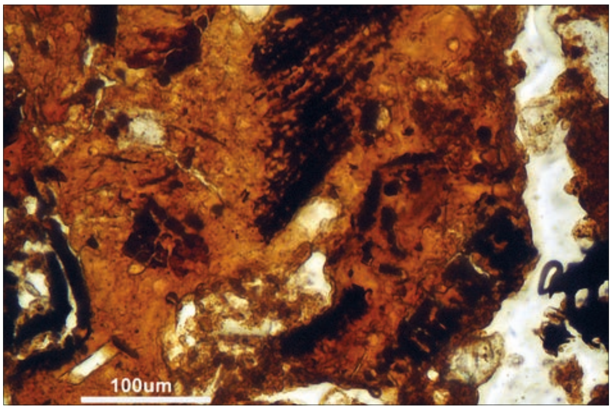


Fig. 3.19 MM8 (as fig. 3.18); detail of coprolite showing organic and charred organic content; spores/pollen are present (not easily visible in image); PPL. – Scale bar 100 µm.

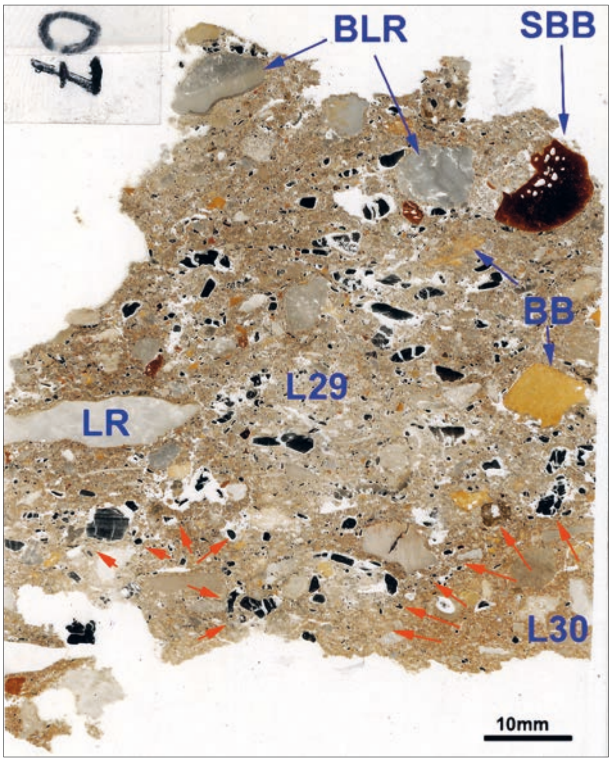


Fig. 3.20 Scan of S8-09-MM7 (crossing boundary between L29 and L30, shown by orange arrows); ashy L29 includes much charcoal, burnt calcareous rock (**BLR**), burnt bone (**BB**) and more strongly burnt bone (**SBB**), with sub-horizontally oriented travertine limestone rock (**LR**). – Scale bar 10 mm.

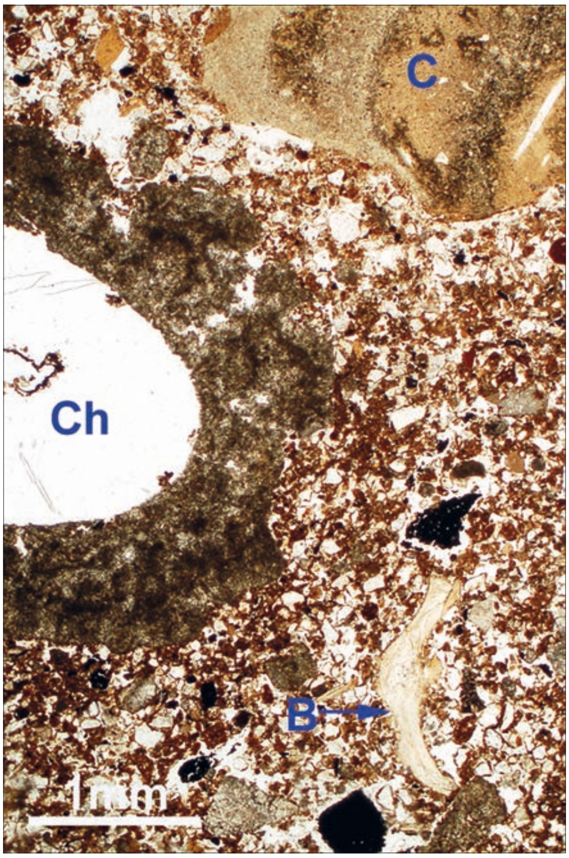


Fig. 3.21 Photomicrograph of S8-09-MM7 (L30); reddish pellety cave earth with coarse yellow (hyaena?) coprolite (**C**), bone fragment (**B**) and micritic calcite (root) channel hypocoating (**Ch**); PPL. – Scale bar 1 mm.

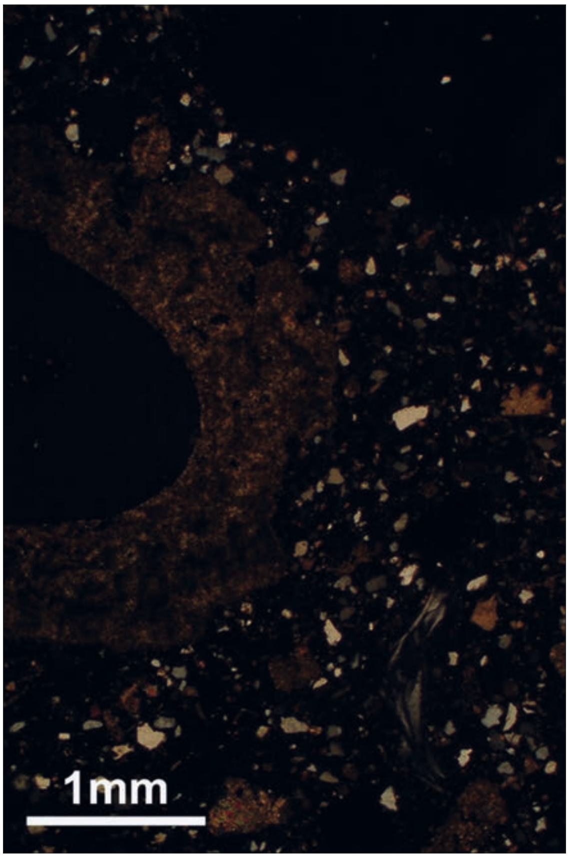
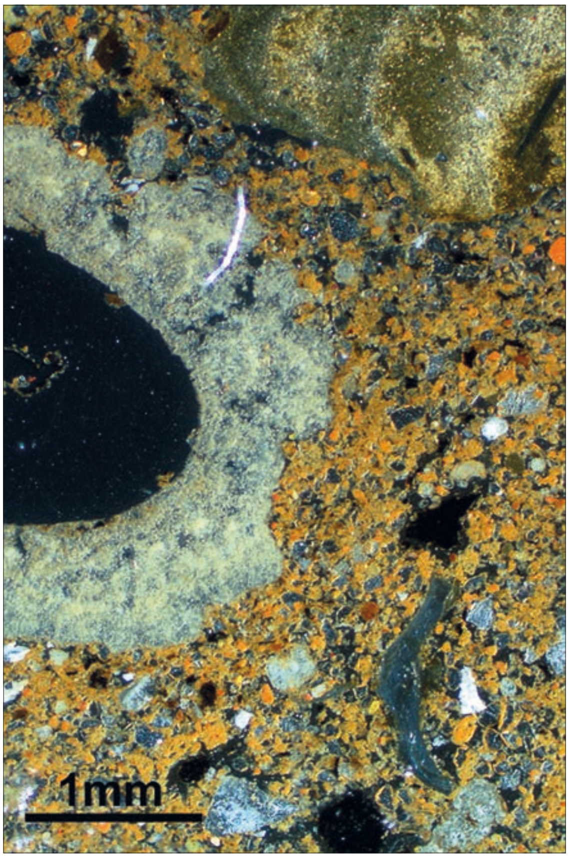


Fig. 3.22 MM7 (as fig. 3.21), under XPL; note silt content of cave earth, micritic calcite channel hypocoating and isotropic coprolite (calcium phosphate), whilst the bone fragment retains some birefringent properties. – Scale bar 1 mm.



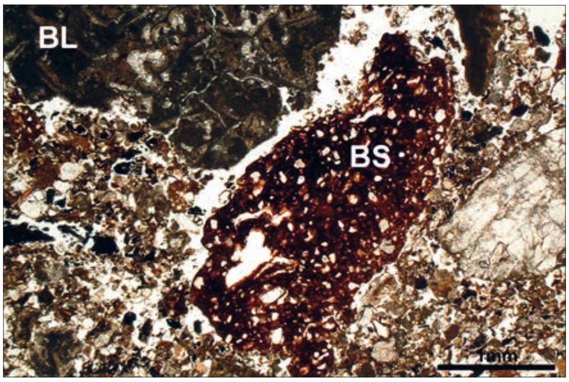


Fig. 3.24 Photomicrograph of S8-09-MM7 (L29); ashy deposits with blackened and fissured burnt limestone (**BL**) and rubefied burnt soil (**BS**) – note root channel feature; PPL. – Scale bar 1 mm.

Fig. 3.23 MM7 (as fig. 3.21), under OIL; cave earth is typically orange; secondary calcite may have formed due to partial decalcification of ashy deposits above in L29. – Scale bar 1 mm.

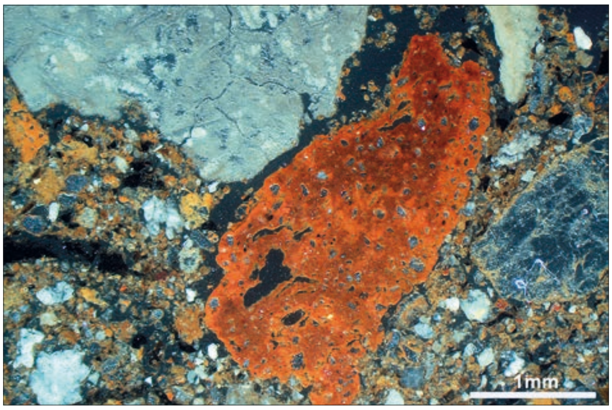


Fig. 3.25 MM7 (as **fig. 3.24**), under OIL. – Scale bar 1 mm.

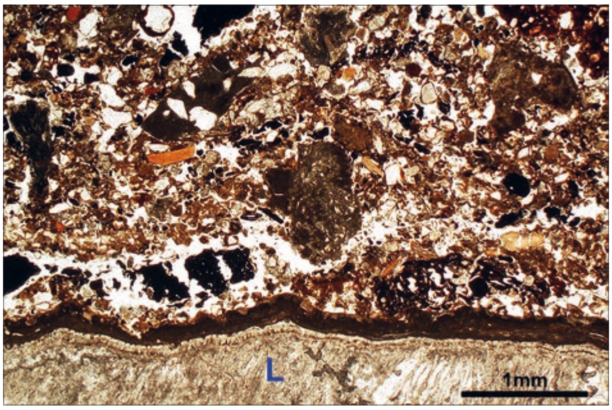


Fig. 3.26 MM7 (as **fig. 3.24**), possibly trampled ashy deposits over coarse limestone (**L**) clast (cf. **fig. 3.20**); PPL. – Scale bar 1 mm.

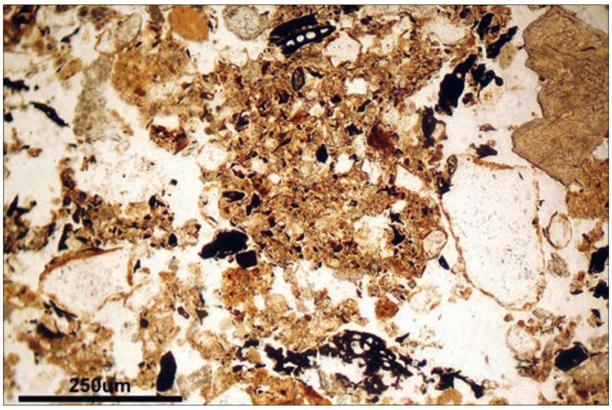


Fig. 3.27 MM7 (as **fig. 3.26**), showing very fine charcoal within ashy residues; PPL. – Scale bar 250 µm.

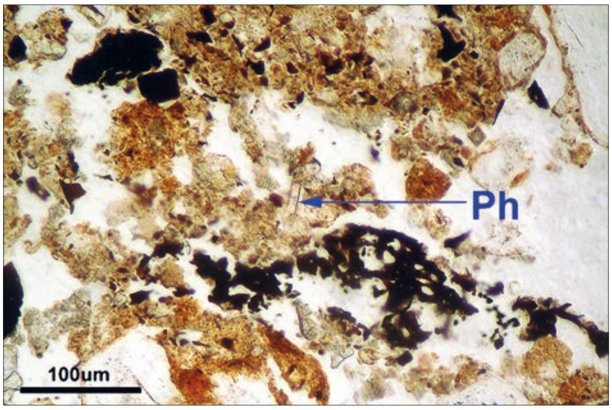


Fig. 3.28 MM7, detail of **fig. 3.27**, showing location of phytolith (**Ph**) within ash residues; PPL. – Scale bar 100 µm.

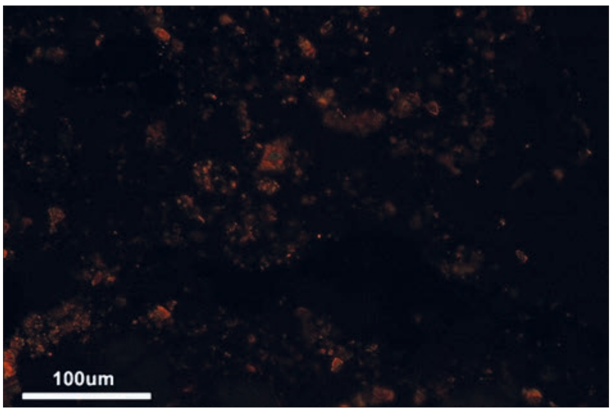


Fig. 3.29 MM7 (as **fig. 3.28**), under XPL; birefringent remains of calcitic ash crystals. – Scale bar 100 µm.

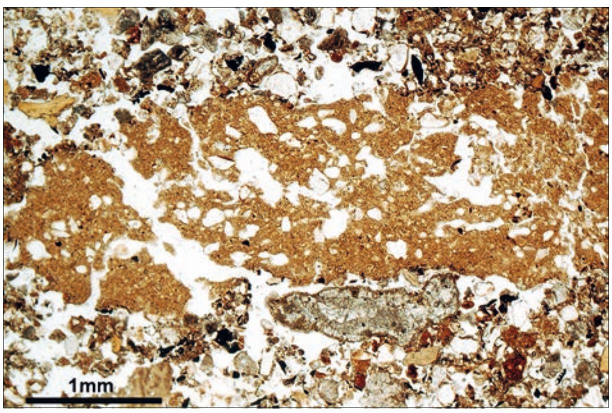


Fig. 3.30 MM7 (as **fig. 3.24**); anomalous clay clast characterised by fine channels and with microfossils, suggesting it has a wetland clay origin, and was imported into the site; PPL. – Scale bar 1 mm.

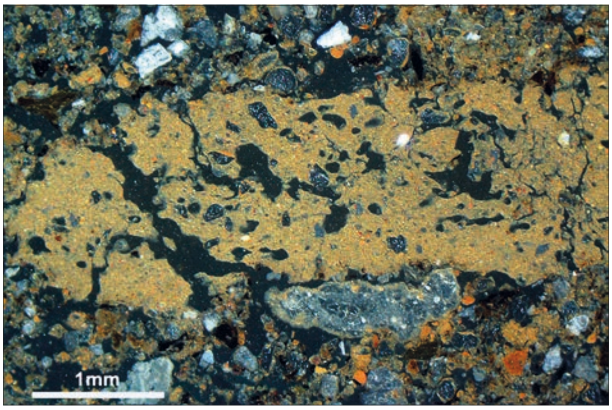


Fig. 3.31 MM7 (as **fig. 3.30**), under OIL. – Scale bar 1 mm.

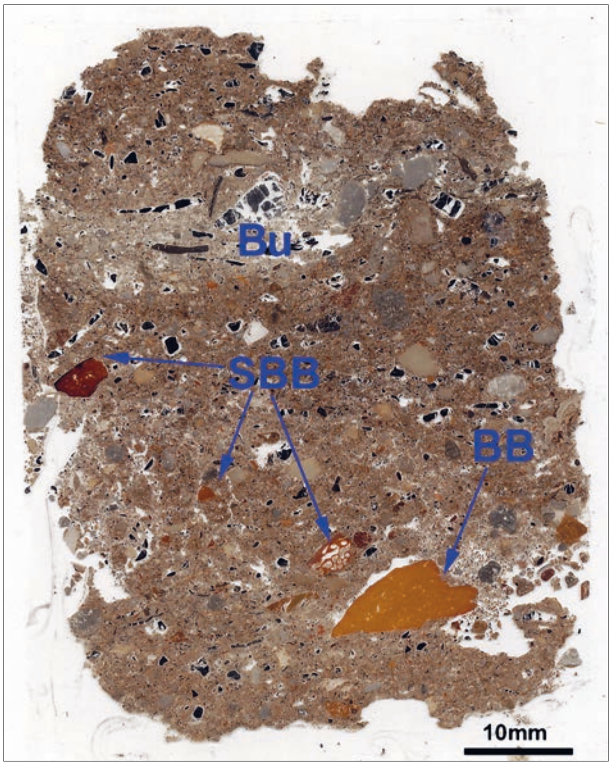
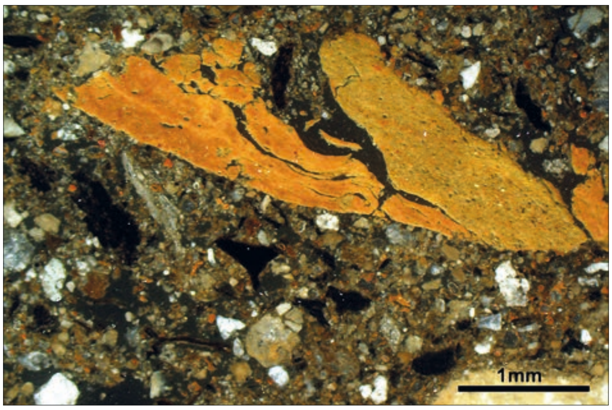


Fig. 3.32 Scan of S8-09-MM6 (L28-L29); dark brownish sometimes recemented ashy deposits with charcoal, burnt bone (**BB**), and strongly burnt bone (**SBB**), with burrow fill (**Bu**) of partially decalcified ash residues. – Scale bar 10 mm.



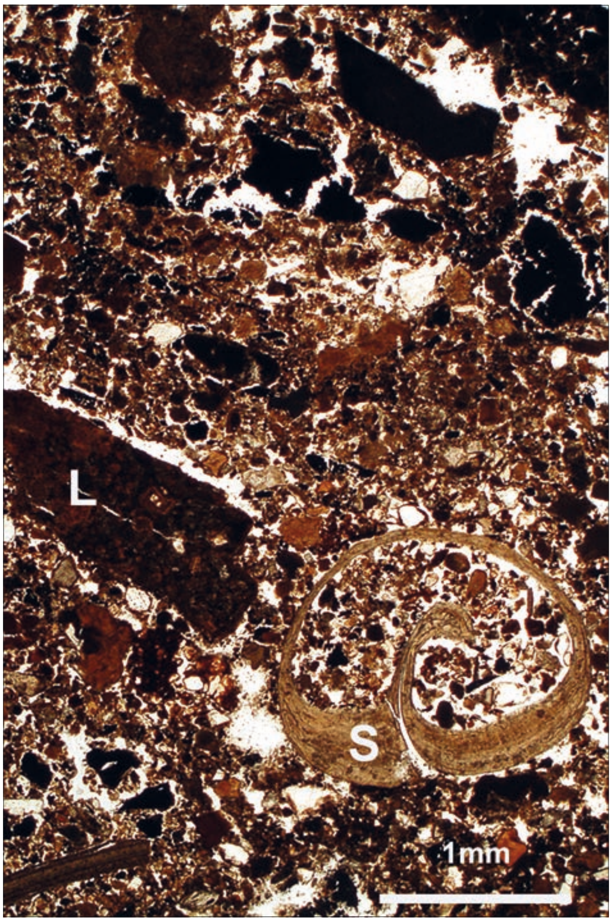


Fig. 3.33 Photomicrograph of S8-09-MM6 (L28-L29); with semi-layered darkish brown ashy remains, heated gastropod shell (**S**) and blackened limestone fragment (**L**); PPL. – Scale bar 1 mm.

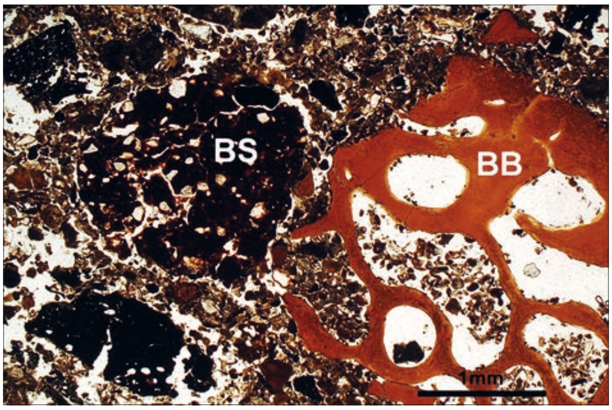


Fig. 3.34 MM6 (as **fig. 3.32**), rubefied burnt bone (**BB**) and blackened burnt soil clast (**BS**) in ashy remains; PPL. – Scale bar 1 mm.

Fig. 3.35 MM6 (as **fig. 3.32**); example of burnt imported (?) wetland clay; OIL. – Scale bar 1 mm.

Fig. 3.36 Scan of S8-09-MM3 (L28 upper); generally dark brownish charcoal rich ashy remains, which are diffusely layered and broadly burrowed (some colour differences relate to variations in thin section thickness); burnt bone and burnt limestone occur (cf. **figs 3.37-3.38**). – Scale bar 10 mm.

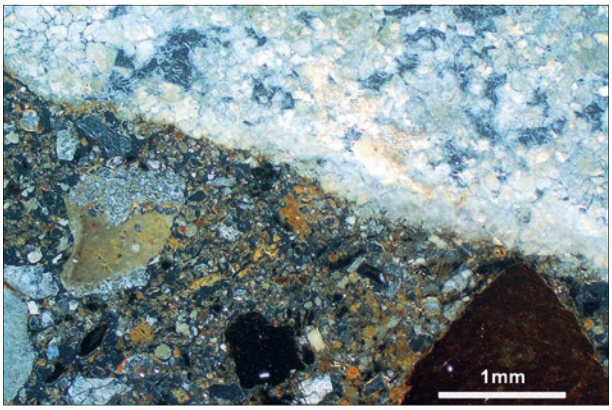


Fig. 3.38 MM3 (as **fig. 3.39**), under OIL. – Scale bar 1 mm.

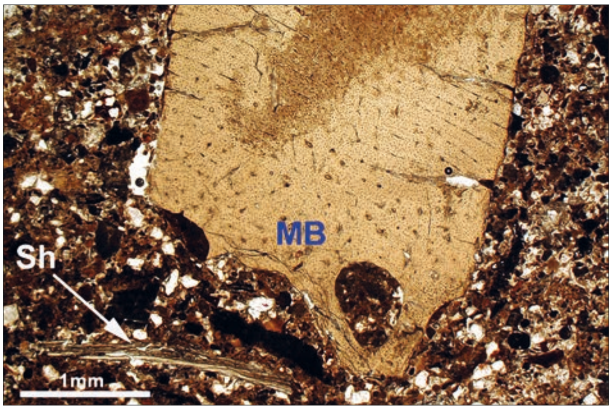


Fig. 3.39 MM3 (as **fig. 3.37**); moderately burnt bone, which has become partially micritised (**MB** – micritised bone); note compact surrounding ash residues and shell (**Sh**) remains; PPL. – Scale bar 1 mm.

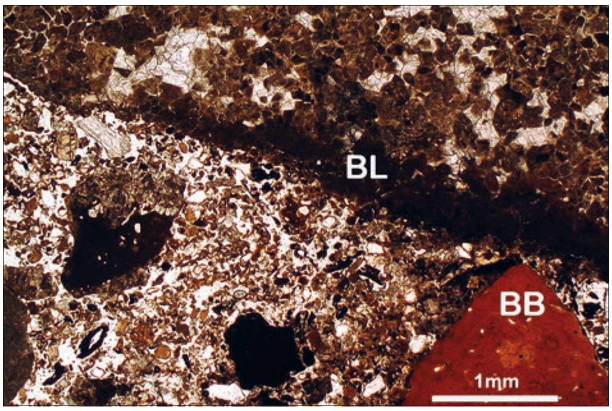


Fig. 3.37 Photomicrograph of S8-09-MM3 (L28 upper); edge of burnt limestone (**BL**) with recrystallisation, ashes and rubefied burnt bone (**BB**); PPL. – Scale bar 1 mm.

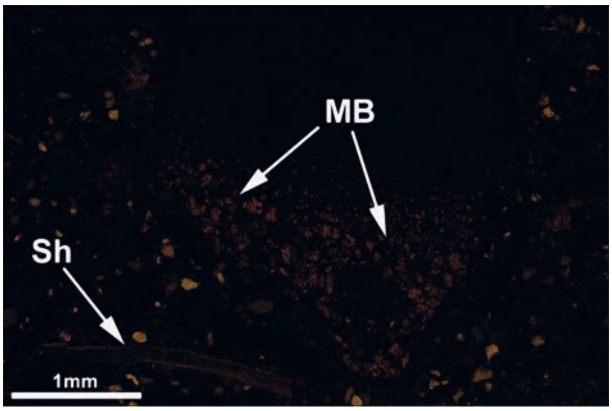


Fig. 3.40 MM3 (as **fig. 3.39**), under OIL, showing micritisation of lower part of burnt bone. – Scale bar 1 mm.

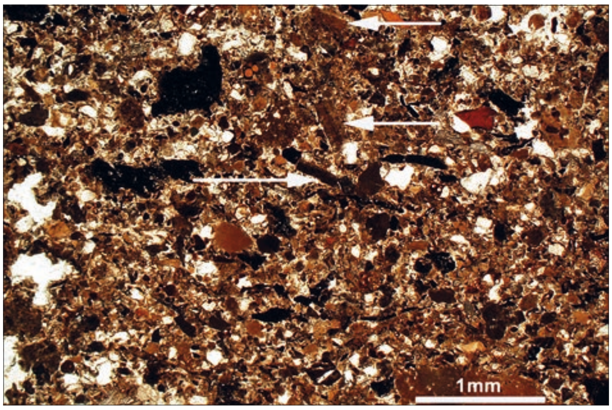


Fig. 3.41 MM3 (as **fig. 3.37**): moderately compact ash remains with traces of earlier probable sub-horizontal orientation, and including very fine to more coarse shell fragments (white arrows); PPL. – Scale bar 1 mm.

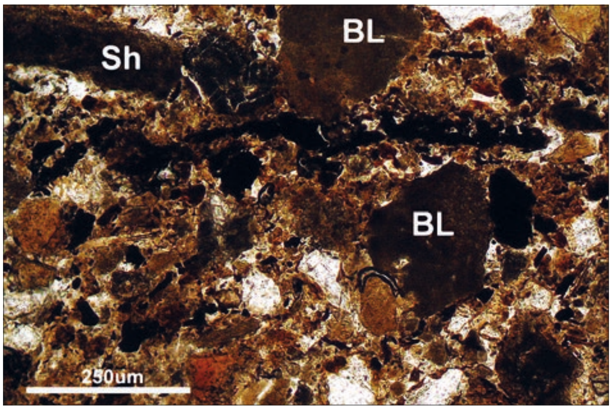


Fig. 3.42 MM3, detail of **fig. 3.41**; ash, charcoal, with fine burnt shell (**Sh**) and limestone (**BL**) material; PPL. – Scale bar 250 µm.

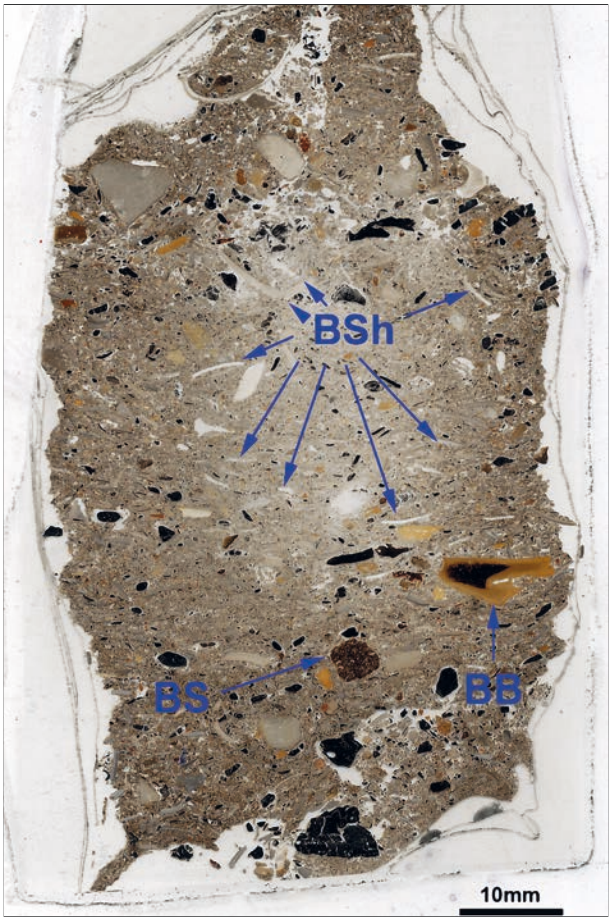


Fig. 3.43 Scan of S8-10-MM2 (L13); ash and often burnt shell (**BSh**) deposits, which are partially burrowed but with large areas of original layered composition (cf. **figs 42-44**); black burnt soil (**BS**) and burnt bone (**BB**) also occur. – Frame width is ~60 mm.

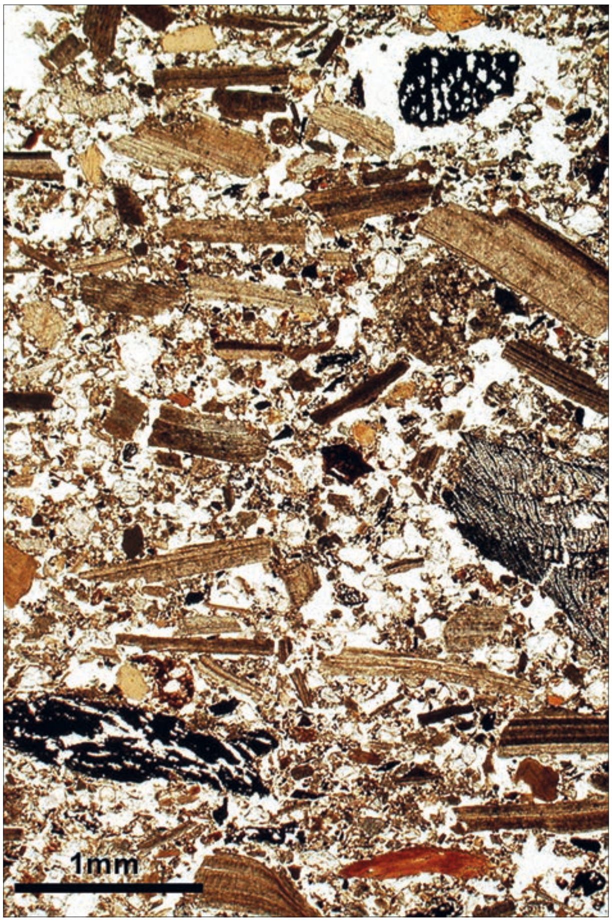


Fig. 3.44 Photomicrograph of S8-10-MM2 (L13); open ashy deposits with much semi-horizontally oriented shell and burnt shell, indicative of being a trampled occupation surface associated with a shell midden accumulation; PPL. – Scale bar 1 mm.

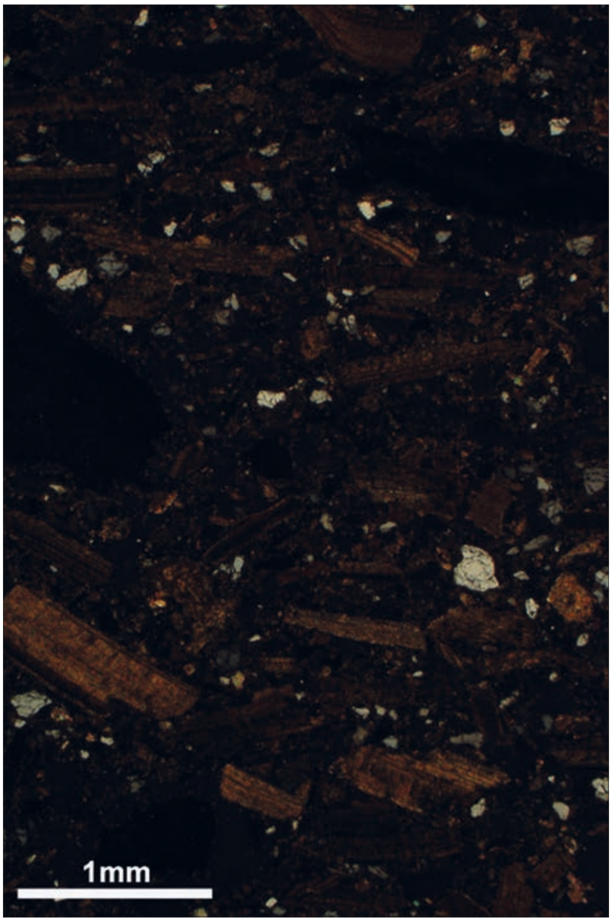


Fig. 3.45 MM2 (as **fig. 3.44**); under XPL. – Scale bar 1 mm.

Fig. 3.46 MM2 (as **fig. 3.45**), under OIL; white shell is clearly burnt. – Scale bar 1 mm.

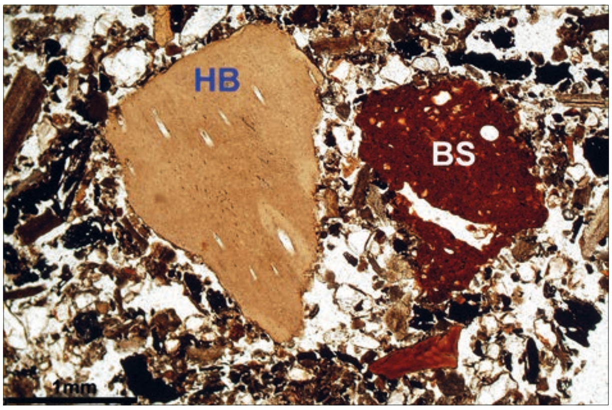


Fig. 3.47 MM2 (as **fig. 3.44**); ash remains include heated bone (**HB**) and burnt soil (**BS**; note relict root channel); PPL. – Scale bar 1 mm.

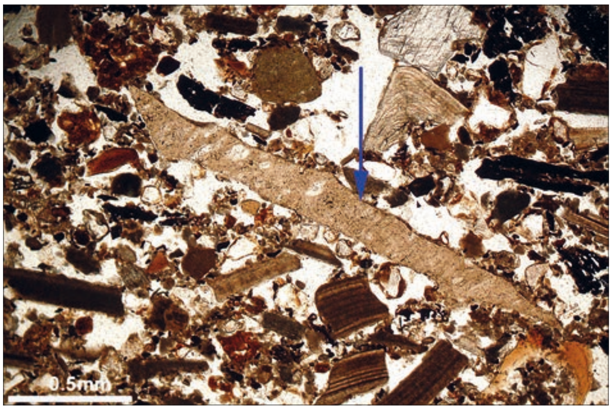


Fig. 3.48 MM2 (as **fig. 3.47**); biologically worked ash residues, with burnt shell and small chert(?) flake (arrow); PPL. – Scale bar 0.5 mm.

Yellow Series

Centred on S8-Yell08[33-38] [equivalent to part of S8-Y2spit2] (thin section S8-09-MM10; 0-70 mm)

This is a cave earth that was apparently originally deposited as a muddy colluvium and which became biomixed with washed sands (**Chapter 2**) of possibly originally windblown origin. There are also coarse inclusions of speleothem and likely hyaena coprolite and bird guano fragments from the cave environment. The colluvium includes very fine charcoal, larger charcoals, a probable fire-cracked siliceous rock (chert?), fine bone (some of which is burnt), all suggesting localised reworking of an occupation surface/combustion zone (Mallol/Mentzer/Miller 2017; Villagran et al. 2017). Reworking processes could include trampling, bioturbation and lastly local wash (Fedoroff/Courty/Guo 2018).

Upper part of Unit S8-Yell08[18-23] [equivalent to the middle part of S8-Y2spit1] (thin section S8-09-MM9 lower; 35-75 mm)

This is a complicated sediment, composed of strongly bioworked calcareous clays, with fine sands, succeeded by a layer of dominant fine sands; the sediment apparently includes no micro-inclusions evident of human activity, unlike sample MM10, for example. As the overall Unit Y2spit1 does in fact contain macro-size chert artefacts (cf. **Chapter 12**), this lack of micro-inclusions may indicate a taphonomic difference with MM10, and/or the absence of a previously existing local occupation surface. The lower part of this interval was probably first formed of colluvial cave earth, which became biomixed with blown fine sand, the whole strongly affected by rooting, biological activity and secondary calcium carbonate formation (root replacement and tufa-like formations) (Durand/Monger/Canti/Verrecchia 2018). Upwards, increasing dominance of sands occurs, some possibly being of a more or less direct windblown origin. Down-washing and burrowing down of reddish clay from above occurred later.

Unit S8-Yell08[16-18] and part of Unit [12-16] [equivalent to the upper part of S8-Y2spit1] (thin section S8-09-MM9 upper; 0-35 mm)

The thin section seems to be recording sterile natural sedimentation in the form of colluvial muddy clayey wash, with periodic originally windblown silt and fine sand sediment, which was sometimes followed by minor bioworking (seasonal activity?). A clean layer of fine and medium sand near the top could result from more or less direct wind action, perhaps forming discrete sheets within the cave.

S8-Yell08[2-12] [equivalent to the middle part of S8-Y1] (thin section S8-09-MM8; 0-75 mm)

Essentially, the middle of Unit Y1 is a poorly calcareous cave earth of possible colluvial origin, but which is now totally bioworked, and characterised by concentrated amounts of bone, coprolitic bone (burnt bone, bird and fish bone probably present) and coprolites (most being hyaena-like). Also present are concentrations of fine and coarse charcoal, likely fine red burnt mineral material, suggesting, with burnt bone, that there was mixed occupation by people and fauna such as hyaenas (Horwitz/Goldberg 1989; Karkanas/Goldberg 2018; Larkin/Alexander/Lewis 2000; Macphail/Goldberg 2012, 68-71). The possibility of one or more omnivore coprolite(s), one of which embeds charred plant remains, pollen/spores and very fine red-burnt(?) mineral, is noteworthy, especially as it closely resembles human types.

Yellow/Grey Series

S8-L30 [top of Yellow Series] (thin section S8-09-MM7 lower; 60(70)-80 mm)

This uppermost interval of the Yellow Series has a diffusely mixed boundary with the overlying Grey Series (see above). This L30 has a similar, but finer sized, content of charcoal, bone and likely hyaena coprolites, compared to the sediment in slide MM8, and is indicative of a human and animal occupied cave earth, characterised by high amounts of biological activity. Coarse speleothem inclusions show partial decalcification, consistent with the original decalcified nature of the cave earth (weathered limestone and dust). Weak micritisation from above and rhizolith formation were additionally noted.

S8-L29 [base of Grey Series] (thin section S8-09-MM7 upper; 0-60(70) mm)

L29 is essentially a totally anthropogenic deposit, composed of fire installation (burnt soil – hearth(?), ash residues and charcoal) and likely kitchen midden (burnt bone and other bone debris) waste (Mallol/Mentzer/Miller 2017; Mentzer 2014). This is a partially trampled discard spread. Cave earth from below (L30) has become incorporated through trample-erosion of the 'natural' substrate. The presence of suggested 'wetland' clay (from the Zegzel Valley?) may indicate importation of a raw material for specialist activities/manufacture (in addition to red Mediterranean soil material) (Macphail/Goldberg 2018b). Phytoliths may come from imported plant material, for bedding, flooring, etc. (Goldberg et al. 2009). There is a marked contrast between the underlying Yellow Series (dominated by natural reddish sedimentation, and probably alternate (hypothetically seasonal at times) occupation by humans and animals) and the overlying grey and ashy anthropogenic deposits (of hearth and kitchen midden origin). A significant occupation use change is indicated.

Grey Series

S8-09/10-L28 lower (thin section S8-09-MM6; 0-70 mm)

This is a partially trampled ash spread/discard deposit, where there has been much less decalcification of the fuel ash; plant pseudomorphs occur and minor recrystallisation has taken place. Presumed kitchen midden content includes mainly burnt bone and shell. Very common burnt limestone and speleothem material (Canti 2017a), along with burnt red soil and (wetland?) clay, are involved in the hearth debris. Rare fibrous rooting has occurred recently.

S8-09/10-L28 upper (thin section S8-10-MM3; 0-100 mm)

This is probably a slightly weathered compact ash and kitchen midden deposit, with traces of trampling (Mallol/Mentzer/Miller 2017; Rentzel et al. 2017), and includes hearth material (calcitic ash, charcoal, burnt soil and minerogenic material, burnt limestone/speleothem) and kitchen debris comprising bone and shell (Canti 2017a; 2017b). Much small invertebrate mesofauna and small animal (5-10 mm wide) burrowing has occurred. Compaction and weathering effects are probably due to post-depositional drainage through the overlying stony deposit above (Chapter 2).

S8-09/10-L13 (thin section S8-10-MM2; 0-95 mm)

L13 is a mainly open layered shell and burnt shell-dominated midden deposit that also includes much burnt bone; whilst, here at Taforalt, terrestrial mollusca dominate, the overall result is not unlike that seen in other, variously dated 'midden' sites with more marine shell (cf. Barton 2000; Canti 2017b; Stein 1992; Villagran/Giannini/DeBlasis 2009). The deposit has probably been trampled in possibly a drier (at least, better drained) environment compared to L28, hence its more open character and presence of finely sorted fragmented shell and charcoal (Courty/Goldberg/Macphail 1994; Gé/Courty/Matthews/Wattez 1993). This unit contains much fewer burnt limestone and speleothem clasts of larger size, in contrast to L28, and thus has much less of an obvious hearth component (but see Chapter 2 concerning the behaviour of calc-limestone when subjected to more extreme pyrolithic processes).

3.4 DISCUSSION AND CONCLUSIONS

The Yellow Series is typically formed of a cave earth that was apparently originally deposited largely as a muddy colluvium and which became biomixed with dusts and finer sands of possible windblown origin. The supply of fine sediment was good and, in most cases, accumulation rates would have been relatively high for a dominantly natural (geogenic) context, although nothing like as fast as they would later become (cf. Chapter 2). As at most other cave sites (e. g. Gorham's and Vanguard Caves on Gibraltar), there are also coarse inclusions of limestone, speleothem, bone, and likely hyaena coprolite and bird guano fragments from the cave environment, along with examples of eggshell and possible fish bone (Horwitz/Goldberg 1989; Karkanas/Goldberg 2018, 68-71; Karkanas et al. 2002; Goldberg/Macphail 2012; Larkin/Alexander/Lewis 2000; Macphail/Goldberg 2012; Macphail/Goldberg/Barton 2012; Shahack-Gross/Berna/Karkanas/Weiner 2004). Certain observations concerning biological activity are relevant to the question of the persistence (or otherwise of) natural processes. Some intervals are particularly rich in bone fragments and likely hyaena coprolites (cf. Gorham's Cave). However, background bird activity was much less marked than in many dominantly natural caves (e. g. many levels at the Middle Pleistocene Westbury-Sub-Mendip Cave, Somerset: Andrews/Cook/Currant/Stringer 1999; Macphail/Goldberg 1999) or at sites with only an occasional human presence (e. g. the Mesolithic levels at Uzzo Cave, Sicily) (Macphail/Goldberg 2018a, 272-273).

In terms of human occupation evidence, the Yellow Series cave colluvium includes very fine charcoal, fine charcoals, probable fire-cracked siliceous rock (chert?), and fine bone, which is burnt, all suggesting localised reworking of occupation surfaces/combustion zones at times (Mallol/Mentzer/Miller 2017; Villagran et al. 2017). There is also the intriguing possibility of one or more omnivore coprolite(s) being present; one example embeds charred plant remains, pollen/spores and very fine red-burnt (?) mineral material, and overall closely resembles human types (Brönnimann et al. 2017; Macphail 2000; Macphail/Goldberg 2018a, 264-266 tab. 7.5). The human presence appears to have been intermittent. Between the organic input from animal occupants, such as birds and hyaena, and from human accumulations, probably with a wide range of organic inputs but demonstrably including debris from vertebrates and mollusca, there would have been ample opportunity for the cave earth to be worked by small invertebrate mesofauna, producing alternations not dissimilar to those in the Mesolithic levels of Uzzo Cave, Sicily (Macphail 2006; Mannino et al. 2007).

The Grey Series strongly contrasts with the Yellow Series by being dominantly anthropogenic in character, with a marked burnt mineral, ash and charcoal content (Chapter 2). In general terms, one is more accustomed to seeing such contrasts in Mediterranean Mesolithic-Neolithic transitions and one may again cite the example of Uzzo Cave (cf. Mannino/Thomas 2007; Mannino et al. 2007; Macphail/Goldberg 2018a, 272-273. 380). As has been noted above, the GS occupation at Taforalt saw a significant change in use, in terms of both types and rhythms. The Grey Series is largely composed of waste from fire installations (burnt soil and rock, ash residues and charcoal) and kitchen middens (shell, burnt shell, burnt bone and other bone debris) (Mallol/Mentzer/Miller 2017; Mentzer 2014), and often incorporates partially trampled discard spreads. Fire installation waste included much burnt limestone and speleothem (cf. Chapter 2; Canti 2017a), and ash preservation was affected by how freely draining the overlying and underlying deposits were, affecting processes such as weathering. Compaction, together with fine fragmentation of semi-horizontally oriented shell and charcoal, are also effects which characterise trampled occupation surfaces.

Especially once the very rapid build-up of the Grey Series was well underway, there was little natural sedimentation in the cave. Of note, therefore, are burnt soil clasts, indicating the human introduction of red Mediterranean soil material (cf. *terra fusca*/*terra rossa*) into combustion zones. The presence of 'wetland clay', surviving both as raw and burnt examples, is even more interesting and suggests importation of this material, possibly from the wet valley bottom of the Zegzel. This was probably a raw material for specialist activities/manufacture (Chapter 14.1). Another category of material that may well have a component introduced by humans is phytoliths. It has previously been suggested that, at sites such as Neolithic Arene Candide, Liguria, and Middle Stone Age Sibudu Cave, KwaZulu-Natal, South Africa (Goldberg et al. 2009; Macphail/Courty/Hather/Wattez 1997), plant material was brought into the cave, possibly for bedding/floor covering. The Moroccan LSA site of Taforalt may now be added to this list, with evidence for such a possibility from the direct observation of phytoliths within the Grey Series sediment microfabric supporting the conclusions of the specific phytolith analyses at this site (cf. Chapter 7).

Seven large thin sections have been employed to investigate the sediment micromorphology of the Yellow and Grey Series in Sector 8 at Taforalt. Even though this must be characterised as merely a pilot study, it is clear that the application of micromorphological techniques to such a sequence provides valuable results and shows considerable potential for future studies.

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4. CHRONOLOGY

4.1 INTRODUCTION

The principal chronological method applied to the LSA Iberomaurusian units at Taforalt was radiocarbon (^{14}C) dating by Accelerator Mass Spectrometry (AMS), performed at the Oxford (UK) Radiocarbon Accelerator Unit (ORAU). Prior to AMS, all samples were chemically pre-treated to remove potential contaminants using standard ORAU protocols for each sample type (Brock/Higham/Ditchfield/Bronk Ramsey 2010). The technique was applied primarily to charcoals of short-lived woody plant species and the methods used for selecting and dating the samples from the site have been described elsewhere (Barton et al. 2013). These charcoals were identified by project wood specialists (R. Gale, D. Challinor and Y. Carrión Marco). A further programme of AMS ^{14}C dating of ostrich eggshell and bone samples was undertaken in parallel with the charcoal but was more restricted, due to the variable quality of collagen preservation and diagenesis of these materials. Significantly, the successfully assayed finds included dated human specimens and cut-marked bone from the burial area (Sector 10). Additionally, direct radiocarbon determinations on small seeds and other charred plant macrofossils were performed as part of a wider programme to identify the uses of food plants (**Chapter 6**), as well as to investigate the stratigraphic integrity of the deposits.

Luminescence dating was also applied to the cave sediments and to a limited number of burnt cherts in the Iberomaurusian units. The methodology for Optically Stimulated Luminescence (OSL) dating of sediments has been described elsewhere (Clark-Balzan et al. 2012; Clark-Balzan 2013), as have the Thermoluminescence (TL) methods on burnt cherts (Rhodes in Bouzouggar et al. 2007). For the OSL dating, metal tubes were hammered into the sections and sand-sized quartz mineral grains were extracted from these samples for measurement. Selected burnt worked cherts were taken for TL dating which entailed wrapping the specimens in aluminium foil immediately upon excavation and obtaining small sediment samples adjacent to the finds for external gamma dose rate determination by neutron activation analysis (NAA) or a combination of inductively coupled plasma mass spectrometry (ICP-MS) and inductively coupled plasma atomic emission spectrometry (ICP-AES). Not all of the luminescence results are reported below. In particular, many of the OSL ages were found to be consistently older than either the TL or the AMS ^{14}C ages. A potential source of error may be associated with the effects of severe burning on the sediment constituents and difficulties in establishing a reliable dose rate. Suspected post-depositional alterations in the chemical composition of the ashy sediment are the subject of continuing investigation.

A third dating method employed at Taforalt was that of tephrochronology. The technique is relatively new and has not yet been widely applied to sites in North Africa (Barton et al. 2015). The method depends on geochemically identifying microscopic vitreous shards (tephra) ejected by individual explosive volcanic eruptions and dispersed through the atmosphere (Lowe 2011). With greater distance from the source volcanoes of these eruptions, the fallout of tephra reduces. Therefore, at distal sites such as Taforalt (there being no known volcanoes close to Taforalt active in the Quaternary), tephra shards are deposited in very low abundances but may, nevertheless, still be identified as non-visible (to the naked eye) concentrations of 'cryptotephra'. So long as the geochemistry of a tephra shard is sufficiently unique, its 'geochemical fingerprint' can be used to identify isochronous markers across potentially large geographic distances (as well as small distances within individual sites), providing tie-points to other distal archaeological or palaeoenvironmental sites, as well as to the ultimate volcanic source. Thus, chronological information from proximal volcanic material, or from other distal sites, can be integrated using these tephra isochrons. Whilst tephra fallout across space can be thought of as contemporaneous with (i.e. generally, within a year of) the eruptive episode, subsequent taphonomic re-working of the primary ashfall can be an issue, and must also be taken into account.

4.2 AMS RADIOCARBON DATING

AMS radiocarbon dating was undertaken in each of the main sectors yielding LSA finds (Sectors 8, 3, 6, 9 and 10). The results are presented by Sector, and discussed in this sequence below. Following radiocarbon convention, all raw radiocarbon determinations are presented as 'BP' ('Before Present', where present is defined as 1950 CE) with calibrated radiocarbon ages given on the current best-estimate calendar timescale in 'calibrated years Before Present' ('cal BP'). It should be noted that throughout this present volume the radiocarbon calibration curve 'IntCal13' (Reimer et al. 2013) has been used (cf. the previous iteration of the calibration curve, 'IntCal09', Reimer et al. 2009, that was applied in previous publications on Taforalt, *inter alia*, by Barton et al. 2013).

Sector 8

The entire stratigraphic sequence in Sector 8 covers a thickness of 5.55 m. A total of 52 radiocarbon determinations (including three duplicated assays) on charcoals and cut-marked bones (collagen fraction) had been previously published from the Iberomaurusian levels in this sector (Barton et al. 2013). The majority of these samples were on individual large charcoal fragments identified to species (**tab. 4.1**). A further 11 AMS radiocarbon determinations from the same profile have been obtained subsequently and are included here. They consist of measurements on eight bone and three charcoal specimens.
The radiocarbon data were subjected to Bayesian statistical modelling (**fig. 4.1** and **tab. 4.1**). This is a well-established tool for combining acquired information (*prior probability*) with chronological measurements (*likelihoods*) to improve the precision and accuracy of the site's chronology (*posterior probability*). We used the freely available computer software OxCal v.4.2 (Bronk Ramsey 2017) for such analysis. Briefly, the Bayesian model in the present case consisted of four separate Poisson process ('**P_Sequence**') deposition models (Bronk Ramsey 2008) – one for the Grey Series and three for the underlying Yellow Series (**fig. 4.1**). The model averaging approach of Bronk Ramsey/Lee (2013) was utilised to independently estimate the optimal rigidity of these **P_Sequences** (i.e. the variability in deposition rate, defined by the '**k**' parameter in OxCal). The Yellow Series was split into three separate **P_Sequences** due to empirically observed breaks (hiatuses) down the list of dates (i.e. from the radiocarbon data themselves, rather than anything sedimentologically observable at the site).
The precise position (represented by 'nominal depth') of samples in the sequence included some uncertainty (ranging from ± 1 cm to ± 16 cm) when transferring positions onto the single composite depth scale for the Sector, as described in **Chapter 2**. This was accounted for in the Bayesian modelling by placing the individual radiocarbon dated samples in a series of individual sequences, between corresponding upper and lower

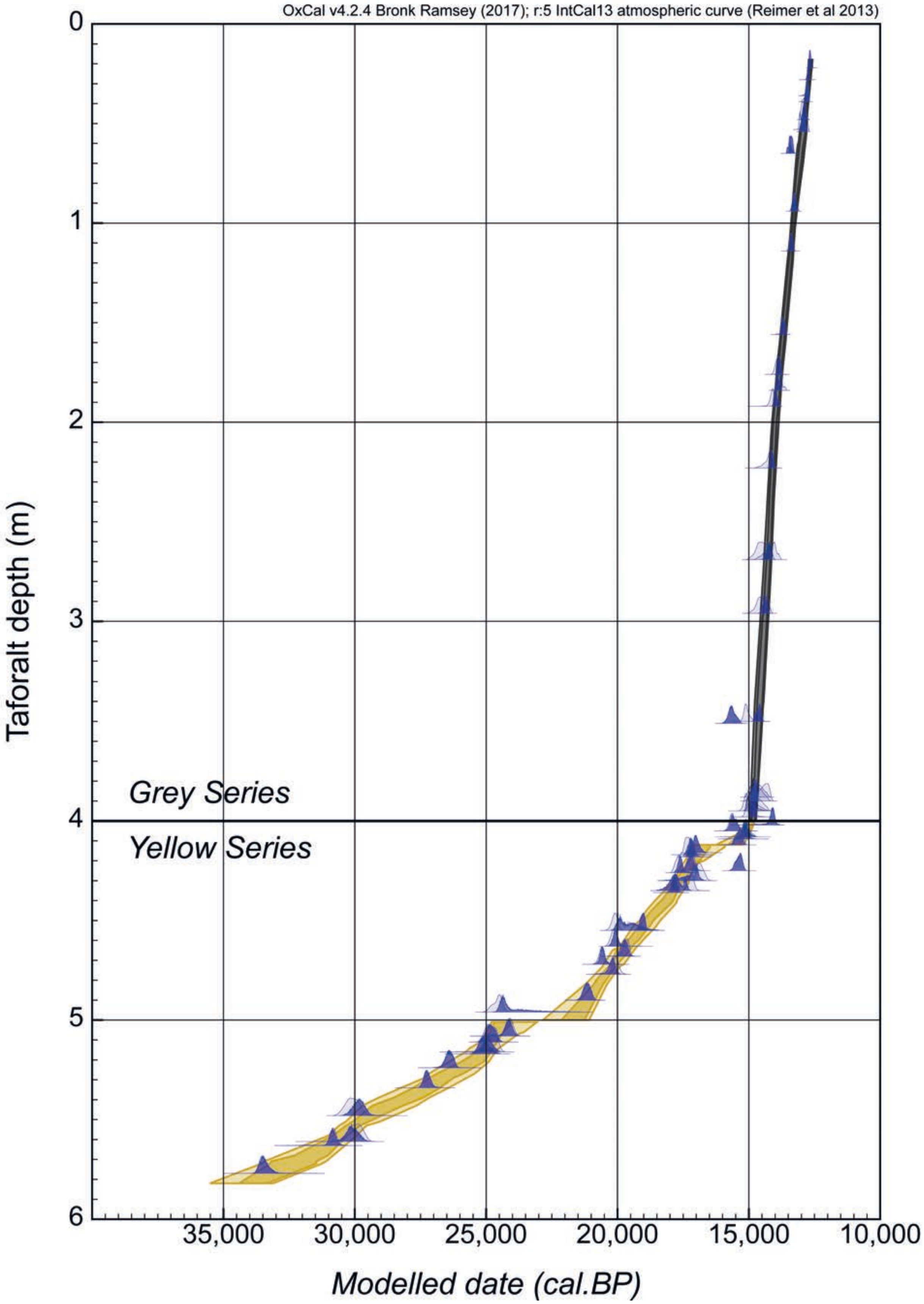

Fig. 4.1 Bayesian age-depth model of AMS ^{14}C data for Taforalt cultural sequence; the posterior 68.2 % and 95.4 % uncertainty envelopes are plotted in grey and gold for the GS and YS, respectively; note that the y-axis represents *nominal* depth measurements.

ORAU lab code	Conventional ^{14}C age BP (± 1σ)	Calibrated age (cal BP) 95.4 % range	Modelled† age (cal BP) 95.4 % range	Unit	Nominal depth†† (m)	Species	<TAF Ref>
OxA-24111	10,680 ± 45	12,566-12,713	12,611-12,725	L2	0.18-0.26	*Ammotragus lervia*	TAF09-7319
OxA-34434	10,855 ± 50	12,686-12,814	12,688-12,788	G88	0.18-0.38	*Quercus* sp.	TAF03-200a
OxA-13479	10,935 ± 40	12,705-12,900	12,720-12,828	G88	0.31-0.41	*Pinus* sp.	TAF03-200b
OxA-23404	10,870 ± 45	12,693-12,813	12,700-12,817	L3	0.26-0.52	*Pinus* sp.	TAF09-7525
OxA-13480	10,950 ± 45	12,711-12,950	12,730-12,866	G89	0.34-0.44	*Pinus* sp.	TAF03-202
OxA-13516	11,065 ± 45	12,799-13,059	12,798-12,985	G89	0.43-0.53	*Pinus* sp.	TAF03-203
OxA-24112	11,165 ± 45	12,905-13,125	12,804-13,045	L4	0.52-0.54	*Ammotragus lervia*	TAF09-7997
OxA-13517	10,990 ± 45	12,730-12,990	12,819-13,010	G90	0.49-0.59	Dicotyledonous	TAF03-204
[a]OxA-24113	11,540 ± 50	13,281-13,468	13,280-13,467	L6	0.61-0.69	*Gazella*	TAF09-8289b
[a]OxA-23405	11,615 ± 50	13,329-13,562	13,330-13,562	L6	0.61-0.69	*Juniperus / Tetraclinus*	TAF09-8275
OxA-27276	11,410 ± 55	13,123-13,384	13,169-13,344	L8	0.86-1.02	*Ammotragus lervia*	TAF09-8552
OxA-23407	11,465 ± 50	13,193-13,435	13,200-13,354	L8	0.86-1.02	*Juniperus / Tetraclinus*	TAF09-8590#
OxA-23406	11,445 ± 55	13,151-13,420	13,200-13,354	L8	0.86-1.02	*Juniperus / Tetraclinus*	TAF09-8590#
OxA-23408	11,545 ± 55	13,275-13,476	13,310-13,467	L11	1.09-1.19	*Pinus* sp.	TAF09-8849
OxA-23409	11,890 ± 55	13,555-13,828	13,590-13,780	L15	1.52-1.60	*Pinus* sp.	TAF10-9159
OxA-27277	12,040 ± 55	13,754-14,051	13,750-13,945	L17	1.71-1.81	*Ammotragus lervia*	TAF10-9368
OxA-27278	11.945 ± 55	13,590-13,976	13,780-13,989	L19	1.81-1.86	*Ammotragus lervia*	TAF10-9484
OxA-27281	12,210 ± 55	13,925-14,312	13,831-14,077	L20	1.86-1.99	*Ammotragus lervia*	TAF10-9578
OxA-27280	12,290 ± 55	14,033-14,600	13,999-14,233	L23	2.07-2.39	*Ammotragus lervia*	TAF10-9775
[c]OxA-27279	12,310 ± 55	14,064-14,649	14,135-14,423	L24	2.51-2.86	*Ammotragus lervia*	TAF10-9881
[c]OxA-34435	12,420 ± 55	14,177-14,855	14,147-14,421	G96-2	2.61-2.77	*Pinus* (charred seeds)	TAF03-G96-2A
[c]OxA-34436	12,145 ± 55	13,815-14,177	14,131-14,421	G96-2	2.61-2.77	*Pinus* (charred seeds)	TAF03-G96-2B
[c]OxA-23410	12,405 ± 55	14,156-14,855	14,244-14,545	L25	2.92-3.00	*Juniperus / Tetraclinus*	TAF10-10052
[b]OxA-13477	12,675 ± 50	14,829-15,271	14,483-14,810	G97	3.40-3.60	Conifer	TAF03-36

Tab. 4.1 Sector 8 (and inward continuation): radiocarbon data. OxCal v.4.2 Bayesian Modelling; †† for explanation of "nominal depth", see **Chapter 2**. – All calibration has been produced using IntCal13.
Same sample measured twice.
* Plausibly a date on a Y1 object physically disturbed and drawn down into Y2 during very obvious plastic deformation affecting the contact zone between the two units (note also apparent mixing of lithic artefacts at this level).
** Uncertain (Y2 or Y4?); relative depth for ordering / modelling estimated from actual surveyed depth.
[a] Samples plausibly displaced from their original position (also yielding posterior outlier probabilities of > 95 % in the modelling); [b] Samples possibly displaced from their original position (also yielding posterior outlier probabilities > 50 % in the modelling); [c] Particularly stony units (clast-supported) in the centre of the Grey Series (with highest sedimentation rates expected; less reliable contexts for tiny objects like charred seeds).

ORAU lab code	Conventional ^{14}C age BP (± 1σ)	Calibrated age (cal BP) 95.4 % range	Modelled† age (cal BP) 95.4 % range	Unit	Nominal depth†† (m)	Species	<TAF Ref>
[a]OxA-23411	13,060 ± 65	15,345-15,895	15,339-15,902	L28	3.42-3.60	*Juniperus*/ *Tetraclinus*	TAF10-10319
OxA-13478	12,495 ± 50	14,314-15,052	14,664-14,924	G99	3.78-3.98	Juniperus/ Tetraclinus	TAF03-90
OxA-22902	12,370 ± 50	14,129-14,740	14,658-14,927	G99 sqD17	3.80-4.00	Conifer	TAF08-6834
OxA-22904	12,490 ± 50	14,303-15,052	14,670-14,930	G99	3.80-4.00	Conifer	TAF08-6840
OxA-22787	12,545 ± 55	14,443-15,131	14,710-14,955	G99	3.85-4.05	Conifer	TAF08-6841
OxA-22785	12,500 ± 55	14,313-15,066	14,716-14,956	G99 sqD17	3.85-4.05	cf. *Juniperus*	TAF08-6833#
OxA-22784	12,660 ± 70	14,731-15,285	14,716-14,956	G99 sqD17	3.85-4.05	cf. *Juniperus*	TAF08-6833#
OxA-24109	12,605 ± 55	14,684-15,199	14,734-14,970	G100	3.88-4.08	Bos	TAF04-466
		(Grey/Yellow Boundary)	(Irregular Diachronic Erosion Event)				
OxA-22786	12,200 ± 55	13,910-14,292	13,853-14,788	Y1 sqD17	3.92-4.12	cf. *Juniperus*	TAF08-6836
OxA-22903	13,045 ± 50	15,356-15,838	15,320-15,808	Y1 sqD17	3.95-4.15	cf. *Cedrus*	TAF08-6835
OxA-22905	12,665 ± 50	14,806-15,256	14,933-15,289	Y1	4.03-4.13	cf. *Arbutus*	TAF08-6842
OxA-14349	12,690 ± 55	14,844-15,299	14,855-15,306	Y1	3.98-4.18	*Struthio* (ostrich eggshell)	TAF04-657
OxA-27282	12,730 ± 60	14,908-15,365	14,940-15,368	L30	4.00-4.18	*Alcelaphus* sp.	TAF10-10710
OxA-22788	12,850 ± 55	15,144-15,576	15,180-15,615	Y1	4.07-4.17	Conifer	TAF08-6844
		(Major Erosion Event)					
OxA-16267	14,005 ± 60	16,716-17,256	16,745-17,214	Y2	4.11-4.21	Tetraclinus articulata	TAF06-5415
OxA-22907	14,230 ± 55	17,120-17,523	16,964-17,446	Y2	4.12-4.22	cf. *Juniperus*	TAF08-6853
OxA-22906	14,135 ± 55	16,996-17,437	16,972-17,380	Y2	4.13-4.23	Conifer	TAF08-6852
OxA-22908	14,110 ± 55	16,954-17,413	17,009-17,447	Y2	4.20-4.30	cf. *Arbutus*	TAF08-6854
[a]OxA-27283	12,875 ± 60	15,160-15,618	15,157-15,614	L31*	4.20-4.30	*Equus* sp.	TAF10-10847
OxA-16268	14,515 ± 60	17,500-17,903	17,273-17,817	Y2	4.21-4.31	Tetraclinus articulata	TAF06-5416
OxA-13519	13,905 ± 55	16,585-17,075	16,765-17,906	Y2	4.20-4.40	*Juniperus*/ *Tetraclinus*	TAF03-317
[b]OxA-22909	14,140 ± 55	17,004-17,443	17,307-18,231	Y2	4.30-4.40	Conifer	TAF08-6855
OxA-16272	14,630 ± 60	17,621-17,995	17,652-18,010	Y2	4.31-4.41	*Quercus* sp.	TAF06-5421
OxA-16269	15,790 ± 60	18,882-19,217	18,886-19,236	Y2	4.50-4.60	*Juniperus* sp.	TAF06-5417
[b]OxA-14350	16,660 ± 70	19,880-20,337	18,862-20,136	Y2 spit5A	4.45-4.65	*Struthio* (ostrich eggshell)	TAF04-1734
OxA-14351	16,695 ± 70	19,925-20,378	19,760-20,347	**	4.53-4.73	*Struthio* (ostrich eggshell)	TAF04-1927

Tab. 4.1 (continued)

ORAU lab code	Conventional ^{14}C age BP (± 1σ)	Calibrated age (cal BP) 95.4 % range	Modelled† age (cal BP) 95.4 % range	Unit	Nominal depth†† (m)	Species	<TAF Ref>
OxA-16270	16,285 ± 65	19,477-19,908	19,514-19,993	Y3	4.63-4.73	*Pinus* sp.	TAF06-5418
OxA-13518	17,085 ± 65	20,404-20,835	20,309-20,807	Y3	4.62-4.82	*Quercus* sp.	TAF03-316
OxA-16242	16,630 ± 75	19,826-20,315	19,940-20,643	Y4	4.72-4.82	Dicot unidentified	TAF06-5419
OxA-16273	17,515 ± 75	20,894-21,430	20,882-21,436	Y4	4.80-5.00	*Pinus* sp.	TAF06-5422
		[LSA / MSA transition]					
OxA-16271	20,420 ± 90	24,253-24,945	22,293-24,635	Y4	4.91-5.01	*Pinus* sp.	TAF06-5420
		(Minor Erosion Event)					
OxA-16274	20,630 ± 90	24,499-25,192	24,514-25,152	Y5	5.06-5.16	Conifer	TAF06-5424

Tab. 4.1 (continued)

Boundaries delineating the total depth uncertainty for those samples. These upper and lower **Boundaries** were then cross-referenced into the four primary **P_Sequences**.
Duplicate measurements were combined using the **R_Combine** function in OxCal to produce a weighted average. Objective outlier analysis was also utilised to account for potential statistical outliers in the radiocarbon data. The '**General**' outlier model of Bronk Ramsey (2009) was applied, accounting for errors in the calendar age scale of samples (i. e. primarily issues of residuality or intrusion within the deposition environment). Additionally, the '**SSimple**' outlier model was applied to the duplicate measurements within the **R_Combine** functions (Bronk Ramsey 2009). All samples were assigned a prior outlier probability of 5 %, since there was no reason *a priori* to believe that any samples were more likely to be erroneous than others.
The modelled chronology for the Iberomaurusian sequence in Sector 8 is reproduced in **table 4.1**. In terms of the outlier analyses applied, four samples (OxA-17283, OxA-23405, OxA-24113 and OxA-23411) yielded posterior outlier probabilities of > 95 %, and were therefore excluded from the final model (presented here). A further 3 samples gave posterior outlier probabilities > 50 % (OxA-14350, OxA-22909 and OxA-13477).
The boundary between the Yellow and Grey Series dates to shortly after 15,000 cal BP (base of GS 14,966-14,733 cal BP; top of YS 15,070-14,767 cal BP; 95.4 % ranges) according to our revised Bayesian modelling against IntCal13, and should be considered as superseding the modelling presented by Barton et al. (2013). The overall picture gained from Bayesian modelling of the S8 radiocarbon dataset, through both the YS and GS, supports the basic plotting of the calibrated dates shown in **figure 2.17**. We conclude that our understanding of the chronology of the S8 sequence is robust.

Sector 3

This sector is separated from Sector 8 by both Ruhlmann's south trench and Roche's subsequently excavated northwards notch. The dates presented by Roche (1976) are not considered reliable enough for making direct comparisons. However, our new AMS ^{14}C dates (**tab. 4.2**) confirm the interpretation of the linkage between Sectors 3 and 8. The lowermost two ^{14}C samples relate to units containing pre-Iberomaurusian finds.

ORAU lab code	Conventional ^{14}C age BP (± 1σ)	Calibrated age (cal BP) 95.4 % range	Unit	Species	<TAF Ref>
OxA-26484	13,980 ± 80	17,254-16,620	4-6	*Cupressus* sp. or *Juniperus*	TAF08-5820
OxA-26639	14,800 ± 60	18,204-17,824	11-13, top RXII	*Prunus* sp.	TAF08-6159
OxA-16264	15,355 ± 65	18,781-18,471	22, RXII = Y3	*Quercus* sp.	TAF06-5412
OxA-16265	15,585 ± 65	18,976-18,692	30, RXII = Y3	*Pinus halepensis*	TAF06-5413
OxA-26640	16,170 ± 65	19,726-19,278	28-30	*Cupressus* sp.	TAF08-6633#
OxA-26641	16,165 ± 65	19,717-19,272	28-30	*Cupressus* sp.	TAF08-6633#
OxA-26642	16,030 ± 65	19,561-19,140	30-32, RXIII mid	*Juniperus*/*Tetraclinus*	TAF08-6646
OxA-26643	17,070 ± 75	20,832-20,355	38-40, RXIII base	*Juniperus*/*Tetraclinus*	TAF08-6705
OxA-16266	20,500 ± 90	25,044-24,350	58, RXIV = Y5	Conifer cf. *Cupressus*	TAF06-5414
OxA-26644	22,580 ± 110	27,238-26,541	58-60, RXIV mid	*Pinus* sp.	TAF08-6858

Tab. 4.2 AMS ^{14}C data for Sector 3. # Sample measured twice.

ORAU lab code	Conventional ^{14}C age BP (± 1σ)	Calibrated age (cal BP) 95.4 % range	Unit	Species	<TAF Ref>
OxA-16263	13,975 ± 60	17,196-16,670	S6-(N)2	*Juniperus* sp.	TAF06-5411
OxA-16262	15,995 ± 65	19,526-19,081	S6-(N)6	*Pinus* sp.	TAF06-5410

Tab. 4.3 AMS ^{14}C data for Sector 6.

Sector 6

The units dated here belong to the Upper Laminated group but it is not yet certain how, or even if, they correlate with the sequence in the Raynal type-section in Sector 1.

Sector 9

Six AMS radiocarbon determinations relate to the dating of the Iberomaurusian in Sector 9. They comprise five dates on charcoal and one on ostrich eggshell. The two charcoal dates from Units U1 and U2 (OxA-16260 and OxA-16240) come from the inner, west end of S9 and lie stratigraphically above CTX9 at the east

ORAU lab code	Conventional ^{14}C age BP (± 1σ)	Calibrated age (cal BP) 95.4 % range	Unit	Species	<TAF Ref>
OxA-16260	18,005 ± 75	21,559-22,058	S9-U1	*Tetraclinus articulata*	TAF06-5407
OxA-16240	18,185 ± 75	21,825-22,292	S9-U2	Charcoal unidentified	TAF04-1133
OxA-35508	16,410 ± 70	19,583-20,025	S9-CTX5	*Pinus* cf. *pinaster*	TAF16-14786
OxA-35993*	16,670 ± 55	19,915-20,318	S9-CTX6	*Struthio*	TAF16-14995
OxA-35509	19,230 ± 80	22,912-23,459	S9-CTX9	*Pinus* sp.	TAF16-15374
OxA-36628	18,505 ± 80	22,166-22,569	S9-CTX10	*Juniperus*/*Tetraclinus*	TAF17-15921

Tab. 4.4 AMS ^{14}C data for Sector 9. *ostrich eggshell dates problematic.

(outer) end of the Sector 9 trench. The charcoal from the base of CTX9 (OxA-35509) is so far the oldest date for the Iberomaurusian at Taforalt. CTX10 is a hearth-like band that lies a little higher, within CTX9, therefore explaining its younger age. The dates on ostrich eggshell from CTX6 (OxA-35993) and charcoal from the CTX5 (OxA-35508) appear to be too young. There is a systematic problem in dating ostrich eggshell at this site. The charcoal date in CTX5 is from the truncated top of the outer, east end of S9, and is suspected as coming from a disturbed context.

Sector 10

Bone and charcoal samples for dating were collected from near the back of the cave in the grey ashy deposits (Grey Series). They comprise human remains from burials (all excavated during the present campaign) plus cut-marked specimens of Barbary sheep (OxA-15441; OxA-15442; OxA-15443) and Ephedra charcoals (OxA-29263; OxA-29264). Although not demonstrably associated with individual burials, the animal bone shows signs of deliberate modification (butchery) and comes from broadly the same sedimentary contexts as the assemblage of human remains. The same is true of the Ephedra specimens. A dated bovid metatarsus shaft fragment (OxA-16688) was recovered from near one of the multiple burials (which includes Individual 4), but from a slightly higher level and in association with further human bones (in which no collagen is preserved). Another one of the Barbary sheep (*Ammotragus*) bones (OxA-24645) is reliably associated with human Individual 5.
Duplicate measurements were undertaken on two samples. OxA-X-2193-45 had a low collagen yield (6.0 mg from 1300 mg starting weight, i.e. 0.46 % yield compared to the ORAU quality assurance threshold of 1 % collagen yield, hence the 'OxA-X-' prefix). The repeat sub-sample, OxA-16688 (yielding 80 mg collagen from 3000 mg starting weight), produced a statistically indistinguishable result. Likewise, OxA-16663 was

ORAU lab code	Conventional ^{14}C age BP (± 1σ)	Calibrated age (cal BP) 95.4 % range	Species	<TAF Ref>
OxA-15441	12,325 ± 50	14,660-14,086	Ovicaprid	TAF05-2530
OxA-15442	12,400 ± 50	14,817-14,156	Ovicaprid	TAF05-3152
OxA-15443	12,310 ± 60	14,670-14,058	Unident. bone	TAF05-3201
OxA-24645	12,305 ± 60	14,662-14,052	*Ammotragus*	TAF08-6716
OxA-27284	12,520 ± 55	15,101-14,365	Canid	TAF10-11398
OxA-X-2193-45	12,590 ± 70	15,211-14,499	Bovid	TAF06-4124#
OxA-16688	12 475 ± 50	15,015-14,275	Bovid	TAF06-4124#
OxA-16663	12,470 ± 100	15,086-14,189	*Homo* Ind 7	TAF06-4797#
OxA-16689	12,485 ± 80	15,080-14,241	*Homo* Ind 7	TAF06-4797#
OxA-23660	12,380 ± 55	14,783-14,130	*Homo* Ind 4	TAF08-5566
OxA-23778	12,265 ± 50	14,468-14,005	*Homo* Ind 5	TAF08 6999
OxA-23779	12,255 ± 50	14,431-13,993	*Homo* Ind 6	TAF08 5733
OxA-23780	12,355 ± 50	14,712-14,116	*Homo* Ind 9	TAF09 8260
OxA-23781	12,410 ± 50	14,846-14,168	*Homo* Ind 14	TAF09 9103#
OxA-23782	12,460 ± 55	14,995-14,242	*Homo* Ind 14	TAF09 9103#
OxA-29263	12,410 ± 50	14,846-14,168	*Ephedra*	TAF13 12047
OxA-29264	13,065 ± 55	15,886-15,372	*Ephedra*	TAF13 12264

Tab. 4.5 AMS ^{14}C data for Sector 10. # Sample measured twice.

Type	Lab code	Age (± 1σ)	Unit	<TAF Ref>
OSL	X1867	19,300 ± 1200	Grey Series	TAF03-[OS]L16
OSL	X1864	21,700 ± 1300	Yellow Series Y2spit4	TAF03-[OS]L13
TL	X2259 [ANU:K0338]	17,400 ± 700	Grey Series G100	TAF04-762
TL	X1866 [ANU:K0317]	19,100 ± 1200	Grey Series base	TAF03-328 ([T]L15)

Tab. 4.6 OSL and TL ages for Sector 8 relevant to LSA units. – (After E. J. Rhodes in: Bouzouggar et al. 2007).

repeated because of a low collagen yield (3.0 mg from 100 mg starting weight, as compared to a further ORAU quality assurance stipulation that collagen yield should exceed 5.0 mg as well as the 1 % threshold). The second determination (OxA-16689) also yielded relatively little collagen (4.7 mg from 260 mg starting weight), but again provided a statistically indistinguishable measurement. For all four of the above subsamples, the C:N ratios (providing an indication of whether or not any contamination had been successfully chemically removed from the remaining collagen) were acceptable (i. e. within the acceptable range of between 3.00 and 3.45, according to ORAU protocol).
The dated human bones relate to a number of different individuals: OxA-16663 is from Individual 7; OxA-23660, Individual 4; OxA-23778, Individual 5; OxA-23779, Individual 6; OxA-23780, Individual 9; and OxA-23781 and OxA-23782 (a duplicated sample), Individual 14. These are further discussed in **Chapter 15**.

4.3 LUMINESCENCE DATING

Sector 8

Sampling in the early stages of the project in 2003 was undertaken by ER and provided two OSL dates on sediments and two TL age determinations on burnt chert artefacts in Sector 8 (**tab. 4.6** and Barton et al. 2007, fig.15.2). The luminescence dating methods taken together have produced a set of results which is internally consistent. However, the dates from the Grey Series are at odds with the results of the radiocarbon dating, and this will be further referred to in the discussion at the end of this chapter.

Sector 3

Of the OSL samples from Sector 3, two were located in the Iberomaurusian sequence above the distinctive Y5 marker horizon (see **Chapter 2**). The results are presented in **table 4.7** and are considered slightly older than the AMS radiocarbon dates in the same sequence.

Sample	Multigrain Age (ka) (± 1σ)	Single Grain Age (ka) (± 1σ)	Unit
X3362 [OSL-TAF08-13]	20.0 ± 1.7	18.2 ± 1.4	S3-AOH09[8-29]
X3361 [OSL-TAF08-12]	22.9 ± 2.2	20.2 ± 1.8	S3-AOH09[40-44]

Tab. 4.7 Sector 3 OSL ages for Iberomaurusian levels. – (After Clark-Balzan 2013).

Sample	K (%)	Th (ppm)	U (ppm)	Gamma Dose Rate* (Gy ka^{-1})	Depth (cm)**	Cosmic Dose Rate (Gy ka^{-1})	Total Wet Dose Rate (Gy ka^{-1})	Age (ka)
OSL-TAF09-20	1.58	5.6	1.6	0.55 ± 0.03	35-45	0.094 ± 0.009	1.87 ± 0.13	18.6 ± 1.7
OSL-TAF09-21	0.96	4.3	1.3	0.57 ± 0.03	70-80	0.091 ± 0.008	1.45 ± 0.09	25.1 ± 2.3

Tab. 4.8 Sector 9 values for dose rate calculations and final ages – (sample depth ranges are in cm below surface).
* Determined on site with a portable gamma-ray spectrometer calibrated against the Oxford blocks (Rhodes/Schwenninger 2007).
** The original burial depth of both samples is likely to have been in excess of 3 m due to the removal of substantial amounts of sediment during previous excavations by Ruhlmann & Roche.

Sector 9

OSL samples were taken from Sector 9 by LC-B. Sampling was from one of the cleaned vertical sections at the eastern end of Ruhlmann's north trench and was focused on units in which lithic artefacts and charcoals were present. Lithic artefacts identifiable as Iberomaurusian were recorded only from the top sample at 35-45 cm. The lithostratigraphy is described in **Chapter 2**.

4.4 CRYPTOTEPHRA (SECTOR 8)

Cryptotephra was recovered in low concentrations throughout the top 18 cm of the Yellow Series, in Unit Y1, Sector 8 (Barton et al. 2015, fig. 4). The sediments here have been radiocarbon dated to between 14.8 and 17.2 ka cal BP. Glass shards display elongated vesicles and fluted structures and are the largest so-far observed from the site, with longest axis lengths of up to 100 µm. As an initial test of whether the 18 cm spread of tephra was all from the same eruption, two samples from within this depth range were picked and analysed. The samples returned matching rhyolitic compositions (Barton et al. 2015, tabs 1-2). The sediments of Y1 are characterised by finely laminated, fine to medium sands, indicating emplacement by gentle wash processes. The distribution of the tephra and the homogeneous composition therefore likely reflects the time over which these tephra shards continued to be re-worked (washed/blown) into the cave from the catchment, following a single volcanic eruption.
The major and minor element composition of this rhyolitic tephra is similar to that observed in tephras from potentially diverse geographic source regions. For example, multiple similar rhyolitic tephras from Icelandic and Aeolian volcanoes have been described from distal localities in this time-frame (Davies et al. 2012; Albert et al. 2012). Based upon major element geochemistry, similarities are seen between TAF-S8-Y1 and the Icelandic Penifiler and Borrobol tephra layers (13,939 ± 66 cal BP and 14,098 ± 47 cal BP, respectively (Bronk Ramsey et al. 2015), i. e. slightly post-dating the modelled age of the tephra in Taforalt), as well as the Lipari Gabelotto Fiumibianco from the Aeolian Islands. However, comparison of the limited available trace element geochemistry data shows that tephra from both of these sources is distinctly different from TAF-S8-Y1 (Barton et al. 2015), and the tephras from Iceland are currently not identified beyond NW Europe. The size and abundance of shards do not necessarily reflect distance from source: the relationship is not particularly straightforward as the magnitude of the eruption, height of the plume, and the strength and direction of the wind will control tephra dispersal and deposition, whilst taphonomic processes govern the preservation.

That said, longest axis lengths of up to 100 µm is a characteristic likely ruling out an Icelandic source. The source of the cryptotephra in TAF-S8-Y1, for the present, remains unknown.
Cryptotephra has also been located in various units of Sector 9 (Victoria Smith, pers. comm.). This is currently under investigation.

4.5 DISCUSSION

The key sequence for the Iberomaurusian at Taforalt is in Sector 8 for which we have obtained 63 ^{14}C determinations. This comprises two main sediment units: the upper part of the Yellow Series (YS) and the Grey Series (GS). Overall, the GS represents a rapid sediment accumulation brought about by a significant increase in anthropogenic activity in the cave. Our dating evidence suggests a commencement in GS deposition within a couple of centuries of 15,000 cal BP, although it has to be remembered that the GS has an irregular and erosive base and this is corroborated by variation in dating results of the undulating surface of this deposit. The youngest age from the top of the GS (and by definition related to Iberomaurusian occupation) is given by a Barbary sheep phalange at 10,680 ± 45 BP (12,568-12,713 cal BP at 95.4 % probability). However, it cannot be ascertained exactly when human activity ceased at the site because the top of the deposits were removed by the military authorities in 1939 (see **Chapter 1**). The dates confirm a rapid deposition rate in the GS, generally faster in the lower parts and slowing somewhat towards the top.
In the YS a much slower accumulation rate is recorded, as shown by sediment analysis and confirmed by AMS ^{14}C dating. Another point worth highlighting is that the oldest preserved Iberomaurusian deposits occur, not in Sector 8, but on the opposite side of the cave in Sector 9 (**tab. 4.4**). The latter deposits form part of a 'local' sequence that cannot be correlated directly with the units in Sector 8. As discussed in **Chapter 2**, we suspect that the marginally earlier dates in Sector 9 are probably due to better distinguishability from our perspective, the slight differences in sedimentary accumulation modes and rates on either side of the cave having left the S9 sequence less condensed than in S8. In any case, the LSA Iberomaurusian deposits began to accumulate sometime between 22,912-23,459 cal BP (at 95.4 % confidence) (**tab. 4.4**).
Finally, one issue that we cannot yet resolve is the apparently systematic discrepancy between some of the luminescence and AMS ^{14}C dating results. This is especially pronounced in the Grey Series in Sector 8 which, as has previously been mentioned, consists dominantly of burnt sediment and ash. TL and OSL dates obtained from samples collected within the Grey Series appear to systematically overestimate the true depositional age by more than 2000 years. Whilst, in the case of TL, such older dates might be explained by the reworking of chert artefacts from older deposits, the same would be very unlikely for OSL dated quartz mineral grains. The heavy burning of the sediment provides ideal conditions for the full resetting of the luminescence signal with little concern for potential issues pertaining to partial bleaching. Exposure to heat is also expected to greatly improve the sensitivity of the quartz for dating purposes. At Taforalt the latter was generally characterised by excellent response to artificial irradiation and samples always display perfect growth curves, low recuperation values as well as good recycling ratios.
Rather than the root of the problem being linked to the TL/OSL measurements themselves, the issue is more likely to stem from an incorrect estimate of the environmental dose rate. Indeed, the high concentration of ashy material incorporated into the Grey Series presents some specific challenges with regards to dosimetry. Elemental analyses of the sediment revealed very low concentrations of radioisotopes. In the case of OSL sample X1867 (**tab. 4.6**), they provided 0.42 % potassium, 9.8 ppm rubidium, 1.37 ppm thorium and

0.33 ppm uranium. These are responsible for very low external gamma dose rates ranging from 0.21 to 0.35 Gy/ka (based on OSL sample X1867 and TL samples X1866 and X2259).

The low concentrations of potassium may seem particularly surprising given the substantially higher concentrations of 1.17 % and 1.43 % recorded from samples X1864 and X1865 in the directly underlying Yellow Series. Wood ash, and leaf ash in particular, are also known to enhance considerably the concentration of potassium in soils (Ohno/Erich 1990) with wood ash generally containing c. 4 % of potassium. However, the high solubility of potassium in well drained coarse sediments, such as those forming the bulk of the GS, could also lead to depletion of ^{40}K over time, notably during prolonged periods of increased precipitation. Due to leaching in the past, the recorded modern values may thus not reflect the original concentrations and the calculated beta and external gamma dose rates may therefore not necessarily be reliable. A small increase of only 0.15 % to 0.20 % in the amount of potassium present within the sediment would be sufficient to bring most of the OSL and TL dates into alignment with the AMS ^{14}C dates. The unusual nature of the heavily burnt and powdery sediment may also require a downward revision of the mean sediment density which, for the purposes of most dose rate calculations, is generally assumed to be similar to compacted sand with values typically centred around 1800-1900 kg/m³. The bulk density of wood ash is considerably lower (i. e. 600-900 kg/m³) and, given the high occurrence of ashy debris contained within the GS, it seems reasonable to conclude that a lower value of c. 1200 to 1500 kg/m³ would provide a better approximation. The effect of this would be to further reduce the calculated age estimates. Further quantification of these effects will be required in order to provide more reliable luminescence age estimates for samples collected from the GS.

Y. CARRIÓN MARCO

5. CHARCOAL ANALYSIS: WOOD EXPLOITATION AND FIRE

5.1 INTRODUCTION

Taforalt Cave or Grotte des Pigeons is located approximately 40 km from the Mediterranean coast, at 720 m a. s. l. within the Beni Snassen mountains, which are part of the SE foothills of the Atlas/Baetic System. The influence of the Mediterranean climate is remarkable in this region (see **Chapter 1**). The cave is located within the thermo-Mediterranean bioclimatic zone (Rivas-Martínez/Loidi 1999), with a well-marked moisture gradient from east (sub-humid) to west (semi-arid).

Because of its biogeographical particularities, the region around the Strait of Gibraltar (Baetic-Rifean region) has been identified as a hot-spot of plant diversity (Médail/Quézel 1997), although in recent times human modelling of landscape around the Rif and Beni Snassen areas, including intense deforestation, has become particularly evident. Interest in this biodiversity has led to some recent studies on flora and vegetation (e. g. Charco 1999; Valdés et al. 2002) but a diachronic long-term analysis is absolutely necessary to understand fully the genesis of current landscapes and their evolution under climate and/or human impact. Nowadays, the local vegetation is dominated by *Pinus halepensis* and *Tetraclinis articulata*, associated with *Quercus ilex* and *Juniperus* sp. and other sclerophyllous shrubs.

Taforalt marks a milestone in research on prehistory in North Africa and, particularly, on palaeobotanical analysis since the mid-20th century, as some authors working in the cave began laying the methodological and interpretive bases of the discipline. Thus, S. Santa (1958-59) highlighted the suitability of archaeological charcoal for the reconstruction of past vegetation, using thin sections of charcoal from Taforalt. Other pioneering works carried out in North Africa include those by L. Balout (1952), J. Momot (1955), S. Santa (1961) and M. Couvert (1977). These researchers put forward some of the main lines of interpretation in anthracology and even proposed a climate approach based on the flora identified in prehistoric charcoal assemblages (Couvert 1976; Couvert/Roche 1978). For the early 1990s, we must highlight the work performed on several deposits from eastern Morocco by L. Wengler and J.-L. Vernet (1992) and the summary by K. Neumann (1992) about Late Quaternary Mediterranean vegetation, including North Africa.

In 2007, the PhD thesis by S. Ward (University of Oxford) is another reference work, because it comprises several sites in North Africa (including Taforalt) and Gibraltar, and it offers an extensive discussion about the changes in vegetation and their influence on the main cultural transitions (among other topics); some of the results of this thesis will be considered below.

Despite these pioneering works, there was a general lack of regional, systematic studies of plant macro-remains in North Africa until the team led by Lydia Zapata and Leonor Peña-Chocarro began to undertake several studies within the framework of the PALEOPLANT project (ERC-2013-CoG) (Barton et al. 2016; Morales et al. 2013; 2015; 2016; Zapata et al. 2013; Carrión Marco et al. 2018; among others). The importance of charcoal analysis in North Africa, besides offering knowledge about landscapes of the past in a region where there is still a considerable information gap, is based on the local provenance of the wood, thus enabling the reconstruction of the mosaic of landscapes that existed in the past as well as their exploitation over time.

Methods of Charcoal Analysis

In this volume, we present the study of wood charcoal assemblages from Sectors 8 and 10, although the analysis of charcoal from other sectors (2 and 9) is ongoing; other, non-woody charred plant remains are considered in **Chapter 6**.

Charcoal analysis is based on the botanical identification of carbonised wood, i.e. determining which species the charcoal is derived from. Each fragment is observed under a reflected light brightfield/darkfield optical microscope with different lenses ranging from 50x to 1000x magnification. Wood anatomical features are compared with specialised literature on plant anatomy (Greguss 1955; 1959; Jacquiot 1955; Jacquiot/Trenard/Dirol 1973; Neumann et al. 2001; Schweingruber 1990; among others) and a reference collection of current charred wood. The charcoal from Taforalt was analysed in the Laboratory of Prehistory and Archaeology Milagro Gil-Mascarell at the University of Valencia, where there is a complete collection of Mediterranean woods, including numerous woody species from North Africa.

For the standard analysis, charcoal is broken manually and no chemical treatment is needed, so these samples can be used later for radiocarbon dating (Vernet/Bazile/Evin 1979). For the observation of specific features and for taking pictures, we used a Hitachi S-4100 scanning electron microscope (SEM) held at the Central Service for Experimental Research Support (SCSIE) at the University of Valencia.

The frequency of taxa identified is measured as a percentage of fragment counts when the sample contains a statistically meaningful number of charcoals, generally between 100 and 200 fragments, depending on the taxonomic diversity of the sample (Badal 1992; Chabal 1988; Chabal/Fabre/Terral/Théry-Parisot 1999). The identified taxa reflect part of the woody vegetation that was exploited and, thus, present among the local flora (Chabal 1997), so charcoal analysis is a reliable tool for palaeovegetation reconstruction. However, other species could have been present in the environment but not reflected in the anthracological spectra, as in the case of herbaceous plants or woody species that were not collected for socio-cultural reasons.

Charcoal was very abundant in both Sectors 10 and 8 of Taforalt; the former presents a number of *in situ* human skeletons and a limited accumulation of sediment, so there is not a highly developed stratigraphy, but there may be lateral dispersion of charcoals from as yet unidentified locations. On the other hand, Sector 8 offered a long sequence covering an LSA-relevant chronology between c. 23,000-12,600 cal BP (underlain by still earlier material).

The macro-botanical remains were obtained by flotation of the sediment. Charcoal was very abundant, so we analysed between 100 and 170 fragments per sample in Sector 8, a sufficient number to stabilise the taxonomic curve and ensure a representative assemblage, that is, a number likely to include more or less the full range of exploited species (Chabal 1997). In the cemetery area, we analysed numerous samples to be sure that there are no biases in the spatial distribution of the taxa. To do this, between 50 and 100 fragments per sample were analysed, giving a total of 1786 fragments for these burial levels. In both sectors, charcoal fragments of different sizes (>4 mm and 4-2 mm) were selected for analysis using a column of sieves. Once analysed, no significant differences in the taxonomical content of the samples were observed depending on size, so the results are presented together.

Particular Identification Challenges

During the analysis, we had some challenges in botanical identification, mainly regarding certain species, or groups of species, that are anatomically very similar to each other (**fig. 5.1**).

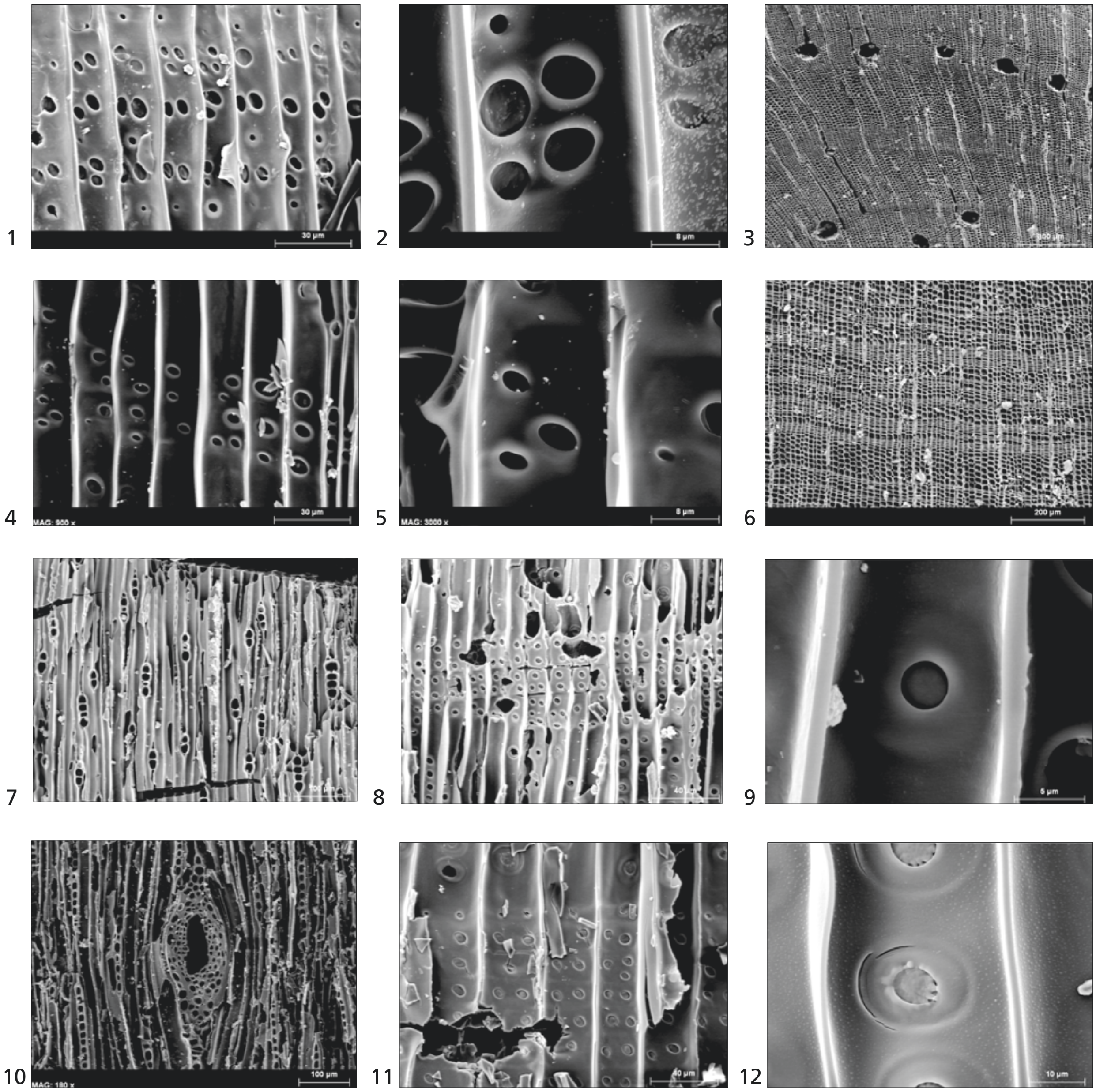

Fig. 5.1 SEM photographs of conifers identified at Taforalt: **1** *Pinus* tp. *pinaster*, radial section, crossfield pits x900, Sector 10; **2** *Pinus* tp. *pinaster*, radial section, crossfield pits x3000, Sector 10; **3** *Pinus* tp. *pinaster*, cross-section, x80, Sector 10; **4** *Pinus* tp. *halepensis*, radial section, crossfield pits x900, Sector 10; **5** *Pinus* tp. *halepensis*, radial section, crossfield pits x3000, Sector 10; **6** *Juniperus*/*Tetraclinis*, cross section, x130, Sector 10; **7** *Juniperus*/*Tetraclinis*, tangential section x200, Sector 8 G100; **8** *Juniperus*/*Tetraclinis*, radial section, crossfield pits x600, Sector 8 G100; **9** *Juniperus*/*Tetraclinis*, radial section, bordered pit x3000, Sector 8 G100; **10** *Cedrus* sp., tangential section x180, Sector 8 G97; **11** *Cedrus* sp., radial section, crossfield pits x600, Sector 8 G97; **12** *Cedrus* sp., tangential section, bordered pit x2000, Sector 8 G97.

In the charcoal assemblage from Taforalt, at least four conifer species were identified, belonging to the Pinaceae and Cupressaceae families, whose identification involved some challenges in terms of anatomical discrimination. With regard to the family Pinaceae, *Pinus* tp. *pinaster* and *P.* tp. *halepensis* were identified, plus a percentage of fragments that could not be determined beyond genus level (*Pinus* sp.). According to the atlases, differences between different pine species are marked by the distribution of the resin ducts along the growth rings that are visible on the cross section of wood, as well as by cross-field pits and ray tracheid wall morphology on the radial section (Greguss 1955; Jacquiot 1955; Schweingruber 1990; Riou-

Nivert 1996). Two groups of pines, the highland species and the lowland/Mediterranean ones, are clearly differentiated thanks to the presence of fenestriform pits in the cross-fields of the former group; at Taforalt, all the pines identified belong to the Mediterranean group.
Another problematic group is the Cupressaceae: this is the case of *Juniperus*, which is anatomically very close to *Tetraclinis articulata* (both are present in the area today) (Charco 1999). The main difference between them is the presence of wedge-shaped cell walls around the bordered pits in *Tetraclinis* (Schweingruber 1990, 145), a feature that is absent in junipers and which can only be (rarely) confirmed by observation under SEM equipment. A morphometric study of ancient samples from Taforalt compared to current individuals from the reference collection (some from the area of the site) did not provide conclusive results in terms of anatomical discrimination (as other variables related to combustion, conservation, etc., also influenced the observation of these anatomical features), so we identified the taxon *Juniperus/Tetraclinis*, as already discussed by Zapata et al. (2013) in other analyses of the region.
Finally, the taxon *Cedrus* sp. was identified on the basis of its distinctive anatomical characteristics (Schweingruber 1990, 111), such as high rays (up to 30 cells) and radial resin canals on the tangential section or tracheid pits with scalloped tori.

5.2 PALAEOENVIRONMENT

The Species Collected and their Ecological Significance

As mentioned above, the species most frequently collected by the inhabitants of Taforalt were conifers (**fig. 5.1**), which account for approximately 80 % of total wood remains found in Sector 10 and 87 % in Sector 8. Their presence in the cave indicates that they would probably have been accessible and abundant in the vicinity of the site. Despite uncertainty about the identification of certain conifers, as discussed in the preceding section, some of these species offer interesting ecological information.
Juniperus/Tetraclinis systematically appear in considerable percentages in both Sectors. Despite the aforementioned problems distinguishing between these genera, their presence can provide some very interesting ecological information. The entire Mediterranean region of North Africa is a natural area inhabited by Phoenician juniper (*Juniperus phoenicea*), in addition to *Juniperus oxycedrus* in coastal areas; it is also the natural habitat of the araar tree (*Tetraclinis articulata*), so it can be assumed that all of these species could be present in the charcoal remains from Taforalt, as they are currently found in mixed formations (Charco 1999). All of these are characterised by very open heliophilous forest formations, which are accompanied by Labiatae, *Cistus* and Fabaceae shrubs in the area being studied, as well as *Olea europaea* and *Pistacia lentiscus*, among others.
Pines are also common in the charcoal of both Sectors, with the advantage that they can often be identified at species level, which can provide very precise ecological and/or edaphic information. The pines identified at Taforalt are two lowland species: *Pinus pinaster* and *P. halepensis*. Although *P. halepensis* is currently the most widely distributed species of pine in North Africa, it is a minority species in the area that we are studying, principally the natural range of *P. pinaster*. In Morocco, it is an essentially calcicolous species, although it can also grow on siliceous soils. These are considered climax forests, which have decreased largely as a result of anthropic causes (Charco 1999). In the western Rif, *P. pinaster* is found alongside the Phoenician juniper in warm areas and sandy soils, but also with cedar and fir formations at an altitude of 2000 m, which shows how adaptable it is to different temperatures. The associated flora is also varied, as is

the habitat in which they grow but, at the altitude where the site is located, different species of Fabaceae, cistus, rosemary, *Quercus coccifera*, *Tetraclinis articulata*, *Juniperus oxycedrus* and *Pistacia lentiscus* can be found, among others.

Cedar is present in the upper units of Sector 8. It is a highly adaptable species in terms of soil type and even altitude (from 2500 to 900 m in particularly cool, damp terrain). Its distribution is characterised by rainfall, although in this regard there is also a great deal of variability: the annual rainfall in the Rif cedar area is currently within the 2000-1700 mm range, although in other areas of the Maghreb it can be as low as 450-500 mm (Charco 1999, 76). Many of the cedar forests are poor in understorey vegetation, as this tree generates very dense, almost monospecific masses. However, in the central Rif, on siliceous soils, there are formations with *Pinus pinaster* ssp. *maghrebiana* that grow in a humid to hyper-humid environment. Cedars also grow alongside *Juniperus oxycedrus*, *Taxus baccata*, *Acer opalus* and *A. monspessulanum*, *Prunus avium*, *Quercus ilex* and *Quercus canariensis*, among other species. Some of these taxa could be present in the charcoal found at Taforalt, as they have been identified at least at genus level (*Acer*, evergreen *Quercus*, deciduous *Q.*), indicating the presence of this type of forests within the radius of firewood collection by the occupants of the cave.

The case of *Quercus* is interesting, as only two types can be identified from its wood: evergreen and deciduous. In terms of evergreens, both tree (*Q. ilex*) and shrub (*Q. coccifera*) species grow naturally in the surroundings of the site; as for deciduous species, *Q. canariensis* grows from thermo-Mediterranean to meso-Mediterranean zones, i. e. in warm, temperate or cool climates, but in a humid or hyper-humid environment. In the supra-Mediterranean zone, this species is mixed with *Q. faginea*.

Riparian vegetation is weakly represented by a few fragments of wood from *Salix-Populus* and *Tamarix*.

Species of scrub and other shrubs are varied in the anthracological record of Taforalt but, in terms of percentages, they are scantily represented, accounting for approximately 1.5 % of all the charcoal from Sector 8 and somewhat less than 3 % of that from Sector 10. The families Cistaceae, Compositae, Labiatae and Fabaceae are present, as are Monocotyledons, *Olea europaea*, *Pistacia*, *Rhamnus-Phillyrea* and *Rosmarinus*; most of these taxa form the thermo-Mediterranean sclerophyllous scrubland that is characteristic of the zone in which the site is located.

Local Woody Flora, Landscape and Climate Reconstruction

The species documented show that the cave's inhabitants frequented different ecological environments from which firewood was gathered and which could be found in the more or less immediate surroundings of the site. In general, all the species identified could live anywhere from the mountainous areas of the Rif and Beni Snassen to the coastal plain, and the position of the site provides access to both environments (**fig. 5.2**). The taxa identified do not vary significantly in terms of their presence throughout the sequence obtained for Sector 8, although quantitative changes can be seen in the composition of the spectra, which could be attributed to possible variations in the composition of vegetation and / or changes in firewood gathering strategies in the different formations that could be accessed from the cave.

The sequence from Sector 8 dates from c. 15,000 to 12,600 cal BP for the Grey Series, which has been analysed in this study, and dating back to 31,000 cal BP (MSA – the two lowest bars in **fig. 5.3**, retained for comparison with the overlying LSA period samples) in the Yellow Series. As mentioned above, the taxa with the greatest presence throughout the sequence are basically pines and Cupressaceae and, to a lesser extent, evergreen *Quercus*. All of these can grow in a warm, temperate environment without requiring too much water, except for cedar, which requires more moisture and grows in cooler climates (**fig. 5.2**), suggesting

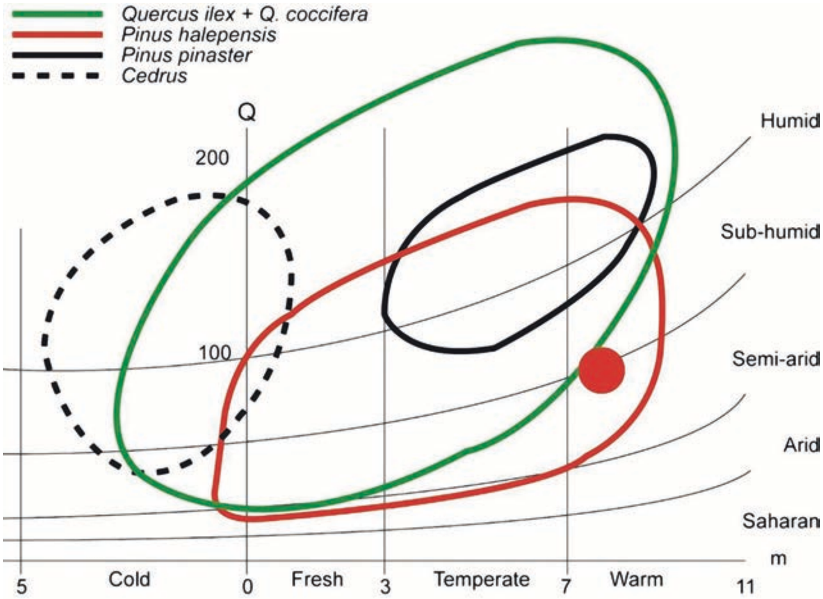

Fig. 5.2 Distribution of some ecological markers identified at Taforalt according to the Emberger's precipitation index 1936, 1939 (**Q**), and the mean minima of the coldest months (**m**); based on Quézel (1976), modified; the red spot marks the current bioclimatic location of Taforalt.

that there was access to a different type of ecosystem than the one currently found in the immediate surroundings of the cave.

In the diagram obtained for Sector 8 (**fig. 5.3**) some changes can be seen in the composition of the floristic spectra from the base to the top of the sequence.

In the Yellow Series, the presence of charcoal is much scarcer than in the Grey Series. The earliest LSA occurs in S8-Y4spits1-2 with the prior transition being estimated at S8-Y4spit3. The sediments in the latter show a distinct dry-cold (dust) episode but no changes were identified in the original charcoal samples (Ward 2007). In general, the abundance of *Juniperus*/*Tetraclinis* can be seen to occur across this mini-sequence, whilst there is a more modest presence of pines, of which three different species have been identified: *Pinus halepensis*, *P. pinaster* and *P. pinea*, the last of which is limited to just a few fragments (Ward 2007). There seems to be a noticeable peak in *Quercus* close to the appearance of the LSA (**fig. 5.3**). More detailed sampling of the lower YS would be necessary to explore the possibility of identifying short-term cooling events such as HE2.

The identification of predominantly *Pinus halepensis* in the YS (in modest percentages, approximately 5-10 %) coincides with the analyses carried out by pioneering researchers in the region, who noted the presence of this species in the charcoal found in the cave (Santa 1958-1959, cited in Neumann 1992). In our latest analyses, a greater presence of *P*. tp. *pinaster* can be seen, supported by the identification of scales of this species and comparative morphometric studies using SEM (**fig. 5.1**). In any case, all the pines identified are lowland species, the range of which may coincide throughout most of the territory, and it is not surprising that various species were present within the radius of firewood collection by the inhabitants of the cave.

The base of the Grey Series shows a massive presence of *Juniperus*/*Tetraclinis*, representing up to 90 %, and a pronounced lack of taxonomic diversity in general (following the trend already apparent in the top of the YS). The pine curve began at about 15,000 cal BP, with very modest values at first, but it later underwent a rapid and progressive expansion. There is also a continuous presence of evergreen *Quercus* (representing 1.5 to 3 %) and *Acer* sp., although the latter is much more sporadic. We cannot assess the presence of 20 % of this last species in an isolated unit (G98-2), unless it is due to a chance concentration of wood of this species, probably due to a heterogeneous distribution of charcoal at this level.

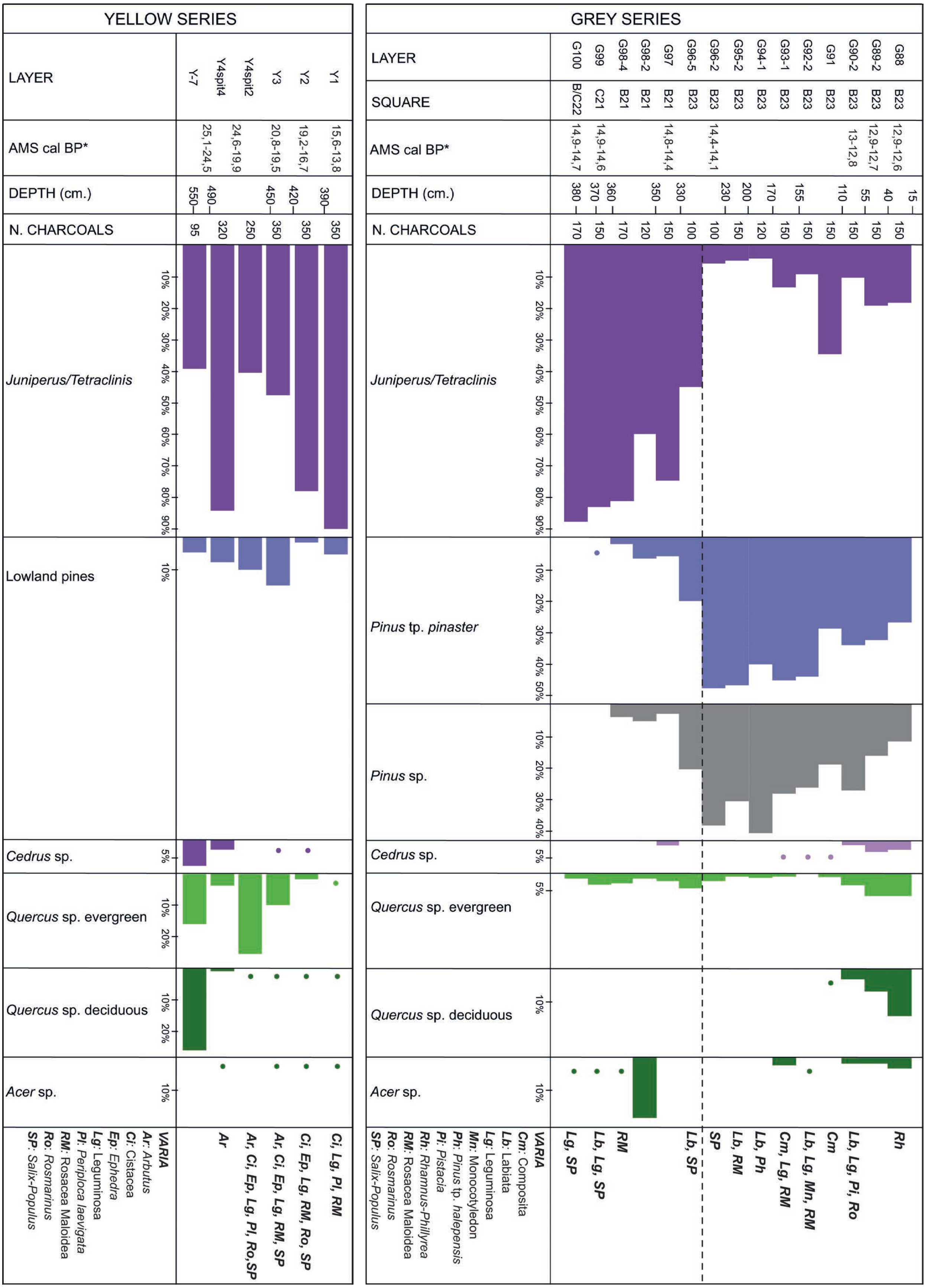

Fig. 5.3 Charcoal diagram of Sector 8; data from the Yellow Series synthesised from S. Ward's thesis (2007); (*) see the complete set of dates in tab. 4.1.

The most important change seen in the diagram begins at a level dated to 14,244-14,545 cal BP (OxA-23410) (tab. 4.1) using charcoal of *Juniperus/Tetraclinis* (cf. Barton et al. 2013). From that point on there is a clear replacement of what had until then been the dominant taxon, *Juniperus/Tetraclinis*, by pines, which then remain at values of 50 to 90 %.

Deciduous *Quercus* and *Cedrus* become more abundant towards the top of the GS sequence, which may indicate that the conditions became cooler and more humid (fig. 5.2). The chronology of the top of the Grey Series coincides with the start of the Younger Dryas, so cooler environmental conditions would have led to a descent in the altitude of cedar formations, making them more accessible for the inhabitants of Taforalt. In fact, cedar appears intermittently in the cave's sequence from low in the Yellow Series (dated to the MSA), almost completely disappearing from the middle of S8-Y4 (maybe just before the LSA) to S8-Y1, and reappearing in level G93 (fig. 5.3). This suggests that there were alternating humid phases, indicated by the presence of cedar and other similar taxa such as deciduous *Quercus*, and arid phases, as seen from the dominance of *Juniperus/Tetraclinis*, which have much lower moisture requirements.

Couvert/Roche (1978) noted the presence of *Cedrus* at Taforalt in a Yellow Series level (Roche XII equivalent to our S3[20-31]) dating to the earlier LSA, based on which they concluded that the conditions were cool and humid, which would have allowed forests of this species to grow at lower altitudes than at present. This leads to an interesting debate about the original range of cedars, which currently are rare in the surroundings of the site.

A rise in moisture would also be compatible with the aforementioned replacement of *Juniperus* by pines, as seen in the diagram of Sector 8, which began approximately 15 cal ka BP, as *Pinus pinaster* needs more moisture than junipers, despite being a species that basically prefers warm conditions.

The few anthracological sequences available for the region in question corroborate the systematic presence of *Juniperus* and *Tetraclinis articulata* formations that fluctuate with pines and with the *Olea-Pistacia lentiscus* combination in warmer areas when changes in humidity occur (Wengler/Vernet 1992). At Taforalt, earlier analyses carried out by Santa (1958-1959) and Couvert/Roche (1978) show the fluctuating presence of plant assemblages from different biogeographical contexts (albeit largely in an earlier, MSA, time-frame): a succession of supra-Mediterranean, humid vegetation (with cedar and oak), oro-Mediterranean (with cedar and junipers) and thermo- and meso-Mediterranean vegetation similar to the current vegetation (with pines, *Juniperus*, *Quercus ilex* and *Olea*) is recorded. Despite the occasional difficulty of correlating sequences from previous and recent works at Taforalt (see Chapter 2), the alternation between *Juniperus/Tetraclinis* and vegetation that grows in more humid conditions (*Cedrus, Pinus*), as well as the combination of *Cedrus* and deciduous *Quercus* at times when humidity increased and temperature decreased, constitute the main trends observed in the charcoal sequences. Judging from the presence of these species, at the altitude at which the site is situated, climatic fluctuations at the end of the Pleistocene would have been more evident than on the coastal plain, ranging between one or two vegetation zones (cited in Wengler/Vernet 1992).

5.3 PALAEOECONOMICS AND GENERAL HUMAN BEHAVIOUR

Identifying Human Input

The plants represented in a site's record are a human 'selection' from the biomass available in the surrounding environment for specific needs, in this case for use as fuel. Various studies have attempted to explain the parameters used for this selection, which may be aimed, if not at specific species, then at least at a certain type of diameter or physiological state (dry, dead, green wood, etc.), depending on the needs or purpose of the fire (Théry-Parisot 2001). Although there was a certain degree of selection of the wood that was used, the charcoal record of a long sequence with sufficiently repeated occupation ends up being representative of the surrounding vegetation, one of the paradigms of anthracological analysis that makes it possible to reconstruct the environment (Chabal 1997).

At Taforalt, it has been argued that all the species in the anthracological record are ecologically coherent with at least two types of plant formations (**fig. 5.2**), one that is more characteristic of sublittoral plains and one that is characteristic of the mid-montane zones of the Rif and Beni Snassen, the borders of which may have been in contact in the vicinity of the site and have fluctuated over time due to climatic changes. The species present in the charcoal therefore show the area from which firewood was collected by the inhabitants of the cave, which in turn adapted to changes that may have occurred in the range of plant formations.

The results seem to suggest a greater representation of tree or tall shrub species, specifically pines and *Juniperus/Tetraclinis*, followed by *Quercus* and *Cedrus*. Scrub species are scantily represented (at least in terms of percentage) despite the fact that, according to vegetation studies of the area, conifer formations should have had a rich understorey, with a variety of scrub species (Charco 1999). This may suggest that wood was gathered from tall shrubs or trees and that the use of scrub was marginal. In passing, it may be noted that we have found scrub species systematically in other comparable sites; the charcoal size can be smaller than in other species (just as is the original diameter), but scrub charcoals are usually preserved and identifiable.

The wood from different species of *Juniperus* has specific characteristics. In fact, these are not strictly speaking tree species, as they tend to branch out into several trunks from the base. Some studies carried out on present-day *Juniperus thurifera* formations have shown that it is very common for the species to have a shrub-like structure with several trunks (some produced more than 10 from the base) and perfectly synchronous stem growth, as shown by their growth rings (Bertaudière/Montès/Badri/Gauquelin 2001). The use of these plants would have been far more beneficial in terms of biomass than single-stemmed plants. In fact, extensive use of *Juniperus thurifera* specimens with these characteristics for various purposes (fuel, building, etc.) was observed in traditional Moroccan villages, and this species' huge capacity for regeneration after human exploitation was also noted (Barbero et al. 1990).

The presence of very narrow growth rings, with less than 100 microns of annual growth, was observed in many *Juniperus/Tetraclinis* fragments at Taforalt; the decrease in secondary growth of these genera is a characteristic of longer-living trees, so the presence of these narrow, straight rings (**fig. 5.1**, photo 6) might indicate the use of adult, long-living trees, i. e. we might infer the existence of a 'mature' forest.

With regard to pines, these are trees whose size and physiognomy differ somewhat from one species to another. The two main species identified at Taforalt, *P. halepensis* and *P. pinaster*, have low, accessible branches that would make them suitable for wood cutting. In the latter case, its lower branches die as the tree grows upwards, even in low-density formations, but once dead they remain adhered to the trunk, i. e. accessible as firewood.

One variable that allows inferences to be made about the type of wood gathered is the systematic presence of xylophagous microorganisms, primarily hyphae of fungi, as this may provide evidence of the use of dead wood collected from the forest. Several authors have suggested the possibility that prehistoric groups collected dead wood as fuel, since this would be an easy resource that would save the effort of cutting wood and it would be very suitable if they were seeking dry wood (Théry-Parisot 2001; Badal 2001; among others). One way to assess this would be, *a priori*, to note the systematic presence of fungi in archaeological charcoal. There is a great deal of debate about how this translates to the selection of green or dead wood, as experimental studies have shown that it is difficult to differentiate between contaminated dead wood, contaminated live wood at the foot of the tree, or healthy wood that was contaminated during a more or less prolonged storage period. A system has been created to classify the effects of fungi on wood for application in archaeology (Théry-Parisot 2001; Moskal-del Hoyo et al. 2010; Henry/Théry-Parisot 2014; Vidal Matutano 2016; among others).

In the charcoal remains found at Taforalt, few cases of wood contaminated by fungi have been documented (less than 1 % of the fragments); S. Ward (2007) noted the very occasional presence of alterations resulting from fungi in the remains analysed, suggesting that the same trend applies to the materials analysed in both studies.

Another issue concerns specific fuel needs in terms of the type of fire that is required (flames, live coals, smoke, etc.), for which different species or different types of wood from the same species can be used. For example, kindling is generally needed to start the fire, for which dry dead wood and/or thin branches, scrub, etc. can be used, followed by a 'maintenance' fuel whose characteristics help to control the rate at which it burns, for example, by varying the moisture content of the wood (Henry 2011; Henry/Théry-Parisot 2014). These selection variables appear to be more important than the species selected. The characteristics of the charcoal found at Taforalt seem to indicate that wood with a medium or large diameter was selected, and more sporadic use was made of a wide range of accompanying species, including plants of different sizes and diameters.

However, a more detailed analysis of the remains shows the use of different parts of some plant species, such as the presence of pine bracts among the charred remains. It is important to mention that, whilst some of these bracts were recognised on the basis of their external morphology, most were identified only from their internal anatomy, as their outer appearance was the same as the rest of the charred wood, which indicates that they were treated in the same way during the burning process. The bracts that could be identified belonged to the *Pinus pinaster* species (see Chapter 6). The large size of the pine cones of this species and the separation of their scales once dried make them a very suitable fuel for lighting a fire. In fact, they are known popularly as 'fire starters', since they burn easily and are consumed without going out (López González 2007). This may have been what they were ultimately used for at Taforalt, as they appear systematically throughout the Sector 8 sequence.

The pine kernels of this species also are edible, so although they were used as fuel, it is entirely plausible that the pine kernels would have been eaten first. In any case, they can be removed by simply toasting the pine cones slightly (Morales et al. 2015; see Chapter 6), so their complete carbonisation supports the idea that they were subsequently reused on the fire. The presence of charred bracts at other sites also shows this double use: the pine kernels were eaten and the bracts subsequently used as fuel (Badal 1998).

Wood Collection in a Changing Environment?

In view of the above, there is a fundamental question that we must ask ourselves with regard to the changes observed in the Sector 8 sequence: was there a significant change in the vegetation or did the wood collection strategy change? Perhaps the vegetation around the cave remained essentially the same but its inhabitants accessed other formations that were further away from the cave.

Various ethnographic studies on hunter-gatherer groups show that the radius for gathering wood to meet daily needs, i. e. without seeking any specific type of fuel, could generally be within a maximum radius of 500 m from the site (Henry 2011). In the case of archaeological sites, it is difficult to define the radius of action for gathering firewood, as it is affected by several different variables, including the distribution of plant species in the past or the existence of specific fuel requirements.

As mentioned above, the ecological requirements of the taxa identified in the case of Taforalt refer to two types of formation, one sub-humid type that prefers cooler conditions, represented by the presence of cedars (and pines), and another type that grows in a largely semi-arid environment, with *Juniperus/Tetraclinis* formations. The dominance of these two types in the vicinity of the cave may have alternated according to variations in the humidity conditions. So, as proposed by Couvert/Roche (1978), cedar forests would have been more widespread than at present and access to these formations would have meant valuable new resources, since the rapid growth and large size of cedars yields more wood than other conifers (M'Hirit 1982; 1999).

One of the main arguments for claiming that there was an environmental change based on the spectra from Sector 8 is provided by the diverging curves for *Juniperus/Tetraclinis* and pines. Unfortunately, scrub and other companion species of pine and juniper are so scarce and appear so infrequently that it is difficult to assess whether there were changes in the vegetation based on their presence (as they tend to be good ecological markers that are sensitive to any environmental change). The appearance of cedar at the top of the sequence, as well as the appearance of deciduous *Quercus* and the progression of pines, which replace juniper in the anthracological spectra, seems to suggest a noticeable increase in humidity, although in the light of anthracological data we can only affirm that there was a change in the main source of large diameter wood from juniper to pine. It is likely that they both continued to be available in the environment, but a change in the distribution or proportion of these formations could have meant that one species came to be used more than the other.

Other environmental analyses also suggest that the area being studied was sensitive to high- and medium-intensity climate changes that occurred in the late Pleistocene. It was mentioned earlier that previous anthracological analyses in Taforalt had detected different phases characterised by a pronounced decrease in temperature and increase in humidity, to the point that the site was under oro-Mediterranean conditions (cited in Wengler/Vernet 1992). Vernet (1986) estimates that fluctuations in the Taforalt sequence were within a range of 8-9ºC, which would represent a decrease of two bioclimatic zones at the time of the glacial maximum or earlier. Thus, according to the sequence obtained in recent analyses (**fig. 5.3**), the presence of cedar in the charcoal would have coincided with cold events, such as that potentially recorded in YS S8-Y4spit4 (Ward 2007), and later possibly with the Younger Dryas at the top of the Grey Series.

Pollen sequences that are available for the Alboran Sea clearly show alternations between forest (basically *Quercus*) and semi-arid (*Artemisia*, Chenopodiaceae, *Ephedra*) formations, coinciding with increases and decreases in the sea surface temperature, respectively (Dupont 1993; Hooghiemstra et al. 2006; Fletcher/Sánchez Goñi 2008). During the glacial maximum, and up to approximately 14,900 cal BP, there was a strong growth of the aforementioned semi-arid and steppe formations, although the presence of *Quercus* (evergreen and deciduous) confirms that this taxon remained in benign enclaves, as evidenced by its identification in terrestrial records such as that of Taforalt. From this date onwards, there was a rapid growth of Mediterranean *Quercus* forests and a reduction in steppe formations in the mentioned pollen sequences. The Younger Dryas marked a reversal of this trend, with a renewed expansion of semi-desert species, although the decrease in tree pollen was slight. The presence of *Cedrus* during this event would therefore suggest that the montane vegetation of North Africa responded positively to the cooling of the Younger Dryas, as it is particularly abundant at the beginning of this phase (Fletcher/Sánchez Goñi 2008, fig. 4), i.e. these areas would have experienced the drop in temperature but the humidity would not have been affected. However, it is important to stress that the progression of pines at Taforalt began at least 1500 years before the dating available for the upper (*Cedrus*) level of the sequence, meaning that we are dealing with a progressive increase in humidity, culminating in the appearance of cedars, rather than a short-lasting event.

The charcoal found at Taforalt shows an almost complete absence of scrub species that are characteristic at times of decline of forest formations (including Ericaceae). This may be due to the 'invisibility' of these species in the record because, although they were present in the landscape, they were used less, as discussed before.

To summarise, the anthracological records of Taforalt show greater access to forest formations (pines, cedars) at certain points in the sequence, which most probably coincide with a greater expansion of these forests during climatic events, in particular, those when the humidity increased. In this regard, there would be a certain amount of opportunism when gathering wood, meaning that they would use the species that were most accessible from the cave but, within the selection patterns, several vegetative plant organs (pine cones) would also be used to meet different fuel requirements. This pattern would be consistent with observations about the source of other materials found in the cave, which show the use of very local resources for materials related to daily or very frequent needs (which would have included firewood), although more idiosyncratic resources (certain lithic materials or shells) were collected from further afield (Barton et al. 2005; Ward 2007).

5.4 SUPPORTING CEMETERY EVIDENCE (SECTOR 10)

Wood Remains from the Cemetery Area

In the cemetery area of Sector 10, a representative assemblage of charred remains (1810 fragments) has been analysed. They correspond to a total of 20 samples (positions) distributed throughout the cemetery area excavated during the present campaign. Most of the samples correspond to sediment dispersed around the cemetery Sector.

The charcoal analysis has revealed a certain taxonomic richness, as 24 different taxa have been identified (**fig. 5.4**). However, pines and junipers (*Juniperus/Tetraclinis*) constitute almost 80 % of the total and are also the most ubiquitous taxa in all the samples. Evergreen *Quercus*, *Acer* and *Salix* are present to a lesser extent; the presence of other taxa is rarer (there are at least 13 species with values < 1 %, corresponding to thermo- and meso-Mediterranean shrub species, including various sclerophyllous shrubs (**fig. 5.4** and **tab. 5.1**). The massive use of coniferous species supports the strong presence of these woodlands in the environment, and the charcoal assemblage provides an image of open formations with some mesophilic taxa, probably relegated to more benign areas or riversides. This image matches the one obtained in Sector 8 for the same chronology (15,000-13,700 cal BP). A sizeable presence of pine cone bracts has also been identified among the fuel remains (approximately 7 % of the pine remains are bracts), which poses the same considerations here as for Sector 8 and supports the existence of a wood gathering pattern that is very similar in every way.

In comparison with the results of Sector 8, it is therefore shown that use was made of the wood that was available (and probably more abundant/accessible in the surroundings), but in the case of charcoal no bias is seen in the selection of species for a specific ritual. However, it is more difficult to assess whether there were species that were not used due to social conventions, as there would be no record of these among the charred remains. In this regard, for example, cedar wood has not been found in the cemetery area, which, given its only very occasional presence in the Sector 8 sequence, is difficult to interpret, one way or the other.

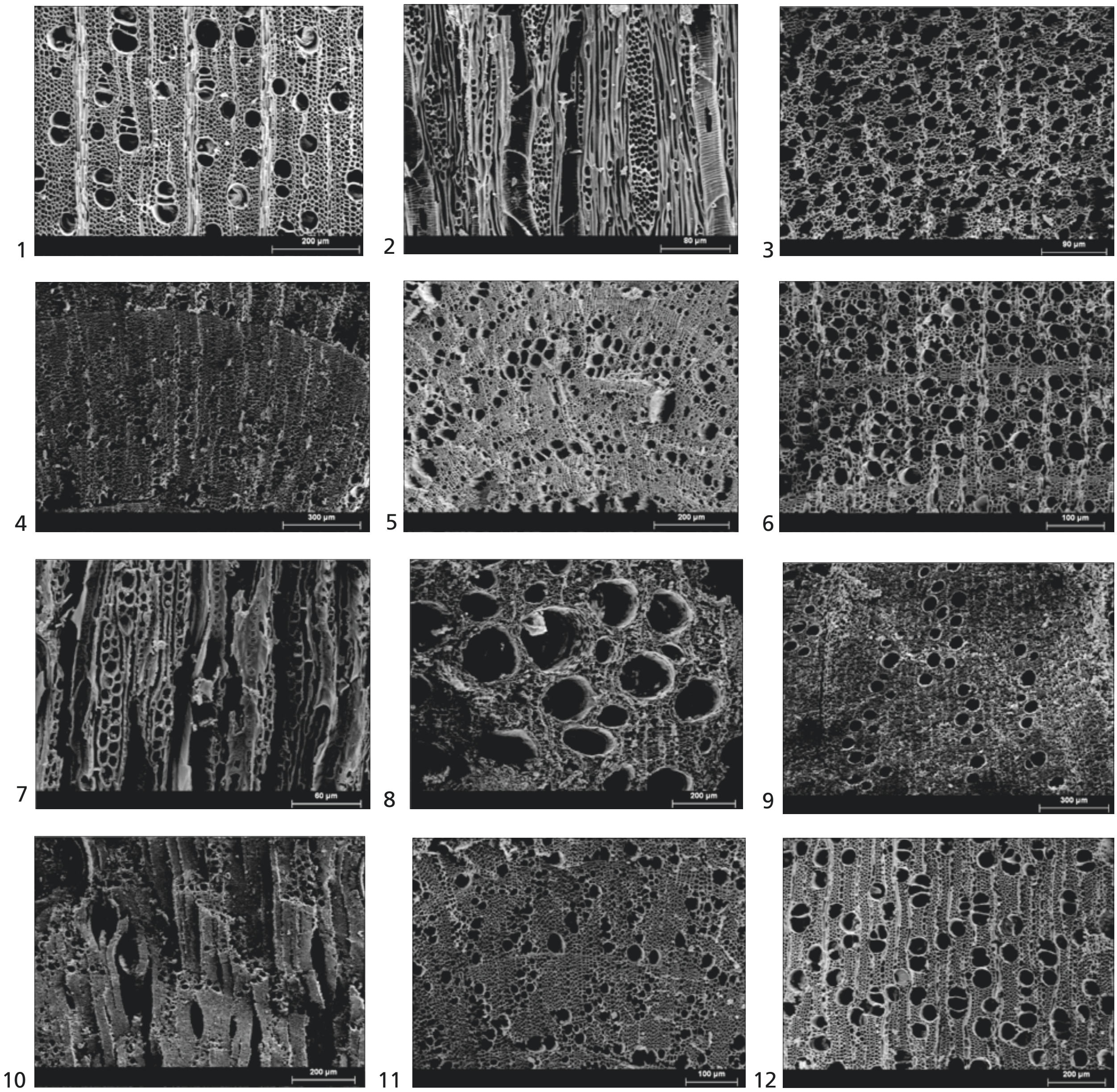

Fig. 5.4 SEM photographs of some taxa identified in Sector 10: **1** *Acer* sp., cross-section x150; **2** *Acer* sp., tangential section x300; **3** Cistacea, cross-section x250; **4** Composita, cross-section x90; **5** Fabacea, cross-section x130; **6** Maloidea, cross-section x200; **7** Maloidea, tangential section x400; **8** *Quercus* sp. deciduous, cross-section x110; **9** *Quercus* sp. evergreen, cross-section x80; **10** *Rhamnus-Phillyrea*, cross-section x110; **11** *Rosmarinus* sp., cross-section x180; **12** *Salix* sp., cross-section x100.

As in Sector 8, heavy use of medium and large sized wood (tree or tall shrub species) is seen in the cemetery area, whereas scrub species are only represented marginally, although there is a wide range of these (fig. 5.4 and tab. 5.1). In other contexts, some authors see this emergence of predominantly tree species as a clear selection of fuel for ritual purposes (Diogo Monteiro et al. 2014), although in the case of Taforalt, we cannot infer a specific practice for funerary contexts based on the fact that this situation also occurred in the other records that were analysed.

<TAF Code> Volume in litres	11020 4	11738 6	11771 7	11773 4	11808 4	11832 1	11843 3	11879 4	11896 6	11940 3	11984 5	12047 6	12084 7	12134 7	12198 7	12264 7	12378 8	12815 3	12954 7	13592 6	Total	
Taxa	N.	N.	N.	N.	N.	N.	N.	N.	N.	N.	N.	N.	N.	N.	N.	N.	N.	N.	N.	N.	N.	%
Acer sp.	3			3	5		1	1	3			7	4	1	2	4	6	2	2	9	**53**	**2.93**
Cistaceae			1									1					1				**3**	**0.17**
Compositae											1										**1**	**0.06**
Fabaceae			1			1							1	1		2	1				**7**	**0.39**
Juniperus sp.	58	49	90	35	23	17	19	22	35	21	20	65	40	54	39	58	43	24	29	36	**777**	**42.93**
Labiatae					1				1	2	1	2		1	1	3	3		5		**20**	**1.10**
Monocotyledon												1									**1**	**0.06**
Olea europaea																		1			**1**	**0.06**
Pinus pinaster	10			6	28	7	17	25	12	9	6	17	12	12	14	14	12	38	27	20	**286**	**15.80**
Pinus pinea - P. pinaster	11			2	21	9	10	34	22	8	7	24	18	12	19	28	8	1	2	1	**237**	**13.09**
Pinus sp.	3			1	7		1	4		1	2	13	3	1		7	3	12	16	11	**85**	**4.70**
Pine scale	6	1			1	2	1	2	2	2	1	3	4	1	2	7	1	3	3	3	**45**	**2.49**
Pistacia tp. *lentiscus*						1			1	1		2		1	1		1				**8**	**0.44**
Quercus sp. *deciduous*								1							1	1					**3**	**0.17**
Quercus sp. evergreen			6	3	6	6		9	12	3	6	15	8	9	15	15	9	6	9	11	**148**	**8.18**
Quercus sp.									1			2	1	1	1		3	1			**10**	**0.55**
Rhamnus-Phillyrea			1		1	1			3			1									**7**	**0.39**
Rosaceae/ Maloideae						2			2		1		1							2	**8**	**0.44**
Rosaceae tp. *Rosa*												1									**1**	**0.06**
Rosmarinus officinalis									2			2	1		1	1	1				**8**	**0.44**
Salix sp.	5				5	2	1			1	4	2	5	5	2	5	4				**41**	**2.27**
Tamarix sp.					1			1													**2**	**0.11**
Conifer	2					1										3		7	5	5	**23**	**1.27**
Bark					1					1		1	1			1	3				**8**	**0.44**
Undetermined	2																				**2**	**0.11**
Indeterminable			1			1		1	4	1	1	1	1	1	2	1	1	5	2	2	**25**	**1.38**
Total	**100**	**50**	**100**	**50**	**100**	**50**	**50**	**100**	**100**	**50**	**50**	**160**	**100**	**100**	**100**	**150**	**100**	**100**	**100**	**100**	**1810**	**100**

Tab. 5.1 Frequencies of the taxa identified in Sector 10 (shaded columns correspond to the samples next to a skeleton).

Firewood for Life and Death

One of the most interesting aspects of studying charcoal (and other materials) that appeared in funerary contexts is endeavouring to establish what role it played within the ritual, i.e. what role fire had in the funerary practice and attempting to discern whether it had some kind of symbolic connotation. In any case, the origin and purpose of plant and fire-related remains in these contexts is a complex matter, as its stratigraphic association with human remains is often uncertain.

With regard to the systematic and highly abundant presence of charred wood in the archaeological levels of the cemetery area at Taforalt, which is apparently associated with burials, we are equally uncertain about its use and purpose. *A priori*, there is no evidence of occupation of this sector for anything other than funerary purposes, despite the fact that the systematic presence of disarticulated bones and alteration of the oldest burials suggest that this area was heavily used (Humphrey et al. 2012; **Chapter 15**). Thus, any remains of the use of fire may be associated with the funerary activities carried out there or elsewhere, remembering, of course, that no *in situ* burning (no hearths or even less formal traces) have been recovered from Sector 10 itself. However, it should not be assumed that fire necessarily formed part of some kind of ritual; it may also be possible that it formed part of more ordinary activities, such as providing heat or lighting while the corpses were being buried. Alternatively, at least some charred material may have been displaced inadvertently, during fill accretion.

The excellent preservation of the charcoal (very angular fragments that are not rounded), as well as its considerable size, are probably due to the specific use of this sector as a cemetery, since the charcoal was not altered by other activities. This state of the charcoal also reveals more or less immediate removal from its original source (fireplaces), and its dispersion could be explained by this movement.

The results of the analysis of charcoal from Sector 10 show that the taxonomic composition of the samples is similar to the spectra obtained in Sector 8 for the same chronology, which appears to rule out any ritual use of selected species and leads us to believe that the inhabitants of the cave systematically used whatever was "closest to hand" in the surrounding area.

Few anthracological analyses have been performed in funerary contexts from the end of the Palaeolithic-Epipalaeolithic. The presence of charred wood remains is frequently mentioned in these analyses but charcoal is often considered merely as a potential element for radiocarbon dating or, in some cases, palaeoenvironmental reconstruction. Therefore, there is still very little discussion about the specific context of these remains within the ritual itself. Studying charcoal morphology or the taxonomic composition of the sample, among other aspects, helps us assess whether or not fire formed part of the funerary ritual. Certain authors have presented the same considerations because, although there are other materials that are clearly a fundamental part of the burial, fires (even *in situ*) are difficult to associate with the deliberate burning of materials that are related to the ritual itself. Comparison with regional analyses of vegetation (pollen and charcoal) makes it possible to infer whether a small number of species were used in relation to a wide range of available resources (Diogo Monteiro et al. 2014) but there are limited records for the area being studied here.

Data from Taforalt's cemetery indicate that, despite the enormous complexity of the ritual carried out (Humphrey et al. 2012), the wood that was used in this area does not differ substantially from that recovered in the outer habitat areas.

5.5 CONCLUSIONS

The anthracological analysis carried out for Taforalt Sectors 8 and 10 returns to some of the questions initially considered by pioneering researchers who first set forth their interest in reconstructing the past landscapes and climate of North Africa by examining plant remains. This interpretative approach has gradually come to include other cultural aspects, such as fuel usage strategies and management of firewood collection areas. In this study we have investigated the use of wood as fuel at the Taforalt site in different areas of daily and symbolic life, since two contexts with a similar chronology (around 15,000 cal BP) could be representative of the domestic and funerary activities that took place in the cave.

The wood taken to the site provides a survey of the composition of the landscape around the cave, since, by gathering wood, the occupants of the cave involuntary 'sampled' the surrounding vegetation. The results suggest that the inhabitants of the cave made use of woody species available in the immediate environs of the cave, probably for various purposes, but principally as fuel for their everyday fires.

Identification of the fuel used indicates that there were coniferous woods in areas that were accessible from the site, in addition to evergreen *Quercus* and other broad-leaved trees such as maples, whereas scrub species are generally scantily represented. The sequence of occupation shows an alternating pattern of vegetation that is characteristic of a more arid climate (in particular *Juniperus*/*Tetraclinis*) and vegetation that grows in sub-humid environments (represented by pines and cedars at the top).

In general, we observed a fuel selection based on availability, abundance and accessibility of wood, with its repeated use in various contexts, as no significant differences were noted between the living area (Sector 8) and the cemetery area (Sector 10) in terms of the range of species used. Furthermore, certain patterns are repeated (preference for medium-large wood diameter, use of pine cones, etc.), suggesting that this wood gathering activity would have followed an established pattern. The considerable presence of a few predominant species certainly leads us to consider the case of plants that may have been present in the landscape but not used as firewood; however, the results include traces of these species (mostly scrub and species that are typical of thermo- and meso-Mediterranean environments) that were relegated to sporadic use only.

6. OTHER CHARRED PLANT MACRO-REMAINS (SEEDS, FRUITS, ETC.)

6.1 INTRODUCTION

Plants are fundamental for humans as a source of food, fuel, raw material to produce tools, clothes, medicines and so on (Cotton 1996). However, there is a marked paucity of macro-botanical evidences in Later Stone Age (LSA) sites of north-western Africa, resulting in a limited and biased knowledge about plant use at that time. Plant remains such as wood charcoals, seeds and fruits are more fragile and less prone to be preserved in pre-farming sites than other botanical finds, such as starch, pollen or phytoliths (Piperno 2006; Henry / Brooks / Piperno 2011). Nevertheless, the absence of remains is also due to the lack of systematic methods for plant collection in archaeological excavations of pre-farming sites. A large proportion of LSA sites were excavated in the early part of the 20th century and no systematic sampling and analysis of plant evidence were practiced at that time. Only large pieces of wood charcoals picked up on site were analysed (Santa 1958-1959; see **Chapter 5**). The only available evidence of seeds and fruits in North Africa comes from recent excavations at Early Holocene sites in Morocco (Morales et al. 2013; 2016), Tunisia (Morales et al. 2015) and Libya (Barker et al. 2010), where systematic sampling and flotation of sediments have been carried out. In those sites, charred remains of nuts, fruits and seeds are abundantly recorded. Data on Late Pleistocene sites are scarcer and, to our knowledge, there is little published information recording archaeological seeds and fruits (but see Carrión Marco et al. 2018; Morales 2018).
In the present chapter, we examine the macro-botanical remains from the LSA levels at Taforalt. Excellent conditions here have allowed the preservation of a rich set of charred plants that were recorded in levels dated between approximately 21,000 and 12,600 cal BP. Taforalt is thus a key site to the understanding of the use of plants during the Late Pleistocene of north-western Africa. A first record of this evidence has been published in Humphrey et al. (2014). The aim of the present study is to provide a full report of the macro-botanical evidence and to discuss the role of plants in the economy and general human behavior of this period. Seeds and fruits are gathered from the environment and thus they can provide some valuable information about the palaeoflora and palaeoclimatic conditions. However, these plant remains do not represent the entire environment and they only provide information about the plants that were more commonly used (Van der Veen 2007). In many cases, the plant remains correspond to the residues of cooking activities and they provide unique information about the role of plants in the diet of the inhabitants of Taforalt. In addition, some of the plant material recorded could correspond to residues of basketry. Here the evidence is presented and its significance discussed.
Considerable overgrazing and human disturbance have transformed the modern landscape around the cave and towards the bottom of the valley and the side ravines. Here, most of the vegetation comprises pine trees (*Pinus halepensis*) from re-afforestation, tree crops such as figs and carob trees, and also other exotic or invasive plants such as Eucalyptus and the "tree of heaven" (*Ailanthus altissima*) – indeed, there is a specimen of this last species currently growing upon the Grey Series at the entrance of the cave. However, in the highland in front of the cave (to the north), the vegetation and the landscape are less transformed. No evidence of old fields is apparent, only of animal grazing. Here, the vegetation is dominated by araar / thuja

(*Tetraclinis articulata*) in the sunniest and rockiest areas, whilst, on north-facing slopes and on the higher ground, Holm oak (*Quercus ilex*) is more common. Wild olive (*Olea europaea*), dwarf palm (*Chamaerops humilis*) and pine (*Pinus halepensis*) are also common, the last again mostly due to re-afforestation. Esparto/alfa (*Stipa tenacissima*) is also quite common in the highlands, especially across the summits, as is diss grass (*Ampelodesmos mauritanicus*), another large perennial grass.

6.2 METHODOLOGY

The macro-botanical remains analysed in the current work come from the systematic sampling of sediment in Sector 8 (S8). The macro-plant remains from the burial area in Sector 10 are currently under analysis and will not be included here. Samples from S8 comprise both the Yellow Series (YS) and Grey Series (GS). They were collected from the G-sample column during the fieldwork between 2003 and 2005 (see **tab. 6.1**), and from the MMC-sample column during the fieldwork in 2009 and 2010 (see **tab. 6.2**) (see also **Chapter 2** for locations and stratigraphic sequences). One hundred samples of sediment were analysed in total, with a volume of 350 litres. The coarse stone fraction had already been removed from the sediment samples on site and is excluded from volume measurements.

Macro-botanical remains were retrieved from the sediment by floating each sample and then sieving the flot (light fraction) using a stack of sieves (2, 1 and 0.5 mm). All plant remains are carbonised and very well preserved. The identification has been done with a binocular microscope of 8x and 80x magnifications and by comparing the archaeological remains with modern seeds of the reference collections at the Department of Historical Sciences, in the University of Las Palmas de Gran Canaria, Spain, and at the McDonald Institute for Archaeological Research, University of Cambridge, UK. For botanical nomenclature, we follow Fennane et al. (1999), Fennane/Ibn-Tattou/Ouyahya/El-Oualidi (2007) and Fennane/Ibn-Tattou/Ouyahya/El-Oualidi (2014). A summary of the results is shown in **table 6.1** and **table 6.2**, while a complete table with full results is provided in the appendix (**A6**). Formal taxonomic nomenclature is given in **table 6.1** and **table 6.2**. **Figure 6.1** illustrates the most important plant species discussed in the text.

6.3 EVIDENCE OF NON-WOOD MACRO-PLANT REMAINS

The systematic sampling and flotation of the sediments have provided a rich assemblage of charred macro-plant remains from S8. A total number of 1,206 items were collected here. 98 % of the remains were recorded in the GS (n = 1,182), while in the YS the number of seeds is greatly inferior (n = 24). Density of remains is important, averaging about 3.55 items per litre of sediment, being much higher in the GS (4.37 items per litre of sediment) than in samples from the YS (0.34 items per litre of sediment).

A total number of twenty-two taxa have been identified in S8. Samples from the YS have only produced 8 taxa, mostly annuals such as cleaver (*Galium* sp.; n = 10) and wild legume (*Vicia*/*Lathyrus* sp.; n = 1), and shrubs such as ephedra (*Ephedra* sp.; n = 6) and rockrose (Cistaceae; n = 1). The great majority of the YS seeds were recorded in Units Y4 (n = 11) and Y1 (n = 11). On the other hand, samples from the GS are characterised by the abundance of arboreal or large shrub species. Holm oak (*Quercus ilex*) is the most abundant taxon in the samples (n = 495; 39.6 % of total plant remains in the GS) but other tree species, such as Maritime pine (*Pinus pinaster*), juniper (*Juniperus phoenicea*) or Terebinth pistachio (*Pistacia terebinthus*), are also

	Yellow Series			Grey Series													Total
Y/G units	Y4	Y2	Y1	G1OO	G99	G98	G97	G96	G95	G94	G93	G92	G91	G90	G89	G88	
Number of samples analyzed	4	2	3	1	4	10	1	5	4	2	2	3	1	7	2	2	**53**
Volume of sediment (in litre)	38.6	20.5	8	12.5	12.5	30	1.5	19.3	26	13.5	21	23	7	35.7	10	17.5	**296.6**
Avena sp. (wild oat), seed	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	**2**
cf. *Bromus* sp. (large seeded grass), seed	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	**2**
Cistaceae, seed	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**1**
Ephedra sp., cone bract	1	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	**6**
Fabaceae (wild pulse), seed	-	-	-	-	-	1	-	1	-	-	3	-	-	-	-	-	**5**
Fumaria sp. (fumitory), seed	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	**1**
Galium sp. (bedstraw), seed	7	-	2	-	3	5	-	-	-	1	1	1	4	9	4	5	**42**
Juniperus phoenicea L. (juniper), seed	-	-	-	-	-	4	-	-	1	1	10	17	6	26	1	2	**68**
Lens cf. *nigricans* (M. Bieb.) Godr. (wild lentil), seed	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	**1**
Pinus pinaster Ait. (Maritime pine), seed	-	-	-	-	-	2	-	1	2	1	-	3	-	2	-	-	**11**
Pinus pinaster Ait. (Maritime pine), seed scale	-	-	-	1	2	12	1	21	30	12	14	11	8	56	3	4	**175**
Pistacia terebinthus L. (Terebinth pistachio), seed	-	-	-	-	-	-	-	-	-	-	-	3	2	15	8	1	**29**
Poaceae, seed	-	-	-	-	-	4	-	-	-	-	-	-	-	1	-	-	**5**
Quercus ilex L. (Holm oak), cupule	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	3	**5**
Quercus sp (acorn), cotyledon	-	-	-	-	-	-	-	-	-	-	-	2	1	1	2	-	**6**
Quercus sp. (acorn), cupule	-	-	-	-	8	44	2	58	43	14	36	33	3	30	8	3	**282**
Quercus sp. (acorn), abscission scar	-	1	-	-	-	2	-	1	2	-	2	1	7	18	3	2	**39**
Quercus sp. (acorn), pericarp	-	-	-	-	-	-	-	-	-	-	-	2	2	3	1	1	**9**
Rosaceae, seed	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	**1**
Rubiaceae, seed	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	**1**
Small seeded legume, seed	-	1	-	-	-	1	-	-	-	-	-	-	-	-	-	-	**2**
Stipa tenacissima L. (alfa/esparto), rhizome	-	-	-	-	-	8	-	3	4	2	6	18	2	5	6	4	**58**
Tetraclinis articulata (Vahl) Masters (araar), leaf	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	**2**
Vicia/*Lathyrus* sp. (wild pulse), seed	1	-	-	-	-	2	-	3	2	1	-	2	-	3	-	2	**16**
Woody legume, seed	-	-	-	-	-	-	-	-	2	2	-	1	7	5	-	3	**20**
Indeterminated type Rosaceae, seed	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	**1**
Indeterminated type Rosaceae, fruit	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	2	**3**
Indeterminated seed	1	-	-	-	-	5	3	-	1	-	2	4	-	-	-	-	**16**
Indeterminated fruit	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	-	**2**
Total seeds	11	2	8	1	14	93	6	88	87	34	74	101	42	180	36	34	**811**
seed density per litre of sediment	0.28	0.09	0.8	0.08	1.12	3.1	4	4.55	3.34	2.51	3.52	4.39	5.85	5.04	3.6	1.94	**2.73**

Tab. 6.1 Macro-botanical remains from occupational levels in Sector 8 (Y and G units), with numbers of seeds unless otherwise stated.

	Yellow Series		Grey Series													Total
MMC units	108	107	106 to 97	96 to 92	91 to 88	87 to 80	45 to 32	31 & 28	30 to 29 & 27 to 26	25	24 to 20	19 to 15 & 13	14	12 to 5	4 to 1	
Number of samples	1	1	3	1	1	4	7	1	4		5	7	1	4	3	
Volume of sediment (in litre)	1	1	3	1	1	3.5	7	1	4	1	5	7	1	4	3	**42.5**
Avena sp. (wild oat), seed	-	-	-	-	-	-	3	-	1	-	3	3	-	-	1	**11**
cf. *Bromus* sp. (large seeded grass), seed	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	**2**
Cariophyllaceae, seed	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	**1**
Chenopodiaceae, seed	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	**1**
Fabaceae (wild pulse), seed	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	**1**
Fumaria sp. (fumitory), seed	-	-	-	-	-	-	1	-	-	-	-	-	1	-	-	**2**
Galium sp. (bedstraw), seed	1	-	-	-	-	1	2	-	-	-	2	5	4	2	1	**18**
Juniperus phoenicea L., seed	-	-	-	-	-	-	7	-	7	3	13	8	2	2	3	**45**
Lens cf. *nigricans* (M. Bieb.) Godr. , seed	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	**2**
Pinus pinaster Ait., seed	-	-	-	-	-	1	1	-	1	-	5	5	-	-	-	**13**
Pinus pinaster Ait., seed scale	-	-	2	1	3	7	18	1	11	5	18	27	6	4	3	**106**
Pistacia terebinthus L., seed	-	-	-	-	-	-	7	-	8	1	3	6	1	2	7	**35**
Poaceae, seed	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	**1**
Quercus sp (acorn), cotyledon	-	-	-	-	-	-	2	-	-	-	-	1	-	5	-	**8**
Quercus sp. (acorn), cupule	-	-	4	7	-	12	4	-	4	2	17	4	-	1	1	**56**
Quercus sp. (acorn), abscission scar	-	-	1	-	1	2	8	-	6	2	9	5	-	2	4	**40**
Quercus sp. (acorn), pericarp	-	-	-	-	-	-	1	-	2	-	1	-	1	1	1	**7**
Sambucus nigra/ebulus L., seed	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	**1**
Small seeded legume, seed	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	**1**
Stipa tenacissima L., rhizome	-	-	-	-	-	-	1	-	6	1	4	-	-	1	1	**14**
Tetraclinis articulata (Vahl) Masters, leaf	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	**2**
Vicia / Lathyrus sp. (wild pulse), seed	-	-	-	1	-	-	4	-	1	-	-	-	-	-	-	**6**
Woody legume, seed	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	**1**
Indeterminated seed	-	2	-	-	-	-	1	-	1	-	1	2	3	1	1	**12**
Indeterminated fruit	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	**1**
Indeterminated nut	-	-	-	-	-	-	-	-	1	-	3	1	-	-	3	**8**
Total	1	2	7	9	4	24	61	1	49	14	82	71	19	23	28	**395**
seed density per litre of sediment	1	2	2.3	9	4	6.85	8.71	1	12.25	14	16.4	10.14	19	5.75	9.33	**9.29**

Tab. 6.2 Macro-botanical remains from occupational levels in Sector 8 (MMC units), with numbers of seeds unless otherwise stated.

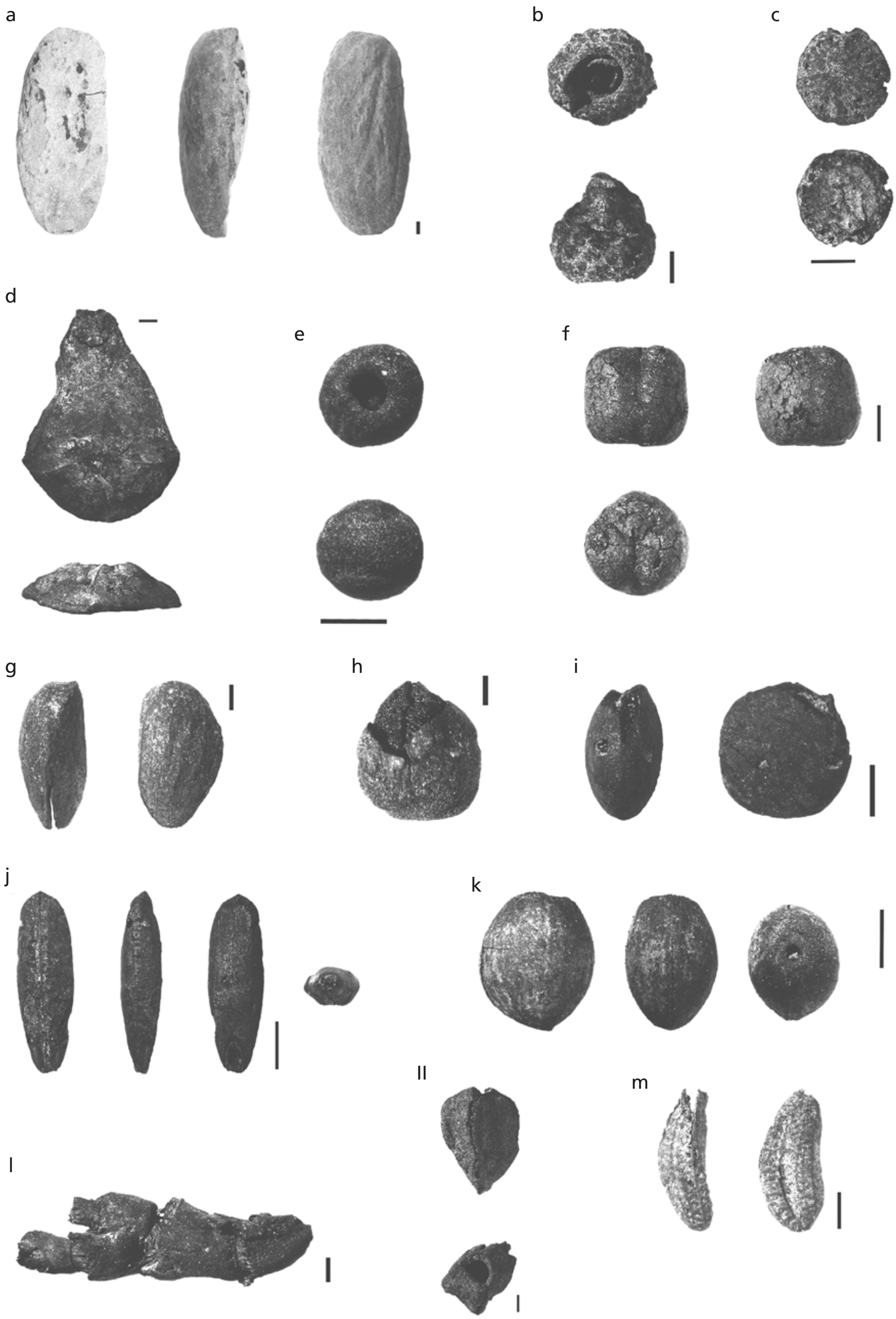

Fig. 6.1 Macro-botanical remains from Sector 8: **a** *Quercus* sp., cotyledon; **b** *Quercus ilex*, immature cupule; **c** *Quercus* sp. abscission scar; **d** *Pinus pinaster*, cone scale; **e** *Galium* sp., seed; **f** *Vicia / Lathyrus* sp., seed; **g** *Pinus pinaster*, seed; **h** *Ephedra* sp., cone bracts; **i** *Lens* cf. *nigricans*, seed; **j** *Avena* sp., seed; **k** *Pistacia terebinthus*, seed; **l** *Stipa tenacissima*, rhizome fragment; **ll** *Juniperus phoeniceae*, seed; **m** *Sambucus nigra*, seed. – (Photos J. Morales). – Scale bar 1 mm.

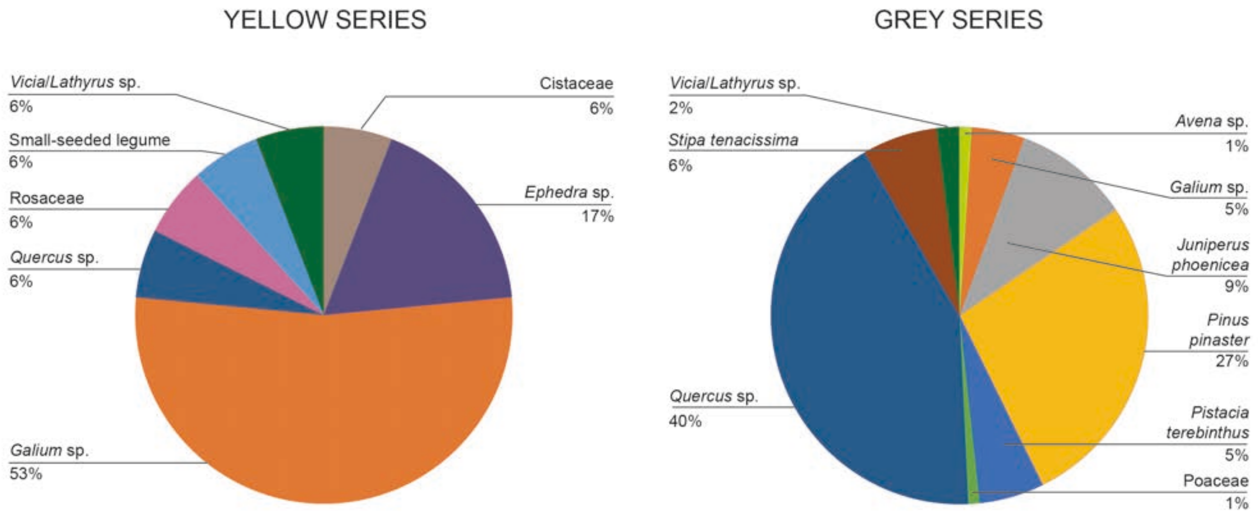

Fig. 6.2 Percentage of macro-botanical remains in the Yellow Series and Grey Series, Sector 8.

Fig. 6.3 Acorn cupule fragments found in a single sample from the Grey Series (Unit S8-G96-3). – (Photo J. Morales).

Fig. 6.4 Pine seed scales fragments recorded at a single sample from the Grey Series (Unit S8-G90-2). – (Photo J. Morales).

common here (**fig. 6.2**). The richest units in number of remains are G90, G92, and G98 (**tab. 6.1**); as well as MMC units 21, 15, and 14 (cf. **A6**). For seed density per litre of sediment the richest layers are G90 and G91, as well as MMC layers 21 and 4. The presence of taxa through the different GS units is homogeneous, with acorns and pine nuts being the most frequent species in all units, except Unit G100 that only presents two items (**figs 6.5** and **6.6**). Two taxa, juniper and Terebinth pistachio, are mostly recorded in units from the upper part of the sequence, from G92 to G88. In fact, Units G90 and G88 are the richest for plant diversity, although samples from the lower Unit G98 also present a high diversity of plant taxa (**figs 6.5** and **6.6**).

Descriptions of the taxa recorded from S8 are provided below. These include ethnographic data recorded in the Mediterranean area about the exploitation of each taxon. Ethnobotanical data are utilised here to provide models of plant processing and consumption that will be used to interpret the archaeological plant remains.

Holm oak (*Quercus ilex*) remains were mostly recorded in the GS; only one fragment of acorn was recorded in the YS (Unit Y2). They comprise abscission scar, pericarp (shell), cupule (cup) and cotyledon (seed) fragments (**fig. 6.1**). Cupules are the most frequent item and they have been recorded in all units from the G-sample column excepting G100 (**fig. 6.3**); fragments of cotyledon and pericarp are less common, being identified only in Units G92 to G88. In the MMC column sample, the pattern in the frequency of remains

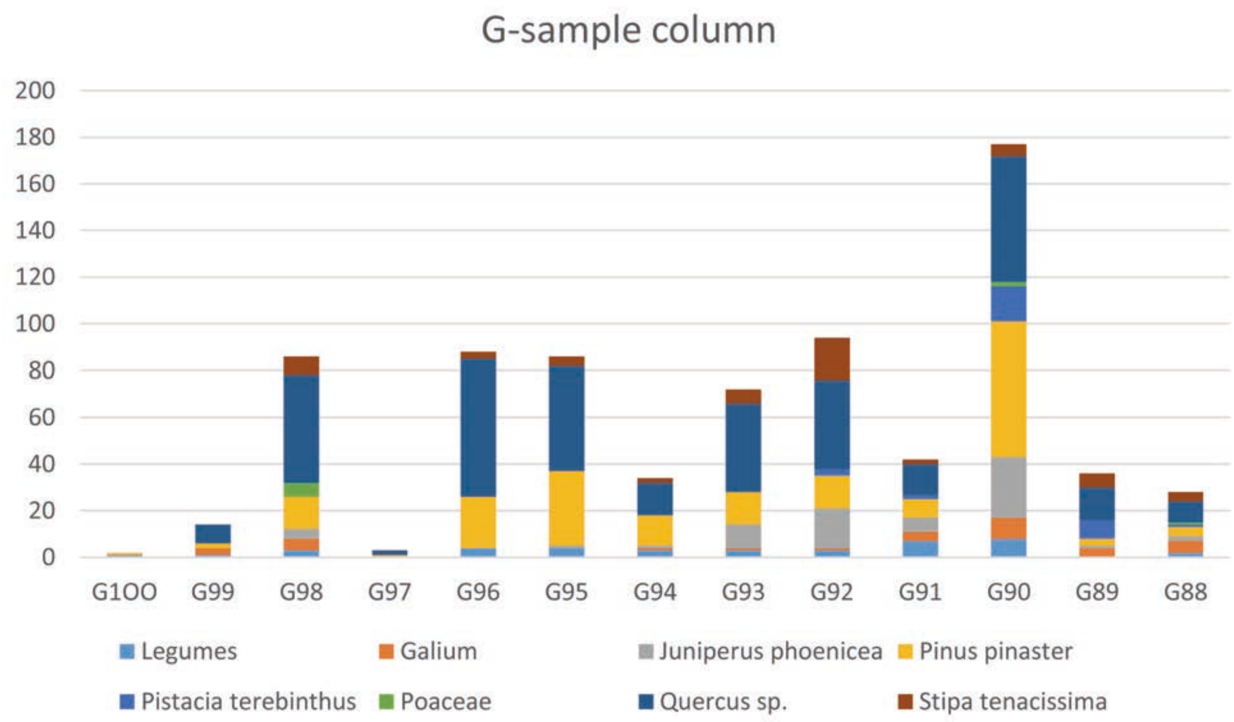

Fig. 6.5 Numbers of macro-botanical remains of the most frequent taxa in units from the G-sample column in Sector 8.

of acorns is similar (**tab. 6.2**). The cupule is a wood-like structure that partially encloses the seed and it is made of successive layers of sclerified and suberised bracts (Fey/Endress 1983; Kaul 1985). Cupules are species-characteristic and they are a diagnostic key in the identification of oaks (Kaul 1985). Identification of Holm oak (*Quercus ilex*) was only possible for 5 cupule fragments keeping the scales (**fig. 6.1**), so it is possible that other oak species currently growing in the region are also present in the samples.

Acorns are a very common food around the northern hemisphere, both for hunter-gatherer and farmer populations (Mason 1996). They are currently consumed in Morocco, where they can be found in local markets (author's personal observation). Acorns have also been consumed in other Mediterranean countries until relatively recently (Bainbridge 1985; Rivera/Obón 1991; Pereira-Sieso 2010; Rivera/Matilla/Obón/Alcaraz 2011). They are rich in carbohydrates and also contain proteins and lipids (**tab. 6.2**). Due to their low tannin content, acorns from the Holm oak can be eaten raw after the cupules and the shells are removed (Pereira-Sieso 2010; Prado-Nóvoa et al. 2017). Acorns from other Mediterranean oaks have a higher content in tannins and need processing to make them edible (Ayerdi et al. 2016). There are several ways of reducing the tannin content, such as parching or leaching (Mason/Nessbit 2009). Once tannins are removed, acorns can be consumed after boiling or roasting, or dried for storage or further processed into a type of flour (Pereira-Sieso 2010; Ayerdi et al. 2016).

Maritime pine (*Pinus pinaster*) macro-botanical remains are only recorded in the GS, where they are abundant (**fig. 6.2**). Pine remains include both seeds and seed scales. Seeds are less common, while seed scales are present in most of the samples analysed (**fig. 6.4**). The scales, a woody part of the cone in which the seeds ripen before falling to the ground, have a prominent and pyramidal apophysis, a diagnostic feature that enables identification as *Pinus pinaster* (Fennane et al. 1999). In some cases, the apophysis was not preserved, so it is possible that other pine species could also be present in the archaeological assemblage.

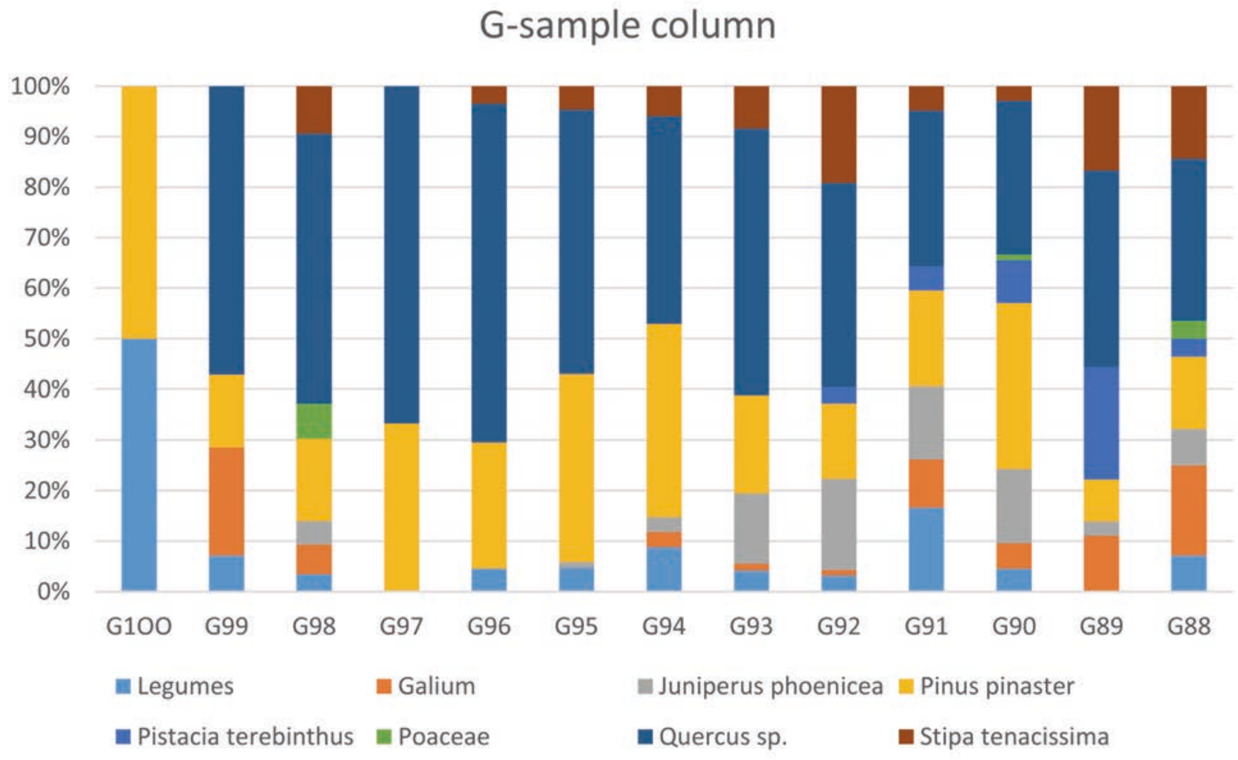

Fig. 6.6 Percentage of macro-botanical remains of the most frequent taxa in units from the G-sample column in Sector 8.

Cones of *Pinus pinaster* and other Mediterranean pines such as *P. halepensis* and *P. pinea* have traditionally been gathered to collect the pine nuts for human consumption (Rivera/Obón 1991; Rivera/Matilla/Obón/Alcaraz 2011). Usually, cones are gathered in autumn and early winter, when they are still closed and unripe. In this way seeds can be stored inside the cone with no damage for a long period. When it is time to consume the pine nuts, cones are laid out in the sun or put in the fire, as low humidity provokes the opening of the scales and release of the seeds (Morales et al. 2015). Pine nuts can be eaten raw as a snack or pounded to produce a kind of porridge (Rivera/Obón 1991; Morales et al. 2015). Pine nuts are rich in energy and contain high quantities of lipids and proteins (Lanner 1981). Once all the seeds have been extracted, the empty cones are collected and stored to be used later as fuel. This overall technique increases the preservation of seed scales and reduces the opportunities for seeds themselves to be charred (Morales et al. 2015).

Remains from juniper (*Juniperus phoenicea*) are only recorded in the GS, where they are common (9.12 % of total plant remains in the GS). Seeds and fruit fragments from this small tree were recorded in the samples (fig. 6.1). Berries from *J. phoenicea* have been gathered until recently in traditional communities of the Mediterranean basin (Rivera/Matilla/Obón/Alcaraz 2011). They are relatively rich in carbohydrates (Debussche/Cortez/Rimbault 1987). In both Turkey and Tunisia, the fruits are crushed and then boiled for several hours to obtain a high-energy liquid (Semiz/Isik/Unal 2007; Rivera/Matilla/Obón/Alcaraz 2011). Once boiled, the fruit fragments and seeds are discarded (Semiz/Isik/Unal 2007).

Seeds of Terebinth pistachio (*Pistacia terebinthus*) are present in the GS (5.12 % of total plant remains in the GS) and absent in the YS. Nutlets from the Terebinth pistachio are rich in lipids, and the oil extracted from them has been used for human consumption and for medicinal purposes in the Mediterranean area (Rivera/Obón 1991; Rivera/Matilla/Obón/Alcaraz 2011). According to ethnographic data from exploitation of *Pistacia* seeds in Sardinia (Loi 2013), the oil is extracted by heating the squeezed fruits in a recipient with water. The oil is deposited over the water surface and it is later collected, while the fruits are discarded or used to feed domestic animals (Loi 2013).

Other less common small trees or shrubs identified in S8 are elderberry (*Sambucus nigra/edulis*), ephedra (*Ephedra* sp.) and rose hip (Rosaceae). One seed of elderberry was recorded in the GS. Elderberries are used for human consumption in the Mediterranean area after they are processed in a kind of marmalade (Rivera/Obón 1991). One seed of rose hip was retrieved from the YS (Unit Y1). Rose fruits are rich in vitamin C and still consumed in jams (Rivera/Obón 1991; Rivera/Matilla/Obón/Alcaraz 2011). Cone bracts of *Ephedra* have only been recorded in the YS layers. This plant is a known stimulant and has been used in folk medicines in both the Old and New Worlds (Caveney et al. 2001). Fruits (seed cones) can be eaten in a fresh or dried state, and juice may be extracted from the fleshy cones, which contain higher amounts of crude protein and crude fat than other cultivated fruits (Khasbagan/Soyolt 2007).

Seeds of wild legumes are present in both the YS and GS, but they are more abundant in the GS (**tabs 6.1** and **6.2**). We have been able to distinguish three taxa, wild lentil (*Lens* cf. *nigricans*), wild vetch (*Vicia/Lathryus* sp.) and an indeterminate large-seeded legume (Fabaceae) (**fig. 6.1**). Seeds from wild legumes have been broadly consumed in the Mediterranean basin, where those plants are frequent (Rivera/Obón 1991; Butler 1998; Rivera/Matilla/Obón/Alcaraz 2011). They are very nutritious, being high in carbohydrates and relatively high in protein but, in some cases, they also contain toxic substances that may be removed by roasting or leaching (Aykroyd/Doughty 1982). Seeds can be eaten raw when they are unripe. Once they are ripe, seeds are usually consumed after boiling them or they are pounded to produce flour (Tardío et al. 2006). In order to store the seeds and eliminate potential pests, legume grains can be briefly roasted (Butler 1998).

Wild grasses are uncommon, with only 13 seeds of wild oat (*Avena* sp.) and two of brome (*Bromus* sp.) being identified. Remains of grasses are only recorded in the GS. Grains from wild oats are rich in carbohydrates and proteins (Sosulski/Sosulski 1985). Currently, only domesticated oats (*Avena sativa*) are broadly consumed but there is ethnographic evidence for the consumption of wild oats in the Mediterranean basin in the recent past (Rivera/Obón 1991; Rivera/Matilla/Obón/Alcaraz 2011).

Other annual plants recorded in the samples are fumitory (*Fumaria* sp.), cleaver (*Galium* sp.) and small-seeded legumes. Small-seeded legume is a category that includes plants of the Trifolieae tribe such as *Trifolium* L., *Trigonella* L., *Medicago* L. and *Melilotus* Miller (Butler 1995). Cleaver and small-seeded legumes have been recorded in both the YS and GS. The three taxa are nowadays common weeds in places disturbed by humans, so it is possible that they grew near the site and reached the deposits either naturally or unintentionally. We also need to consider that seeds from these taxa might have been gathered for different human uses (Rivera/Obón 1991; Butler 1995; 1998; Rivera/Matilla/Obón/Alcaraz 2011), so we cannot rule out the possibility that some of them were exploited by the inhabitants of the site.

Finally, we must highlight our recovery of a large number of rhizome fragments of alfa grass (*Stipa tenacissima*). Evidence of alfa grass is only present in the GS (5.92 % of total plant remains in the GS). Alfa is a native perennial grass in the western Mediterranean area that has been extensively used as raw material for basketry (Sánchez-Sanz 1982; Louis/Despois 1986; M'Hamdi/Anderson 2013). Leaves are the useful part of the plant, whilst rhizomes are a common by-product or residue of gathering and processing that is often used as fuel (Morales et al. 2015).

6.4 DISCUSSION

Differences in the Presence of Seeds in the YS and the GS: Environmental Change or Plant Processing Innovation?

The excellent conditions at Taforalt have allowed the preservation of a rich set of charred plants that represents one of the largest and best preserved macro-botanical assemblages of the Late Pleistocene period in North Africa. Plant remains have been recorded throughout the stratigraphic sequence analysed, covering the time span between approximately 21,000 and 12,600 cal BP. However, the seed assemblage recorded at Taforalt shows a marked difference in number of items and plant taxa between the YS and the GS. In the YS, the assemblage is characterised by the low presence of seeds, only 24 items (2 % of total macro-botanical remains), all of which belong to annual plants and shrubs. The bulk density of plant remains in the samples analysed is also reduced, with 0.34 items per litre of sediment (**tabs 6.1** and **6.2**). In contrast, in samples from the GS, the number of macro-plant remains and plant taxa is much higher, as well as the bulk density of seeds, with 4.37 items per litre of sediment (**tabs 6.1** and **6.2**). Here, seed and fruit remains of small tree species, such as Holm oak, Maritime pine, juniper and Terebinth pistachio, are the most common taxa recorded (**fig. 6.2**).

It must be noted that sedimentation rates are different for YS and GS, with sediments in the GS accumulating approximately ten times faster on average than in the YS (cf. **Chapter 2**). We have compared the rate of plant remains deposition and sedimentation within the cave through the concept of 'productivity', an index calculated from the bulk density of seeds and sedimentation rates, adjusted for stoniness (**tab. 6.3**). In the GS, 'productivity' is some 50-fold higher than in the YS. The highest values of 'productivity' in the GS are probably related to frequent human activities, while the low values for the YS may be the result of more natural (non-human origin) sedimentation episodes, coupled with lower intensity of activity when humans are indeed present. Within the GS, the highest 'productivity' is apparent in Unit G96, which is probably related to the large quantities of stones found in this interval, quickly providing structural protection for fragile remains in the stable interstices. Nevertheless, Unit G96 shows the highest percentage of acorn remains for all the units in S8 (67 % of total remains) (**fig. 6.6**), and this may also be related in another way to the extreme stoniness in this unit, suggesting that some of these rocks (most of which show heat effects) could have been used in acorn processing (**Chapter 2**), although this is a hypothesis that needs to be tested in future research at the cave.

Absolute numbers of seeds and percentage for each taxon are similar throughout units of the GS, with acorn and pine remains being the most frequent (**figs 6.5** and **6.6**). Nonetheless samples from units in the upper part of the sequence, such as Units G91 and G90, show a higher diversity of plant species, with some taxa, such as Terebinth pistachio, being recorded only in those layers. The presence of a higher diversity of plants in the upper layers may be related to some environmental change, or may be linked to economic practices, that increased the number of plant taxa being used by the inhabitants of the cave. On the other hand, overall 'productivity' appears to drop somewhat in these upper units which, given the lower sedimentation rate and reduction in stoniness, might suggest a taphonomic effect, with greater attrition in these assemblages from concentrated human activity (treadage/trampling and other forms of disturbance) (**tab. 6.3**). If this was indeed the case, the observed rise in diversity in some of these upper units may actually have been even greater than seen in the surviving remains.

This disparity in the numbers of plant remains from the YS to the GS may indicate an environmental change, with better conditions for plant growing during the GS that allowed the development of a denser arboreal vegetation. In contrast, evidence of annual plants and shrubs in the YS may indicate the presence

S8 Units	Litres	Items	Items/ l	Index 'stoniness'	Sed Rate m/ky	Index 'productivity'	Y-Comparison increase in GS
Y4, 2-1	67.1	21	0.313	1	0.17	0.053	1
MMC107-108	2.0	3	1.500	1	0.17	0.255	(sample too small)
merged	69.1	24	0.347	1	0.17	0.059	1
G100-97	56.6	114	2.014	3	4.0	2.686	51-fold
MMC106-97	3.0	7	2.333	3	4.0	3.111	[59-fold]
merged	59.6	121	2.030	3	4.0	2.707	46-fold
G96	19.3	88	4.560	5	4.0	3.648	69-fold
MMC96-80	5.5	37	6.727	5	4.0	5.382	[102-fold]
merged	24.8	125	5.040	5	4.0	4.032	68-fold
G95 [no equiv MMC]	26.0	87	3.346	4	4.0	3.346	63-fold
G94-88	127.7	501	3.923	3	1.11	1.452	27-fold
MMC45-1	33.0	348	10.545	3	1.11	3.902	[74-fold]
merged	160.7	849	5.283	3	1.11	1.955	33-fold

Tab. 6.3 'Productivity' of non-tree charred plant macro-remains; 'productivity' (an essentially dimensionless number) has here been estimated using the formula: ((items/l)/stoniness) × (sedimentation rate).

of arid conditions when this part of the stratigraphy was deposited. Results obtained from the analysis of wood charcoals recorded in S8 also suggest a marked vegetation change, with arid and cold-tolerant taxa such as juniper/araar (*Juniperus/Tetraclinis*) dominating during the YS, followed by an increase of warmth- and water-demanding taxa such as pine (*Pinus* sp.) and oak (*Quercus* evergreen) and a decline of *Juniperus/Tetraclinis* during the GS (see **Chapter 5**). Other palaeoenvironmental proxies obtained in the region from marine sediments (Rodrigo-Gámiz et al. 2011; Moreno 2012; Barton et al. 2013) indicate the presence of colder and arid conditions during the YS, the most extreme coinciding with a so-called Heinrich Event just pre-dating the arrival of the LSA people. The start of the GS is dated close to the beginning of Greenland Interstadial 1e and the Series continued through most of GI1, a warmer and humid period (Barton et al. 2013). The proportions of different taxa are indeed similar throughout the Grey Series (**figs 6.5** and **6.6**), giving the impression that the plant assemblage is homogeneous and the environmental conditions were relatively stable during this period. However, archaeological assemblages of seeds do not represent the entire flora around the site, but only those plants gathered for their use; their significance as a proxy for the reconstruction of the palaeoenvironment is thus limited.

On the other hand, it must be recognised that variations in the number of plant remains must also be linked with the different activities carried out in the cave. Wood charcoals of pine (*Pinus*) and oak (*Quercus*) are recorded in sediments of the YS (see **Chapter 5**). This evidence indicates that those arboreal taxa were still growing around the site, despite the arid conditions that were prevalent at this time, with the Beni Snassen mountains probably acting as a refuge for some plants. Whilst wood from those arboreal taxa was gathered for fuel during this period, seeds were not collected or did not become carbonised, since they have not been recorded in the YS, apart from one acorn fragment. Thus, the lack or presence of seeds at the site must also be related to other taphonomic factors, such as the frequency of their use and the processing they went through (Van der Veen 2007).

Evidence from Taforalt suggests that the start of the GS is contemporaneous with a change in the processing and use of plant by the inhabitants of Taforalt. This change resulted in an increase in the number of plant species exploited and an extensive use of fire for processing them, as it is indicated by the high number of carbonised botanical remains. In contrast, in samples from the YS, only two potential food plants were recorded, legumes and ephedra.

In most cases, macro-botanical evidence from the GS is indicative primarily of food debris. The rarity of charred seeds themselves and the abundance of the unpalatable parts of the fruits, such as acorn cupules and pine seed scales, indicate that the plant assemblage recorded in the GS is mostly made of by-products of processing and cooking these plants (for acorns, see Ayerdi et al. 2016). Acorns and pine nuts were consumed and the inedible part was discarded in the fire to become preserved by carbonisation. The rarity of charred acorns and pine nuts throughout the GS implies that seeds of both plants were not directly exposed to fire during preparation. Although their numbers are low it must be highlighted that the presence of seeds (cotyledons) and shells (pericarp) of acorn is not recorded through all the GS but only in the upper parts, in Units G92 to G88 and MMC units 41 to 4 (**tab. 6.1** and **Appendix 6**). In older strata, the acorn remains only consist of cupules and abscission scars. This change in the representation of the acorn remains may be the result of introducing new processing techniques. Acorns are usually roasted when they are still covered by the shell (pericarp), whilst in contrast, when acorns are boiled, the shell is removed beforehand (Primavera/Fiorentino 2013). Thus the presence of charred shells and seeds in the upper strata may indicate an increase in the use of roasting as a technique for processing acorns. Nevertheless, the assemblage analysed is still quite small and this conclusion must remain tentative. On the other hand, huge quantities of burnt and heat-shattered rock are found throughout the GS deposits and are probably largely the result of deliberate heating of stones for cooking and processing purposes (cf. **Chapter 2**). Heated stones can be used to boil fresh or dried seeds in water-filled vessels made from basketry or animal skin (Mason/Nesbitt 2009). Alternatively, patties made from ground seeds could have been cooked directly on heated stones (Ayerdi et al. 2016).

For juniper and Terebinth pistachio, the seeds are probably the by-product, since the edible content is in the flesh of the fruits. In the case of wild legumes, seeds are usually roasted for storage and to remove toxins (Butler 1998), so it is possible that they could become accidentally charred and preserved during this processing. For wild grasses, it is also common to parch the seeds for de-husking, moments during which the seeds can come into contact with fire and be preserved (Weiss/Kislev/Simchoni/Nadel 2005). It cannot be ruled out that some of the seeds and fruits recorded in S8 were accidentally introduced into the site as part of the wood used for fuel. However, differences in the proportions of seeds and wood charcoal (cf. **Chapter 5**) for each taxon in the YS and GS indicate that each had different uses and taphonomic pathways, with the seeds probably being used as food.

Role of Plants in Human Diet at Taforalt

Most of the plants identified in S8 are recorded in ethnobotanical studies as edible items, and they have been consumed in the Mediterranean basin by traditional peasant communities until recently, so it is quite plausible that they represent food remains of the past inhabitants of Taforalt. These plants provide a broad range of nutrients, being rich in carbohydrates (wild legumes, wild grasses and acorns), and fats (Terebinth pistachio, and pine nut), and relatively rich in proteins (pine nuts, and wild legumes) (**tab. 6.4**; cf. also **tab. 18.1** and accompanying text).

The assemblage of taxa recorded in Taforalt reveals a preference for plant foods rich in carbohydrates and fats, which are the most common at the site, especially in the GS. Dietary studies on modern hunters-gatherers emphasises the preference of those populations for wild plants rich in carbohydrates and fats (Jenike 2001; Kelly 2013), particularly in highly seasonal environments with a pronounced dry season (Speth 1987). In addition, it is possible that an extensive use of fire to process plants during the GS resulted in a rise in the net energy value of this food source. The benefits of thermal food processing include: increased digestibility

Species	Common name	Nutritional value (g/100g)			Ripening season
		Carbohydrates	Lipids	Protein	
Avena sp.	wild oat	55.0	8.0	20.0	late spring-summer
Juniperus phoenicea	juniper	18.0	4.0	5.0	autumn
Lens cf. *nigricans*, *Lathyrus* sp., *Vicia* sp.	wild legume	58.0	2.0	26.0	late spring-summer
Pinus pinaster	pine nut	5.0	51.1	33.2	autumn
Pistacia terebinthus	terebinth pistachio	5.0	61.0	4.0	autumn
Quercus ilex	acorn	53.0	10.5	3.0	autumn
Sambucus nigra/ebulus	elderberry	55.0	1.0	7.0	autumn

Tab. 6.4 Nutritional value and ripening season of the most common plants identified in Sector 8. – (Data assembled from published sources: Debussche et al. 1987; Fennane et al. 1999; 2007; 2014; Sosulski/Sosulski 1985).

of carbohydrates, fats and protein; reduced costs of digestion; and reduced energetic costs of detoxification and defense against pathogens (Carmody/Wrangham 2009; Groopman/Carmody/Wrangham 2015). Reliance on plants providing carbohydrates and lipids as a staple food could account for the high caries prevalence recorded among the individuals buried at Taforalt, since frequent consumption of fermentable carbohydrates is a key factor in the initiation and progression of this disease (Humphrey et al. 2014; see **Chapter 16**). Processing and cooking of starchy foods to improve digestibility causes increased food stickiness and reduced food clearance rates within the oral cavity, providing an ideal environment for acid-tolerant bacteria (Tayles/Domett/Halcrow 2009). In this context, several grinding stones have been recovered in Sector 10 at Taforalt (and, previously, throughout the GS, cf. **Chapter 14.2**), suggesting that some foods could have been pounded; systematic use-wear analyses of these tools remains to be carried out (**fig. 6.7**). Archaeobotanical analyses from contemporaneous sites in the Mediterranean basin, which share a similar flora, further suggest a preference of Upper Palaeolithic hunters-gatherers for energy-rich plants. Charred acorns have been recorded in sites of the Near East and Mediterranean Europe (Mason/Nessbit 2009). In North Africa, charred acorns are present in Epipalaeolithic and Neolithic layers of Ifri Oudadane (Morales et al. 2013; 2016) and in Neolithic-Capsian levels of Cappeleti Cave, Algeria (Roubet 1979). For pine nuts, there is evidence of seed scales and seeds of *Pinus pinea* at the Upper Palaeolithic site of Nerja Cave, Spain (Badal 1998). In North Africa, new research carried out in Haua Fteah, Libya, has provided abundant records of *Pinus halepensis* in Libyco-Capsian (Early Holocene) levels (Barker et al. 2010). Evidence of juniper berries has also been attested in some Upper Palaeolithic-Epipalaeolithic sites from the Mediterranean basin, such as in the caves of Santa Maira, Spain (Aura/Carrión/Estrelles/Pérez-Jordà 2005), and in Abeurador (Vaquer/Ruas 2009) and Agnels (Bouby 2004), both in France, in Ifri Oudadane, Morocco (Morales et al. 2013; 2016) and in Haua Fteah, Libya (Barker et al. 2010).

For wild legumes, there is a very wide record in Upper Paleolithic and Epipalaeolithic sites from the Mediterranean basin (Butler 1998). Legumes are especially abundant at Franchthi Cave, Greece (Hansen/Renfrew 1978), in Abeurador, France (Vaquer/Ruas 2009) and in Santa Maira, Spain (Aura/Carrión/Estrelles/Pérez-Jordà 2005). In North Africa, legumes have also been identified in Ifri Oudadane (Morales et al. 2013; 2016) and Haua Fteah (Barker et al. 2010), suggesting that seeds from these plants were a common food for pre-farming populations of the Mediterranean basin.

Other less common taxa at Taforalt, such as Rosaceae fruits, *Pistacia terebinthus* and wild grasses, have also been documented at some Upper Palaeolithic sites from the Mediterranean region. Rosaceae fruits have been recorded in sites in France and the Iberian Peninsula (Aura/Carrión/Estrelles/Pérez-Jordà 2005; Vaquer/Ruas 2009), and also in Epipalaeolithic and Neolithic layers at Ifri Oudadane, Morocco (Morales et al. 2013; 2016). For *Pistacia terebinthus*, the records are limited to the Epipalaeolithic layers of Abu Hureyra, Syria (Hillman 2000); however, finds of other *Pistacia* species, such as *P. lentiscus* and *P. atlantica*,

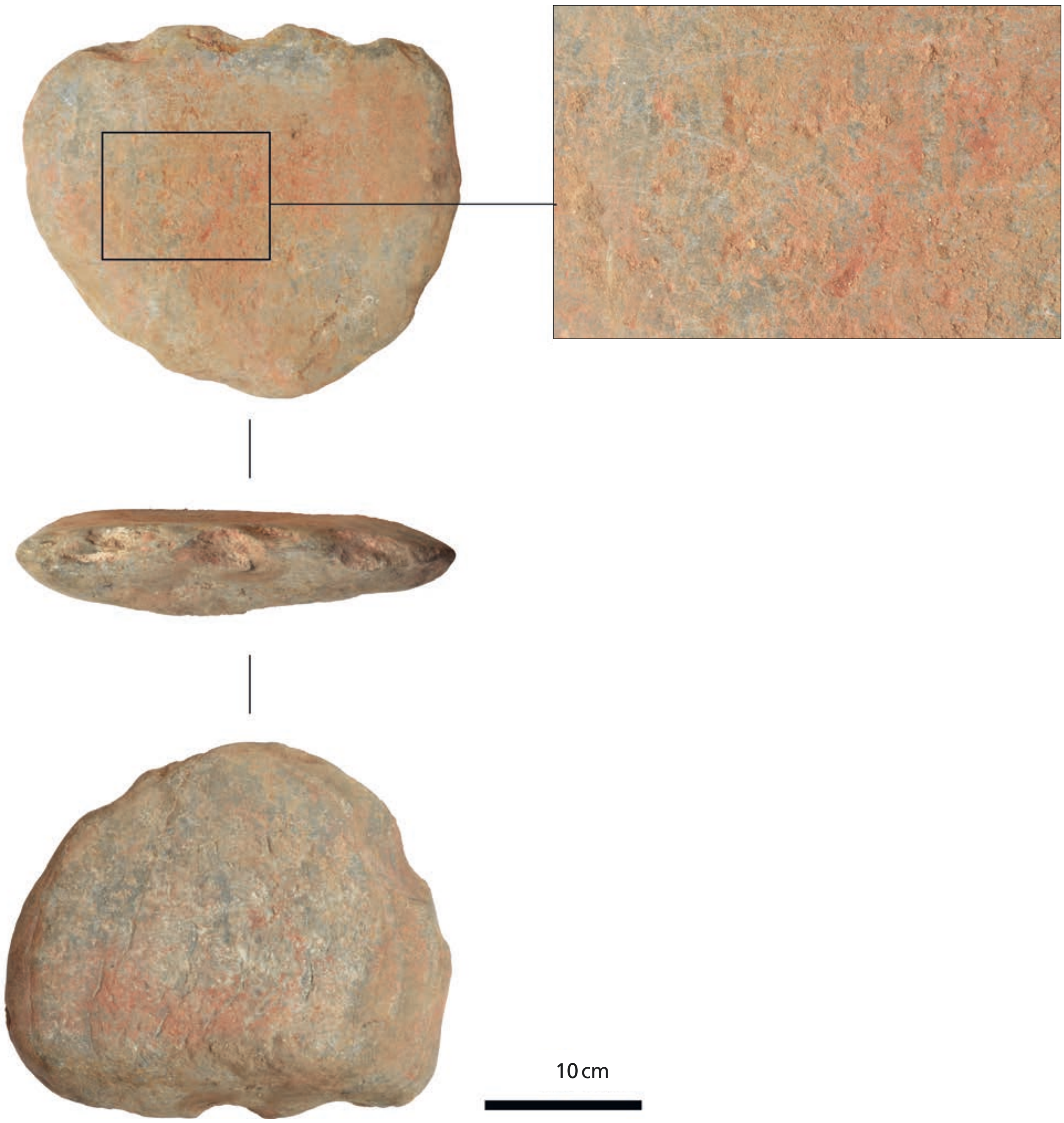

Fig. 6.7 Grinding stone recovered from Sector 10 during the 2010 season <11456>. – (Photo J. Morales).

are common in Upper Palaeolithic and Epipalaeolithic sites of the Mediterranean basin (Arranz-Otaegui/Ibañez/Zapata 2016; Hansen/Renfrew 1978; Aura/Carrión/Estrelles/Pérez-Jordà 2005; Morales et al. 2013). Archaeobotanical evidence of *Avena* and *Bromus* grains in Upper Palaeolithic sites is scarcer. There are a few records of *Avena* and *Bromus* at the 23,000 cal BP site of Ohalo II (Weiss/Kislev/Simchoni/Nadel 2005). *Avena* grains are also present at Franchthi Cave, Greece (Hansen/Renfrew 1978) and Santa Maira, Spain (Aura/Carrión/Estrelles/Pérez-Jordà 2005), as well as in Haua Fteah, Libya (Baker et al. 2010).

Ripening time of plants identified at Taforalt may provide an idea of when they were harvested and consumed. While seeds from annual plants such as wild grasses and wild legumes ripen in late spring and early summer, most taxa from arboreal species ripen in autumn (see **tab. 6.4**). Those data imply a human pres-

ence at the site during late spring/early summer and in the autumn. Nevertheless, Taforalt is in a mountainous region, in which altitudinal gradient results in different ripening times for plants, with plants ripening earlier at lower altitudes and later at higher altitudes. Other geographical factors, such as orientation (facing north) and availability of water in the ground, may also modify the ripening time. Considering those facts, it is possible that harvesting of plants could be conducted all year round if people were moving around the Beni Snassen mountains for their gathering activities.
In addition, we need to consider that people at Taforalt could be harvesting the seeds and fruits still unripe to avoid competition from animals and other human groups, as well as to extend the time available for harvest. In the case of acorns, the high number of cupules points to systematic gathering of unripe acorns, as cupules detach naturally once the acorn is ripe (Primavera/Fiorentino 2013). Ethnographic records describe the beating of trees to enable collection of green acorns, because ripe acorns are more prone to be eaten by ground-feeding competitors or infested by insects or fungi (Pereira-Sieso 2010). Evidence of pine seed scales at Taforalt, as well as ethnographic data (Rivera/Obón 1991; Rivera/Matilla/Obón/Alcaraz 2011), also point to the collection of the cones when they are still unripe and closed, keeping all the unreleased seeds.
Storage was also an activity that could allow a year-round consumption of plants, permitting a better adaptation to high seasonal variability in the environment (Speth 1987; Morgan 2012). There are no direct data about storage at Taforalt but ethnographic records and indirect evidence suggest that storage could have been practiced during the GS. Ethnographic data on acorn and pine nut consumption indicate that both plants have been stored in traditional communities of the Mediterranean (Pereira-Sieso 2010), but also by hunters-gatherers in other regions of the northern hemisphere (Mason 1996; M. K. Anderson 2005; Morgan 2012). For acorns, ethnographic data record the seeds as being stored unripe and unprocessed, but also as a prepared food (Mason 1996; M. K. Anderson 2005; Pereira-Sieso 2010). In the case of pine, seeds are stored inside the cones until needed (Lanner 1981; Morales et al. 2015). At Taforalt, the abundance of charred cone scales and the scarcity of the seeds suggest that pine nuts were stored in the cones and later processed to release and consume the seeds, re-using the cones as fuel once they were empty. If cones were only used as fuel and the pine nuts not released and thus not consumed, we should expect the presence of more carbonised seeds in the archaeological assemblage. Charred seeds of wild legumes may be indicative of storage as well; on occasion, seeds are briefly roasted to eliminate potential pests and to allow better preservation (Butler 1998). During this processing, legume seeds can become carbonised accidentally and, being discarded as waste, increase the possibilities of being preserved in the archaeological record. It is thus possible that some of the charred legume seeds identified at Taforalt are the result of processing for storage. In broad terms, thermal processing is a way to store food, since the cooking stops the action of bacteria and other pathogens that make the foods decay (Carmody/Wrangham 2009). So, any plants processed by fire at Taforalt for later consumption would have needed a method of storage.

Indirect Evidence of Basketry

Direct evidence of baskets, mats or other products from basketry has not been recorded at Taforalt for the time being (see **Chapter 2**). Well preserved desiccated examples of baskets and ropes are common in early-middle Holocene sites from the interior mountain massifs in the Libyan and Algerian deserts (di Lernia/Massamba N'siala/Mercuri 2012); however, this type of preservation has not been recorded (is effectively impossible) at Taforalt, where all the plant remains were preserved by charring. Nonetheless, carbonised rhizomes fragments of alfa grass (*Stipa tenacissima*) are common throughout the GS samples. Alfa is a native perennial grass in the western Mediterranean area that has been extensively used as raw material for basketry and other craft items in North Africa (Louis/Despois 1986; M'Hamdi/Anderson 2013) and the Iberian Peninsula (Sánchez-Sanz 1982). Leaves from alfa grass are the material used for basketry and rhizome fragments are a common by-product of this process. Carbonised rhizome fragments have been recorded at other prehistoric sites from the Iberian Peninsula (Buxó 2010) and North Africa (Morales et al. 2013; 2015; 2018), being interpreted as waste from basketry production. Their presence implies that whole alfa plants were uprooted and carried to the site, where the leaves could be collected to produce basketry and the rhizome fragments were discarded and later re-used as fuel.

6.5 CONCLUSIONS

The data presented in this chapter validate the systematic sampling of sediments during excavation, together with processing by flotation, as an efficient method of obtaining plant evidence at archaeological sites, even (perhaps especially) in the case of pre-farming sites. At Taforalt, the analyses carried out in Sector 8 have provided the largest dataset of macro-botanical remains from a Late Pleistocene site in North-Western Africa. Nevertheless, the information provided here is still preliminary, since the evidence comes from only one sector of the cave. Future studies should focus on other sectors at Taforalt, and in other Iberomaurusian sites from the Maghreb, where data on the use of plants are still rare.

Our analyses show two different patterns in the plant assemblage that are clearly linked to the formation of the YS and GS. During the YS, macro-botanical evidence is scarce, corresponding in most cases to annual plants and small shrubs. In contrast, sediments from the GS are rich in carbonised plant remains from trees, shrubs and annuals. This change in the assemblage of botanical evidences is possibly linked to environmental shifts, from colder and arid conditions during the formation of the YS, to warmer and more humid conditions throughout the GS. Nevertheless, the change in the set of plants recorded in both periods is also the result of modifications in the processing of foods and the intensity in the use of those resources. Data recorded at Taforalt indicate that during the GS there is a concerted gathering and thermal processing of acorns, pine nuts, juniper berries, Terebinth pistachio nutlets, wild legumes, wild grasses, and so on. Those resources were available during the YS, as is proven by the presence of wood charcoals from those taxa in the YS, but they were not commonly gathered for food or, most probably, they were not processed with fire. All of them are edible and rich in basic nutrients, such as carbohydrates, lipids and proteins. Indirect evidence suggests that some of them could be stored. Processed and stored plants are more nutritious and last longer, thus making a more important contribution to the diet. Evidence of this change in the diet during the GS is also visible in the oral health of the individuals buried in the cemetery (Sector 10), showing high rates of caries that are the probably result of a daily consumption of processed plants rich in carbohydrates (Humphrey et al. 2014; Chapter 16).

Our data indicate that the shift in the nature and composition of the YS and GS was possibly affected by environmental changes but was also due to technological and economic innovation (at least, within the Taforalt frame of reference), that necessarily reflected different ways of life during each period.

Acknowledgements

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7. PHYTOLITHS

7.1 INTRODUCTION

Phytoliths, also called plant opals or opaline silica, are a type of plant microfossil ($SiO_2.H_2O$) which are amorphous in nature (Mann/Perry 1986). Soluble silica, in the form of monosilicic acid (H_4SiO_4) is absorbed by plants through groundwater uptake before being precipitated both within and around the cells within the plant (Piperno 1988; 2006; Hodson/White/Mead/Broadley 2005; Shillito 2011; 2013a; Hodson 2016). Phytoliths are an increasingly important archaeological archive due to their taphonomic durability (Ball et al. 2016; Hart 2016). In addition, they usually represent a more local vegetation input than pollen (Rovner 2001; Blinnikov/Busacca/Whitlock 2001). After the plant dies and plant organic matter is decomposed, the silica bodies, which are chemically stable and resistant to decomposition, remain as microfossils in soils and sediment. As phytoliths are mineral deposits, they are preserved for long time periods, in both aerobic and anaerobic conditions. Many phytolith are morphologically distinctive, although some taxa have less distinctive masses, which are difficult to characterise by shape and size. Phytolith analysis can provide insight into vegetation characteristics from both natural sequences, e.g. lake samples (Parker et al. 2004), or from archaeological contexts (Ishida/Parker/Kennet/Hodson 2003; Parker/Lee-Thorp/Mitchell 2011). Furthermore, phytoliths are well preserved in semi-arid environments, where pollen preservation is often poor (Jenkins/Baker/Elliott 2011; Burrough/Breman/Dodd 2012). However, pollen assemblages from Pleistocene cave deposits present such challenges to understanding, at every taphonomic stage, that reliable vegetational information from that source is rarely available.

The volume of phytoliths produced is highly variable, with most trees being low producers whilst monocotyledonous plants (mostly grasses) are prolific producers (Hodson/White/Mead/Broadley 2005; Barboni/Bremond/Bonneville 2007; Mercador et al. 2010; Weiner 2010); indeed, many Mediterranean trees (including most of the woody taxa recorded as charcoals in **Chapter 5**) may produce very few phytoliths and some none at all (cf. Tsartsidou et al. 2007), especially in their actual wood, as opposed to bark and leaves which may have somewhat higher phytolith content. This variability is important to consider when interpreting phytolith assemblages, especially as the causes of this variability (which may apply at intra- as well as at inter-specific and higher levels) are currently not well understood but are thought to be connected to both genetic and environmental factors (Jenkins/Jamjoum/Al Nuimat 2011; Shillito 2013a). In addition to variable levels of production, there are two further complications to be taken into consideration when interpreting phytolith assemblages. These are redundancy – where a particular morphotype occurs in many different plants – and multiplicity – where many different phytolith morphotypes occur in a single taxon (Twiss 2001; Jenkins/Jamjoum/Al Nuimat 2011). Furthermore, the lack of modern reference collections for some regions (such as the northeast of Morocco) will limit assemblage interpretation. Recent work on phytolith morphotypes from modern vegetation in Africa and the Mediterranean has yielded much needed new information for the application of plant biogenic silica studies in palaeoenvironmental reconstruction (Mercader et al. 2010; Cordova 2013). These studies suggest that a number of morphotypes traditionally used to separate C_3 and C_4 vegetation, especially grass silica short cell morphotypes, are found across a number of C_3 and C_4 grass tribes. There is thus greater redundancy in morphotypes than previously thought. Nevertheless, some morphotypes and morphotype groups can be attributed to particular grass sub-families, sedges and woody taxa. In particular, short cell short saddle forms are attributed to chloridoids, lobates to panicoids, papillae and achenes to sedges, and globular rugose/globular granulates to dicot trees and shrubs and globular echinate to palms (Mercader et al. 2010; 2013).

7.2 PREVIOUS STUDIES IN NORTH AFRICA

There are few published phytolith studies relevant to the latest Pleistocene of North Africa. In one marine core off the coast of Sierra Leone (CAMEL-1), researchers have utilised phytoliths (in conjunction with other proxy evidence) to reconstruct climatic changes on the African continent. High levels of phytoliths were observed in the Marine Isotope Stage 2 (MIS 2) levels of the core, also associated with lower levels of foraminifera. These high levels of phytoliths are interpreted as an indicator of more arid and increasingly seasonal conditions. These researchers have suggested that phytoliths are deposited in marine cores during arid periods due to the introduction of material into the atmosphere through increased wildfires from burning of tall-savanna grasslands (Flores/Bárcena/Sierro 2000), although surface erosion of burnt landscapes will also feed fluvial systems. In the Holocene period, lower levels of phytoliths were present compared to MIS 2. Wetter conditions were suggested as being indicative of reduced burning. The study was limited though, as it did not provide details of the phytolith morphotypes found or vegetation composition.

Two terrestrial sites are of interest here, Hattab II, northern Morocco (10,000-7,800 BP; Barton et al. 2008), and Aïn Misteheyia, eastern Algeria (9,800-6,000 cal BP; Shipp/Rosen/Lubell 2013; Lubell/Feathers/Schwenninger 2009). These deposits date from later than the sediments studied from Taforalt but can provide useful information regarding interpretation of phytolith assemblages in the region. Both Hattab II and Aïn Misteheyia suggest a mixed grassland ecology, dominated by temperate C_3 taxa but with some arid-adapted C_4 grasses[65]. In layers 6 and 6a of the older Hattab II cave site, the abundant phytoliths are interpreted as being evidence of the use of grasses as a fuel. Additionally, the high percentage of elongate dendritic phytoliths is interpreted as suggesting a spring-summer occupation of the cave (A. G. Parker in: Barton et al. 2008). The slightly later open air shell midden site of Aïn Misteheyia covers both the Typical and Upper Capsian periods dating to 9,800-9,500 cal BP and 8,000-7,200 cal BP, respectively. Multiple differences in the phytolith assemblages between these periods confirm that phytoliths are a useful palaeoenvironmental indicator, which can also help to identify changes in subsistence strategy. The Typical Capsian period contained a diverse abundance of phytoliths dominated by morphotypes from woody plants and Cyperaceae (sedges). These are interpreted as being the main fuel types utilised at the site, with dried Cyperaceae being used as a type of kindling. Moreover, the number of Cyperaceae multi-cells recovered could be interpreted as the remains of woven baskets, bedding or matting which were possibly disposed of (burnt) after use. The low ratio of elongate dendritic phytoliths in the Typical Capsian militates against a seasonal spring occupation at this site (Shipp/Rosen/Lubell 2013, 837-839).

65 The terms "C_3" and "C_4" refer to two of the (three) possible carbon-fixation pathways in plants, C_3 (more wasteful of carbon, water and energy due to photorespiration) being the most common and ubiquitous, C_4 (with an extra step to capture more carbon efficiently) being much rarer and often associated with higher temperatures and environmental drought/stress. The third pathway (CAM) is an even more specific drought (desert) adaptation, not recognised in the present data.

7.3 METHODS

The present text is based primarily upon analyses carried out during postgraduate research (Ward 2007; Jones 2013). The method described here is that used for the larger analysis (Jones 2013), in which phytolith samples were taken from the mollusc column MMC, a standing section in Sector 8 (see **Chapter 8**). Wherever possible, the sub-samples taken followed the stratigraphy of the deposits. However, in layers with large concentrations of fire-cracked rock, arbitrary sub-samples were taken at 5 or 10 cm intervals, with larger samples taken every 10 cm to obtain one litre of fine sediment.

Initially a systematic subsampling strategy (every fourth sample) was employed to ensure coverage of the entire sequence of deposits. A few additional subsamples were selected which corresponded to interesting peaks and troughs in the plant macrofossil remains. In total, 36 phytolith samples were prepared and studied.

The dry ashing method (rather than acid extraction) was chosen to remove organics rapidly from samples and to aid the preservation of multi-celled phytoliths (Piperno 2006, 92; Jenkins 2009; Jenkins/Baker/Elliott 2011). Samples were mounted onto slides using Canada balsam (Piperno 1988; 2006).

Samples were analysed using a Nikon Eclipse E400 microscope and a Leica DME microscope at x400 and x100 magnifications. All photographs were taken on the Leica DME microscope with a Leica DFC290 camera attachment. Phytoliths were identified and counted according to morphotype and described following the International Code for Phytolith Nomenclature (Madella/Alexandre/Ball 2005). Phytoliths of consistent morphology (Albert et al. 1999, 1254) were counted to a total of >500 per slide (actual subsample total counts falling into the range 509-611), larger consistent morphotype subsamples than available to Ward (2007) who used a target of >250. Phytolith results are presented using the program C2 (Juggins 2007) and shown in **figures 7.1, 7.4** and **Appendix 7.1a-c**.

7.4 RESULTS

A total of 46 morphotypes and some 19,600 phytoliths were identified and counted in the MMC column study (see **Appendices 7.1a-c** and **7.2** for the complete phytolith diagram and the numerical archive for the raw phytolith data respectively).

Local Phytolith Assemblage Zones

The total phytolith collection has been divided into four local phytolith assemblage zones (LPAZs), derived from the results of constrained cluster analysis in conjunction with a visual examination of the main changes in the phytolith stratigraphy shown in **Appendix 7.1a-c**. Zones are reported in MMC sample intervals (remembering that these Zones comprise only discontinuous subsamples of the whole sequence).

LPAZ-TAF-1 (MCC130-MMC108)

The basal sample of the sequence records the presence of high levels of woody taxa (see below), whilst the rest of the samples within this Zone show the dominance of C_3 grassland. C_4 taxa are present within the

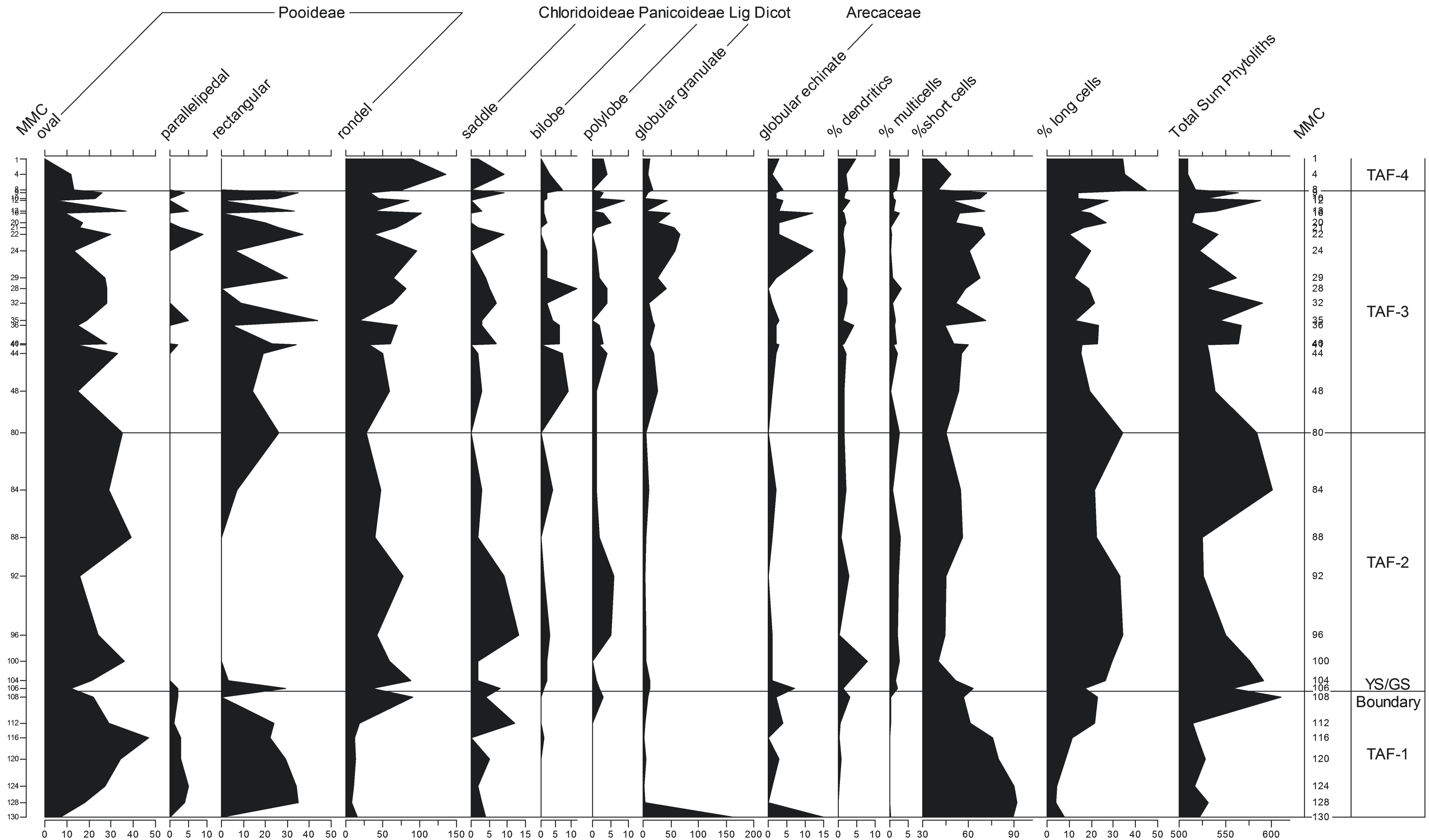


Fig. 7.1 Diagram showing the key phytolith morphotypes identified in the Taforalt assemblage; black lines demarcate phytolith Zones; note the varying scales between the graphs, all but the last four columns being actual counts (dividing counts by 5 will give an approximate conversion to percentages; see **Appendix 7.2** for exact subsample total counts).

local area, possibly reflecting high levels of water stress within this Zone. Short cell morphotypes dominate the phytoliths found with long cells appearing towards the top of the Zone. The top sample in this Zone lies just below the sedimentary transition from the Yellow to the Grey Series. The basal sample of this Zone has high levels of the ligneous dicotyledon (globular granulate, fig. 7.2f-g) morphotype and Arecaceae (formerly 'Palmae') types, which decline with the subsequent expansion of Poaceae (formerly 'Gramineae') morphotypes. In MMC112 (high in S8-Y2spit1), there is a small peak of Chloridoideae C_4 taxa, although, despite this, the majority of the grassland taxa comprise temperate C_3 taxa (oval – 50 counts and rectangular reaching <40 counts). Bilobate and polylobate forms often, but not exclusively, associated with Panicoideae grasses are very low in this Zone with trace levels present. In addition, high levels (174 instances) of an unidentified morphotype (fig. 7.2n-p) are present in the basal sample (MMC130, equivalent to the latest MSA interval in S8-Y4spit4) of this Zone. Short cell morphotypes dominate the assemblage (fig. 7.1) with low counts for long cells (less than 10 % in MMC130-MM120). Long cells increase from 12 % in MMC116 to 23 % in MMC108).

LPAZ-TAF-2 (MMC106-MMC80)

This Zone is characterised by the continuation of C_3 grassland dominance, with stable but low inputs from woody taxa. The reduction of the ligneous dicotyledon morphotype, globular granulate, to c. 10 observations throughout the Zone could suggest low water availability, which would also explain the low levels (<5 counts) of the Arecaceae morphotype. The lowest levels of woody taxa in the Zone do correlate to increased numbers of C_4 saddle morphotypes (MMC96, MMC92, figs 7.1 and 7.2e) indicating drier conditions compared to LPAZ-TAF-1. Polylobate panicoid morphotypes also increase in these two samples but the numbers are still relatively low (~4 counts in each). Despite this xeric grassland component, C_3 temperate taxa continue to dominate the assemblage (oval between 15-45 counts and rondel reaching 75 counts, fig. 7.1). At the base of the Zone there is an increase in dendritics to 8 % in MMC100. Multicell phytoliths, whilst low in number, appear throughout LPAZ-TAF-2 having been absent in LPAZ-TAF-1. The proportion of long cells to short cells in LPAZ-TAF-2 increases in LPAZ-TAF-2 (up to 34 % in MMC96 and MMC80) compared to LPAZ-TAF-1.

LPAZ-TAF-3 (MCC48-MMC10)

The phytolith assemblage in this Zone is again characterised by C_3 grassland dominance, although there is an increasing C_4 component as denoted by saddle morphotypes. Bilobate and polylobate forms are present throughout LPAZ-TAF-3 but in low numbers with higher levels of bilobates noted between MMC48-MMC28. Increasing levels of woody taxa were also observed throughout LPAZ-TAF-3 but notably from MMC24 upwards. This assemblage has been separated from TAF-2 based upon the increasing fluctuation in the levels of all morphotypes. High levels of globular granulate (up to 60 counts) and globular echinate (up to 12 counts) morphotypes are recorded between MMC24-MMC13. Oscillating but overall high levels of temperate Pooideae grasses (>100 rondels) are recorded with enantiomorphic peaks of C_4 types (saddle, bilobe and polylobe, figs 7.1 and 7.2e. a-c. w respectively). Dendritic forms are found throughout accounting for between 1 and >4 %. In LPAZ-TAF-3 the proportion of long cells falls slightly, with values ranging between 12 % in MMC29 to 27 % in MMC12.


20 µm
a
20 µm
b
20 µm
c
20 µm
d
20 µm
e
20 µm
f
20 µm
g
20 µm
h
20 µm
i
20 µm
j
20 µm
k
20 µm
l
20 µm
m
20 µm
n
20 µm
o
20 µm
p
20 µm
q
20 µm
r
20 µm
s
20 µm
t
20 µm
u
20 µm
v
20 µm
w
20 µm
x

LPAZ-TAF-4 (MMC9-MMC1)

C_3 grassland dominance continues in this Zone, with C_4 saddle, bilobate and polylobate forms found throughout but in low numbers. Globular granulate (ligneous dicotyledons) and globular echinate (Arecaceae) forms are lower in LPAZ-TAF-4 compared to LPAZ-TAF-3. Overall, there is a drop in temperate Pooideae C_3 morphotypes (oval, parallelipedal, rectangular) but an increase in rondel forms with stable, but low, levels of C_4 (xeric) morphotypes, which decrease from about MMC4 upwards. Unfortunately, further analysis of this assemblage is problematical, due to the truncation of the sediments in the historic past and the possibility of some disturbance. Long cells values increase in LPAZ-TAF-4 20 ~40 %+ (MMC8 to MMC1)

Phytolith Short Cells-Long Cells and Multi-Cells

Overall, phytolith preservation was excellent (figs 7.2 and 7.3), although some pitting was observed in the lower Yellow Series samples and especially the basal sample MMC130. This suggests some post-depositional changes within this part of the sequence. Several studies have suggested that the ratio of short versus long cells can be applied to infer preservation and diagenesis. Long cells are more often less silicified and offer wider surface area to chemical and physical attack. Therefore, they represent weaker typologies than short cells, and tend to disappear more easily. Assemblages with a high number of long cells versus short cells should emphasize a higher degree of preservation (Madella/Lancelotti 2012). In LPAZ-TAF-1 the number of long cells is low when compared to shorts cells at less than 10 % in the lowermost samples but increasing up profile to ~20 at the top of the Zone. The proportion of long cells to short cells shows a marked increase in LPAZ-TAF-2 increasing to ~30 % with slightly lower proportions in LPAZ-TAF-3 to ~20 %. In LPAZ-TAF-4 long cells increase to ~40 %.

The percentage of multi-cells displays an interesting level of variation through the sequence. The shape of the trace shows an enantiomorphic tendency with respect to the graphs of globular granulate and globular echinate. Phytolith multi-cells are most commonly derived from monocotyledons, so the changing relative presence of woody taxa in these deposits probably explains this tendency. In addition, the lack of conjoined phytoliths in the midden thin section micromorphology sample MM02 (from Unit S8-L13, approximately equivalent to S8-G93-1 or MMC44; see Chapters 2 and 3) suggests that high levels of trampling could also influence the survival of multi-celled remains. The rarity of multi-cells (< 1 %) in the Yellow Series is taken up in the Discussion below. The peak of elongate dendritic morphotypes (8 %; figs 7.1; 7.2x; 7.3c-d) in MMC100 could be interpreted as an indicator of spring-summer occupation, as this morphotype is found in mature grass panicles (Barton et al. 2008, 206; Shipp/Rosen/Lubell 2013, 837; Novello/Barboni 2015). Novello/Barboni (2015) suggest that abundances of dendritics >> 3 % relative to the sum of grass silica short cell phytoliths plus dendritics are likely to indicate anthropogenic accumulation of grass inflorescences. It should be noted that these phytoliths could also and/or otherwise be due to storage activities or have entered the cave naturally, by wash or even wind; again, this point is taken up in the Discussion below.

Fig. 7.2 Examples of single-cell phytoliths from the Taforalt sequence: **a-c** bilobe; **d** bulliform; **e** saddle; **f-g** globular granulate; **h-j** rondel; **k** conical; **l-m** trapezoid; **n-p** unidentified morphotype; **q-r** elongate sinuate; **s** elongate psilate; **t-u** elongate echinate; **v** lanceolate; **w** polylobe; **x** elongate dendritic. – (Images S. L. Jones).

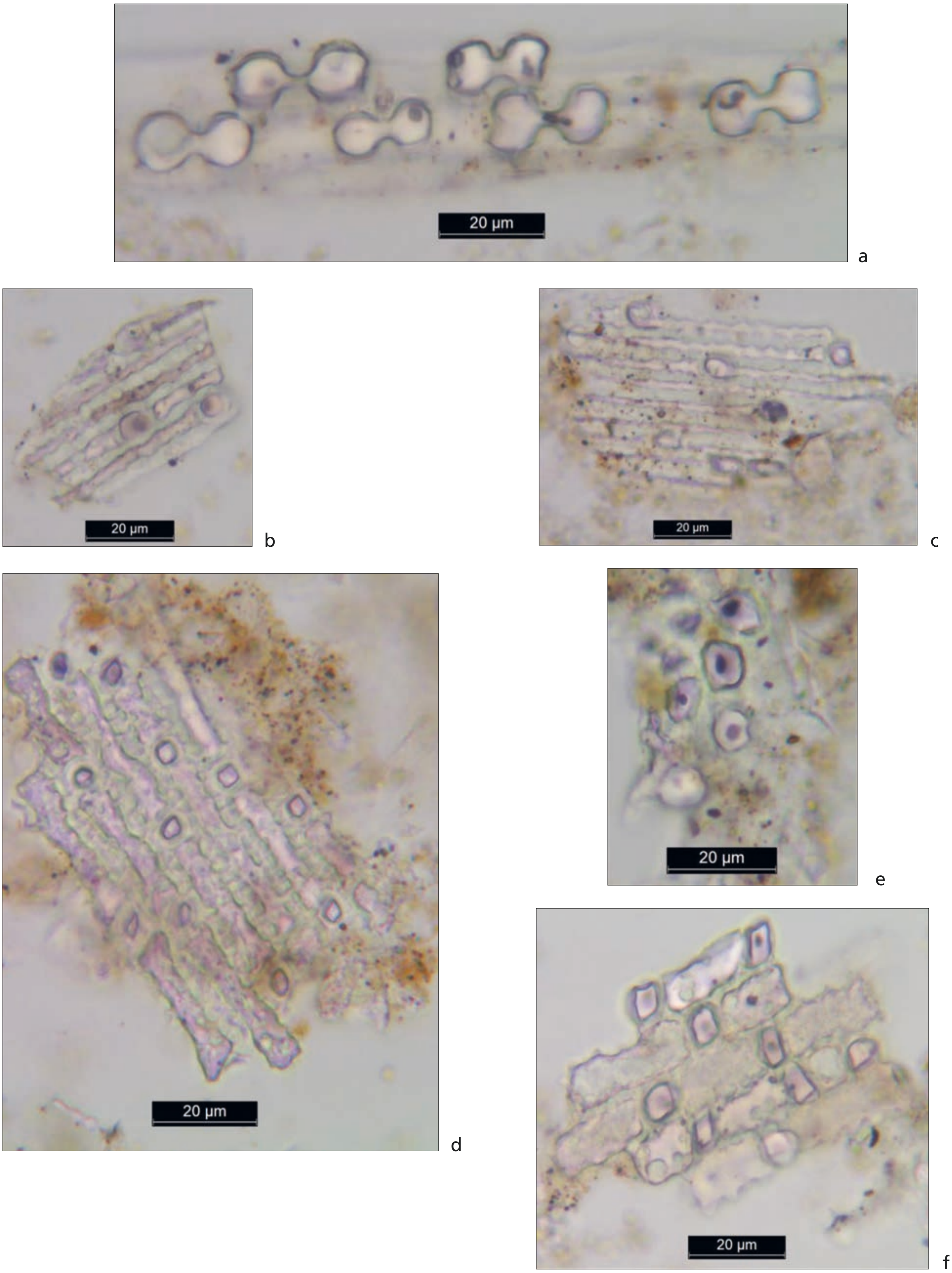


Fig. 7.3 Examples of multi-cell phytoliths from the Taforalt sequence: **a** articulated bilobes; **b** elongate sinuate multi-cell; **c** elongate dendritic multi-cell; **d** elongate dendritic and trapezoid multi-cell; **e** papillae multi-cell; **f** elongate echinate and short cell multi-cell. – (Images S. L. Jones).

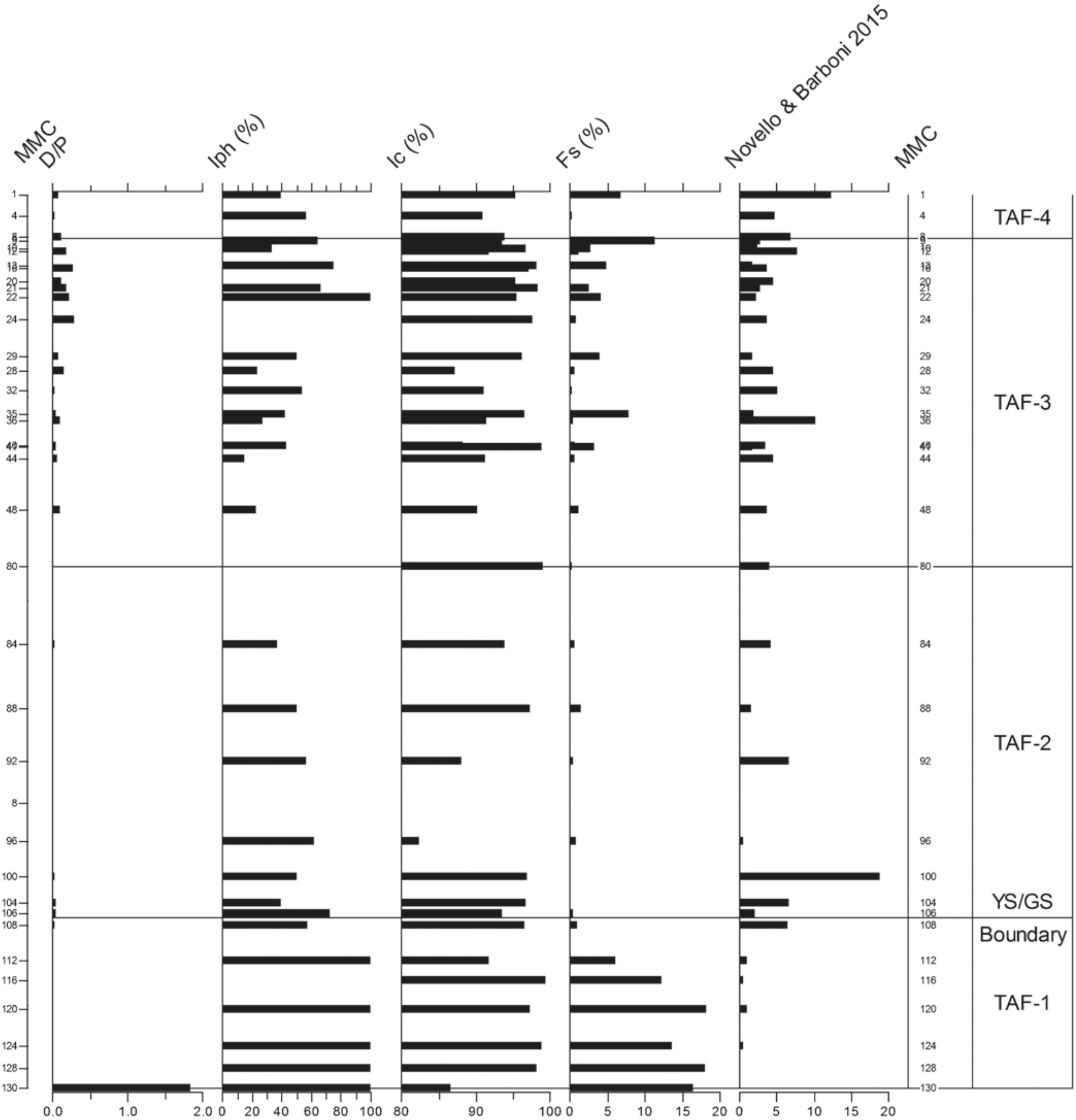


Fig. 7.4 Diagram showing the phytolith indices results for each sample; black lines demarcate phytolith Zones.

Phytolith Indices (fig. 7.4)

A number of phytolith indices have proved useful when interpreting phytolith assemblages, and to identify key vegetation changes in the Mediterranean (Bremond/Alexandre/Véla/Guiot 2004; Delhon et al. 2003) and Africa (Barboni/Bonnefille/Alexandre/Meunier 1999; Bremond/Alexandre/Peyron/Guiot 2005; Bremond et al. 2008; Parker/Lee-Thorp/Mitchell 2011; Burrough/Bremond/Dodd 2012). These indices are applied here to the Taforalt MMC column samples.

D/P

D/P is the ratio of ligneous dicotyledons (globular granulate and echinate morphotypes) to Poaceae short cells; the index was developed to provide an estimate of the density of woody species in West Africa (Alexandre et al. 1997). In Senegal, D/P values of <1 characterise environments with abundant grass species, like savannah, whilst in Ethiopia D/P values of 0.1-0.7 characterise shrub vegetation on the border of riparian forest (Barboni/Bonnefille/Alexandre/Meunier 1999, 96). At Taforalt, the basal sample (MMC130, the youngest MSA level in Sector 8) shows high levels of woody taxa (>2) compared to the rest of the sequence, which never exceeds 0.5. This means that, whilst in this basal sample woody taxa outnumber grasses, in the rest of the sequence, grass morphotypes always outnumber ligneous species. The D/P ratio is lowest in LPAZ-TAF-2 (MMC106-MMC80) with an increase in LPAZ-TAF-3 to ~0.3 towards the top of this Zone (MMC24-MMC12). D/P values fall in LPAZ-TAF-4 (MMC8-MMC1).

Iph %

The Iph % index expresses adaptation to aridity (Diester-Haass/Schrader/Thiede 1973) and measures the Chloridoideae percentage of C_4 grasses. High Iph % indicates Chloridoideae xeric adaptations, whilst low Iph % indicates Panicoideae mesic C_4 adaptation. 'Maximum' Iph % in most of the Yellow Series and in MMC21 should not be over-interpreted, due to the nature of the mathematical calculation (i.e. if no Panicoideae phytoliths are observed then 0/Chloridoideae = 0 %, hence the exaggerated "100 %" default). In West Africa, Iph % values at about 40-45 % would distinguish tall-grass mesic savannah (<40-45 %) from arid-adapted short grasses (>40-45 %) (Alexandre et al. 1997). The Iph % oscillates through the Taforalt sequence (range: 15-75 %), with mesic grassland types (<45 %) dominant between MMC84 and MMC35. Iph% values >45 % are found across the YS/GS transition (MMC108-MMC106), in LPAZ-TAF-2 (MMC96-MMC88) and in the upper part of LPAZ-TAF-3 (MMC22-MMC9).

Ic %

Ic % was defined by Twiss (1992) as a way to measure the ratio of C_3 plants in the American Plains. High Ic % indicates high levels of Pooideae temperate C_3 taxa, whilst low Ic % indicates a greater proportion of more xeric C_4 taxa. Barboni/Bonnefille/Alexandre/Meunier (1999) calculated, from data collected from the North American Plains by Fredlund/Tieszen (1994), that Ic % values of 70 % indicate C_3 dominated plains, whilst values around 30 % indicate C_4 dominance. The Ic % values from Taforalt fluctuate through the sequence but never fall below 82.5 %, showing the dominance of C_3 grasses throughout. Many of the grass species of potential importance to humans that were available in the Late Pleistocene were C_3 plants, including *Avena* sp., *Bromus* sp. and *Stipa tenacissima*. In addition, some C_4 non-grass species were present in the charred macro-botanical remains (Caryophyllaceae and Chenopodiaceae), which are not reflected in the phytolith assemblage (J. Morales, pers. comm.). Shipp/Rosen/Lubell (2013) identify the C_4 grass *Desmostachya bipinnata* (halfa/alfa grass) in their phytolith assemblage from Aïn Misteheyia (Algeria), although this grass species was only recovered from the Eastern Mediterranean zone in a comprehensive study of grass species in Egypt (Batanouny/Stichler/Ziegler 1988); in that study, C_3 plants comprised 52-63 % of the monocotyledonous flora in the Mediterranean coastal zone (ibid., p. 546).

Fs %

The Fs % index was defined by Bremond / Alexandre / Peyron / Guiot (2005) as an indicator for water stress. It measures the proportion of fan-shaped bulliform morphotypes (**figs 7.2d** and **7.4**) to Poaceae short cells. Samples taken from a longitudinal transect of climatic zones in West Africa found that Fs % values increased northwards towards the Sahelian and Saharan zones; thus, high Fs % levels indicate high water stress. At Taforalt, zone LPAZ-TAF-1 shows the highest Fs % levels. There is then a sharp decrease, with LPAZ-TAF-2 showing the lowest levels of water stress in this sequence. In LPAZ-TAF-3, the Fs % value fluctuates considerably and could indicate climatic events or could possibly record human selection of grass types. High levels of water stress are recorded at the onset of LPAZ-TAF-4, although a possible amelioration after this initial deterioration is also observed.

Statistical Analyses

Jones (2013) carried out multivariate analyses (Cluster Analysis and Detrended Correspondence Analysis [DCA]) on the main phytolith sequence. The first two DCA axes were found to display a significant similarity to the D / P and Fs % indices respectively, suggesting that the environmental eigenvector plotted against the first DCA axis largely represented the environmental gradient of woody to grassland vegetation, whilst the variation along the second DCA axis was mostly explained by changing levels of water stress. It would therefore seem that these two indices (see previous subsection) are the most sensitive to the changing environmental / climatic conditions at Taforalt. This having been said, Jones found that a very considerably lower percentage of the variance in the DCA analysis, especially that on the first axis, was accounted for in the Grey Series (GS) data than in that for the Yellow Series (YS), causing her to suggest that plants were being more heavily selected by people for specific uses in the Grey Series, as compared to a closer representation of the natural environment in the Yellow Series. Jones's final conclusion from her statistical analyses was that there did not appear to be evidence for a strong change in environment between MMC108 (her only S8-Y1 sample) and MMC106 (and higher samples), across the YS / GS boundary. One may also note that her statistical results for MMC112 (the upper part of S8-Y2spit1) look markedly 'intermediate' between those of the stratigraphic units directly below and above.

Phytolith Abundance

Quantitative analysis to asses overall phytolith abundance within the sediment samples was not undertaken (Jones 2013). Ward (2007) followed a semi-quantitative method, allowing him to isolate the 'acid insoluble fraction' (AIF) and the phytolith fraction, and thus, by micro-weighing, to estimate number of phytoliths per gram of AIF; since the resulting figures are very large numbers, for convenience here, they will be rounded to the nearest 1000 and referred to as an 'abundance index'. Whilst this approach does have the advantage of standardising phytolith counts (the index) to the non-soluble portion of the sediment fine-matrix, it cannot take into account either independent availability rates of non-solubles (such as fine quartzitic sand and silts) or overall sedimentation rates, such that care is needed to avoid the resulting intrinsic uncertainties (especially important in any comparison between the very different contexts in the YS and GS).

In the Yellow Series, fine quartzitic sand and silt was constantly added by natural processes but the sedimentation rate was relatively slow (cf. **Chapter 2**). Ward reported index values for his YS samples as follows

(2007, tab. 5.4 fig. 5.24): Y4spit1 = 1; Y3 = 10; Y2 = 8; Y1 = 6. Ward reported one more sample from the YS: a hearth in Y1 = 145.

Turning to the Grey Series, there was little opportunity at most levels for input of quartzitic sands by natural processes but the bulk sedimentation rate was at least ten times that of the YS, although much of this material was in the coarse (stone) grades (cf. **Chapter 2**); there is no way to calculate an accurate YS/GS comparative factor but it is suggested here that, were phytoliths to be generated at roughly the same rate throughout the sequence, one might expect the abundance index (as calculated) to show values perhaps 2-5 times higher in the GS than in the YS. Ward reported index values for his GS samples (none of them recorded as being from undisturbed burning events) as follows: G100 (approximately equivalent to MMC106) = 8; G98 (approximately equivalent to MMC104-MMC100) = 234; G96 (approximately equivalent to MMC95-MMC80) = 244; G94 (approximately equivalent to MMC50-MMC46) = 1600; G89 (approximately equivalent to MMC12-MMC5) = 138.

7.5 DISCUSSION

The MMC column analysis confirms the dominance of C_3 taxa found by Ward (2007), but also demonstrates that in many levels (as shown by the Iph %) there is a C_4 component. We may note, in passing, that nowhere in the Taforalt LSA sequence do phytolith morphotypes (e.g. jigsaw pieces) usually associated with more humid environments ever reach greater than trace proportions. Modern sediment samples, collected by Ward, local to the cave, showed that the grass morphotypes rondel and elongates were dominant (2007, 379-380). This is in agreement with the results of the more detailed MMC column study (**Appendices 7.2a-c** and **7.3**), which found rondels (2,105 counts) in conjunction with elongate echinate (2,269 counts) and elongate sinuate (2,376 counts) morphotypes to be dominant. In the following discussion, it should be remembered that phytolith analysis best reflects the state of the local grassland components, due to the normally much lower phytolith production in woody taxa and may also reflect a bias due to selected plant resources being collected and utilised at the site. It should also be noted that woody taxa produce fewer phytoliths than monocot taxa, especially grasses, so may be under represented in the sequence.

The phytolith sequence has been compared with the radiocarbon dating provided in **Chapter 4**, making possible suggestions of correlation with known sequences of Late Pleistocene climate change (the Greenland Ice Core Record being the standard global model used here).

Palaeoenvironment

The basal LPAZ-TAF-1 contains samples from the Yellow Series. This Zone sees the highest values of the Fs % index, interpreted as indicating a generally high level of water stress. The dating (see **Chapter 4**) would include the Last Glacial Maximum (LGM) and Heinrich Events 1 and 2 (HE 1 and 2) during MIS 2. The basal sample (MMC130, the latest MSA level) is recognised as separate in the statistical analyses, due to the high levels of woody taxa. This corresponds to Alboran Sea core data which indicates an abrupt rise in temperate taxa in this period before the onset of HE 2 (Combourieu Nebout et al. 2002; 2009). There is then a decline in woody taxa identified in the phytoliths from most of the remainder of LPAZ-TAF-1 (cf. also **Chapters 5-6**), coupled with a rise in various grasses, always dominated by shifting proportions of C_3 types. This having been said, the YS peak in C_4 Chloridoideae in MMC112 (equivalent to an interval from high within

S8-Y2spit1) stands out from the otherwise 'intermediate' (possibly physically mixed) trends and is plausibly a true signal from the driest phase of HE 1; in support of this proposition, one may note that Ward (2007) also found the lowest C_3/C_4 morphotype ratio in his Sector 8 LSA sequence within his Y2 sample. One may further cite the recording by Ward (ibid.) of a very low C_3/C_4 morphotype ratio in Unit 2 of Sector 9, an interval with early LSA, well developed in that part of the cave (just above sediments thought to date from HE 2; see **Chapter 2**) but extremely compacted (if present at all) in Sector 8. However, turning to the top of this Zone, in the phytolith assemblage for Y1, there is a marked decrease in the Fs % and corresponding decreases in the bulliform and saddle morphotypes. There is also an increase in woody taxa (especially platy forms). Additionally, there are increases in the rondel, conical and polylobe (Panicoideae) short cells and elongate dendritic and elongate sinuate long cells. These trends suggest a slight shift to more humid, possibly even warmer conditions. All this evidence suggests that phytoliths can be a reliable proxy for wider, as well as local, climatic variations.

This having been said, a note on comparative taphonomy is needed at this point. The Yellow Series in Sector 8 comprises relatively fine sediments, dipping out of the cave, interpreted as having been emplaced largely by natural processes, dominated by gentle wash but with some reworked aeolian input originating in the drier intervals (see **Chapter 2**). Whilst humans were certainly repeatedly present within YS time, vegetational structure and natural transport processes probably dominated the phytolith taphonomy, with most specific human input subject to some redistribution (note that the phytolith subsampling from the MMC column did not include any primary or strong secondary human accumulations, such as S8-Y3). The rare occurrence of multi-cells (< 1 %) in the YS samples is consistent with this taphonomic picture, although more localised diagenesis (cf. pitting) may also have played a part at some levels. This is supported by the low numbers of long cells to short cells, which are more prone to pitting and dissolution, suggesting that digenesis may have played a role (*sensu* Madella / Lancelotti 2012) in the YS and TAF-1 samples, especially in the lower part of this Zone (MMC130-116). The higher numbers of short cells may also reflect increased wind borne phytoliths being delivered into the sequence through selective entrainment of smaller phytoliths by wind from outside the site. In contrast, the Grey Series is overwhelmingly an anthropogenic accumulation (see **Chapter 2**). Whilst humans could only have selected from what the vegetation mosaic made available in any particular period, any environmental signal in the GS must be deciphered through the potential filter of human preferences. Indeed, looking again at the data from Y1, it may be that an increasing human presence was already affecting the phytolith assemblage rather more than had previously been the case, perhaps with the exploitation of a greater variety of plant resources and the deliberate selection of materials being brought into the site. This view is supported by the increase in dendritics observed in the GS from TAF-2 onwards with values reaching > 3 % (*sensu* Novello / Barboni 2015 – see below for discussion).

The remainder of the phytolith assemblage Zones (LPAZ-TAF-2 to 4) derive from the Grey Series. The basal sample of LPAZ-TAF-2 (MMC106) has an unusually high Iph % of 73 % indicative of a significant xeric C_4 component accompanying cool, arid conditions. Whilst some caution must be applied here, due to the demonstrable physical mixing associated with human activity at the base of the GS 'midden' deposits, it may be noted that there is also a very specific distribution of the various C_3 Pooideae phytolith types in MMC106 which could not have resulted from any plausible mixing of material from the samples immediately below and above, an observation which suggests that MMC106 retains some true environmental signal.

The LPAZ-TAF-2 assemblages generally have high values of temperate C_3 taxa, with lower C_4 elements and the lowest recorded values for water stress. After the very base (see above), this is a Zone of climatic amelioration, consistent with expectations for Greenland Interstadial 1e (GI 1e) time, the most temperate phase in this interstadial (Genty et al. 2006; Combourieu Nebout et al. 2009; Rodrigo-Gámiz et al. 2011). The division between LPAZ-TAF-2 (highest sample MMC80) and LPAZ-TAF-3 (lowest sample MMC50), at c. 14,200 cal BP (see **Chapter 4**), approximately at or just before the beginning of GI 1d, is based upon several characteristics. The phytolith signal becomes more 'noisy' and there is a rather erratic increase in Chloridoideae C_4 taxa and in levels of water stress from MMC44 upwards. This change would correspond with a date (c. 13,600 cal BP) a little into GI 1c time (Björck et al. 1998; Walker et al. 1999). The assemblage throughout LPAZ-TAF-3 remains dominated by C_3 species and also sees a slight increase in woody taxa which suggests the continuation of interstadial conditions and a certain level of water availability.

LPAZ-TAF-4 begins with an increase in water stress to an Fs % of 11, the highest since the values recorded in the Yellow Series. The xeric C_4 percentage of the assemblage also sees an increase (to an Iph % of 64) at the onset of this Zone, although this index was already showing erratic high values in the uppermost parts of LPAZ-TAF-3. These signs of aridity in the earliest sample of LPAZ-TAF-4 may presage the onset of the Younger Dryas (YD or Greenland Stadial 1 [GS1]), at c. 12,600 cal BP. The assemblage nevertheless does not show characteristics that would suggest that the climatic conditions were as severe as those seen in the Yellow Series, and especially not as in the HE 'minima' (cf. Fletcher/Sánchez Goñi 2008; Combourieu Nebout et al. 2009). As has already been stated, the upper part of LPAZ-TAF-4 is problematical and will not be discussed further here.

There would therefore appear to be some broad correlation between the Greenland isotopic stratigraphy of the last interstadial/stadial cycle and LPAZ-TAF-2 to (basal) 4. However, it has already been noted that only a relatively small proportion of the statistical variance in these phytolith assemblages can be attributed to climatic factors, the picture having most probably been blurred by human activity.

Palaeoeconomy and General Human Behaviour

As has been noted above, disentangling the environmental from the cultural signal in phytolith results is rarely a straightforward matter.

Phytolith Abundance

Several points of interest arise from Ward's (2007) analysis of phytolith abundance (always bearing in mind that only eight samples were considered from the whole LSA stratigraphic interval). Looking first at the Yellow Series (equivalent to Jones's LPAZ-TAF-1), the abundance index is generally low, with a slight up-turn in a unit (Y3) demonstrably comprising a strong but generalised (washed) anthropogenic influence. Most striking is the result for an undisturbed hearth in Unit Y1; this specific burning event is confirmed as producing perhaps two orders of magnitude higher phytolith abundance than the YS 'background'. Remembering that it has been estimated that a 'uniform' real abundance of phytoliths throughout the LSA sequence would be likely to result in index values perhaps 2-5 times higher in the GS than in the YS (see explanation above), the abundances actually observed by Ward in the Grey Series (his samples here excluding an undisturbed hearth) are noteworthy. At the very base, there is little appreciable change, suggesting that there is probably a strong admixture of YS sediment into this level of the GS. However, immediately upwards and through the lower part of the GS (equivalent to most of Jones's LPAZ-TAF-2), the index values rise by well over two orders of magnitude compared to the YS 'background', to levels about 2 times that seen in the sampled undisturbed hearth in Unit Y1. Furthermore, the phytolith abundance index rises to over three orders of magnitude higher than the YS 'background' in a sample near the base of the upper part of the GS (equivalent to a level low in Jones's LPAZ-TAF-3), although it must also be noted that the sedimentation rate is here known to have halved with respect to the lower part of the GS (see **Chapter 2**). Even if Ward (2007, 239) did dismiss any abundance figures of less than a million phytoliths per gram as "quite low" (presumably on the grounds that the Taforalt numbers are a little lower, perhaps by a factor of 3-5, than in phytolith studies in 'classic' eastern Mediterranean cave site, such as Kebara; cf. Albert/Weiner 2000; 2001), there can be no other explanation for these escalating numbers than correspondingly increasing human import of vegetable matter (remembering that phytolith abundance is naturally production-biased towards monocots and grasses in particular). However, Ward's uppermost sample (at least overlapping with the start of Jones's LPAZ-TAF-4) shows a down-turn, to an index level again only some two orders of magnitude above the YS 'background', plausibly interpreted as a moderate reduction in human input, perhaps as a cultural response to the climatic conditions slipping towards the Younger Dryas (GS1).

Phytolith Variance

From LPAZ-TAF-3 upwards, the phytolith signal shows increasing variation compared to the zones below. This noisiness, expressed both as 'saw-tooth' traces for individual morphotypes or groups on the graphs and as continually shifting combinations of morphotypes (cf. **fig. 7.1**), and also as increasing variability in indices (cf. **fig. 7.4**) as well as in the multivariate statistical analyses, is not typical of more smoothly varying natural sequences and is therefore suggestive of increasing human activity at the site.

Woody Phytolith Taxa

Although most of the Yellow Series and basal Grey Series samples all show very low levels of woody taxa in the phytolith record, the upper part of the GS (LPAZ-TAF-3) shows increasing, if sporadic, levels of such taxa (especially globular granulate forms). Jones (2013) counted only phytoliths of consistent morphology in the MMC column. It has been suggested (Albert et al. 1999; Albert/Weiner 2001; Albert et al. 2006) that irregular (or variable) morphotypes are typically more common in woody tissue and bark than in leaves and grasses. Thus, Ward (2007, 403-404) noted irregular/consistent morphotype (I/C) ratios that were relatively high (but still showing probable grass dominance) in G89, G95 and G100 samples (Sector 8 Grey Series), thought to reflect the increased wood burning and human occupation in these units. It should also be noted that woody taxa tend to produce fewer phytoliths than monocots and therefore may under-represent the proportions of woody taxa to non-woody taxa. These observations are consistent with the charcoal data from the cave (see **Chapter 5**), with the implication of increasing use of wood as a fuel.

Phytoliths from Grasses and Other Fibres

The grass and other monocot phytolith signal is by far the dominant motif throughout the Taforalt LSA sequence, as is not unexpected from the natural production bias. However, once the increasing phytolith abundance in the Grey Series is taken into account (see above), it is reasonable to assume that large proportions of the imported vegetation were indeed grasses and similar plants. Phytoliths are not usually fit for detailed plant identification, so that we must here point to the charred finds, such as *Avena* sp., *Bromus* sp. and *Stipa tenacissima*, reported in Chapter 6. Grasses could – plausibly would – have been an important dietary resource for Iberomaurusian peoples, with additional (perhaps even more important) uses for bedding, fire-lighting, cooking matrix, matting, cordage, basketry (for both collection and storage) and other crafts.

Jones (2013), looking at a GS thin section (equivalent to part of LPAZ-TAF-2, at the stratigraphic level of approximately G97/upper L28/MMC100-MMC96; cf. MM03 in Chapter 3), noted a section occurrence of c. 3 % phytoliths, dominantly grass short cells, with some multi-celled forms reaching 150 µm and some localised 'layering', which could be the result of plant material use for bedding or matting.

There is also sporadic evidence for possible plant storage at Taforalt in the phytolith record. As discussed, the Novello-Barboni index for sample MMC100 (in LPAZ-TAF-2) is 19 %, representing the peak (8 % of total consistent forms) in elongate dendritic morphotypes found in mature grass panicles. There is some support for this peak being the result of human activity, as Novello / Barboni (2015) argue that, if the elongate dendritic morphotype is markedly greater than 3 % (compared to the sum of Poaceae short cells and elongate dendritics), this is an indicator for an anthropogenic origin; the value of the Novello / Barboni index for this sample (MMC100) is 19 % (Appendix 7.2). In this case, the peak would either indicate spring-summer occupation or would point to storage outside the normal growing season. There is only one other small 'peak' of dendritic phytoliths corresponding to around 5 % of the assemblage (12 % on the Novello / Barboni index) in LPAZ-TAF-3 in MMC36. The lack of repetitive peaks elsewhere in the sequence may favour interpretation of these two instances as related to the storage of mature grass panicles in these units.

Neither Ward (2007) nor Jones (2013) recorded more than very low levels of burnt phytoliths, using simple visual recognition; indeed, in absolute terms, Jones's (very low) counts are three times higher on average for the YS than for the GS units (see Appendix 7.2c). Neither researcher used systematic refractive index techniques, and one must also take into account the fact that burnt phytoliths are more soluble (cf. Cabanes / Weiner / Shahack-Gross 2011), such that it appears likely that burnt specimens are markedly underrepresented in the available Taforalt data. It is nevertheless possible that significant quantities of discarded grasses and grass 'products' may have decayed *in situ* without conscious or accidental burning (see also the so far unsuccessful attempts, reported in Chapter 2, to recognise fragments of grass 'products' in a charred state, on the cusp between destruction by full burning or by normal decay).

Finally, not all fibrous plants are grasses. Higher levels of Arecaceae (formerly 'Palmae') phytoliths were recovered in samples MMC24 and MMC16 (increasing more than ten-fold with respect to neighbouring samples), in LPAZ-TAF-3 at around 13,300 cal BP. Palms do not only provide edible fruits but the leaves are also utilised as building and craft materials to produce containers, thatch and rope (Madella et al. 2002; Jenkins / Jamjoum / Al Nuimat 2011; Bretzke et al. 2013). It may also be noted that there is a slightly higher peak in the Arecaceae in MMC130 (latest MSA), but there in a context with a much higher ligneous wood presence overall. Overall, the trend for globular echinates follows that of globular granulate forms (ligneous dicotyledons).

7.6 CONCLUSIONS

These two sets of samples constitute an important terrestrial phytolith record, providing evidence relevant to Late Pleistocene environment and plant use, both at Taforalt and more widely in the Iberomaurusian/Later Stone Age of North Africa. The potential of phytolith studies in Pleistocene cave sediments is clear and this potential has been confirmed at Taforalt. It should be recognised, however, that such studies are arduous (involving multi-phase sample preparation, including heavy-liquid separation) and some detailed studies require access to advanced equipment. The two studies contributing to this chapter were carried out by individual researchers, each undertaking multi-topic analyses (beyond phytoliths alone). The actual coverage in the phytolith data from Taforalt is therefore still at very low stratigraphic precision and focus. Phytolith analysis requires only very small samples, compared with most other studies, and can therefore be targeted towards a whole range of subtle research questions. Even expressing the Taforalt deposits as a mere vertical sequence, there are some four metres of Grey Series sediments and a composite total (working in different sectors of the site) of up to two metres of LSA-relevant Yellow Series sediments, not to mention the thick MSA levels below. Few other sites will offer such access to small increments of microfossil biostratigraphy. It is to be hoped that future phytolith work at Taforalt can add volumes to the understanding achieved to date.

V. K. TAYLOR · M. BELL

8. LAND MOLLUSCS

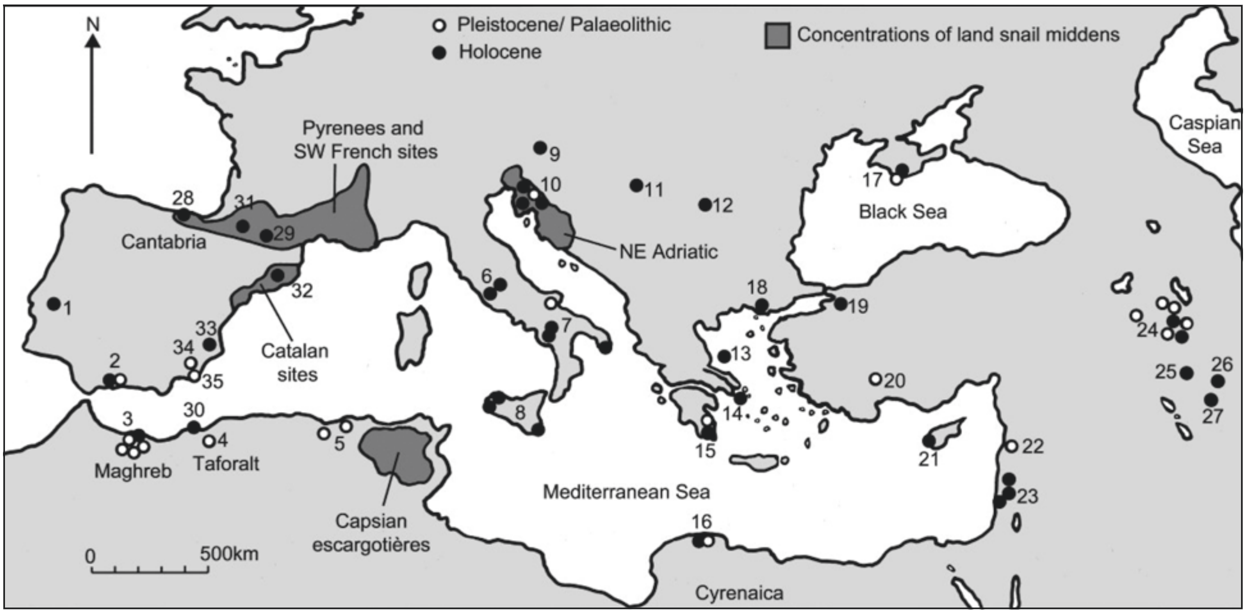
8.1 INTRODUCTION TO MEDITERRANEAN LAND MOLLUSC MIDDENS

The field of molluscan research in archaeology has been geographically somewhat patchy. Palaeoeconomic studies of land mollusc middens occur particularly in the Mediterranean, whilst palaeoenvironmental studies of land molluscs have been concentrated in Britain (Evans 1972) and in North America and Scandinavia; there has been a focus on marine mollusc middens with less emphasis on the contribution of land Mollusca (Claassen 1998; Andersen 2000). More recently there is a growing appreciation of the value of an integrated perspective and a growing range of ways in which Mollusca can contribute to archaeological research (Thomas 2015a; 2015b; Allen 2017).

Land snail middens are a widespread phenomenon occurring throughout Southern Europe, the Near East and North Africa (**fig. 8.1**; Lubell/Barton 2011), yet few have been excavated and recorded in detail (Lubell 2004b; Rabett et al. 2010). Some of the most well-known examples are located in North Africa, particularly in the Maghreb (Morocco, Tunisia and Algeria) and in Cyrenaica, Libya. The archaeology of these middens is mainly attributable to two cultural groups: the Iberomaurusian and the Capsian. Those belonging to the former are found in caves and rockshelters, often near the coast, and date to between c. 18,800 and 11,000 cal BP (Lubell/Sheppard/Jackes 1984; Lubell 1984; 2001). Those belonging to the Capsian tend to be open-air sites, are found further inland, mainly in Algeria and Tunisia, and are Holocene, dating between 11,000 and 7,000 cal BP (Morel 1974; Lubell/Hassan/Gautier/Ballais 1976; Lubell 2001). Key sites in North Africa include: the present mollusc study at Taforalt, also known as Grotte des Pigeons; Ifri n'Ammar (Moser 2000), Ifri Oudadane (Morales et al. 2013) and Taghit Haddouch (Hutterer/Linstädter/Eiwanger/Mikdad 2014) in Morocco; Tamar Hat (Saxon 1976) and Aïn Mistehiya (Lubell et al. 1975) in Algeria; and Haua Fteah in Libya (McBurney 1967; Hill et al. 2015).

After North Africa, the French Pyrenees has one of the highest concentrations of land snail middens. Important sites in the region include Grotte de Poeymaü and Mas d'Azil (Bahn 1983a; 1983b). Land snail middens can also be found in other European countries, such as Croatia, where Pupicina Cave has been investigated (Miracle 1995; 2001), and Italy (Bonizzoni/Bruni/Girod/Guglielmi 2009; Lubell et al. 1995). Middens are also found in Portugal and Spain. Some of the most well-known shell middens are in Spain. The Asturian middens along the Cantabrian coast (Aparicio et al. 2001; Lubell 2004a) are particularly known for their marine shell component but many also contain large numbers of land snail shells, as recorded at La Fragua Cave (Gutierrez-Zugasti 2011). Land snail middens can also be found outside of this region, such as at Nerja Cave in Andalucía (Auro Tortosa et al. 2002) and a chain of sites close to the east coast of Spain (Lloveras et al. 2011; Fernández-López de Pablo/Gómez Puche/Martínez-Ortí 2011).

In contexts where there are accumulations of shells without substantial middens, consideration must be given to whether the accumulation results from human activity or could be a natural death assemblage (Girod 2011). The latter will generally be characterised by a range of growth stages and species, many not edible, and the absence of associated anthropogenic artefacts. Assemblages derived from human consumption are generally of one edible species, or a narrow range of edible species, mostly fully grown, and they occur in specific contexts with cultural material. Examples are also often heat-affected.



1. The Muge middens
2. Nerja Cave
3. Ifri n'Ammar, Ifri-el-Baroud, Taghit Haddouch, Hassi Ouenzga
4. Taforalt
5. Afalou bou Rhumel, Tamar Hat
6. Grotta di Pozza, Grotta Continenza
7. Grotta della Madonna, Grotta Paglicci, Grotta di Latronico
8. Grotta dell'Uzzo, Grotta di Levanzo, Grotta Corrugi
9. Rosenburg
10. Pupićina Cave and other Istrian sites
11. Donja Branjevina
12. Foeni Salas
13. Cyclope Cave
14. Maroulas
15. Franchthi Cave
16. Haua Fteah
17. Lapsi VII
18. Hoça Çesma
19. Illipinar
20. Öküzini Cave
21. Kissonegra Mylouthkia
22. Ksar'Akil
23. Djebel Kafzeh, Hoyonim Cave, Erq el-Ahmar, Mugharet ez- Zuitina, Ein Gev
24. Asiab, Gerd Banahilk, Jarmo, Karim Shahir, Nemrik 9, Tepe Sarab, Shanidar Cave Layer B, Warwasi, Zawi Chemi Shanidar
25. Bestansur
26. Sheikh-e Abad
27. Jani
28. La Fragua
29. Mas d'Azil
30. Ifri Oudadane
31. Grotte de Poeymau
32. Balma del Gai
33. Arenal de la Virgen and Casa Corona
34. Algarrobo
35. Caballo

Fig. 8.1 Map of land mollusc middens of the Mediterranean and Near East. – (Drawn by J. Foster after Lubell 2004b with additions).

The earliest clearly defined land snail middens are Upper Palaeolithic in date, the best examples of which are those associated with the 'Epipalaeolithic' (Late Stone Age, LSA) Iberomaurusian culture in North Africa, such as at Taforalt, Ifri n'Ammar and Tamar Hat. The earliest substantial midden layers are c. 18,800 cal BP (Unit IV) at Tamar Hat (Saxon et al. 1974, 50; Hogue/Barton 2016). On two sites north of the Mediterranean, land mollusc use is attested in the Palaeolithic, the earliest at Cova de la Barriada c. 31,000-27,000 BP (Fernandez-Lopez de Pablo et al. 2014) and a later case at Nerja Cave in Southern Spain from c. 12,000 cal BP (Jorda/Avezuela/Aura/Martin-Escorza 2011). There is a notable increase, particularly north of the Mediterranean, in the number and distribution of land snail middens in the early Holocene, with the majority of sites being Mesolithic in date, such as the middens in Northern Spain and the Pyrenees. Le Fragua Cave in Spanish Cantabria contains a substantial midden estimated at 15,000 land snail shells, beginning c. 10,900 cal BP (Gutierrez Zugasti 2011). The Capsian middens in North Africa also date to the early Holocene; however, many extend into the Neolithic period, with land snail consumption continuing alongside early domestication at sites such as Ifri Oudadane (Morales et al. 2013). There is evidence for land snail consumption into the Neolithic, Roman and Hellenic periods in Libya, indicating that "eating of gastropods seems to have been a consistent feature of the coastal Cyrenaican sites through the Holocene" (Hunt et al. 2011, 24). A post-Neolithic midden has also been observed at Aounout, c. 1.5 km from Taforalt (Taylor 2014).

Smaller accumulations of land snails are also regularly found at archaeological sites in the Zagros Mountains (Eastern Iraq and Western Iran), with ongoing work in the region by the Central Zagros Archaeological Project continuing to produce evidence of small accumulations of *Helix salamonica* at Neolithic sites, including Bestansur, Sheikh-e Abad and Jani (Shillito 2013b; Iversen 2015). Recent work by Rabett et al. (2010) has highlighted the presence of a midden dominated by land snails in Hang Boi Cave (Fortune Teller's Cave) in Trang An Park in Vietnam. Exploitation of the Giant Land Snail (family Achatinidae) is also reported in the Middle Stone Age Bushman Rock Shelter in South Africa, where some were heat-affected (Badenhorst/Plug 2012), and there is also possible evidence for their consumption in Later Stone Age contexts in Kuumbi Cave, Zanzibar (Shipton et al. 2016). These sites push the known distribution well beyond the circum-Mediterranean. It seems likely that the distribution of evidence for land mollusc consumption will continue to expand as archaeologists become more aware of their potential contributions to the diet.

Consumption of a wide range of land mollusc species continues to this day in Mediterranean countries and beyond. We have purchased them as hot street food snacks in spicy broth near the project base at Saïdia and there are many pictures on the World Wide Web of them being sold as street food in Marrakech and elsewhere. Today, 10,000 tonnes of snails are harvested annually in Morocco for export, mainly to Spain (Independent 2011). In Europe, *Helix pomatia*, eaten as "*escargot*", is particularly well known and *Helix aspersa* (in the UK now designated *Cornu aspersum*, R. Anderson 2005) is similarly consumed. In Portugal *Theba pisana* is a traditional dish with some 4,000 tonnes being consumed annually.

8.2 RESEARCH QUESTIONS RAISED BY THE MIDDENS

In research terms, the land mollusc middens present questions similar to those of the coastal marine mollusc middens, such as those along the Atlantic seaboard of Europe (Milner/Craig/Bailey 2007), particularly in Denmark (Andersen 2000), and in many other parts of the world (Bailey/Hardy/Camara 2013). Where an accumulation of shells is found, the question must be asked: could they be a natural death assemblage, or one formed by people, or a combination of both? They may potentially provide evidence for environmental, climatic and dietary change. The quantities of shells can be enormous but their significance in the diet must be evaluated alongside other, sometimes less obvious, animal and plant resources (as reviewed in other chapters). Confronted with the question of how such large numbers of land snails could have been acquired, some writers have even advanced the highly questionable proposition that they were farmed in some way (Bahn 1983a; 1983b; Fernández-Armesto 2001). There is also the question of whether such a concentration of food debris is itself indicative of sedentary communities and whether there is evidence, in the form of periodic banding of the shells, or fluctuations in isotopic composition, for seasonality or year round exploitation of molluscan resources (cf. Katsi 2016). In the case of some examples of both Atlantic marine mollusc middens and Mediterranean land mollusc middens, theories of sedentism have been strengthened by the occurrence of human burials associated with the middens. The assumption is that burial is more likely to occur when settled populations identify with a specific place. The occurrence of large numbers of burials during the Iberomaurusian phase at Taforalt (Humphrey et al. 2012; Chapter 15) gives a particular significance to questions of seasonality and sedentism in this case.

Fig. 8.2 Mollusc sample column (red outline) through the Grey Series and the top 0.9 m of the Yellow Series; the artefact column (with 'L-units') is under excavation to the left and outlined in blue.

8.3 INVESTIGATIONS AT TAFORALT

The monograph on Taforalt by Roche (1963) included a table of mollusc identification but only recording presence/absence of species in each of the main recognised *Niveaux*, without any further quantification.

Thus, there were minimal data on this, one of the main components of the Iberomaurusian midden. 15 terrestrial species were recorded, of which 10 were present in all geographic zones of the top two of Roche's three excavation units (i. e. "*Niveaux I-V*", see **Chapter 2** for correct interpretation). The others were mostly confined to the upper unit or to single lower *Niveaux*. Three freshwater species were also identified and seven marine species (see **Section 13.2**).

During the recent field investigation, sampling of the mollusc column was undertaken in 2009 by Ingrid Brack and Martin Bell and in 2010 by the authors of this chapter. Small scale, detailed sampling was done of the standing section left by previous excavations. A 20 cm wide mollusc column (MMC – master mollusc column) was excavated in Square A23 of Sector 8. The mollusc column was located 1 m to the right of the column excavated by J. Hogue (the L-units) for lithics and other artefacts, as shown in **figure 8.2**. The adjacent placement of these columns enables some stratigraphic linkage between columns (**Chapter 2**) and allows radiocarbon data obtained from the lithic column to be applied to the mollusc column (cf. **Chapter 4**). Samples were taken following natural stratigraphy where possible, with arbitrary spits being used where there was a thick unit with no evident stratigraphic subdivision. The instability of the loose section prevented the excavation of a continuous column over the two excavation seasons and, in 2010, a new column was sited 20 cm to the right (when facing the section, inwards in the cave) of the 2009 column. The Yellow Series deposits had not previously been excavated in a vertical face as far back (laterally, towards the cave wall) as the Grey Series, preventing excavation of the column in a continuous straight line without significant disturbance of the remaining section. During the early excavations of the Morocco Caves Project, a c. 1 m^2 section of the Yellow Series at a 90° angle to the exposed face of the Grey Series, directly below the mollusc column, was prepared and recorded; this section was cleaned and used for the Yellow Series part of the mollusc column.

The Grey Series formed the local interval from 0 (top)-3.9 m and from this samples MMC1-106 were taken. The sequence was continuous but a gap of 29 numbers (from 51 to 79 unused) was left between the two seasons, so the total number of samples in the GS was 77. **Figure 8.3** shows a small area of the Grey Series with shells (some calcined), stones (some heat-fractured), lithic chips and bones. Only the upper parts of the Yellow Series sediments were sampled from depth 3.9 m to 4.8 m, producing samples 107-130 which were considered to correspond to the Iberomaurusian activity. There was no sampling for Mollusca below the Iberomaurusian levels, which were considered to be beyond the remit of the Cemeteries and Sedentism Project. The total number of samples in the whole (composite) MMC column was thus 101.

In the field, a minimum of 2 litres of sediment was taken from each MMC unit where possible, in order to try to recover the 100 molluscs per sample recommended by Evans (1972) for molluscan analysis. Large molluscs visible in the section were removed separately during excavation, in order to prevent further fragmentation during processing. Sub-samples were taken from each bulk sample, one for specialist phytolith analysis (**Chapter 7**) and one for particle size analysis.

Earlier reports on the present molluscan study at Taforalt may be found in Taylor et al. (2011), Taylor (2014) and Taylor / Bell (2017). The present final report includes revisions as to species nomenclature and a refined chronology and interpretation.

8.4 SIEVING AND SORTING STRATEGY

One litre of sediment was sieved (after the hand-removal of rocks larger than 5 cm) at the excavation base in Morocco. The sediment was dispersed in water and flot fractions were repeatedly decanted onto a 0.5 mm

Fig. 8.3 Taforalt cave molluscs, horizontal view of Grey Series sediments with *in situ* mollusc shells, an example lower in the photograph blackened and degraded by fire; lithic debitage is also present. – Scale division 10 cm.

sieve until no further shells floated. The sink fraction was then washed using a hose spray with multiple easily controllable settings onto a nest of sieves of 4 mm, 2 mm, 1 mm and 0.5 mm mesh. The dusty midden sediments were easy to disaggregate and clean in this way (**fig. 8.4**). The fractions were then dried and bagged ready for transport to the laboratory.

All fractions of each sample were fully sorted using a binocular microscope at the University of Reading. The material removed was quantified by count (shown on the graphs in **figs 8.5-8.6**) and weight, excepting charcoal which has only been quantified by weight due to variable fragmentation. Molluscs are quantified using the NRE (non-repetitive element) method of MNI (Minimum Number of Individuals) quantification (Giovas 2009). The NRE selected is the apex; however, other diagnostic fragments were also removed (but not quantified) to aid species identification.

Materials recovered from the mollusc column samples (including: mollusc apices; charcoal; animal bone fragments; percentage burnt and unburnt bone; microfauna (vertebrate); and lithics, mostly microdebitage) are shown in **figure 8.5**. A total of 37,980 animal bones were recovered (mostly tiny fragments), 91 % of which came from the Grey Series. Of those, 65 % were burnt, which is much higher than the 22 % from the Yellow Series which showed signs of burning. A piece of decorated bone was recovered from MMC85 (c. 14,244-14,545 cal BP) in the Grey Series. Two segments of *Dentalium* shell bead were also recovered,

Fig. 8.4 Washed and sieved sample with mollusc shells, bone, lithics, etc. – Scale division 1 cm.

one in Sample MMC81 in the Grey Series, the other in MMC118 in the Yellow Series. Sorting of the flots also revealed the presence of numerous, well preserved, charred plant macrofossils, which have been analysed by Jacob Morales (**Chapter 6**). This corrects the previous work of Ward (2007), who reported an absence of seeds in samples from Sector 8, something which he interpreted as most likely being a result of a lack of seed consumption in the Iberomaurusian period.

Figure 8.6 compares mollusc occurrence with two measures of particle size in the column, both after stones larger than 5 cm had been removed. It shows the proportion of 1 litre samples less and more than 0.5 mm in size and the weight of the 4 mm fraction. The Yellow Series shows three distinct stony horizons and a further increase in stone content to its top. Dating led to the identification of a significant erosion phase in the Yellow Series above MMC109 and the increased stone, lithic, bone and microfaunal evidence is above this. **Figure 8.6** highlights the less stony nature of the Grey Series above c. MMC46 (see also **fig. 8.2**). There is also a less pronounced decline in particles larger than 0.5 mm from bottom to top of the Grey Series. Decreased stoniness above c. MMC46 may be a contributory factor to increased mollusc numbers but it is not likely to be the whole explanation since the increase in molluscs occurs earlier, from c. MMC84.

Figures 8.5 and **8.6** demonstrate very clearly the contrast between the Yellow Series sediments, with far smaller and declining numbers of Mollusca between the base at 20,882-21,436 cal BP and the Grey Series boundary. The micro-vertebrates also decline upwards in the Yellow Series although in this case peak numbers are at the boundary and continue into the lowest Grey Series samples. Charcoal occurrence is very low in the Yellow Series and animal bone and chert low, compared to the Grey Series. There is evidence of an

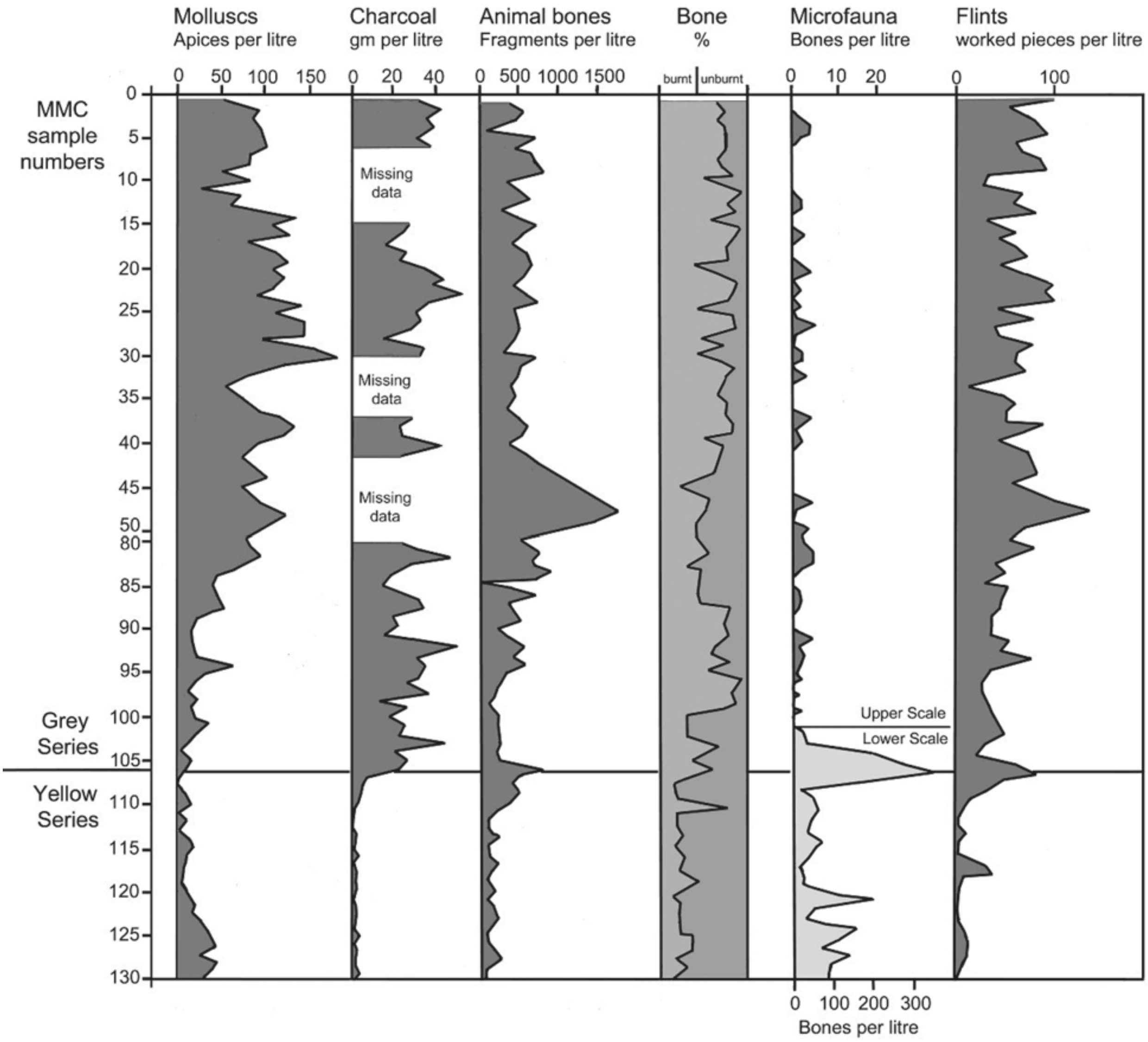


Fig. 8.5 The results of sieving the mollusc column samples in the MMC sequence, showing the occurrence of: Mollusca; charcoal; animal bone (mostly fragments); percentage of bone (burnt and unburnt); micro-vertebrates; and lithics (mostly microdebitage). – (Drawn by J. Foster).

hiatus between Yellow Series Y1 and Y2 (at c. MMC110) at or just before c. 15,180-15,615 cal BP. Each of the categories of material picked out of the samples increases at the very top of the Yellow Series.

In the Grey Series, micro-vertebrates were only present in very low numbers (note the change of scale on **fig. 8.5**) whereas the classes of artefact were much more abundant in the Grey Series than in the Yellow Series. Mollusc numbers are low (<50) below MMC84 in the Grey Series but above this they increase with a peak between MMC50-14. Charcoal shows a moderate increase up the Grey Series profile, as does chert, and, together with the molluscan results, might be interpreted in terms of increasing intensity of activity. Interestingly the peak of animal bone fragments occurs at the base of the molluscan peak which might be interpreted in terms of a shift from vertebrate to molluscan exploitation.

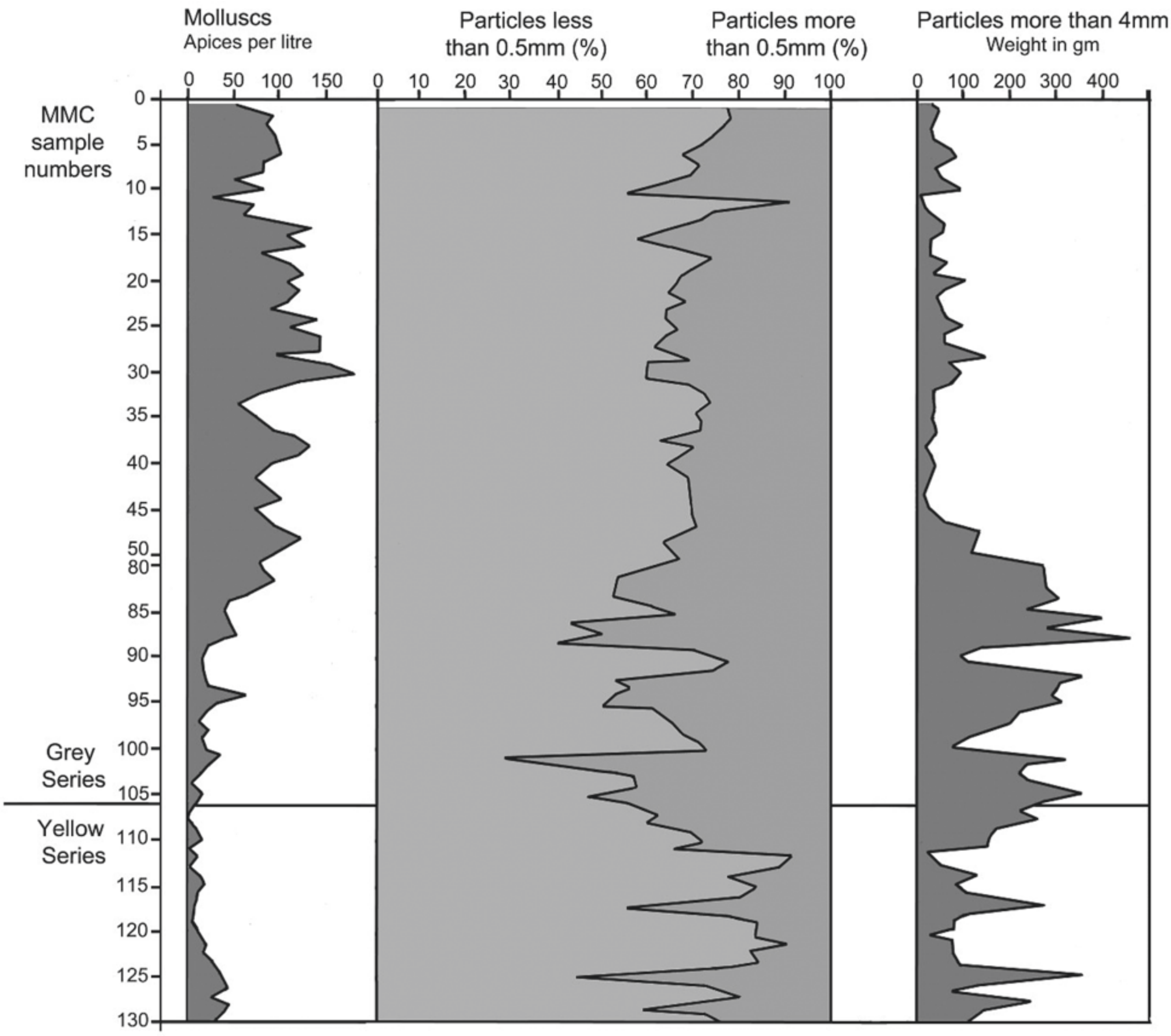


Fig. 8.6 Mollusc occurrence compared to measures of particle size in the column: percentage of sediment less and more than 0.5 mm; weight of particles larger than 4 mm. – (Drawn by J. Foster).

8.5 SPECIES IDENTIFICATION AND TAXONOMIC ISSUES

When studying archaeological molluscan material from sites in well documented areas such as Britain and much of Europe, it is possible to refer to published guides which outline key identification features and some information as to the habitat and distribution of the relevant species (Kerney/Cameron 1979; Welter-Schultes 2012a). North Africa has been widely recognised as having an interesting and diverse malacofauna with many endemic species (Pond/Chapuis/Romer/Baker 1938). However, there has been a lack of recent systematic work, except in relation to individual species. Most of the work was done by French malacologists in the late 19th and early 20th centuries, such as J.-R. Bourguignat, who had a tendency to split species based on characteristics which might be more appropriate to identification of sub-species (Dance 1970). The result is that there are many synonymous species, taxonomic descriptions are limited and there is very limited information about the ecological context from which specimens were collected. Some molluscan collection was

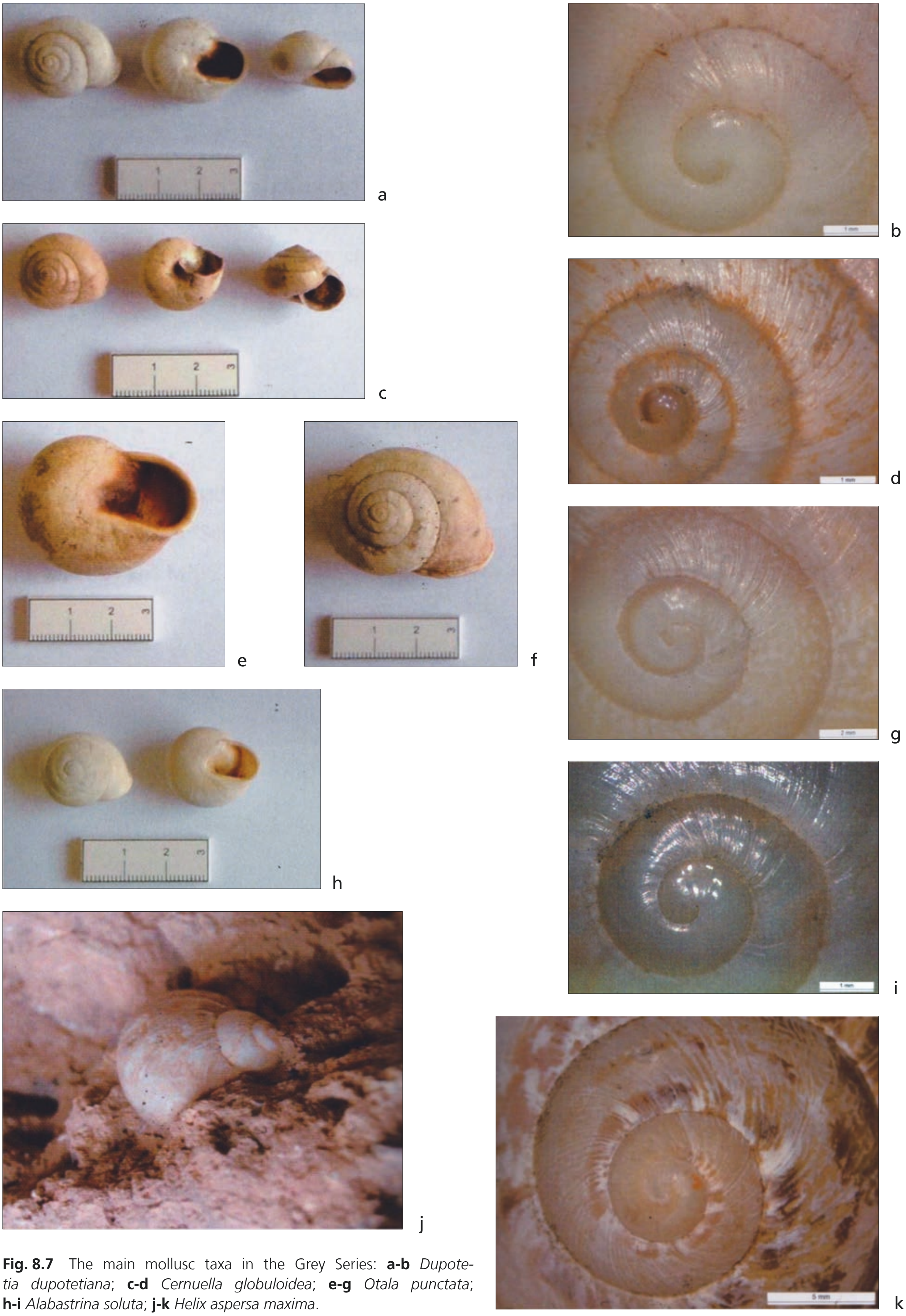


Fig. 8.7 The main mollusc taxa in the Grey Series: **a-b** *Dupotetia dupotetiana*; **c-d** *Cernuella globuloidea*; **e-g** *Otala punctata*; **h-i** *Alabastrina soluta*; **j-k** *Helix aspersa maxima*.

done in the Taforalt area by Capt. P. Martel (Pallary 1920a; 1920b) and also as part of a more recent study of the Mollusca of Morocco by Dr. Mary Seddon and Dr. David Holyoak, the material from which is housed in the National Museum of Wales and has been consulted as part of the present study (Holyoak / Seddon 1986). Recent publications which provide species inventories for Morocco include Rour / Chahlaoui / Van Goethem (2002) on terrestrial species and the Ramdani et al. (1987) inventory of freshwater Mollusca. Despite this and other recent work on individual taxa (cf. Hutterer / Greve / Haase 2010; Abbes / Nouira / Neubert 2011), not unfortunately key components of the Taforalt assemblage, there remain considerable problems of taxonomy and large scale revision of the molluscan species of the Maghreb is very much needed. These taxonomic problems mean that it is necessary to describe and illustrate each of the taxa which formed the main components of the Taforalt midden; more detailed descriptions including those of species present in low numbers are contained in Taylor (2014). Images of each of the main species can be found in **figure 8.7**.

Dupotetia dupotetiana **(Terver 1839)** (fig. 8.7a-b)

H. 13-17 mm × W. 22-25 mm. Shell globular, of varying height, with convex spire and strong, everted lip. Dextrally coiled. Moderately thick and strong shell with moderate suture and wide aperture (2/3 of width). Umbilicus closed in adults and open in juveniles. One clear tooth on basal lip, 2/3 of distance from column. Colour white or brown-banded with fine radial ribs and very slight spiral grooves.
Taxonomy is particularly confused for this species and there is evidently a large amount of synonymy within this genus. Possibly the same species as the *Otala tigri* (Marès 1857) in the land snail midden layers at Taghit Haddouch (Hutterer / Mikdad / Ripken 2011; Hutterer / Linstädter / Eiwanger / Mikdad 2014). No published information on habitat preference. Abundant today on the plains north of the Beni Snassen (see below).

Otala punctata **(Muller 1774)** (fig. 8.7e-g)

H. c. 22 mm × W. c. 38 mm. Large, slightly depressed, globular shell with strong, reflected lip. Protoconch smooth with no sculpturing. Dextrally coiled. Thick, strong shell with moderate suture which is deeper in the later stages, from around 1.5 whorls. Last whorl deeply descending by aperture. Aperture almost half the width of the shell. Umbilicus closed in fully adult shell, open in juveniles. Thickening around lip with callus close to columellar area, approximately half way along lower lip. Lip is strong and thickened, especially on lower side, and everted on upper side. Shell grey-brown in colour with some indistinct bands (c. 2-5) interrupted by small, white irregularly shaped marks. In early growth stages irregular, fine, radial ribs are visible. In later growth stages the shell has a more irregular, puckered appearance. Distinguishable from closely related *Otala lactea* by larger overall size, less distinct bands and more puckered surface sculpture on later whorls.
Hutterer / Mikdad / Ripken (2011) state that specimens of *Otala punctata* from Taghit Haddouch are likely to be the same species as similar specimens found at Taforalt. Favours cultivated coastal plains, gardens, dry wasteland and areas around rocks and walls (Welter-Schultes 2012a, 624).

Alabastrina soluta **(Michaud 1833)** (fig. 8.7h-i)

H. c. 12-14 mm × W. 20-22.mm. Globular, convex shell with smoothed profile and alabaster-like appearance. Juvenile far more keeled at margin. Dextrally coiled. Moderately thick shell with shallow suture, par-

ticularly in early whorls, and rounded aperture (around half width of shell). Closed umbilicus in fully adult shell, open in juveniles. Slight thickening on right side of basal aperture, 4/5 of distance from columellar. Shell entirely white or light brown with dark brown bands. The numbers of this species are likely to be an underestimation of the total count, as the apical whorl can appear similar to that of *Dupotetia dupotetiana* in highly fragmented, archaeological specimens.
It should be noted that all individuals identifiable as *Alabastrina* sp. will be referred to in the text as *Alabastrina soluta* for ease of description but it is acknowledged that we may be dealing with more than one species, particularly if the name *Alabastrina alabastrites*, which was previously assigned to this species (Taylor et al. 2011), does indeed belong to a white-shelled variant as stated by Hutterer / Mikdad / Ripken (2011). Very abundant today in the immediate vicinity of Taforalt and Moulouya River. Terver (1839) frequently observed *Alabastrina soluta* on rocks and cactus plants in Morocco.

***Helix aspersa* var *maxima* (Taylor 1913)** (fig. 8.7j-k)

H. c. 38 mm × W. c. 34-40 mm. Tall, wide shell with 4-5 whorls and large, oval aperture (greater than half the width of the whole shell, c. 25 mm × c. 25 mm). Dextrally coiled. Moderately thick shell with deep, clear suture and closed umbilicus. Lip is strong and reinforced at the base of aperture. 4-5 interrupted, brown, bands are visible in addition to a distinctive wrinkled surface sculpture.
Helix aspersa has been widely dispersed by people over time but has a Mediterranean origin. It can live in a wide variety of habitats including gardens, parks, dunes, woods, rocks, shrubs, light woods, etc. (Kerney / Cameron 1979; Welter-Schultes 2012a). *Helix aspersa* var *maxima* is a large variety of *Helix aspersa* endemic to North Africa (Taylor 1913). In the UK nomenclatural list, *H. aspersa* is now designated as *Cornu aspersum* (R. Anderson 2005).

***Cernuella globuloidea* (Terver 1839)** (fig. 8.7c-d)

H. c. 15 mm × W. c. 20 mm. Globular shell with conical spire. Very tightly coiled, bulbous apex, darker in colour than body whorls. Dextrally coiled. Thin walled shell with open umbilicus (c. 2 mm) and circular aperture, slightly less than half width of body. Suture is pronounced at apex, becoming clear in later growth stages. Lip is weakly developed with some thickening on the inside. Shell pale brown with one prominent band (sometimes 2) and several weaker, thinner bands which are less prominent and more interrupted. Surface sculpturing comprises very fine radial ribs from early growth stages. Sculpture more irregular and slightly puckered in later growth stages.
Infrequent in Epipalaeolithic deposits at Taghit Haddouch (Hutterer / Mikdad / Ripken 2011). Recorded by Terver (1839) on spiny shrubs and bushes in Morocco. Not found during modern mollusc study.

8.6 DATES FOR THE MOLLUSC COLUMN

A radiocarbon dating sequence relevant to the mollusc column (S8-MMC) is provided in **table 8.1**, which shows the mollusc column and other units which can be correlated with reasonable confidence to specific MMC samples, or groups of samples. This provides dates for 15 horizons within the mollusc sequence. The

MMC	Unit	^{14}C date	Lab No.	Cal BP modelled range 95.4 % range
4	L2	10,680 ± 45	OxA-24111	12,611-12,725
c. 9	L3	10,870 ± 45	OxA-23404	12,700-12,817
c. 14	L4	11,165 ± 45	OxA-24112	12,804-13,045
20-24	L6	11,540 ± 50	OxA-24113	13,280-13,467
25-30	L8 (top)	11,445 ± 50	OxA-23406	13,200-13,354
46	L15	11,890 ± 55	OxA-23409	13,590-13,780
88-91	L25	12,405 ± 55	OxA-23410	14,244-14,545
97-106	L28	13,060 ± 65	OxA-23411	15,339-15,902
106	c. L29	12,605 ± 55	OxA-24109	14,734-14,970
107	Y1 (top)	12,200 ± 55	OxA-22786	13,853-14,788
110	Y1 (base)	12,850 ± 50	OxA-22788	15,180-15,615
111	Y2spit1	14,005 ± 60	OxA-16267	16,745-17,214
119	Y2spit4/5	15,790 ± 60	OxA-16269	18,886-19,236
125	Y3	16,285 ± 65	OxA-16270	19,514-19,993
126-130	Y4spit2	17,515 ± 75	OxA-16273	20,882-21,436

Tab. 8.1 Relationship between: the mollusc samples (MMC); the units (L) in one of the more substantial excavated columns in the Grey Series (or, in one case, a close equivalent) and stratigraphic units in the Yellow Series (Y); and correlated radiocarbon dates (the radiocarbon dates and calibrations (adjusted in a Bayesian model) follow **Chapter 4**).

actual number of dated samples published by Barton et al. (2013) was 40 and 16 dates have been assayed subsequently, making a total of 56 for the Sector 8 sequence; however, only some dated samples could be tied to particular mollusc samples, due to the extremely variable nature of the Grey Series deposits which have lenses, patches and pockets of sediment. The radiocarbon dates and calibration follow the revised model developed in 2018 (cf. **Chapter 4**). The modelled dates have been followed precisely except that, in the present chapter, a date of 14,830-15,190 cal BP has been taken as the Yellow Series – Grey Series boundary (Barton et al. 2013). Other dates given in the text follow **table 8.1**, and have not been rounded, to facilitate ready comparison of table and text.

The earliest modelled date at the base of the mollusc column, at the top of Unit S8-Y4spit2, is c. 20,882-21,436 cal BP. The transition from the Yellow to Grey Series takes place 14,830-15,190 cal BP. Near the top of the surviving Grey Series and the mollusc column sample, MMC4 corresponds to a modelled date of c. 12,611-12,725 cal BP. Thus the mollusc column spans a period c. 6,200 years, during which this part of the Yellow Series sediment accumulated, and c. 2,300 years for the Grey Series sediment. Overall, the mollusc column spans c. 8,500 years.

8.7 RESULTS OF MOLLUSC ANALYSIS

The results, from the sequence of 101 samples over a depth interval of 4.8 m, are shown in **table 8.2** and **figure 8.8**, and will be described from the earliest to the latest samples. **Figure 8.8** also demarcates 5 Molluscan Assemblage Zones (MAZ-1 to MAZ-5), and in the case of MAZ-1, 3 sub-zones, into which the sequence has been divided.

Sample no.	*Cernuella globuloidaea*	*Alabastrina soluta*	*Dupotetia dupotetiana*	*Dupotetia* type	*Otala punctata*	Hygromidae sp.	*Leonia mamillaris*	*Ferussacia* sp.	*Helix aspersa*	Unidentified terrestrial	Other molluscs		Total
1	9	4	29	3	8	-	-	-	-	-			53
2	5	2	52	21	8	-	-	-	-	1	*Vitrea contracta* *Rumina* sp.	1 1	91
3	10	-	57	5	15	-	-	-	-	-		-	87
4	4	1	66	13	10	-	-	-	-	2	*Vitrea contracta*	2	98
5	2	-	68	7	22	-	-	-	-	-		-	99
6	3	-	70	16	12	-	-	-	-	1		-	102
7	3	1	47	4	28	-	-	-	-	-		-	83
8	1	-	44	18	19	-	-	-	-	-		-	82
9	-	1	20	20	8	-	-	-	2	-		-	51
10	1	-	47	3	33	-	-	-	-	-		-	84
11	-	1	18	5	6	-	-	-	-	-		-	30
12	1	-	53	12	6	-	-	-	-	-		-	72
13	-	-	38	7	16	-	-	-	-	-		-	61
14	1	-	99	14	23	-	-	-	-	-		-	137
15	1	2	74	11	20	-	-	-	-	-		-	108
16	-	3	73	21	30	-	-	-	-	-		-	127
17	-	-	58	17	12	-	-	-	-	-		-	87
18	1	2	67	22	23	-	-	-	-	-		-	115
19	1	1	82	18	24	-	-	-	-	-		-	126
20	-	4	65	2	33	-	-	-	2	-		-	106
21	-	-	82	17	23	-	-	-	-	-		-	122
22	1	2	72	14	23	-	-	-	-	-		-	112
23	1	1	58	17	16	-	-	-	-	-		-	93
24	3	-	79	15	42	-	-	-	-	-	*Carychium tridentatum*	1	140
25	-	3	90	5	18	-	-	-	1	-		-	117
26	10	-	105	20	9	-	-	-	-	-		-	144
27	9	4	87	20	24	-	-	-	1	-		-	145
28	1	-	78	9	11	-	-	-	-	-		-	99
29	7	-	86	29	36	-	-	-	-	-		-	158
30	1	1	135	6	33	-	-	-	-	-		-	176
31	5	3	59	23	32	-	-	-	-	-		-	122
32	1	4	46	12	19	-	-	-	-	-		-	82
33	-	3	33	12	9	-	-	-	-	-		-	57
35	-	3	49	12	9	-	-	-	-	1		-	74
36	2	1	51	21	20	-	-	-	1	-		-	96
37	4	2	91	14	5	-	-	-	-	-		-	116
38	6	6	76	24	21	-	-	-	-	-		-	133
39	6	5	68	16	24	-	-	-	1	-		-	120
40	1	1	58	21	13	-	-	-	-	-		-	94
41	1	3	43	20	12	-	-	-	-	-		-	79
44	4	1	71	16	10	-	-	-	-	-		-	102
45	1	1	56	6	9	-	-	-	-	-	*Carychium minimum* Unid freshwater	1 1	75
47	-	4	77	9	6	-	-	-	-	-	Unid freshwater	1	97

Tab. 8.2 Molluscs in each MMC unit.

Sample no.	*Cernuella globuloidaea*	*Alabastrina soluta*	*Dupotetia dupotetiana*	*Dupotetia* type	*Otala punctata*	Hygromidae sp.	*Leonia mamillaris*	*Ferussacia* sp.	*Helix aspersa*	Unidentified terrestrial	Other molluscs		Total
48	-	7	96	5	15	-	-	-	-	-		-	123
50	3	9	56	6	18	-	-	-	1	-		-	93
80	15	5	46	2	11	-	-	-	-	1	*Galba truncatula*	1	81
81	32	1	44	5	-	-	-	-	-	1		-	83
82	40	-	46	4	4	-	-	1	-	-	*Ceciloides* sp. *Galba truncatula* *Bithynia tentaculata*	1 1 1	98
83	22	-	36	-	4	-	-	-	-	-		-	62
84	24	1	21	1	-	-	-	-	1	-		-	48
85	23	-	18	-	2	-	-	-	-	-	*Amnicola pycnolena*	1	44
86	23	-	21	-	3	-	-	-	-	-		-	47
87	19	-	31	-	3	-	-	-	-	1		-	54
88	28	1	10	-	2	-	-	1	-	-	*Carychium tridentatum*	1	43
89	14	-	7	-	-	-	-	1	-	-		-	22
90	10	-	10	-	-	-	-	-	-	-	*Carychium minimum*	1	21
91	15	-	5	-	1	-	-	-	-	-	*Bithynia tentaculata*	1	22
92	10	1	7	-	2	-	-	-	1	-		-	21
93	17	-	4	-	1	-	-	-	-	-	*Carychium minimum*	1	23
94	35	-	16	2	7	-	-	-	-	1	Succineidae	1	62
95	14	-	11	-	7	-	-	-	1	-		-	33
96	13	-	6	-	1	-	-	-	-	1	*Bithynia tentaculata*	1	22
97	8	-	5	-	-	-	-	-	-	-	*Carychium tridentatum* *Bithynia tentaculata*	2 1	16
98	9	-	7	-	1	-	-	-	-	-	*Carychium minimum* Unid freshwater *Amnicola pycnolena*	1 1 1	20
99	5	-	7	-	1	-	-	-	-	1	*Carychium minimum*	1	15
100	5	-	7	-	7	-	-	-	-	0		1	19
101	11	1	9	1	5	-	-	-	-	4	*Candidula submeridionalis* *Carychium tridentatum* *Galba truncatula*	1 1 1	34
102	5	-	13	-	3	-	-	-	-	2	*Carychium minimum* *Acanthinula aculeata*	2 1	26
103	4	-	6	2	1	-	-	-	-	-	*Carychium minimum* *Bithynia tentaculata*	1 1	15
104	1	-	2	-	2	-	-	-	-	-	*Carychium tridentatum* *Bithynia tentaculata*	1 1	7
105	5	-	5	-	3	-	-	2		-	*Carychium tridentatum*	1	16
106	4	-	1	-	-	-	-	-	-	3	*Candidula submeridionalis* *Carychium tridentatum*	2 1	11
107	-	-	-	-	-	-	-	-	-	1	*Vertigo* sp. *Galba truncatula*	1 1	3
108	-	-	-	-	-	-	-	-	-	-	*Pyramidula pusilla* *Vitrina* sp.	1 1	2
109	-	-	-	-	1	5	1	-	-	1	*Galba truncatula*	1	9

Tab. 8.2 (continued)

Sample no.	*Cernuella globuloidaea*	*Alabastrina soluta*	*Dupotetia dupotetiana*	*Dupotetia* type	*Otala punctata*	Hygromidae sp.	*Leonia mamillaris*	*Ferussacia* sp.	*Helix aspersa*	Unidentified terrestrial	Other molluscs		Total
110	-	1	-	-	1	-	4	-	-	5	Succineidae *Ceciloides* sp. *Galba truncatula*	1 1 1	14
111	-	-	-	-	1	-	1	2	-	-		-	4
112	-	1	-	-	-	2	1	-	1	-	*Galba truncatula* *Bithynia tentaculata*	2 1	8
113	-	1	-	-	-	-	-	2	-	-	*Candidula submeridionalis* *Galba truncatula*	1 1	5
114	-	-	-	-	-	2	1	1	6	1		-	11
115	1	-	-	-	-	-	2	7	2	2	*Vitrina* sp. Unid freshwater	1 1	16
116	-	-	2	-	-	1	-	3	-	2	*Carychium minimum* *Carychium tridentatum* *Vitrina* sp. *Galba truncatula*	1 1 2 1	13
117	1	-	2	-	-	1	2	1	-	4		-	11
118	-	-	-	-	-	2	-	2	1	-	Succineidae *Vitrina* sp.	1 2	8
119	-	3	-	-	1	-	-	2	2	-	*Vitrina* sp.	1	9
120	-	1	-	-	2	1	3	1	-	4	*Vitrea contracta*	1	13
121	-	2	-	-	1	5	1	1	1	-	*Chrondina* sp. *Vitrina* sp. *Galba truncatula*	1 5 5	22
122	-	4	-	-	1	3	0	2	1	-	*Vitrina* sp. *Galba truncatula*	2 7	20
123	-	3	-	-	3	6	1	6	-	7	*Candidula submeridionalis* *Vitrea contracta*	1 1	28
124	-	1	-	-	2	2	-	7	1	17	*Vitrea contracta* *Pupilla* sp. *Galba truncatula*	3 1 1	35
125	-	-	-	-	-	3	2	5	4	7	*Vitrea contracta* *Vertigo* sp. *Carychium tridentatum*	6 1 1	29
126	1	2	-	-	2	8	6	7	1	13	*Merdigera obscura* *Vitrina* sp.	1 3	44
127	-	-	-	-	-	5	7	4	-	8	*Candidula submeridionalis* *Pupilla* sp.	1 1	26
128	1	1	1	-	2	4	15	7	1	13		-	45
129	-	1	-	-	1	1	13	7	1	8		-	33
130	1	1	-	-	2	1	9	7	2	6	*Vitrea contracta* *Vertigo* sp. *Galba truncatula*	1 1 1	31
Total	525	119	3335	625	904	52	69	79	36	119		109	5972

Tab. 8.2 (continued)

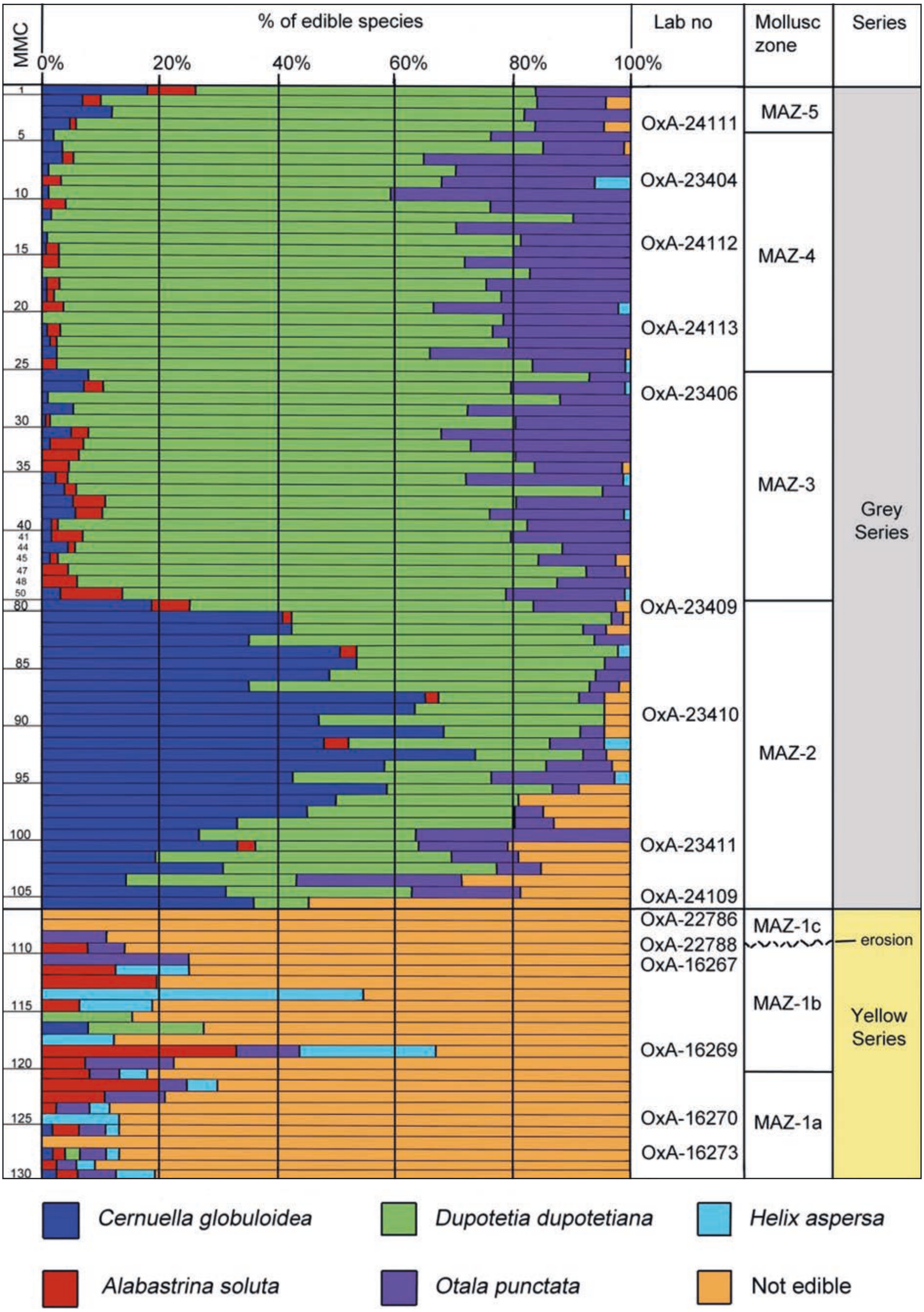


Fig. 8.8 Taforalt mollusc diagram, showing percentages of species, edible and not edible, in relation to the sequence of mollusc samples (MMC); dates to the right are extrapolated across from ties to the adjacent artefact column ('L-units'); date values are given as modelled ages in **tab. 8.1**; the diagram also shows the Molluscan Assemblage Zones (MAZ). – (Drawn by J. Foster, modified).

Yellow Series

(MAZ-1) Mollusc numbers in the Yellow Series are low, no sample producing more than 44. The bottom 8 samples (MAZ-1a) were more productive in terms of the range of species and numbers than those above in the Yellow Series. This might imply an environment which was a little more favourable, perhaps more humid, for molluscan life. Alternatively it could be an artefact of more rapid sedimentation above MMC121, although stoniness does not increase. The Yellow Series deposits were more natural, in terms of their formation processes, than the largely anthropogenic Grey Series. They are also nearly all dominated by mollusc species which are regarded as inedible, that is to say they are neither known to have been eaten nor, by virtue of their tiny size, likely to have been eaten. Those species which are present in any numbers, *Leonia mamillaris*, *Ferussacia* sp., *Vitrea contracta* and *Vitrina* sp., are all frequent in rather rocky, dry and sometimes disturbed areas. The Yellow Series material was more fragmentary than that above, creating problems of identification. There are several unidentified family Hygromidae and other unidentified terrestrial species which limits ecological interpretation. A small number of freshwater taxa are present in the Yellow Series, especially *Galba truncatula* particularly in MMC121-2; this, being a semi-terrestrial species, implies no more than small wet patches within the cave. The presence of 79 ostracods in the Yellow Series may also be consistent with wet areas in the cave, though they have not been identified. A single example of *Bythnia tentaculata*, which is mainly found in larger waterbodies, is perhaps more likely to have been introduced with material from elsewhere.

Notwithstanding the dominance of inedible species in all but two Yellow Series samples, there are small numbers of the species which overwhelmingly dominate the Grey Series midden above, and for this reason are candidates for species which were eaten, given that lithic artefacts, and other material of anthropogenic origin, are also well represented in this upper part of the Yellow Series. Although mollusc numbers were very low between MMC121 and 108 (MAZ1b), the species which may have been eaten comprised a higher proportion than in the lower part of the column. Three of these were present in about half of the Yellow Series samples and were present in the low 20s from the Yellow Series as a whole: *Alabastrina soluta*, *Helix aspersa*, *Otala punctata*. The other two are present in just 3 or 4 samples being represented by just 4 or 5 individuals in the Yellow Series as a whole: *Dupotetia dupotetiana* and *Cernuella globuloidea.* In the Yellow Series as a whole, species which may have been eaten account for only 17 % of the Mollusca. Mollusc numbers are very low in the upper samples of the Yellow Series and the top two have only inedible species (MAZ-1c).

It should also be noted that some molluscs were also observed much lower in the Taforalt sequence but have not been analysed because they were beyond the remit of the present project. Individual large shells of *Otala punctata* were observed in the Taforalt Calcareous Group sediments Unit R26 dated c. 90-95,000 BP (**fig. 8.9**), although here there were no concentrations of shells and only scattered worked lithics and charcoal (S. Collcutt, pers. comm.). More significant were concentrations of land molluscs in ashy hearth deposits in the Lower Laminated Group Unit R22 which is dated to c. 80-82,000 BP (Clark-Balzan et al. 2012; Barton et al. 2015). This layer also contained perforated shell beads of the marine mollusc *Nassarius gibbosulus* which is regarded as among the earliest evidence of human symbolic behaviour worldwide (Bouzouggar et al. 2007; D'Errico et al. 2009).

Grey Series

The onset of the Grey Series occurs c. 14,830-15,190 cal BP (Barton et al. 2013) and it is essentially an anthropogenic midden. The contrast with the Yellow Series is very marked on the mollusc diagram. MAZ-2

Fig. 8.9 *Otala punctata* in the much older Middle Stone Age (Calcareous Group) sediments (for comparison with LSA examples).

covers MMC-106-80. In the Grey Series, with the single exception of the lowest sample, where there was some intermixing of Yellow Series sediment, the vast majority of the species are those which are considered to have been eaten. The numbers of inedible species declines steadily and above MMC87 there are just a few patchy occurrences. Despite the marked change in species composition, it is notable that the bottom few samples of the Grey Series are characterised by very low mollusc numbers and in this respect the base has some similarity to the underlying Yellow Series. Mollusc numbers steadily increase upwards as do animal bones and lithics (**fig. 8.5**).

Below MMC82 there are, on average, 30 shells per sample and, above this, 88 shells per sample. At about the same point, MMC80, there is a marked change in the assemblage. From MMC107 up to MMC80, thus from 13,853-14,788 to 13,590-13,780 cal BP, there is the steady decline of inedible species and steady increase in overall mollusc numbers already noted. In this zone the predominant species is *Cernuella globuloidea* which peaks at c. 60 % around 14,244-14,545 cal BP. In this zone the second most important species is *Dupotetia dupotetiana* at around 20-40 %. There is a smaller proportion of *Otala punctata*, and the occasional presence of *Alabastrina soluta* and *Helix aspersa*.

Above MMC80 (MAZ-3) the assemblage is overwhelmingly dominated by *Dupotetia dupotetiana* at between 80-55 %. *Otala punctata* is the second most important species at around 20 %.

Otala punctata proportions show some interesting fluctuations through MAZ-3 and MAZ-4 with c. 15 peaks. Some are restricted to one sample (e.g. MMC24, MMC33), others cover as many as 3 samples

(MMC29-31). Peaks are separated by lower proportions, some of one sample duration, others of up to 12 samples (MMC81-93).

Alabastrina soluta, which was infrequent below, is consistently present between 5-10 % between MMC-80 and 31 but is less frequent above this. *Cernuella globuloidea*, which had dominated the assemblage below MMC-80, is present in most samples until MMC-26 but at low percentages up to c. 15 %. Between MMC-26 and 7 (MAZ-4), it is even less frequent. *Helix aspersa* has only patchy occurrence in this zone and there is patchy occurrence of inedible species.

Near the top of the column a change occurs from c. MMC7 (MAZ-5). *Cernuella globuloidea* steadily increases up to 18 %, in the very top sample there is an increase of *Alabastrina soluta* and there are more non-edible species near the top.

8.8 BURNING, TAPHONOMY AND SHELL MODIFICATION

Evidence for burning on shells is rare in the Yellow Series and frequent in the Grey Series. An estimated 60 % of all shells in the Grey Series show some contact with heat. It is not evident whether burning occurred from direct contact with fire during cooking, or took place after consumed shells were discarded. Shells exposed to heat were dark grey to white in colour, with those most affected being significantly weakened (**fig. 8.3**). Those which had been exposed to the highest temperatures had a powdery texture and were extremely fragile and crumbled to dust. Burning is much less frequent in the larger fractions, with the 4 mm fraction containing no burnt apices. This suggests that burning weakened the shell structure and contributed to higher fragmentation rates. Although it is unclear how much shell material has been lost through burning, this does seem to suggest that the total apical count for the Grey Series may be an underestimation of the original numbers of shells collected. An additional factor contributing to shell fragmentation will have been trampling by people, and possibly at times animals, within the cave.

Hutterer / Mikdad / Ripken (2011; 2014) have recorded intentional perforation marks on a large percentage of land snail shells from Neolithic midden sites in northeast Morocco. This has led to the development of the hypothesis that these perforations were made with lithic tools in order to break a vacuum in the apical portion of the shell which allows the flesh to be easily removed through sucking (Hutterer / Linstädter / Eiwanger / Mikdad 2014). A small number of complete *Dupotetia dupotetiana* shells from Taforalt also show breakages near the apex which are similar in appearance to the Hutterer et al. specimens. Two modern shells of this species were punctured using lithic tools to provide a comparison for the archaeological material. The experimental puncture marks are smaller in size and have sharper edges than the archaeological perforations. These results have been discussed with Hutterer (pers. comm.) who believes that the shells from Taforalt are unlikely to have been intentionally perforated, based on the irregularity of puncture marks and the LSA date of the deposits, almost all shells with more convincing perforations being found in Neolithic contexts at other sites. The current hypothesis is therefore that land snails at Taforalt were not intentionally perforated before consumption.

8.9 INTERPRETATION

A key research question is whether the accumulation of molluscs at Taforalt is natural or anthropogenic in origin. The first criterion indicating anthropogenic accumulation is the presence of shells of a sufficient size to be eaten. This is somewhat more subjective because the shells are mostly so fragmentary, with the result that the size cannot be evaluated metrically. However, the overall impression given by the assemblage (including many whole, unstratified shells fallen at the base of the old section scree, eroding since the 1950s) is that the vast majority of apices derive from more or less fully grown adult shells. As a second criterion, if collected for consumption, we would expect to see a bias towards edible species with ratios between edible and non-edible species being much higher than in a natural assemblage. These criteria are met clearly by the Grey Series samples, and much less convincingly in the Yellow Series. A third criterion would be the association of adult shells with demonstrable anthropogenic refuse such as charcoal, charred plant remains, worked cherts, animal bone, etc. Again the criterion is met very fully by the Grey Series and arguably also by the Yellow Series, where worked lithics and bone were present in the samples (**fig. 8.5**), although in lower numbers than in the Grey Series. Frequent burning of shells could also be a fourth criterion; however, land snail preparation techniques may, or may not, have always resulted in contact with fire. In the Grey Series 60 % of the shells were affected by fire, but this was rare in the Yellow Series.

Four main species dominate the Grey Series deposits at Taforalt: *Dupotetia dupotetiana*, *Otala punctata*, *Alabastrina soluta* and *Cernuella globuloidea*. These four species are classified as 'edible' on the basis of the criteria outlined above. *Helix aspersa* occurs in lower numbers but will also be classified as an edible species due to its large size and its popularity as a food source today (Arrébola Burgos / Álvarez Halcón 2001). *Rumina paviae* is large enough for consumption; however, it occurs in such low numbers that it seems unlikely to have been consumed in the past and is not considered to be an edible species (Lubell et al. 2004a). All other species identified have been classified as 'non-edible' due to their small size and infrequency. Analysis shows that the Grey Series is dominated by edible species (99 %) which is markedly different to the Yellow Series, where they only account for 17 % of the total molluscs recovered.

In **figure 8.5**, the high volume of edible molluscs (of anthropogenic origin) in the Grey Series is clearly mirrored in the plots for the animal bone and the worked chert. Samples from this part of the section show consistently higher levels of debris indicative of human occupation than those from the Yellow Series, all the more so because the dating evidence shows the Grey Series was deposited c. 10 times more quickly than the Yellow Series. The micro-vertebrate data shows the reverse trend with much higher numbers in the Yellow Series. The presence of micro-vertebrate remains is often indicative of lower intensity human activity, thus strengthening the hypothesis that the Grey Series represents a period of intensive, or sustained, use of the site by people.

As regards the transition from the Yellow to the Grey Series, the steady decline in non-edible species at the base of the Grey Series and the low numbers of shells in the first seven samples of the Grey Series demonstrate some degree of continuity or perhaps mixing. However, the two series are separated by two samples with no edible species but larger numbers of lithics, bone and microfauna. Of the species present, only *Otala punctata* occurs in similar proportions in the Yellow Series and the lower part (MAZ-2) of the Grey Series. The proportions of the other four species are markedly different as between the Yellow and Grey Series. That is most likely to be explained by an environmental change but, since they were collected, we cannot exclude a human behavioural explanation.

Otala punctata accounts for 16 % of all apices in the Grey Series and 5 % in the Yellow Series. For much of the Grey Series *O. punctata* is present in relatively low numbers in comparison with *Dupotetia dupotetiana*. Fluctuating peaks in the abundance of *Otala punctata* may represent targeted selection of this species, perhaps during times of abundance, either at specific times of the year, or during years which are favourable to population growth, possibly due to fluctuations in the local climate and environment. Although the overall numbers of *Otala punctata* are notably less than *Dupotetia dupotetiana*, it is important to note that, from a nutritional perspective, *Otala punctata* contains more protein per individual due to its significantly larger size, something which may partly account for the lower numbers. It also seems likely that behavioural differences make it easier to collect larger numbers of *Dupotetia dupotetiana* as discussed below in connection with the modern molluscan survey.

Alabastrina soluta, having been the main edible species in most Yellow Series samples, is only occasionally present in the lower part of the Grey Series (MAZ-2). It increases above MMC80, at which point *Cernuella globuloidea* shows a dramatic reduction. A notable increase in the use of *Otala punctata* and *Dupotetia dupotetiana* can also be seen at this point. Perhaps *A. soluta* was not previously favoured due to its small size but, during this transitional period, people were turning to different molluscan resources to mitigate the decline of a previously favoured species as a result of environmental changes.

Helix aspersa is one of the best known edible snails, as it is commonly eaten in many countries today. It occurs very sporadically in small numbers with no visible patterns in use, suggesting that it was an occasional, possibly seasonal, resource which was infrequently used, probably in a similar manner to *Alabastrina soluta*. In terms of distribution throughout the sequence, *Helix aspersa* actually shows the reverse pattern of the other edible species in that it is more prevalent in the Yellow Series, where it accounts for 5 % of the total molluscs, than in the Grey Series where it only accounts for less than 1 % of the total. The higher numbers in the Yellow Series may represent a larger population in the area during this period, or may represent early consumption of molluscs, as its large size means that it has greater nutritional value relative to the other smaller species such as *Cernuella globuloidea* and *Alabastrina soluta*.

8.10 MODERN MOLLUSCAN STUDY

As part of this study, a limited modern ecological study was carried out of the molluscs living within c. 0.5 km of the cave and in a transect down the Moulouya River, the latter as part of a joint investigation with Joshua Hogue into the availability of molluscan resources and raw materials for lithic production. The area around the Moulouya River was selected as it is the largest water course in northeast Morocco (Linstädter / Zielhofer 2010) and was considered to have provided an obvious routeway from Taforalt to the coast in the past. Roche (1963, 153) recorded the presence of a variety of marine molluscan species in the Grey Series layers, including *Ostrea*, *Cardium* and *Columbella*; A. Freyne (**Chapter 13.2**), counting 384 shells mentioned by Roche, has identified further marine molluscs from the recent excavations of Sectors 8 and 10. This indicates either periodic visits to the coast by the occupants of Grotte des Pigeons, possibly as part of a strategy of seasonal mobility, or trade / exchange links which enabled them to obtain marine shells. Our recent sampling took place in May, during which time the weather was dry with high temperatures, particularly at the lower elevations in the Moulouya valley. Weather in the area in May is characterised by average high temperatures of 25°C and a monthly average 24 mm of rain spread over 7 days (www.worldwideweather.com). Since the focus of this research was on the larger edible species, modern molluscan sampling concentrated on these, so that small species are likely to be greatly under represented. The full results of the modern molluscan study are given in Taylor (2014).

The Area around Taforalt

In 2010 and 2012, molluscs were collected from the area directly surrounding Taforalt Cave. Many of the species found in the archaeological layers could be found directly around the cave. Most common were *Ala-*

Fig. 8.10 Contexts in which modern molluscs can be collected today: **a-b** *Dupotetia dupotetiana* resting or aestivating on plant stems in May in the Moulouya River Valley 20 km NW of Taforalt; **c** *Alabastrina soluta* clustered on the shaded part of a rock; **d-e** *Alabastrina soluta* in micro-caves close to Taforalt cave entrance.

bastrina soluta and *Leonia mammillaris*. *Alabastrina soluta* could be found attached to the numerous prickly pear plants (*Opuntia ficus-indica,* an introduced species) which grow around the site, within crevices in the limestone and, as shown in **figure 8.10d-e**, within small holes in the rock which appear to have been formed over the centuries by dissolution by the snails themselves. The name given to this species is suggestive of this habit of limestone dissolution. The process of limestone dissolution has been described in other Mediterranean contexts by Danin (1996) and in the Mendips, UK, by Stanton (1986). *Otala punctata*, another edible species, was also present in the Zegzel Valley in the form of empty shells on the rocky slopes around

Taforalt and as live, aestivating juveniles within piles of limestone boulders at Grotte du Chameau. The lack of live individuals at Taforalt is presumed to be related to their preference for aestivating out of sight within limestone crevices, as observed at Grotte du Chameau. The remaining edible species from the Grey Series, *Dupotetia dupotetiana* and *Cernuella globuloidea*, were not found in the area directly surrounding the cave. A range of non-edible species were also found in the area. Large numbers of *Leonia mammillaris* shells were found around Taforalt, something which is not unexpected given its preference for rocky habitats, although live individuals were not found. *Rumina* sp. occurs more frequently in the modern environment than in the archaeological deposits. Of the other species recorded in the area, *Mauronapaeus* sp., *Sphincterochila corrugata* (Pallary 1920a; 1920b; called *Albea corrugata* by Rour / Chahlaoui / Van Goethem 2002) and a number of small Helicidae do not appear to be present in the archaeological layers, which may suggest that the habitat and distribution of these species has changed over time.

The Moulouya River Environs

Many of the edible species found in the archaeological deposits at Taforalt could be found along the Moulouya River, which forms the western border of the Triffa Plain, a semi-arid plain to the north of the Beni Snassen. The sampled sites are in river valley and coastal lowland locations, well below Taforalt cave which is at 720 masl. Most interesting is *Dupotetia dupotetiana*. Despite being the most commonly occurring species in the Grey Series, it was not found, either living or as shells, in the area directly surrounding Taforalt during any of the excavation seasons. Widening the research area to include the Moulouya River showed that *Dupotetia dupotetiana* occurred very widely in the area. It is possible that the past distribution of this species included the area around Taforalt.

Of particular interest is one sample site (MOU 5, N34.57040, W002.32482) on the bank of the Moulouya, approximately 20 km NW of Taforalt, where there were a variety of small shrubs and bushes on which were extremely large numbers of *Dupotetia dupotetiana* and a smaller number of *Sphincterochila* sp., as shown in figure 8.10a-b. All the molluscs were attached to the stems of plants, either individually, or in clusters of up to 25. On the eroding section of a dry river bed at MOU7 N34.49359, W002.40467, *Dupotetia dupotetiana* was found on shrubby vegetation and sometimes on limestone rocks but *Alabastrina soluta* was only found on the rocks. The relative locations of both are shown in figure 8.10c, with *Alabastrina soluta* clustering on the shaded side of a rock. As at other sample locations, the type of vegetation occupied does not seem to be important, with almost the entire range of bushes containing molluscs. Research by Giokas / Pafilis / Valakos (2005) in Greece observed similar, tight clusters of the Clausilidae, *Albinaria caerula*, during aestivation and concluded that "clustering may offer an effective isolation from environmental conditions, since in this way the exposed total surface area is decreased and a more humid micro-environment obtained, resulting in a lower water vapour pressure gradient to the environment and, therefore, a lower rate of water loss" (Giokas / Pafilis / Valakos 2005, 20). Rizner / Vukosavljević / Miracle (2009), describing Adriatic sites, also suggest that snails could have been collected during periods of inactivity.

This is the first time this clustering behaviour has been documented for *Dupotetia dupotetiana*, something which has important consequences for our understanding of resource procurement strategies in the LSA. At MOU 5, rough estimations calculated each bush to contain approximately 100 snails. With over 20 bushes in the direct area, this would enable a small group of people to collect 2,000 snails in a short period of time, in an area a few metres across.

Helix aspersa is known to dig just below the surface of the soil to protect itself during adverse conditions (Potts 1975). Hunt et al. (2011) suggest that this behaviour of hibernating and aestivating in groups within the soil, under specific plants, could also have provided an easy way in which people could have collected this species in the past. There may also be other species which display such clustering behaviour which could have facilitated their collection.

Edible species occur along the Moulouya River today which are not present in the archaeological record at Taforalt, including *Sphincterochila* sp., which is commonly found in *escargotières* in the Maghreb, particularly in Algeria (Pond 1938; Lubell / Hassan / Gautier / Ballais 1976; Fernández-López de Pablo / Gómez Puche / Martínez-Ortí 2011; Saafi / Aouadi / Dupont / Belhouchet 2013). At the site of Taghit Haddouch, this species accounts for 68.7 % of the total shells recovered, making it the most commonly consumed species during the 'Epipalaeolithic' and Early Neolithic (Hutterer / Mikdad / Ripken 2011). It is likely that the distribution of this species changed over time due to the climatic changes of the early Holocene. The occupation of Taghit Haddouch is considerably later than that at Taforalt, with the earliest deposits from the site dated to 9,717 ± 105 cal BP (Hutterer / Mikdad / Ripken 2011, 59). Also absent from the archaeological record is *Theba pisana* and other related *Theba* species which occur widely in the coastal habitats of Northeast Morocco today (Hutterer / Greve / Haase 2010). The most likely explanation for their absence from Taforalt is again the distance from their preferred coastal habitats to the site. The distance from the site to the modern day coastline is 40 km.

8.11 PALAEOENVIRONMENTAL AND PALAEOCLIMATIC IMPLICATIONS

Since the evidence for human collection of molluscs is so strong, and the numbers of those too small to eat are so few, it is difficult to attribute changes within the sequence to palaeoecological factors, such as environmental or climatic changes. If such evidence is to be identified, it is likely to emerge from a multi-proxy approach involving comparisons between several sources to palaeoenvironmental evidence. Even so, it is important that changes of possible environmental origin are identified to facilitate comparison with the other sources. Comparisons are made on a hemispheric scale with the Greenland ice core GISP 2 (Grootes et al. 1993). Fortunately there is also a more local marine core record from the west Mediterranean, particularly a site in the Alboran Sea c. 150 km NNW of Taforalt (Cacho et al. 2001) which indicates significant regional differences between the west Mediterranean and Greenland palaeoclimatic records.

In the Yellow Series, mollusc numbers are rather higher in MAZ-1a at the base of the sequence declining to low levels just before 18,886-19,236 cal BP. This could suggest slightly more favourable conditions for mollusc life in MAZ-1a, between 20,894-18,882 and 19,514-19,993 cal BP, and less favourable conditions in MAZ-1b, between the last date and c. 15,000 cal BP, particularly very low numbers immediately below the last date in MAZ-1c. Other evidence suggests the probability of an hiatus at the top of Y2 between MMC111 and MMC110 (Chapter 2). The small numbers of species considered to be non-edible, and thus more straightforward to interpret ecologically, do not indicate any marked changes in the Yellow Series. The species which are most consistently present (*Leonia mamillaris*, *Vitrina* and *Ferussacia* sp.) are present through MAZ-1a and MAZ-1b and the first two in MAZ-1c. There is a wider range of non-edible species in MAZ-1a. Most notable is the occurrence of *Galba truncatula* through the Yellow Series, indicative perhaps of wet patches or pools. This may also be indicated by the unidentified ostracods from Yellow Series samples; there is also one example of *Bithynia tentaculata* which is more indicative of moving water. The limited evidence for water may be supported by the banded nature of the Yellow Series indicating deposition in water. *Leonia mammillaris* is commonly found in the Yellow Series. Today, this species favours shrub vegetation and pine woods (Welter-Schultes 2012a) and is common around the cave at Taforalt. It is absent in the lower Grey Series. The non-edible species in the Yellow Series are very much what might be expected in an area of rocks and caves and provides little indication of regional climate.

The boundary between the Yellow Series and the Grey Series at c. 14,830-15,190 cal BP corresponds broadly to the boundary between Greenland Stadial 2 and the last Greenland Interstadial. In North Africa, that marks the transition from more arid conditions to a more humid phase (Limondin-Lozouet/Haddoumi/Lefèvre/Salel 2013). The development of the Grey Series midden might therefore be seen as related to more favourable environmental conditions. That may be reflected in the steady increase in mollusc numbers through the lower part of the Grey Series, perhaps through vegetation succession to favourable ecological communities. It might also reflect increasing intensity, or duration, of human activity. It should be noted that, despite the very marked sedimentary change from the Yellow to the Grey Series, in the lower third of the latter there are still scattered occurrences of the freshwater taxa present in the Yellow Series, which could suggest some continued, but reduced, freshwater input to the cave. The presence of *Carychium minimum* in MAZ-2 may also reflect the presence of wet areas and the presence of a few *Carychium tridentatum* also points to relatively humid vegetated areas, or litter within rubble (Welter-Schultes 2012a, 87). The predominance of *Cernuella globuloidea* in the lower part of the Grey Series (MAZ-2) is followed by its marked decline c. 13,590-13,780 cal BP, at a time when mollusc numbers were high (**fig. 8.5**). MAZ-2 probably corresponds to the first part of the Greenland Interstadial (GI-1e) up to the transition at c. 13,828-13,555 later in the Interstadial (GI-1c). In hemispheric terms GI-1e was the warmest part of the Interstadial. However, in the Alboran Sea record, higher temperatures are indicated in GI-1c (Cacho et al. 2001).

In the succeeding MAZ-3 there are greatly increased proportions of the predominant species *Dupotetia dupotetiana* and *Otala punctata*. These changes could be due to over exploitation of *Cernuella,* or some other cause, but seem more likely to be a result of an environmental change. As to the nature of any change, there is unfortunately little evidence for the ecological preferences of the affected species. Each of them and their relatives are generally found in rather dry rocky places. In Iberia *Otala* is found in rocks and walls in coastal plains and the survey of modern mollusca showed that this species occurs around the cave today. *Dupotetia dupotetiana*, the overwhelmingly predominant species in the upper Grey Series MAZ-3 to MAZ-5), was not found around the cave today but occurred in abundance on scrubby vegetation in the much lower-lying Moulouya River valley and Triffa Plain to the northwest. This could indicate that people were travelling to lower slopes to collect it. However, given the numbers of shells involved, it is more likely that the distribution of this species has changed over time due to the climatic fluctuations of the late Pleistocene and Holocene. A further possible factor is the effect of human communities on the environment since the period of cave occupation. For instance, in Iberia burning has been shown to exert a major influence on molluscan communities (Bros/Moreno-Rueda/Santos 2011). At Taforalt itself, the effects of faunal agents, and in this case recent landscape management, are also very evident in the vegetational contrasts between a large fenced area grazed by reintroduced *Ammotragus* and the rest of the Beni Snassen Ecopark outside the fenced area. Today the coastal lowlands are generally drier with no rainfall in mid-summer and hotter than the hills where Taforalt is located. Drier conditions at the time of cave occupation do not seem particularly likely, given the abundance of resources suggested by the Grey Series midden. Possibly more relevant is an association with scrubby vegetation and perhaps at least periodically damper conditions found today in the lowland close to the river, where the densest concentrations of molluscs were found today. Comparable microenvironments may perhaps have been present at higher elevations during the period of occupation.

MAZ-4 is marked by a further reduction of *Cernuella globuloidea* and a further increase in the predominance of *Dupotetia dupotetiana*. This occurs at c. 13,280-13,467 cal BP, corresponding approximately to the onset of declining temperatures in the Alboran Sea record (Cacho et al. 2001). The final change at the top of the sequence, to MAZ-5, is marked by a steady increase in *Cernuella globuloidea*, *Alabastrina soluta* and some non-edible species. An absence of ecological knowledge of the species involved makes interpretation difficult, although it seems probable that these final changes around 12,611-12,725 cal BP may relate to the Greenland Stadial (GS-1) with the lowest temperatures in both the Greenland and Alboran Sea records at about this time. Wood charcoals from the top of the sequence, nearer the cave entrance (**Chapter 5**), indicate the onset of a significant cool damp period with dates within Greenland Stadial 1.

8.12 MOLLUSCS AND DIET

In cases such as this, it is instructive to consider the dietary contribution of the food resources represented (Hosfield 2016); these would be approximate calculations concerning the importance of molluscs in the Iberomaurusian diet. Inevitably this involves some assumptions concerning the number of molluscs in the cave, their nutritional value and the typical size of hunter-gatherer groups sharing the resource. The volume of the Grey Series, including the full stone content, can be roughly calculated from the cross sections in Roche (1963) and, despite some doubts as to the accuracy of sections and subdivisions, the volume can be calculated (see **Chapter 2**) as at least 1750 m^3. A key assumption is that the number of mollusc shells found in the mollusc column is representative of the Grey Series as a whole. It is assumed that the lower 1/3 of the midden, where mollusc numbers are lower, and the upper 2/3, where they are more numerous, were represented in similar proportions over the area of the cave. The average sample size was 0.2 × 0.2 × 0.05 m so 1 m^3 is equivalent to the volume of 500 samples. In the bottom third of the Grey Series (formed between c. 15,000 and 13,590-13,780 cal BP) there was an average of 30 shells per sample, multiplied by 500 = 15,000 shells per m^3. This estimate is reasonably close to the 25,000 figure given by Lubell et al. (1975) for other sites. Multiplied by the volume of sediment 583 m^3, this gives an estimate of 8.74 million in the lower third of the midden. In the upper two-thirds of the Grey Series (formed between horizons dated to 13,590-13,780 and 12,611-12,725 cal BP), there was an average of 88 shells per sample, multiplied by 500 = 44,000 per m^3; the overall volume of sediment 1167 m^3 would give a total of 51 million shells in the upper two-thirds. The overall hypothetical number of shells in the Grey Series as a whole could be 60 million.

The lower third of the midden accumulated over c. 1321 years and contains 8.74 million shells which is 6616 shells per year or 18 per day. The upper two-thirds of the midden accumulated over 1,048 years and contains 51 million shells which is 48,644 per year or 133 per day.

As regards the nutritional value of snails, 100 gm of snail flesh yields about 85 calories and 17 grams of protein (United States Department of Agriculture 2017). If we assume a typical weight for a snail of 10 gm (*Helix aspersa* ranges from 7-15 gm) then one snail is equivalent to 8.5 calories and 1.7 gm of protein. The adult daily requirement of calories for a hunter-gatherer is generally thought to be c. 3000 calories (Kious 2002).

In terms of protein, the generally recommended intake is 0.8 gm per kg of body weight, so for a 60 kg individual that is c. 50 gm of protein per day but for more highly active hunter-gatherers is likely to have been significantly higher, such that we will work with a figure of 80 gm of protein.

In the lower one third of the midden, molluscs could have provided about 153 (18 × 8.5) calories per day, 5 % of the daily calorific requirement of one person and, in terms of protein, 30.6 gm which is 38 % of adult daily protein requirement. In the upper two-thirds of the midden, molluscs could have provided about 1130 calories (133x 8.5) which is 38 % of the daily calorific requirement of one person and, in terms of protein, 226 gram (133 × 1.7) which is the protein requirement of almost 3 people.

However, it is of course likely that the molluscs would have been consumed, not by one person but by several. It is also absolutely clear from the wide range of food remains in the midden that Mollusca were by no means the only, or even main, food resource (cf. **Chapter 18**). If we assume an Iberomaurusian band of 10 people, then in the lower third of the midden each one could only derive less than 0.5 % of their calorific requirements and 3.8 % of their daily protein requirements from molluscs.

Alternatively, if we assumed that Mollusca were consumed only periodically rather than on a daily basis, then for 10 % of the diet of 10 people 350 shells a day would be required. The shells in the lower part of the midden would have been sufficient to contribute about 10 % of the daily calories to the group's diet on about 19 days of the year, and the molluscs in the upper part on about 139 days.

Such calculations are both mechanistic and averaging and we must not lose sight of the fact that molluscs could have been a particularly important and predictable source of food at times when other sources were scarce, a particularly challenging period for hunter-gatherers, for instance, is early spring. The calculations do suggest that Mollusca are likely to have been especially important for their protein contribution. Nor should we forget the other nutritional elements such as vitamins, which have not been quantified; molluscs are for instance a valuable source of trace elements.

Also notable is the evidence of a marked intensification in the use of molluscan resources from MMC84 shortly before 13,590-13,780 cal BP, when there is the most marked change in the composition of the molluscan assemblage within the Grey Series. Mollusc numbers increase before the decrease in stone content, so the change may not reflect changing particle size. This might point to increasing reliance on molluscan resources, or the increasing duration, or intensity, of occupation.

Each and every one of the assumptions made could of course be significantly in error. However, even within reasonable margins of error, these rough calculations do carry certain implications. It is improbable that molluscs made up a major proportion of the diet through the year, and despite the vast numbers of shells present, which might give the impression of resource abundance, the molluscs alone were certainly not sufficient to allow the site to be occupied all year round. The wide range of other foods present, particularly the important evidence for the use of plant resources (Humphrey et al. 2014; **Chapter 6**) could have provided the basis for permanent occupation.

It may also be misleading to think of molluscs mainly in terms of their nutritional contribution. Today Mediterranean land mollusc consumption is particularly associated with festivals and special gatherings at certain times of year. Examples are snail festivals at Caragol, Spain, in May, Graffignano, Italy, in August, and Digoin, France, in August, at which vast quantities of snails are consumed (Taylor 2014). In Crete recent snail gathering is particularly associated with festivals before Easter and in mid-August (N. Galanidou, pers. comm.); these Cretan festivals occur at times when snails are particularly abundant and easily gathered. Such evidence demonstrates that snails should not just be seen as everyday items of diet, or something to be consumed when other resources are scarce. Indeed, the ethnohistorical evidence identifies them as a delicacy and a food of particular social significance by virtue of its association, however created, with special events. Miracle (1995) identified the molluscan evidence from Pupicina Cave in terms of feasting associated with burial, and, given the numbers of burials at Taforalt associated with the Grey Series, that may be a pertinent factor here.

8.13 MOLLUSC COOKING

It has often been suggested that molluscs were prepared by cooking (Lubell et al. 1975; Bar 1977; Bahn 1983a; 1983b; Heller 2009). That possibility is strengthened by the abundance of charred plant material and heat-fractured rocks at Taforalt, where up to 60 % of Grey Series shells were heat-affected. Today the most commonly employed method for cooking snails is immersing them in boiling water (Arrébola Burgos et al. 2001) which loosens the muscles and enables the flesh to be easily removed from the shell, a method which Lubell et al. (1975) believe was used by prehistoric North African communities. They may have used skins or baskets as containers within which water could be boiled using heated rocks, often called 'pot boilers'. Another possibility is that snails were cooked directly by placing them in the fire bed or onto stones heated in the fire (Bonizonni et al. 2009; Heller 2009; Matteson 1959; Pond/Chapuis/Romer/Baker 1938), or into pits lined with heated rocks, a technique for cooking a range of foods which is widely attested through ethnographic studies (Linderman 1962; Wandsnider 1997; Meehan 1982). Experiments in cookery of *Helix aspersa maxima* at Reading University have shown that these molluscs can be very rapidly cooked in boiling water by adding hot rocks to a container, although those roasted on hot rocks were, to modern taste at least, more palatable (**fig. 8.11**).

8.14 CONCLUSIONS

Analysis demonstrates that the vast majority (c. 99 %) of molluscs in the Grey Series, which accumulated from c. 14,734-14,970 cal BP to 12,611-12,725 cal BP, were anthropogenic in origin. This conclusion is based on the narrow range of species, the large shell size, the lack of very small species and particularly the association with large volumes of anthropogenic material such as charcoal, charred plants, chert tools, animal bone and heat-fractured stone. The base of the mollusc column, within the Yellow Series, is dated to c. 20,882-21,436 cal BP. This is slightly later than the unmodelled date for the start of the Iberomaurusian at Taforalt which is 22,912-23,459 cal BP (in Sector 9, cf. **Chapter 4**). Between here and the transition to the Grey Series at c. 14,830-15,190 cal BP, the sequence was more indicative of natural accumulation, with greater species diversity, more small species, more freshwater shells and less frequent burning. Infrequent shells of large, edible species were, however, still present in the Yellow Series which suggests that land snails were consumed during this period but in much smaller numbers.

Much earlier in the Taforalt sequence, the occurrence has been noted of concentrations of land molluscs in ashy hearth deposits in the Lower Laminated Group Unit R22 which is dated c. 80-82,000 BP. From this it may be concluded that the use of land molluscan resources began in a small scale way by about 80,000 BP, that they became more consistently used after the last glacial maximum, and that they saw major intensification with the onset of midden formation c. 14,830-15,190 cal BP and further intensification after 14,244-14,545 cal BP.

As regards wider comparisons, the earliest substantial land mollusc midden is at Tamar Hat from 18,000 cal BP (Saxon et al. 1974; Hogue/Barton 2016), some three millennia before the Taforalt Grey Series. Evidence for small scale land mollusc exploitation has recently been reported from Cova de la Barriada, Spain from 32,000-26,000 cal BP (Fernández-López de Pablo 2014). Giant African land snails were exploited in South Africa in the Middle Stone Age as reported by Badenhorst and Plug (2012). Marine mollusc exploitation is attested somewhat earlier from 164,000 BP at Pinnacle Point, South Africa (Marean 2007). Whilst Taforalt is not the earliest site with evidence for mollusc exploitation, it is certainly among a rather small group of early sites with evidence for such exploitation and it appears to be unique in providing a discontinuous record of mollusc exploitation over some 67,000 years from c. 80,000 to c. 15,000 cal BP followed by a seemingly continuous record over some 2,300 years between c. 15,000 and 12,611-12,725 cal BP. Thus, in total, mollusc use at Taforalt spans much of the last glaciation.

Fig. 8.11 Experiments in land mollusc cookery at Reading University, showing (**a**) roasting of *Helix aspersa maxima* (and two *Cepaea*) on hot rocks, and (**b-c**) calcined remains of snails in hearth.

Confronted with the numbers of shells on some sites, some writers have flirted with the notion that land molluscs were farmed (Bahn 1983a; 1983b; Fernández-Armesto 2001) but without any convincing evidence in support of this idea. It may be more realistic to think in terms of non-analogue ecological communities in the late glacial, and on other sites in the early Holocene, creating particularly favourable conditions for molluscan life round parts of the Mediterranean. Nor can we exclude the possibility that people contributed in some ways to the creation of niches in which these Mollusca flourished. In a similar and reciprocal way, Mollusca, combined with a diversity of other resources, created niches with a broad spectrum of resources in which some human groups became more sedentary. Although land snails were clearly an important part of the Iberomaurusian diet, particularly from the onset of the Grey Series, there is no evidence to suggest they were ever a staple food as has sometimes been suggested. Indeed, it was suggested above that a significant aspect of the molluscan contribution might have been social in the context of special events, perhaps funerals. All Grey Series samples contained large quantities of animal bone, which was frequently burnt, as were many molluscs; there was also a wide range of charred plants. It is therefore clear that, from the onset of the Grey Series at c. 14,830-15,190 cal BP, the diet was very varied and included a range of plants, animals, and molluscs. On the basis of the mollusc column evidence these do not appear to have been consumed in quantity in the earlier Iberomaurusian period represented by the Yellow Series from 20,882-21,436 cal BP to 14,830-15,190 cal BP. The apparent intensification represented by the Grey Series would seem to represent a particularly noteworthy manifestation of a broad spectrum revolution which seems to have occurred in the Middle East and more widely in the late glacial and initial Holocene. However, in the Taforalt case, broadening was in the context of ameliorating environmental conditions rather than the deteriorating conditions represented on Middle Eastern sites where Flannery (1969) first identified the phenomenon (see **Chapter 18**).

9. LARGE MAMMALIAN FAUNA

E. TURNER

9.1 LARGE MAMMALIAN FAUNAL ASSEMBLAGES

Introduction

In the present chapter, mammalian faunal remains recovered from Late Stone Age (LSA) deposits at the cave site of Grotte des Pigeons at Taforalt are presented. These finds were recovered during excavations in the cave between 2004 and 2015. They represent an important assemblage of faunal remains from an inland and upland site of this period in north-west Africa and are one of the few assemblages in the Maghreb region that have been analysed in detail from a zooarchaeological perspective. The aim of this report is to ascertain which animals were procured by LSA hunters at Taforalt and how they were processed and utilised. In particular, potential diachronic changes in faunal representation and utilisation were addressed, as the human use of the cave switched from intermittent occupations in the early LSA to more or less sedentary habitation during a later part of this period from c. 15,000 cal BP onwards (see **Chapter 4**) at Taforalt.

Methods

The assemblages examined here comprise finds recovered individually during excavation and those retrieved by dry sieving. In the main, they consist of three-dimensionally recorded finds. Objects collected as 'general finds' were examined, but only significant pieces from this find-category (e.g. identifiable remains) were recorded further and analysed. The information obtained was entered into an Excel spread-sheet for each sector of the site. The bulk of the finds was recorded in the field or at the *Institut National des Sciences de l'Archéologie et du Patrimoine* (INSAP) in Rabat. Since a comparative bone collection was not available, identifications to element, side of the body and taxon were made following descriptions in several standard works, including Schmid (1972), Barone (1986) and, with particular relevance for the African faunas, Walker (1985). In addition, the works of authors such as Gabler (1985), Helmer/Rochetau (1994), Peters (1986a; 1986b) and Peters/Van Meer/Plug (1997) proved to be useful. Small numbers of finds were taken on temporary loan to Germany, where they were compared with specimens in the extensive comparative collection of the Zooarchaeology Laboratory of the Monrepos Archaeological Research Centre and Museum for Human Behavioural Evolution in Neuwied.

Since the faunal remains from Taforalt were highly fragmentary, identification to species was not always possible and many remains could only be identified to a broader level, e.g. family. In cases where it was not possible to establish identification even down to a broader level, faunal remains were attributed to an animal-size group, based on a combination of the size of the find (length/breadth) and, where possible, thickness of the cortical bone. The following animal-size groups were established for less identifiable remains, giving examples of animals from the LSA fauna which correspond to each group:

- large size group = large equid, large bovines, rhinoceros
- medium-large size group = Barbary sheep (known locally as 'aoudad'), alcelaphines, small equid

- medium size group = gazelle, unidentified canid
- small size group = fox

Numbers of identified specimens (NISP) were recorded but minimum numbers of elements (MNE) were not calculated due to the fragmentary nature of the material. In cases where sample sizes were too small to be meaningful, counts of faunal remains from related units were combined together. This was the case in the S8-GS series for example, where the total number of describable finds recovered from some of the individual units in this deposit was extremely low. Minimum numbers of individuals (MNI) were calculated, in particular for the larger assemblage from S10. In general, the MNI was calculated on duplicating dental elements, since teeth comprised the bulk of the faunal remains. Due to the small numbers of identifiable bones, individual skeletal elements were grouped into different anatomical regions of the skeleton in order to determine which parts of the carcass were present at the site. The following anatomical regions were utilised:

- head = teeth, mandibles, skull, horn core fragments
- axial = vertebrae, ribs, pelves
- fore limb = scapula, humerus, radius, ulna
- hind limb = femur, patella, tibia, fibula
- fore foot = metacarpus, carpals, sesamoids, phalanges
- hind foot = metatarsus, tarsals, sesamoids, phalanges
- limb = not further identifiable fragments of limb bones
- foot = not further identifiable fragments of foot bones
- limb / foot = not further identifiable fragments of limb or foot bones

The age-structure of the hunted prey was based on the analysis of eruption and wear stages of isolated teeth and teeth in mandibles and maxillae. The same techniques were employed to establish time of death of very young individuals as a contribution to the seasonal timing of the occupations at the site. Several sources were used to age the animals including Ogren (1965) for Barbary sheep. A collection of skeletons of modern Barbary sheep of known age at death in the Palaeoanatomy Section of the State Collection for Anthropology and Palaeoanatomy in Munich was also used for ageing the specimens from Taforalt. Studies on the age-structures of recent horses (Levine 1982) and gazelle (Munro / Bar-Oz / Stutz 2009) were referred to for these taxa.

Various modifications on the bones were recorded, including butchery marks (cut marks, impact notches, chopping marks), burning, and the use of bones as tools, along with traces of carnivore and rodent gnawing. These modifications were identified following descriptions given by Fisher (1975). Cut marks were observed using a hand-held 8x lens and, where applicable, were recorded using the coding system developed by Binford (1981). Different stages of burning on the bones (from 'not burnt' to 'fully calcined') were recorded, following Stiner (2005) and Stiner and others (1995), and long bone shaft circumferences, indicators of predominantly human or carnivore modification of the bones, were also noted, following Bunn (1983).

The faunal remains were photographed using a Nikon D2x and a Canon Eos 30 D, all fitted with 60 mm Macro lens and a Digi Microscope USB from Reflecta. Osteological measurements were taken according to von den Driesch (1976), using Mitutoyo digital callipers and connecting cables. The finds were weighed using an electronic letter scale, produced by the firm Maul.

The LSA Faunal Remains from Sector 8

General Remarks

Faunal remains from units in the Grey Series and from Units Y1-Y4spit2 of the Yellow Series were analysed and recorded. The small size of the area excavated (see **Chapter 2**) meant that the total number of faunal remains individually recorded from this sector was relatively low (n=690) (**tab. 9.1.1**), despite the great depth of the deposits investigated. Absolute dating has shown these deposits range between 20,882-21,436 and 13,853-14,788 for the units from the Yellow Series and between 14,734-14,970 to 12,611-12,725 for the Grey Series (dates are modelled ages cal BP; see **Chapter 4**).

Faunal preservation at Taforalt is excellent and this was also the case for the animal bones from all units in S8. The faunal remains ranged in colour from pale-yellow to brown. There was no demonstrable association of bones of a particular colour to a deposit or layer, although more bones of pale-yellow colour were recorded from S8-L15 to L29 than in the upper units of the GS.

Counts of finds from individual units in S8-GS varied radically and only three units produced proportionally larger quantities of remains: S8-L3, L6 and L29. Whether the higher number of remains in these units reflects phases of more persistent human activity, reflects episodes of sedimentation involving greater accumulations of finds, simply relates to thickness of unit, or represents uneven spatial distributions of faunal remains encountered in some of the units during excavation in a small area, is uncertain. In S8-YS, bulk sedimentation rate was very much slower (by a factor of about 10); those main excavation units to which larger numbers have been recorded, S8-Y1, Y2 and (upper)Y4, thus each represent more time than similarly-sized assemblages from the GS. Using the calculated sedimentation rate (**Chapter 2**), we can obtain a better estimate of the relative 'productivity' in large mammal bones between the YS and GS in S8; a 3.6-fold increase (**tab. 9.1.1** data) or a 3.2-fold increase (**tab. 9.1.2** data) can thus be calculated, probably large enough increases in average 'productivity' to be significant, despite the relatively low numbers overall.

Faunal remains allocated to the medium-large size group dominate not only in the individual units but also globally across the units, attaining 74.0 % and 64.8 % of the total number of finds in the S8-GS and S8-YS assemblages respectively. Medium sized animals are represented by a larger percentage in S8-GS than in S8-YS and a similar pattern of representation was observed for the large size group in these units, albeit by a much narrower margin. Small sized animals were represented in both the GS and YS units by very low percentages.

Traces of butchery (cut marks/fragmentation of bone during marrow procurement) were observed on finds from all levels, except Units S8-L9, L21, L25 and L27. Higher counts of butchery traces occur in S8-L3, L6, L29, and in S8-Y1 and Y2. However, these counts probably reflect the overall higher total number of faunal remains recovered from these units, rather than exhaustive human butchering activities during these particular phases of occupation. Burnt bones are represented in general by even lower counts and are absent in several units in S8-GS and S8-YS. Burnt bones comprise 12.9 % and 6.9 % of the total number of bones in the assemblages from the S8-GS and S8-YS respectively. From an overall total of 690 faunal remains in S8, 7.9 % of the burnt bones were recovered from the GS deposits and 3.0 % from the YS deposits. Considering the S8-GS deposits are characterised by masses of ash and contain several hearths, these results are rather surprising. A higher percentage of burnt bone in the younger deposits in this sector had been expected.

Traces of carnivore gnawing were also observed on the bones from S8. The counts indicate that carnivores appear to have interacted more with bones deposited in S8-YS (3.6 %) than S8-GS (0.3 %). The very low count of carnivore-gnawed bones from the GS deposits is probably an indication of the important role played by humans in the occupation of the site during the accumulation of these deposits. During these periods, carnivores

Sediment group	Unit	Number of finds recorded n / %	Weight in g.	Small size group	Medium size group	Medium-large size group	Large size group	Butchery traces	Bone tool	Burnt	Carnivore gnawing	Rodent gnawing
GS	L2	18*	115	-	3	14	1	4	-	5	-	-
	L3	47* / 12.1	439	1	5	32	9	13	-	9	-	1
	L4	-	-	-	-	-	-	-	-	-	-	-
	L5	11	79	-	1	10	-	1	-	1	1	-
	L6	45 / 11.6	490	2	4	36	3	13	-	5	-	-
	L7	12	150	-	1	11	-	5	-	-	-	-
	L8	13	136	-	-	13	-	5	-	2	-	-
	L9	1	5	-	-	1	-	-	-	-	-	-
	L10	-	-	-	-	-	-	-	-	-	-	-
	L11	8	70	-	-	8	-	4	-	2	-	-
	L12	7	74	-	-	7	-	2	-	1	-	-
	L13	11	131	-	1	10	-	4	-	7	-	2
	L14	6	72	-	1	5	-	1	-	-	-	-
	L15	27	287	-	6	17	4	10	-	3	-	-
	L16	19	230	-	2	13	4	2	-	1	-	-
	L17	17	146	-	-	15	2	2	-	-	-	2
	L18	3	69	-	-	2	1	2	-	-	-	-
	L19	13	170	-	-	11	2	7	-	-	-	-
	L20	24	229	1	1	17	5	9	-	5	-	1
	L21	4	38	-	-	4	-	-	-	1	-	-
	L22	3	9	-	-	3	-	1	-	-	-	-
	L23	8	67	-	4	4	-	1	-	1	-	-
	L24	19	190	1	5	10	3	4	-	-	-	-
	L25	2	56	-	-	1	1	-	-	-	-	-
	L26	8	146	-	2	4	2	3	-	1	-	-
	L27	1	24	-	-	1	-	-	-	-	-	-
	L28	13	250	-	-	11	2	4	-	1	-	-
	L29	46 / 11.9	527	-	9	26	11	14	-	5	-	-
Sub-totals		*386*	*4199*	*5 / 1.2*	*45 / 11.6*	*286 / 74.0*	*50 / 12.9*	*111 / 28.7*	*0*	*50 / 12.9*	*1 / 0.3*	*6 / 1.5*
YS	Y1	91 / 29.9	1131	-	9	64	18	19	-	4	7	-
	Y2	161 / 52.9	1161	3	42	99	17	22	-	12	3	-
	Y3	11	89	-	3	7	1	1	-	1	-	-
	Y4	41 / 13.4	358	-	6	27	4	4	-	4	1	-
Sub-totals		*304*	*2739*	*3 / 0.9*	*60 / 19.7*	*197 / 64.8*	*40 / 13.1*	*46 / 15.1*	*0*	*21 / 6.9*	*11 / 3.6*	*0*
Totals		**690**	**6938**	**8**	**95**	**483**	**90**	**157**	**0**	**70**	**12**	**6**

	Unit	Barbary sheep	Gazelle	Large equid	Alcelaphines	Large bovine	Rhinoceros	Totals
GS	L2	2	-	-	-	-	-	2
	L3	9	2	-	-	2	-	13
	L5	5	-	-	-	-	-	5
	L6	8	3	-	-	-	-	11
	L7	8	1		-	-	-	9
	L8	8	-	-	-	-	-	8
	L9	1	-	-	-	-	-	1
	L11	2	-	-	-	-	-	2
	L12	3	-	-	1	-	-	4
	L13	3	1	-	1	-	-	5
	L14	3	-	-	-	-	-	3
	L15	5	4	2	1	-	-	12
	L16	2	-	1	-	-	-	3
	L17	8	-	-	1	-	-	9
	L18	1	-	1	-	-	-	2
	L19	3	-	-	-	-	-	3
	L20	4	-	-	-	-	-	4
	L21	2	-	-	-	-	-	2
	L22	1	-	-	-	-	-	1
	L23	1	1	-	1	-	-	3
	L24	1	4	2	-	-	-	7
	L25	1	-	1	-	-	-	2
	L26	2	1	-	-	-	-	3
	L28	5	-	1	-	-	-	6
	L29	8	-	3	1	2	2	16
Sub-totals		*96*	*17*	*11*	*6*	*4*	*2*	*136*
YS	Y1	24	1	8	4	3	1	41
	Y2	21	12	2	1	2	-	38
	Y3	1	-	-	-	-	-	1
	Y4	8	1	1	3	1	-	14
Sub-totals		*54*	*14*	*11*	*8*	*6*	*1*	*94*
Totals		**150**	**31**	**22**	**14**	**10**	**3**	**230**

Tab. 9.1.2 Number of specimens (NISP) identified to an animal in S8 (units which produced no identifiable finds or no finds at all have been omitted).

would probably have avoided the cave. However, the very low total numbers (n = 12 / 1.73 %), of gnawed bones indicate a minor role for these agents in the history of bone deposition in S8 during the LSA. Traces of rodent gnawing were observed on only 1.5 % of bones from S8-GS and are absent on finds from S8-YS.

Palaeoenvironmental Indications

A range of animals was identified from the deposits in S8 and the number of identifiable specimens (NISP) is summarised in **table 9.1.2**. Barbary sheep is the dominant species and reflects the location of the cave in

Tab. 9.1.1 Faunal data for individual units excavated in S8: GS = Grey Series; YS = Yellow Series; percentages in GS and YS reckoned from the respective sub-totals for these units; percentages in column 3 are only given in cases where they exceed 10 %.

the Beni Snassen hills, surrounded by stony plateaus, steep valley slopes and coarse wadi bottoms, habitats favoured by this species (Kingdon 1997, 444). Gazelle also occurs infrequently throughout the deposits. Remains of Cuvier's gazelle (*Gazella cuvieri*) were recorded in S8-L6 and possibly the same species (cf. *Gazella cuvieri*) in S8-Y2. The remaining animals, a large equid, large members of the alcelaphines (including some finds identified as the kongoni or hartebeest [*Alcelaphus buselaphus*]), large bovines and rhinoceros are present in some of the units in S8-YS and in S8-L29. These animals indicate regionally open grassy plains or grassland steppe in association with some parkland, bushland, *maquis* scrub mosaics and thickets (Kingdon 1997).

Despite a distinct shift in sedimentation type between the S8-YS and GS units at around 15,000 modelled cal BP, radical changes in faunal composition in the assemblages were not observed. With the exception of gazelle, which is present only in Y1, Barbary sheep, large equids, large alcelaphines and large bovines are present in the youngest of the S8-YS deposits (Y1) and in the oldest unit of S8-GS (L29). The remaining units of S8-GS (L28-L2) are characterised by a sporadic occurrence of these animals, except for Barbary sheep, which is present throughout. Returning, in passing, to the issue of 'productivity' change from the YS to the GS, it may be noted here that there is an average 4.4-fold increase in Barbary sheep and a 3.6-fold increase in fragments of the medium-large group, figures which are comparable to those derived from the entire bone assemblage (see above). This pattern of faunal representation may be due to fluctuating changes in climate and environment associated with regional occurrence/absence of some species, or may reflect an increasingly selective procurement of Barbary sheep by the human occupants of the cave. Either way, the low numbers of identifiable finds in each unit, combined with the possibility of random recovery in a small excavation sample, makes a definitive interpretation of faunal representation in many of the units from the S8-GS deposits difficult.

Minimum numbers of individuals (MNI) offered little additional information on the occurrence of animals in the S8 deposits. In S8-GS, two individuals of Barbary sheep were recorded on dental elements in L28 and in L29 respectively and two individuals of this species were also recorded on teeth from S8-Y1. The remaining units produced counts of just one individual for each of the animals identified, reflecting the low counts of finds in general.

Bone Assemblage Formation and Skeletal Part Representation

Varying counts of a wide range of faunal skeletal elements were recovered from the deposits in S8. The composition of these bone assemblages may reflect hunting decisions by humans and the debris left behind after butchery, the results of various taphonomic processes, random occurrence in a small excavation area or any combination of these factors. Since the number of faunal remains which could be definitely identified was too small to be useful in a body-part analysis for each taxon, other methods had to be applied here to address skeletal representation. In such cases, a useful method is to assign skeletal elements to the anatomical regions described in the methods section. However, even after assignment, the numbers of elements in each anatomical region, particularly those from individual units in S8-GS, remained extremely low. In order to extract some information about the general representation of animal carcasses in these deposits, counts of elements in anatomical regions from each unit were combined, producing a single "assemblage" for the S8-GS deposits (**fig. 9.1.1**). In contrast, counts in S8-Y1, Y2 and (upper)Y4 were analysed as separate assemblages and S8-Y3 was omitted due to the very low total number of finds in this unit (**tab. 9.1.1**).

Some anatomical regions in the assemblages from S8 are clearly over-represented in comparison to others (**fig. 9.1.1**). The head, comprising almost exclusively dental elements, is dominant, a pattern commonly ob-

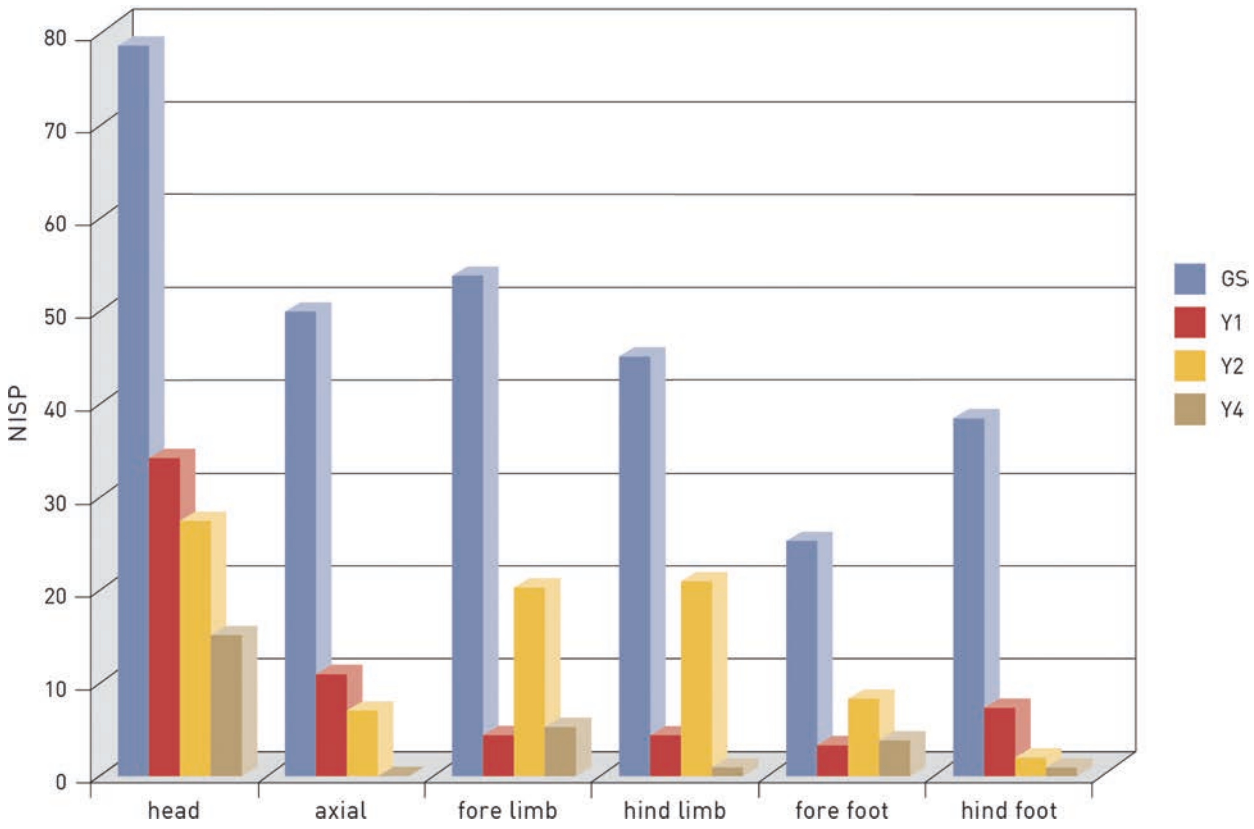


Fig. 9.1.1 Representation of anatomical regions from lithostratigraphic units in GS and YS Y1-Y4spit2 of S8.

served in faunal assemblages since teeth are less susceptible to processes of bone weathering and destruction. The axial region is fairly well-represented in the assemblage from S8-GS, which is unusual since axial elements – particularly the vertebrae and, to some extent, the ribs – are vulnerable to attrition and loss. In contrast, axial elements are characteristically low in S8-Y1 and Y2, whilst (upper)Y4 produced no axial elements at all. The differential representation of axial elements may result at least in part from the different taphonomic contexts in the S8-YS and S8-GS deposits, where bone was probably exposed for longer periods at the surface during the slow accumulation of S8-YS units and had only to survive an initial destructive phase (fires and rocky substrates) for shorter periods during the much more rapid accumulation of S8-GS.
Limbs and feet are also well-represented among the finds from S8-GS, but there is a strong differentiation in representation between fore limb and fore foot in this assemblage, with counts of fore foot elements being much lower, a pattern of representation not fully replicated between hind limb and hind foot elements. In S8-Y2, counts of fore and hind limb are more or less equal. On the whole, the data indicate that all parts of the carcass were recovered from the site, albeit in varying proportions, except for axial elements in (upper)Y4.
Figures 9.1.2 and **9.1.3** depict comparative counts of individual skeletal elements from three of the animal-size groups – large, medium-large and medium. In these graphics, counts for faunal remains from the units in S8-YS have also been pooled to form a second 'assemblage' and counts for small sized animals are not shown, since only a few elements from both S8-GS and S8-YS could be attributed to this group.
In the S8-GS assemblage (**fig. 9.1.2**), the largest group, medium-large, produced a pattern with fairly high counts for teeth, metacarpus and first phalange, and particularly high counts for radius/ulna and tibia. High counts for these elements are not surprising, since they are all robust portions of the skeleton. Even so, it was unusual to observe fairly high counts for crania, vertebrae and ribs, elements which are normally

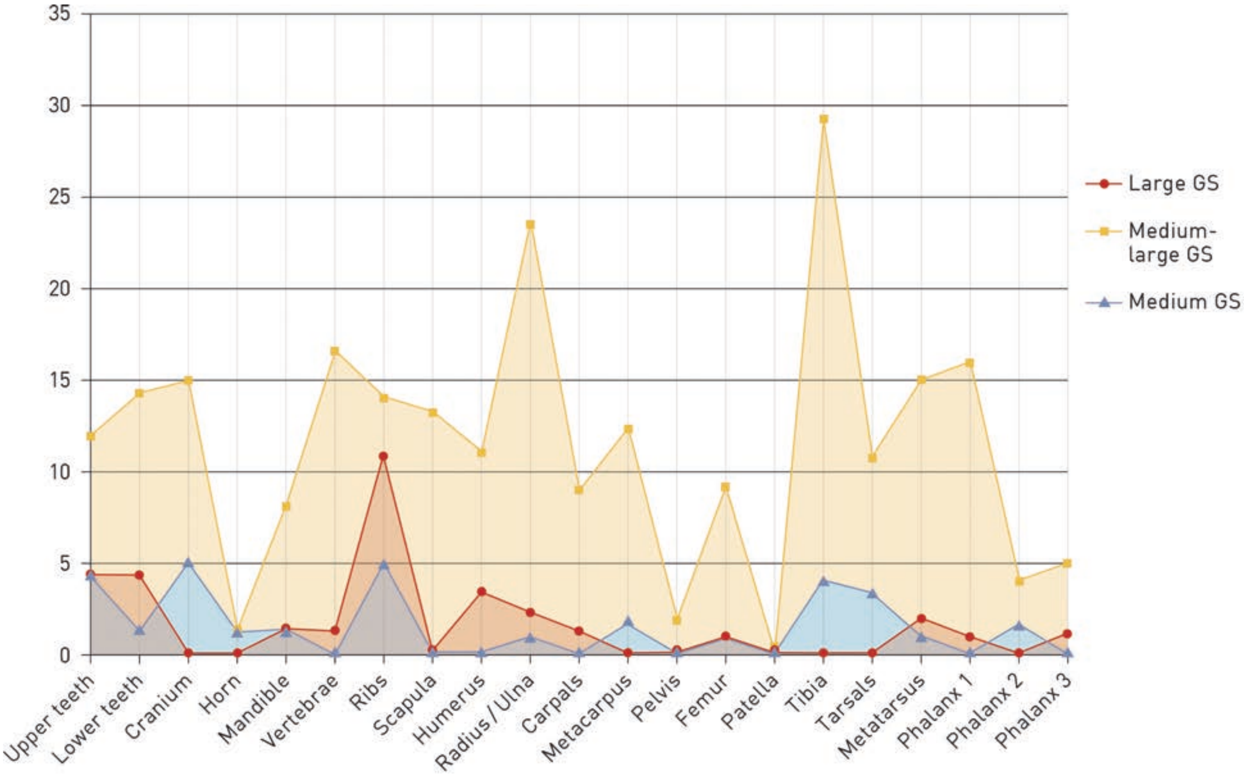


Fig. 9.1.2 Comparative representation of skeletal elements of large, medium-large and medium animal-size groups from all units in S8-GS; all elements, including those identified to species, are included in the size groups.

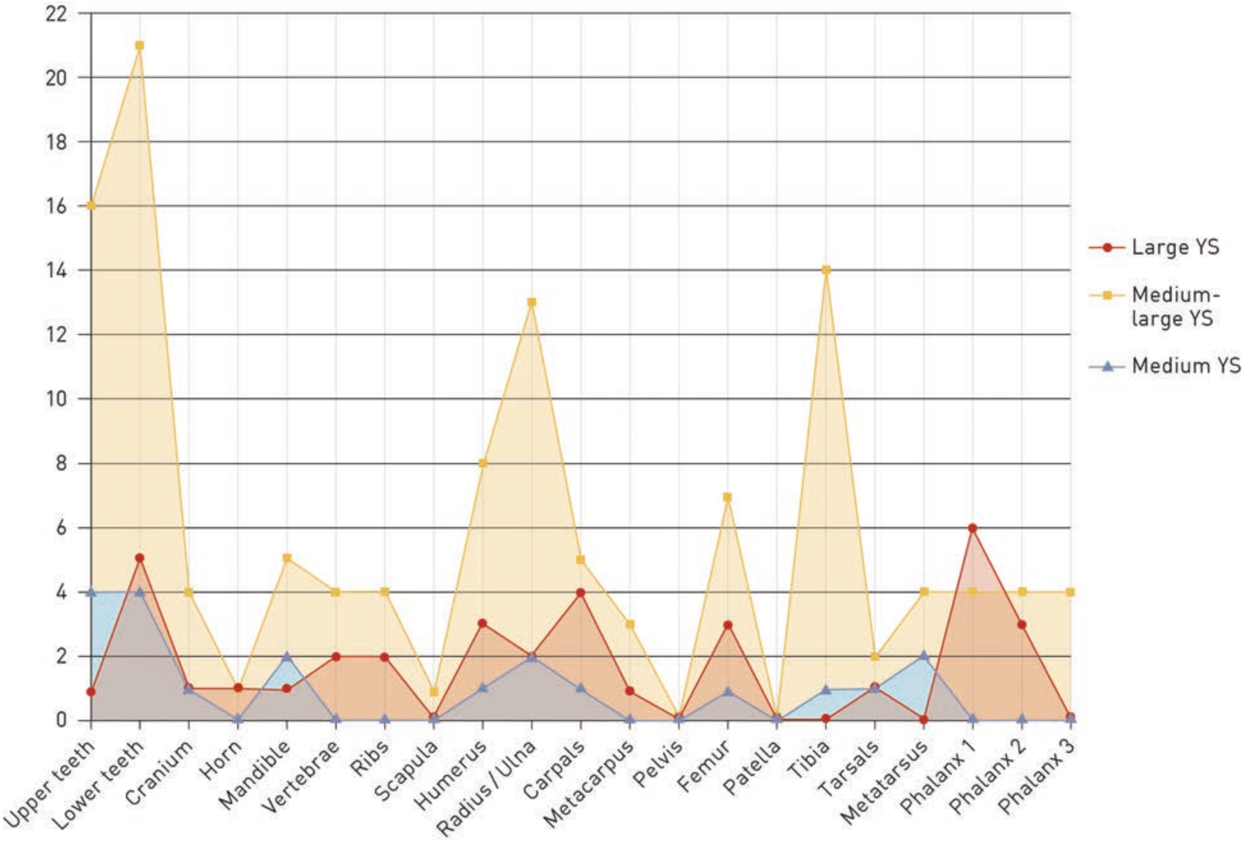


Fig. 9.1.3 Comparative representation of skeletal elements of large, medium-large and medium animal-size groups in YS Y1-Y4spit2 of S8; all elements, including those identified to species, are included in the size groups.

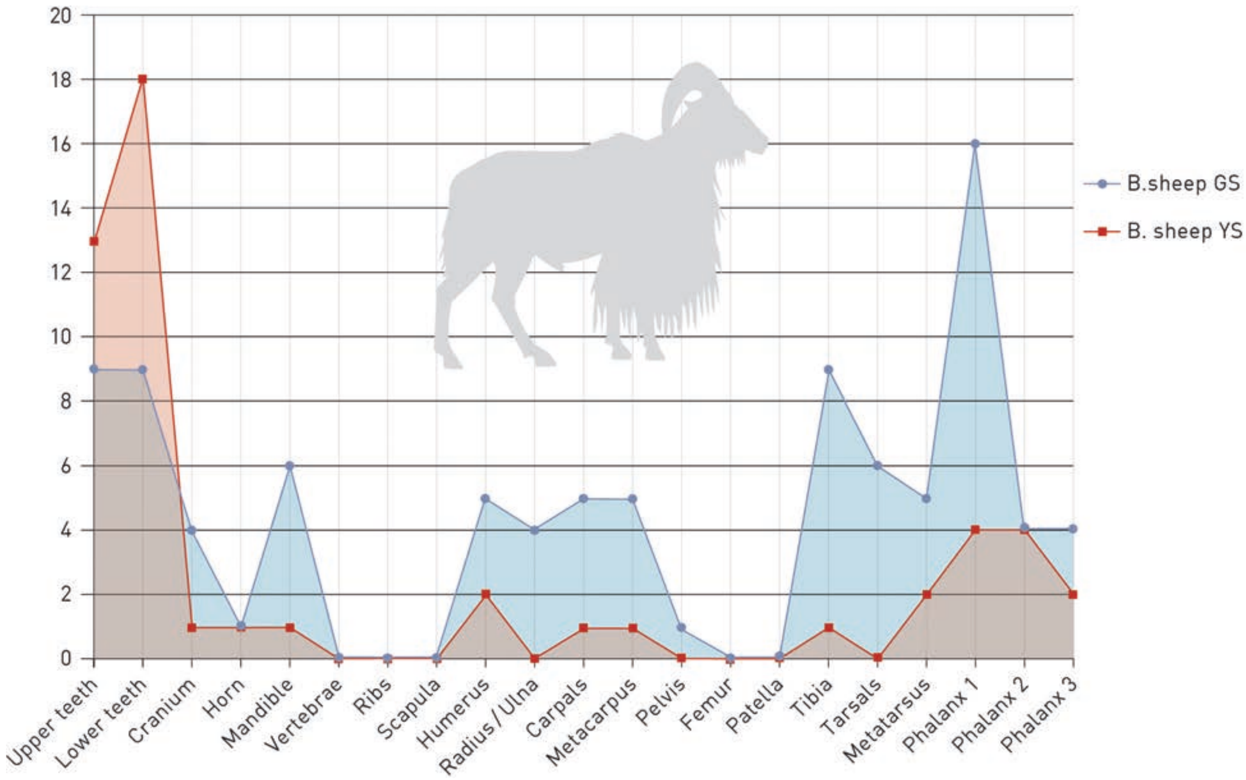


Fig. 9.1.4 Comparative representation of skeletal elements of Barbary sheep from units in GS and from YS Y1-Y4spit2 of S8.

considered fragile. In the case of the vertebrae, counts were slightly higher than those for the upper and the lower teeth, usually the most persistent components in faunal assemblages. Similar patterns of representation were recorded for some elements of the medium-large group in the S8-YS assemblage (**fig. 9.1.3**); for example, high counts for radius/ulna and tibia. In contrast to the S8-GS assemblage (**fig. 9.1.2**), the one from S8-YS is characterised by very high counts of upper and lower teeth (**fig. 9.1.3**). Counts for vertebrae and ribs are higher in S8-GS than in S8-YS.

Remains attributed to the large and medium size groups in S8-YS are characterised by low counts in general and an absence of many elements, particularly in the large size group. Where higher counts were available for the medium group, they tended, at least in the S8-GS assemblage, to reflect the pattern recorded for medium-large animals, producing relatively high counts for cranium, ribs and tibia (**fig. 9.1.2**). In the S8-YS assemblage, a different pattern emerged for the medium size group with lower teeth, mandible, radius/ulna and metatarsus dominating (**fig. 9.1.3**). The strong over-representation of fragments of ribs in the large size group from S8-GS (**fig. 9.1.2**) is a pattern of element representation which differed appreciably from that observed in the other size groups. This may simply reflect the fact that large animals have a more robust bone structure in general, so that even elements with low survival potential, such as ribs, are recovered in proportionally larger quantities or could, again, reflect chance recovery of an accumulation of ribs from a large animal in a small excavation area.

In an attempt to detect details relating to skeletal part occurrence not revealed in **figures 9.1.1-9.1.3**, counts of individual elements were depicted for the main game at Taforalt, Barbary sheep. **Figure 9.1.4** compares the representation of elements of Barbary sheep in the S8-GS and S8-YS assemblages. Strong biases in element representation are apparent, relating, for the most part, to the robusticity or fragility of the bones. Thus, the absence of vertebra, rib, scapula and patella in both assemblages is consistent with a natural deterioration of these friable elements or parts of these elements, such as the blade of the scapula.

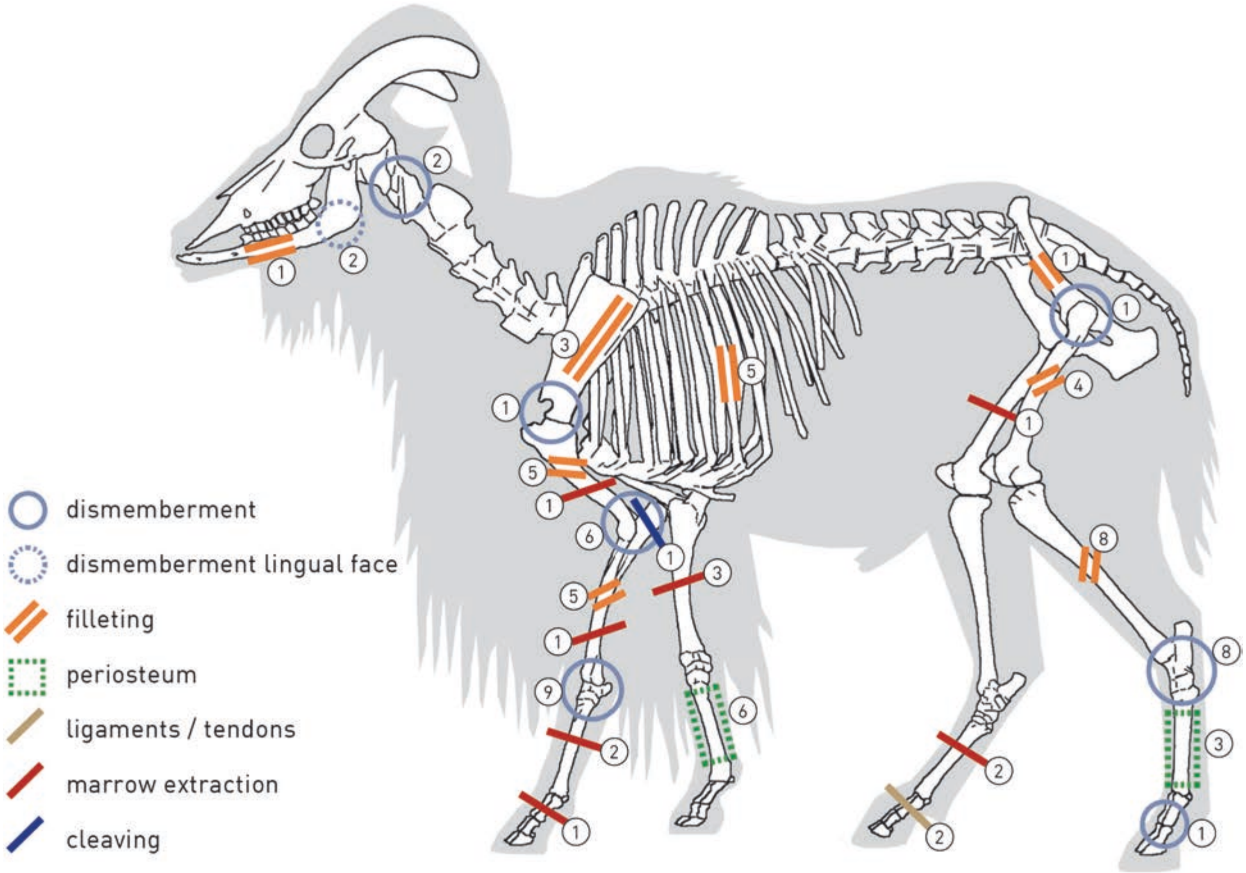


Fig. 9.1.5 Schematic depiction of traces of butchery on the bones of Barbary sheep and animals of the medium-large size group from the GS assemblage of S8; numbers in circles indicate the number of times the butchery stage was recorded on a certain bone; note that the position of the traces on the bones does not necessarily reflect the exact position of the marks; unidentifiable shaft fragments ('long bones') not depicted.

Teeth, the dominant element in figure 9.1.1, are also well-represented in both Barbary sheep assemblages, though to a lesser extent in the one from S8-GS, which is dominated by first phalanges. First phalanges and other robust elements, such as mandibles, long bones of the fore limb and foot (humerus, radiocubitus and metacarpus) and rear limb and foot (tibia, metatarsus) are fairly well-represented in the S8-GS assemblage. Despite fewer finds in S8-YS, the pattern of element representation in this assemblage is similar to that of S8-GS. The skeletal representation of Barbary sheep suggests that all body parts were brought to the cave during the accumulation of both the GS and YS units and that the bones left behind in each assemblage were the products of various taphonomic processes, resulting in a loss of fragile elements and an over-representation of more robust finds.

On the whole, the presence of varying proportions of particular skeletal elements in the levels in S8 could mainly be attributable to differential bone survival, where fragile elements were under-represented and robust skeletal parts over-represented. There were some exceptions to this, namely the over-representation of ribs of large animals in the S8-GS assemblage, and the high counts of crania and counts of radius/ulna and tibia higher than those of teeth in the medium-large group in the S8-GS assemblages, suggesting that other factors were also instrumental in the representation of these elements. All body parts of the dominant taxon, Barbary sheep, seem to have been deposited in the cave, where taphonomic processes led to a loss of fragile elements.

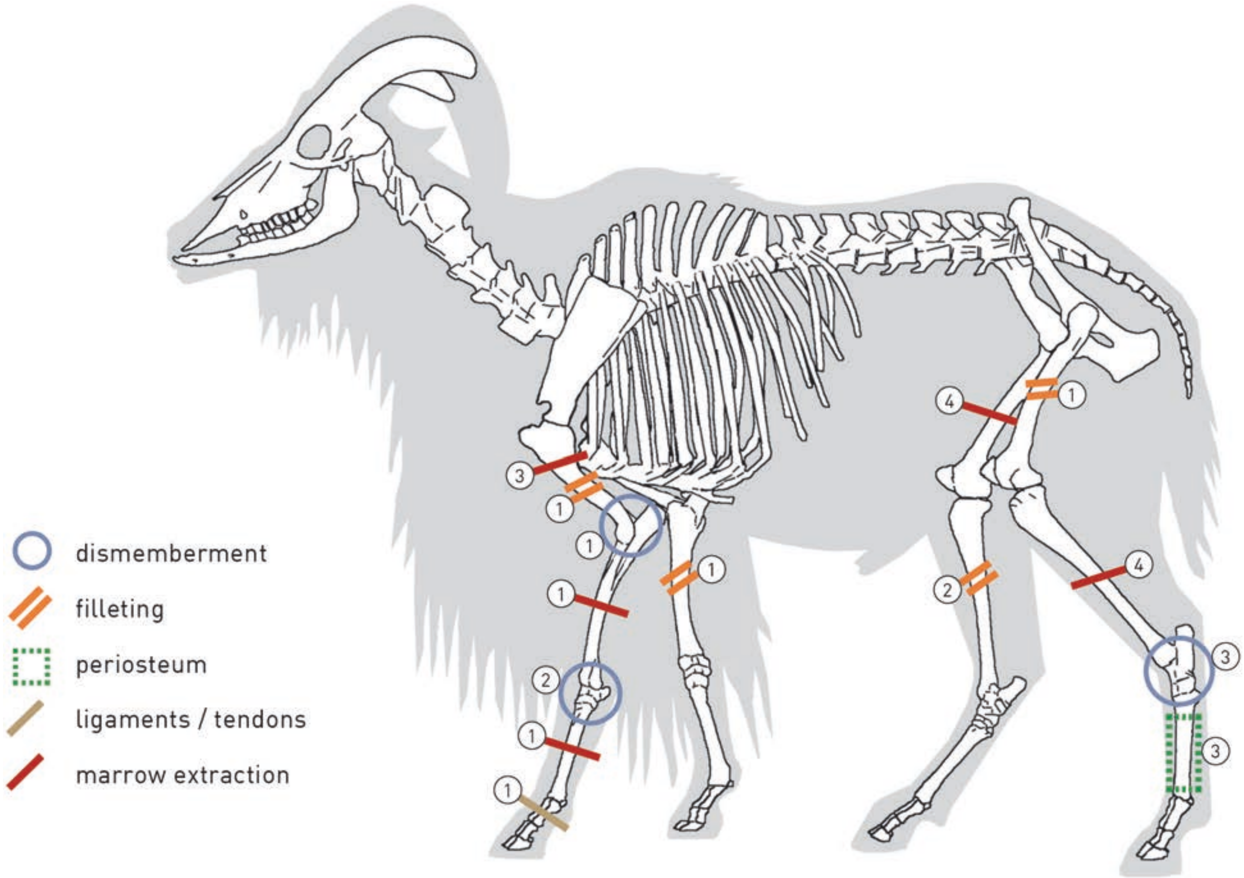


Fig. 9.1.6 Schematic depiction of traces of butchery on the bones of Barbary sheep and animals of the medium-large size group from the YS assemblage of S8; numbers in circles indicate the number of times the butchery stage was recorded on a certain bone; note that the position of the traces on the bones does not necessarily reflect the exact position of the marks; unidentifiable shaft fragments ('long bones') not depicted.

Human Modification

Traces of butchery, such as cut marks resulting from the skinning, eviscerating, dismembering and filleting of animal carcasses, along with evidence of fracturing of bone to obtain marrow and grease, were observed on a total of 111 bones from S8-GS and 46 bones from S8-YS. The total percentage of butchery marks observed on the finds from the S8-GS assemblage (28.7 %) was higher in comparison to that observed in the S8-YS assemblage (15.1 %) (**tab. 9.1.1**). Since there was no association between lower and higher frequencies of marks and poor and good conditions of bone preservation – both assemblages are, in fact, very well-preserved – the higher percentages of butchery marks in the former assemblage probably reflects the more rigorous processing of animal carcasses during the accumulation of the GS deposits.

Summaries of butchery traces on bones identifiable to taxon in the S8-GS and S8-YS faunas are presented in **tables 9.1.3** and **9.1.5**, whereas **tables 9.1.4** and **9.1.6** summarise butchery marks on remains attributable to medium-large, medium and large sized animals from these assemblages. In the latter tables, the bulk of the specimens are from the medium-large animal-size group and it is highly likely that the overwhelming majority of these finds derive from the carcasses of Barbary sheep, even if the remains could not be unequivocally identified to this species. Therefore, these specimens are taken as augmenting butchery traces observed on the bones of identified Barbary sheep. The same argument can be applied to the medium size

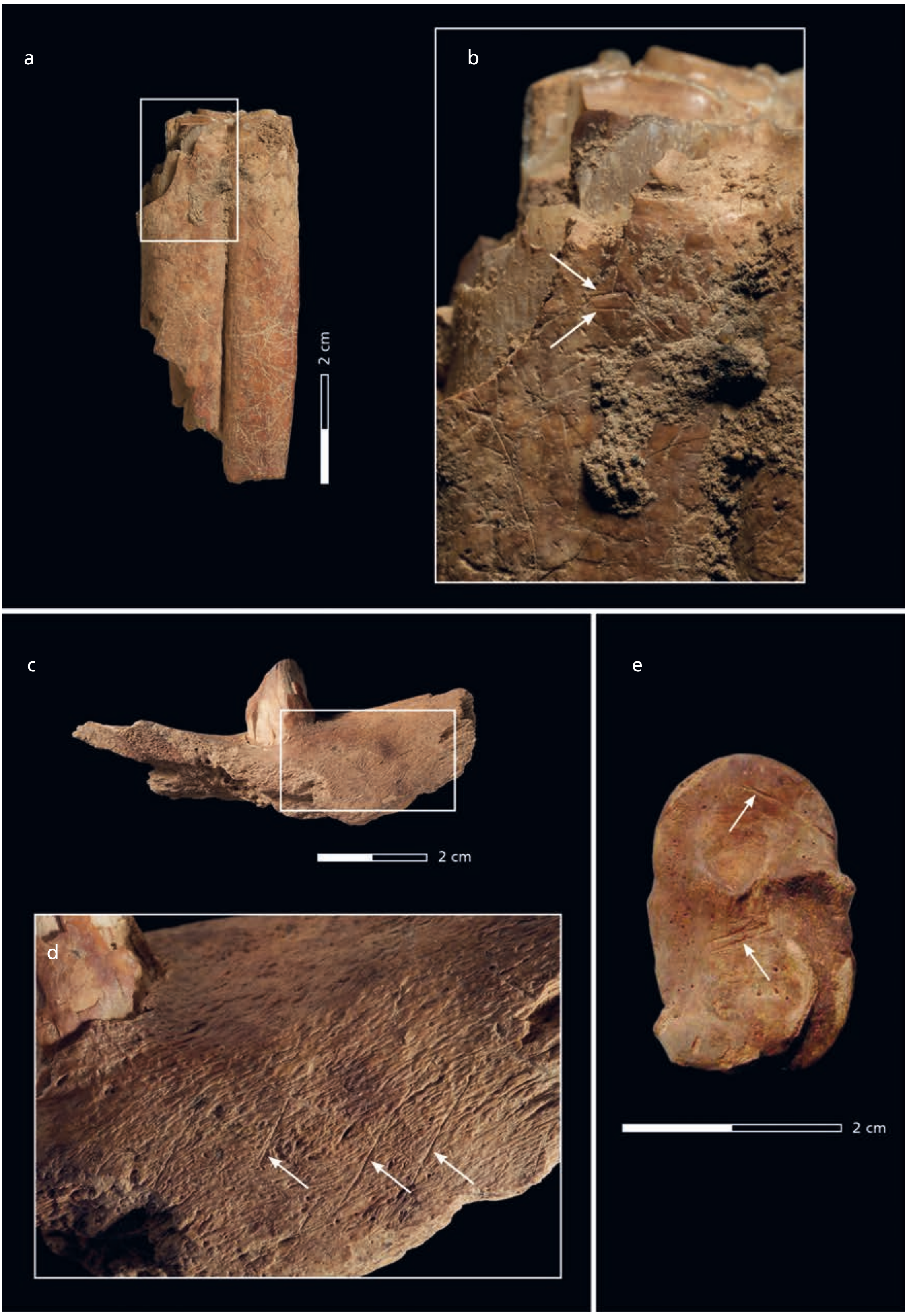
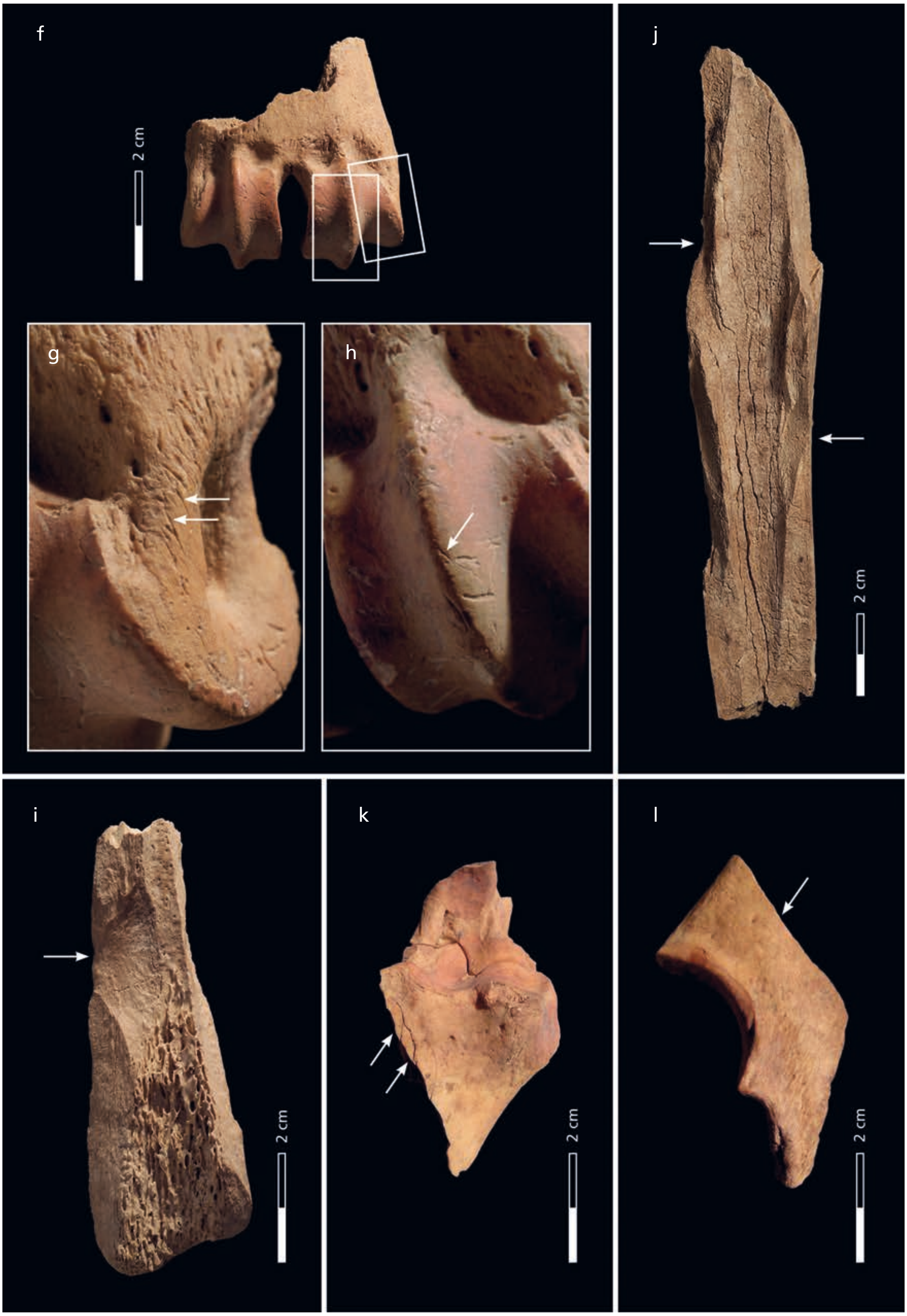


Fig. 9.1.7 Illustrations of butchery traces on faunal remains from the S8-YS and S8-GS assemblages: lower M2 of an equid (**a**) with cut marks on the crown of the tooth produced during removal of gingival tissues (**b**) <TAF10-10422>; mandible of an equid (**c**) with cut marks on lingual face of jaw (**d**) produced during removal of the tongue <TAF04-986>; astragalus of gazelle (**e**) with disarticulation marks on the medial face <TAF09-8916>; distal end of a metacarpus of Barbary sheep (**f**) showing disarticulation marks on the medial face (**g**) and



sagittal ridge (**h**) of the medial trochlea <TAF04-1124>; metacarpus or metatarsus of an equid (**i**) showing large conchoidal flake on inner part of shaft <TAF04-1123> produced during marrow procurement; opposing impact notches on the tibia of a large animal (**j**), indicating use of an anvil <TAF04-1903>; radiocubitus of Barbary sheep (**k**) with impact notches and incipient flakes (arrows) on the dorsal face of the proximal end of the bone <TAF10-9486>; chop mark (arrow) on the olecranon of an ulna of Barbary sheep (**l**) <TAF10-9197>.

Taxa	Units	Skinning	Dismemberment	Filleting	Periosteum	Ligaments/ tendons	Marrow extraction	Multiple traces	Totals
Barbary sheep	L3		carpal (C-1)					metacarpus (dismemberment MCp-1 / longit.split)	
			tarsal (TNC-1)						
	L5							metacarpus (dismemberment MCp-1 / longit. split)	
	L6		humerus (Hd-1, Hd-2 and Hd-3?) radius (RCd-3) * astragalus (TA-2)	tibia					
	L7		tarsal (TE-1)	mandible *		phalange I (tendons)			
				tibia					
	L8			tibia	metacarpus		metatarsus phalange I		
	L11							humerus (dismemberment Hd-2 / oblique Hd-2 / filleting)	
	L12		carpal (C-1)						
	L15		tibia (Td-3) *		metacarpus/ metatarsus			metatarsus (dismemberment MTp-3 / longit.split	
	L17							phalange I (dismember-ment/tendons)	
	L19							radiocubitus (dismemberment RCp-5 / marrow/cleaved)	
	L20		metatarsus (MTp-1)						
	L26			tibia				humerus (filleting/marrow)	
	L28		mandible						
	L29		astragalus (TA-2)	humerus					
Sub-totals		*0*	*11*	*6*	*2*	*1*	*2*	*7*	*29*
Gazelle	L3	cranium							
	L6		tarsal (TNC-1)						
	L13		astragalus (TA-2)						
	L15			tibia	metatarsus				
Sub-totals		*1*	*2*	*1*	*1*	*0*	*0*	*0*	*5*

Taxa	Units	Skinning	Dismemberment	Filleting	Periosteum	Ligaments/ tendons	Marrow extraction	Multiple traces	Totals
Equid	L18 L24 L29			radiocubitus upper tooth lower tooth					
Sub-totals		*0*	*0*	*3*	*0*	*0*	*0*	*0*	*3*
Large bovine	L29			humerus					
Sub-totals		*0*	*0*	*1*	*0*	*0*	*0*	*0*	*1*
Alcelaphines	L12 L13		astragalus (TA-2) carpal (C-1) *						
Sub-totals		*0*	*2*	*0*	*0*	*0*	*0*	*0*	*2*
Totals		**1**	**15**	**11**	**3**	**1**	**2**	**7**	**40**

Tab. 9.1.3 Summary of butchery marks on bones of Barbary sheep, gazelle, horse, large bovid and members of the Alcelaphine group from S8-GS (letters in parentheses e. g. (C-1) denote Binford's (1981) coding system for cut marks; * indicates the bone or one of the bones is from a juvenile individual; longit. split = bone has been split longitudinally).

Animal size group	Units	Skinning	Dismemberment	Filleting	Periosteum	Ligaments/ tendons	Marrow extraction	Multiple traces	Totals
Medium-large	L2			femur tibia* long bones					
	L3		ulna (RCp-2)	humerus (Hd-6) radius (2) tibia* long bone, flat bone	metatarsus				
	L6		atlas vertebra (CV-1) astragalus (TA-2)*	scapula (S-3) humerus long bone*			metatarsus (longit. split)	atlas vertebra (CV-2) dismemberment/cleaved radius (dismemberment/longit. split)	
	L7		carpal (C-1)						
	L8			rib					
	L11			humerus radius*		phalange I			
	L13		scapula	radiocubitus					

Tab. 9.1.4 Summary of butchery marks on bones of animals in the medium-large, medium and large size groups from S8-GS (letters in parentheses e. g. (Hd-6) denote Binford's (1981) coding system for cut marks; * indicates the bone or one of the bones is from a juvenile individual; longit. split = bone has been split longitudinally).

Animal size group	Units	Skinning	Dismemberment	Filleting	Periosteum	Ligaments/ tendons	Marrow extraction	Multiple traces	Totals
	L15			femur*	metatarsus			ulna (RCp-3) (dismem-berment/cleaved) femur (Fp1 / Fp2) (dis-memberment/cleaved)	
	L16			scapula (S-3)					
	L17			rib					
	L18			scapula (S-3)					
	L19		carpal (C-1)	tibia (Tp-3)	metacarpus (2)*			radius (filleting/mar-row)	
	L20		ulna	pelvis femur flat bone	metacarpus				
	L22		carpal (C-1)						
	L24			flat bone			tibia metatarsus		
	L26				metacarpus				
	L28			rib (RS-1)* femur			radius (longit. split)		
	L29		mandible (M-6)	rib (2) long bone (2)	metacarpus				
Sub-totals		*0*	*9*	*31*	*6*	*1*	*4*	*5*	*56*
Medium	L14	cranium							
	L20			rib					
	L23				metacarpus				
	L26						tibia*		
	L29			long bone (2)					
Sub-totals		*1*	*0*	*3*	*1*	*0*	*1*	*0*	*6*
Large	L15						bone flake		
	L16			long bone					
	L19			rib					
	L20			rib					
	L29			long bone; bone fragment					
Sub-totals		*0*	*0*	*5*	*0*	*0*	*1*	*0*	*6*
Totals		**1**	**9**	**39**	**7**	**1**	**6**	**5**	**68**

Tab. 9.1.4 (continued)

group, where the bulk of the finds probably derive from gazelle. Schematical overviews of the butchery traces on remains of Barbary sheep and the medium-large animal-size group are given in **figures 9.1.5-9.1.6** and illustrations of these modifications in **figure 9.1.7**.

Butchery in the Grey Series

Barbary Sheep and Animals in the Medium-Large Size Group
Traces of different stages of butchery were observed on 40 bones identifiable to taxon from S8-GS and the bulk of these (n = 29 / 72.5 %) are the remains of Barbary sheep, the main game animal at the site. A similar situation was recorded for the animal-size groups, for which butchery traces were observed on a total of 71 bones, with bones of medium-large sized animals forming the greater part (n = 56 / 78.8 %).

– Dismemberment of the Carcass
The bulk of the butchery traces on Barbary sheep (n = 11) are cut marks located around the joints of the bones, caused when the carcasses were dismembered (**tab. 9.1.3**). The opposite is the case in the medium-large group, where the bulk of the cut marks derive from filleting (n = 31) (**tab. 9.1.4**). These differences are not indicative of a shift in butchery tactics but simply reflect the ease of identifying to species the proximal and distal ends of bones, where dismemberment marks are generally located, and the difficulties of identifying to species fragments of bone shafts, where the bulk of the filleting marks are found.

– Disarticulating Mandible and Neck
Two sets of scrape-like marks on the buccal face of a mandible of Barbary sheep from S8-L28 (**tab. 9.1.3**) might have resulted from disarticulation of the head and jaw. Cut marks across the masseteric fossa of a mandible (**tab. 9.1.4**, S8-L29, cf. M-6) were probably produced during stripping of the masseter muscle (Binford 1981, 109). Transverse cut marks on the cranial (CV-1) and caudal (CV-2) regions of the ventral surfaces of atlas vertebrae from S8-L6 (**tab. 9.1.4**) indicate the separation of the head from the neck (ibid., 111).

– Disarticulation of the Fore Limb
Cut marks produced when separating the main portions of the fore limb and the foot were recorded on all major joints, including the shoulder, elbow and wrist. Separation of a shoulder blade from the upper part of a fore limb is clearly demonstrated by sets of short, transverse cuts located immediately above the glenoid cavity, on the caudal neck of a scapula (**tab. 9.1.4**, S8-L13).
Several sets of marks around the distal humerus and proximal radiocubitus attest to the separation of the proximal, meatier, section of the fore limb from its less meaty distal part. The distal ends of two humeri of Barbary sheep showed marks clearly produced when this bone was cut out of the deep notch formed by the proximal end of the radiocubitus (**tab. 9.1.3**, S8-L6 and L11). Oblique cuts across the medial faces of both specimens and a mark on the surface of the distal articulation of the bone from L6 are comparable with Hd-2 and Hd-1 respectively, which are commonly produced when this joint is disarticulated (Binford 1981, 124). A set of oblique cuts (oblique Hd-2), higher up on the condyle of the humerus from S8-L11, along with marks located towards the upper margin of the olecranon fossa (Hd-3) on the bone from S8-L6 (**tab. 9.1.3**), may indicate the butchering of flexed joints produced, according to Binford (1981, 126), when the carcass was stiff.
Cut marks were also observed on three proximal ulnas in positions relating to dismemberment of the elbow joint (**tab. 9.1.4**, S8-L3, RCp-2; S8-L15, RCp-3; and S8-L20).

Several cuts on a proximal radius of Barbary sheep (**tab. 9.1.3**, S8-L19, RCp-5) were probably produced during separation of this bone from the humerus. However, the position of the marks on the dorsal edge and on the inner surface of the articulation suggests they were inflicted when the joint had already been partially opened. A single, transverse, mark was observed just above the distal end of an unfused diaphysis of a radius of a juvenile Barbary sheep (**tab. 9.1.3**, S8-L6, RCd-3), and marks in a similar position were observed on the distal end of a radius from an adult animal of medium-large size (**tab 9.1.4**, S8-L6). On the latter bone, the placement of the cut marks again suggests dismemberment when the joint was slightly open or when the joint was flexed. They may be equivalent to Binford's RCd-1, produced during separation of the distal radius from the proximal carpal row (ibid., 126).

– Disarticulation of the Hind Limb

Similar patterns of carcass preparation were noted for the rear leg, with practically all major joints – pelvis, knee and ankle – bearing traces of marks produced during dismemberment.

Two sets of typical dismemberment marks were observed on the neck and on the head of a femur (**tab. 9.1.4**, S8-L15, Fp-1 and Fp-2). These marks are inflicted while severing connecting tissues after dislocation of the femur head from the pelvic socket (Binford 1981, 116).

By far the most common dismemberment mark on the distal tibia is produced by cutting across the dorsal (anterior) surface of the bone when the leg is straight or outstretched (ibid., 119). Binford states that, if this action is carried out lower down on the bone, the marks may continue over the medial face of the joint, leaving cuts on the medial side of the astragalus and the medial distal tuberosity of the tibia. Marks similar to these were observed on three astragali (**tabs 9.1.3**, S8-L6 and L29, TA-2; **9.1.4**, S8-L6, TA-2) and on the unfused distal epiphysis of a tibia from a young individual of Barbary sheep (**tab. 9.1.3**, S8-L15, Td-3).

According to Binford (1981, 119) an alternative method of separating the tibia from the foot is to cut between the tarsals and the proximal metatarsal. Application of this technique leaves behind transverse marks encircling the joint and cuts similar to these were found on a naviculo-cuboid (**tab. 9.1.3**, S8-L3, TNC-1), an internal cuneiform (**tab. 9.1.3**, S8-L7, TE-1), and on the proximal ends of the shafts of two metatarsals (**tab. 9.1.3**, S8-L20, MTp-1; S8-L15, MTp-3).

– Disarticulation of the Foot

Transverse cut marks on the dorsal or outer faces of carpal bones (**tab. 9.1.3**, S8-L3, C-1; S8-L12 cf. C-1; **tab. 9.1.4**, S8-L7 L19 and L22, cf. C-1) and proximal ends of metacarpals (**tab. 9.1.3**, S8-L3 and L5, MCp-1) also attest to the dismemberment of the foot from the lower fore limb (ibid., 126).

Cut marks on the distal end of a first phalange (**tab. 9.1.3**, S8-L17) may attest to the separation of distal elements of the foot.

– Filleting

Filleting marks were visible on a fragment of a mandible of a juvenile Barbary sheep (**tab. 9.1.3**, S8-L7). The marks are longitudinal and located on the lingual face of the bone, just behind the second molar.

Cut marks on the shafts of seven long bones of Barbary sheep (**tab. 9.1.3**) and on 34 remains of medium-large sized animals (**tab. 9.1.4**) could be attributed to filleting.

Three scapulae (**tab. 9.1.4**, S8-L6, L16 and L18) bore traces of filleting of strips of meat from the blade. The specimen from S8-L16 had longitudinal cut marks on both the medial and lateral faces. The latter are comparable with Binford's S-3 marks (1981, 98). Oblique cuts were recorded on a scapula from S8-L6 and L18 but they were probably inflicted during filleting activities too. Binford writes that filleting the scapula is normally associated with meat drying activities (ibid., 98).

Meat had been removed from a total of five ribs. One of these finds (**tab. 9.1.4**, S8-L28, RS-1) bore cut marks just lateral to the head of the rib, usually produced during removal of the tenderloin (ibid., 113). A cut on a fragment of a pelvis (**tab. 9.1.4**, S8-L20) may also have been produced during the stripping of meat.
The majority of the filleting marks were located on major bones of the limbs. These include six humeri, five radii or radiocubiti, four femora and eight tibiae. Filleting marks comparable to Binford's Hd-6 (ibid., 131) were observed on one of the humeri (**tab. 9.1.4**, S8-L3) and oblique cut marks close to the *crista tibiae* on the tibia from S8-L19 (**tab. 9.1.4**) resembled Binford's Tp-3 marks (ibid., 130). In addition, six pieces of not further identifiable long bones and three fragments of flat bones also bore marks which can probably be attributed to the removal of meat.

– Periosteum

Short, often oblique, cuts on the shafts of metacarpals and metatarsals may have been produced in conjunction with filleting activities in general but, on meatless metapodials, are more likely to be associated with the intentional stripping of the periosteum. Removal of this tough, fibrous membrane would have ensured a cleaner breakage of the bone during marrow procurement. Six metacarpals, two metatarsals and an unidentified metapodial bore these traces (**tabs 9.1.3-9.1.4**).

– Ligaments and Tendons

A set of short, transverse, scrape-like cuts is present mid-shaft on the dorsal face of a first phalange of Barbary sheep (**tab. 9.1.3**, S8-L7) and transverse cuts are also visible towards the distal end of the dorsal face of a first phalange from the medium-large group (**tab. 9.1.4**, S8-L11). The position of the cuts suggests they were produced when ligaments were severed (Parkin/Rowley-Conwy/Serjeantson 1986, 325).

– Marrow Procurement

Hammerstone-induced impact notches were observed on a metatarsus and a first phalange of Barbary sheep (**tab. 9.1.3**, S8-L8) and on a radius and a metatarsus from the medium-large sized group (**tab. 9.1.4**, S8-L24). Splitting bones open longitudinally and chopping through the joint also seemed to be options to obtain marrow or grease, and specimens with these characteristics were found throughout the units (**tabs 9.1.3-9.1.4**).

– Multiple Traces of Butchery

12 of the bones had undergone more than one stage of butchery (**tabs 9.1.3-9.1.4**). Some bore cut marks produced during dismembering and filleting; other marks were produced during filleting and removal of ligaments. Several showed cut marks and evidence of marrow fracturing, longitudinal splitting or chopping. One specimen, a radiocubitus of Barbary sheep (**tab. 9.1.3**, S8-L19), had been disarticulated from the carcass, opened to remove marrow and the proximal joint had been chopped, probably to obtain bone grease.
Both adult and juvenile animals had been butchered and a total of eleven butchered bones was attributed to juveniles. Cut marks produced during dismemberment, filleting and removal of periosteum were recorded on 3 bones of juvenile Barbary sheep and eight bones of juveniles in the medium-large animal-size group.

Alcelaphines

A tarsal and a carpal bone from members of the alcelaphine group displayed cut marks (**tab. 9.1.3**). The astragalus in S8-L12 was identified on morphological grounds as *Alcelaphus buselaphus*. The carpal bone from S8-L13 is from a juvenile alcelaphine. Both bones showed marks associated with dismemberment: separation of the tibia-tarsal joint (TA-2) on the astragalus from S8-L12, and separation of the radius from the proximal carpal row in the case of the specimen from S8-L13 (cf. C-1).

Gazelle and Animals in the Medium Size Group

Cut marks were observed on 5 bones of gazelle, attesting to skinning, dismemberment (**fig. 9.1.7e**), filleting and removal of the periosteum (**tab. 9.1.3**). None of the gazelle bones from the S8-GS assemblage showed any form of marrow extraction but traces of these activities were recorded on bones from medium sized animals, namely a tibia of a juvenile (**tab. 9.1.4**, S8-L15).

Gazelle was the only animal to produce bones which showed signs of skinning. A set of short, oblique cut marks was observed on the fragment of a cranium of gazelle (**tab. 9.1.3**, S8-L3). These cuts led away from the edge of the orbit and crossed the zygomaticus bone. They were probably produced when the head of the animal was skinned. Two cut marks on a fragment of a cranium of a medium-sized animal may also have been produced during skinning (**tab. 9.1.4**, S8-L14).

Equids

Cut marks were present on one equid bone and on two teeth. Oblique marks on the shaft of a radius attest to the filleting of this bone (**tab. 9.1.3**, S8-L18). The cut marks on the teeth are located on the upper part of the crown at a level corresponding to the basal and dorsal edges of the maxilla and mandible respectively (**tab. 9.1.3**, S8-L24 and L29). Both sets of marks would have been produced while cutting parallel to the edges of these bones, when the gingival tissues were cut away. On the specimen from S8-L24 (upper M1/2), stone tools had nicked the anterior pillar (parastyle) on the buccal face and, on the specimen from S8-L29 (lower P3/4), had cut into the lingual face of the crown. The roots of the tooth had not closed on the latter specimen, indicating it was from a young adult. Cut marks in these positions on upper and lower molars of equids have been recorded in European contexts, where excellent examples are known from Late Glacial sites in particular (Turner 2002, 48; Street/Turner 2013, 99).

Large Bovines and Animals in the Large Size Group

One bone of a large bovine, a humerus, showed cut marks (**tab. 9.1.3**, S8-L29). These are located on the shaft and were presumably produced during filleting.

In addition, two long bones, two ribs and a bone fragment from the large animal-size group showed cut marks which could be associated with filleting activities (**tab. 9.1.4**). A detached flake from the bone of a large animal was recovered in S8-L15 (**tab. 9.1.4**) and attests to marrow procurement in this group.

Butchery in the Yellow Series

Evidence of butchery was observed on only eleven identifiable animal bones from the S8-YS assemblage and five (45.5 %) of these could be identified as Barbary sheep. A higher count of 34 bones was recorded for the animal-size groups, of which 25 (73.5 %) are from the medium-large size group.

Barbary Sheep and Animals in the Medium-Large Size Group

– Dismemberment of the Carcass

Marks produced during dismemberment (**fig. 9.1.7f-h**) were prevalent among the Barbary sheep remains (**tab. 9.1.5**), but the larger proportion of cuts on remains from the medium-large group derived from filleting (**tab. 9.1.6**). A similar discrepancy was observed between dismemberment and filleting cut marks on Barbary sheep and medium-large animals in the GS assemblage and ascribed to biasing due to problems of identification to species of shafts of bones (see above).

	Unit	Skinning	Dismemberment	Filleting	Periosteum	Ligaments/tendons	Marrow extraction	Multiple traces	Totals
Barbary sheep	Y1			humerus		phalange I			
	Y2		tibia (Td-3) metacarpus (MCd-2) metatarsus (MTp-3)						
Sub-totals		*0*	*3*	*1*	*0*	*1*	*0*		*5*
Equid	Y1			lower tooth (gingival tissue) mandible (removal tongue)	metacarpus/ metatarsus 2 or 4				
	Y2				metacarpus/ metatarsus 2 or 4		1 metacarpus/ metatarsus		
Sub-totals		*0*	*0*	*2*	*2*	*0*	*1*		*5*
Large bovine	Y2							metacarpus/metatarsus (periosteum/marrow)	
Sub-totals		*0*	*0*	*0*	*0*	*0*	*0*	*1*	*1*
Totals		**0**	**3**	**3**	**2**	**1**	**1**	**1**	**11**

Tab. 9.1.5 Summary of butchery marks on bones of Barbary sheep, gazelle, horse, large bovid and members of the Alcelaphine group from S8-YS (letters in parentheses e. g. (Td-3) denote Binford's (1981) coding system for cut marks; * indicates the bone or one of the bones is from a juvenile individual).

Animal-size group	Unit	Skinning	Dismemberment	Filleting	Periosteum	Ligaments/ tendons	Marrow extraction	Multiple traces	Totals
Medium-large	Y1				metatarsus		1 humerus	radius (dismemberment RCP-1 / filleting)	
			tarsal (TE-1)	tibia	metacarpus/metatarsus		1 radius		
				long bone			1 metacarpus		
							1 long bone		
	Y2		long bone					femur (filleting/marrow)	
							femur (2)	tibia (filleting/marrow)	
				long bone (2)			tibia (3)		
							long bone		
	Y4				metacarpus/metatarsus		humerus (2)		
Sub-totals		*0*	*2*	*4*	*3*	*0*	*12*	*3*	*24*
Medium	Y1		rib						
								metacarpus/metatarsus (dis-memberment/periosteum)	
	Y2			long bone			femur (2)		
	Y4				metacarpus				
Sub-totals		*0*	*1*	*1*	*1*	*0*	*2*	*1*	*6*
Large	Y1			long bone	metatarsus				
	Y2			humerus			tibia		
Sub-totals		*0*	*0*	*2*	*1*	*0*	*1*	*0*	*4*
Totals		**0**	**3**	**7**	**5**	**0**	**15**	**4**	**34**

Tab. 9.1.6 Summary of butchery marks on bones of animals in the medium-large, medium and large size groups from S8-YS (letters in parentheses e. g. (TE-1) denote Binford's (1981) coding system for cut marks; * indicates the bone or one of the bones is from a juvenile individual).

– Disarticulation of the Fore Limb and Foot

Dismemberment marks were recorded on the elbow and wrist joints. One set of short marks, located close to the proximal end of the shaft of a radius, is comparable with Binford's RCp-1 cuts, produced during separation of the elbow joint (**tab. 9.1.6**, S8-Y1).

Sets of short, oblique cut marks positioned on the posterior edges of a distal condyle and distal keel of a metacarpus (**tab. 9.1.5**, S8-Y2, MCd-2) were inflicted during dismemberment and indicate separation of the foot bone from the distal segment of the limb.

– Disarticulation of the Hind Limb and Foot

The location of two short, oblique cut marks across the face of the medial malleolus of a distal tibia (**tab. 9.1.5**, S8-Y2) of Barbary sheep correspond to Binford's Td-3 (1981, 119), a common mark produced during disarticulation of the tibia-tarsal joint. Transverse cut marks on the proximal end of a metatarsus (**tab. 9.1.5**, S8-Y2, MTp-3) and on a tarsal bone (**tab. 9.1.6**, S8-Y1, TE-1) attest to the removal of the foot bone from the tarsal row.

– Filleting

Cut marks which were probably produced during filleting were observed on several major limb bones, including a humerus of Barbary sheep from S8-Y1 (**tab. 9.1.5**), a radius, a femur and two tibiae (**tab. 9.1.6**, S8-Y1 and Y2). Fragments of three long bones, not identifiable to skeletal element (**tab. 9.1.6**, S8-Y1 and Y2), were placed into this category, although the cut marks on these finds could have been produced during removal of the periosteum.

– Periosteum

Three fragmentary metapodials (**tab. 9.1.6**) bore traces of cut marks on their shafts probably produced during removal of periosteal tissues.

– Ligaments and Tendons

Cut marks possibly produced during the removal of sinews were only observed on a single first phalange of Barbary sheep (**tab. 9.1.5**, S8-Y1). The marks are located on the lateral or medial face of the shaft and comprise at least two groups comprising several, short oblique cuts.

– Marrow Procurement

A total of 14 bones of medium-large sized animals bore impact notches resulting from marrow procurement (**tab. 9.1.6**). These comprise major limb bones of the fore leg (3 humeri; 1 radius; 1 metacarpus), the hind leg (3 femora; 3 tibiae) and two unidentifiable long bones. Impact notches were not observed on bones identifiable to Barbary sheep and evidence of longitudinal splitting and chopping was not found on bones of this species or on bones of medium-large sized animals.

Animals in the Medium Size Group

Evidence of butchery was observed on a total of only six bones in this size group (**tab. 9.1.6**). None of these finds could be definitely identified to a species. Transverse cuts on the shaft of a rib and a metacarpus or metatarsus (**tab. 9.1.6**, S8-Y1) derive from dismemberment. The remaining finds in this group bear cut marks resulting from filleting or removal of periosteum and marrow extraction. A metacarpus or metatarsus (**tab. 9.1.6**, S8-Y1) had been dismembered and periosteum had been removed from this bone at a later stage of butchery.

Equids

Evidence of butchery was recorded on five remains identified to an equid (**tab. 9.1.5**). Stripping gingival tissues was also performed in S8-Y1, as indicated by a set of transverse cut marks on a lower M2 of an adult individual (**fig. 9.1.7a. b**). Several isolated, oblique cut marks positioned behind the canine on the lingual face of a mandible (**fig. 9.1.7c. d**), were caused as the muscles attaching the tongue to the symphysis were severed (Parkin/Rowley-Conwy/Serjeantson 1986, 321). Sets of long, oblique cuts on a second or fourth metacarpus or metatarsus (S8-Y1) and deep cuts on the lateral edge of a second auxiliary metacarpus or metatarsus in S8-Y2 were probably inflicted when the periosteal sheath was removed from the articulated bones of the foot. A third metacarpus or metatarsus had been opened for marrow (**fig. 9.1.7i**).

Large Bovines and Animals in the Large Animal-Size Group

A long oblique cut mark was observed transversing the sulcus on a fragment of a metacarpus or metatarsus of a large bovine. This bone had been subsequently broken open to obtain marrow (**tab. 9.1.5**, S8-Y2). Four fragmentary bones with evidence of butchery were assigned to the large size group (**tab. 9.1.6**). Cut marks were observed indicating filleting and removal of periosteum in S8-Y1 and Y2. Opposing impact notches are present on the lateral face of a tibia (S8-Y2) (**fig. 9.1.7j**).

Butchery – Summary of Results

Despite the differences in counts of bones bearing evidence of human butchery (with an average of about a six-fold increase in butchery marks between the YS and GS, once indexed by sedimentation rates) in the assemblages, the traces recorded during this analysis indicate that standard techniques of butchering were employed and, more importantly, maintained during the time-phase represented by the GS and YS deposits exposed in S8. For example, in Barbary sheep and animals of medium-large size, the separation of the fore and hind feet from the rest of the leg, illustrated by the C-1, MCp-1, MTp-1, TNC-1 and TE-1 marks, occurred on bones in many of the units in S8-GS and some of these marks were also present in the S8-YS assemblage. Meat was filleted from the bones, the periosteum was removed, a small number of first phalanges testify to the removal of ligaments from the foot, to obtain sinews, and several major limb and foot bones were opened to extract marrow and bone grease. Absent in the S8-YS assemblage are traces associated with the butchery of the head and axial regions of the body, but this may be due to the much lower numbers of axial elements in the YS assemblage in general. There was also no evidence of longitudinal splitting and chopping of bones in the YS assemblage. It is interesting that the same techniques of butchery were applied to animals of different sizes, as illustrated by the presence of C-1 and TA-2 cut marks on the bones of gazelle, Barbary sheep and members of the alcelaphine group in the S8-GS assemblage.

Burning

Traces of burning were recorded on a total of 50 bones from the S8-GS assemblage and on 21 bones from the S8-YS assemblage (**tabs 8.1.1** and **8.7**), again, a 6-fold increase if indexed against sedimentation rates. These bones comprise remains of gazelle, Barbary sheep and equids and those of animals in the small, medium and medium-large size groups in the S8-GS assemblage. Burning was not recorded on bones identifiable to members of the alcelaphine group and the large bovines, and burnt equid bones are absent in the S8-YS assemblage.

Practically all parts of the skeleton were present amongst the burnt bones and burning was recorded on crania, mandibles and teeth, vertebrae, ribs, pelvis, major long bones of the limbs and feet, carpals, tarsals and phalanges.

As was to be expected, the bulk of the burned remains in the S8-GS assemblage (n = 37), is from Barbary sheep and the medium-large animal-size group, reflecting the dominance of the remains of this animal and animals of comparable size in the assemblages as a whole. The same pattern is shown by counts of bones bearing traces of butchery and burning, where medium-large sized animals and Barbary sheep also produced the highest counts of finds (n = 13) with these traces. The highest counts of burnt bones in the S8-YS assemblage (n = 13) also derived from remains of Barbary sheep and the medium-large size group. A total of 15 bones from the S8-GS assemblage and only 2 from the S8-YS assemblage showed signs of butchery (cut marks; marrow smashing) and burning.

All burnt finds were recorded using Stiner's (2005, 45 tab. 3.3) categories of burning damage. Although the total numbers of burnt finds were hardly sufficient to provide a viable impression of the burning of bone in the assemblages, an indication of the different degrees of burning could be gained from some of the units. The bulk of the faunal remains in both S8-GS (n = 336) and S8-YS (n = 283) show no traces of burning. In the S8-GS assemblage, varying stages of burning were present from slightly burnt (Stiner's stage 1) to fully calcined (Stiner's stage 6) in S8-L3 (n = 9), in S8-L13 (n = 7), slightly burnt to more than half calcined (Stiner's stage 5). In contrast, the twelve burnt bones in S8-Y2 were more or less equally distributed through stages 1 – 3. Abundant calcined bones (stage 6), characteristic of the use of bone as a fuel (Costamagno / Théry-Parisot / Brugal / Guibert 2005), are not present in any of the units in S8. However, post-depositional taphonomic effects could account for the low numbers of calcined bone, since these are more susceptible to fragmentation and loss (Stiner / Kuhn / Weiner / Bar-Yosef 1995). Burning of bone could have taken place during the roasting of meat or the deliberate dumping or accidental incorporation of bone debris into one of the many fires lit in the cave during occupation.

Age Structures of the Major Species of Game

Using tooth eruption and wear schedules, Stiner (1994) defined three major age-classes – juvenile, prime adult and old – for her assessments of mammalian mortality patterns. These are used here to assess which age-class or age-classes of game were mainly procured during the LSA at Taforalt. In accordance with Stiner's definitions, "juveniles" comprise animals from birth up till the age when the last taxon-dependent deciduous tooth is lost, "prime adult" is the breeding age and "old" are animals past their prime. Lyman (1994) additionally defined the juvenile and old classes as representing the first 20 % and last 30 % of the natural longevity of an animal.

Barbary Sheep

Although mortality ages using standard techniques of crown height measurements and eruption and wear schedules are well established for one of the taxa at Taforalt – the equids (Habermehl 1961; Levine 1979; 1982; 1983) – and can be successfully applied in establishing age-classes for this family (Turner 2002; Street / Turner 2013), major problems were encountered in assessing the mortality ages and age-classes of the dominant game at Taforalt, the Barbary sheep. These problems are related to the sparse information available on natural longevity and tooth eruption and wear schedules for this species.

Thus, it was necessary to establish a framework to assess the mortality patterns of Barbary sheep from Taforalt. For the youngest group, the juveniles, this was fairly straightforward and, following Stiner (1994),

	Sed. Group	Small	Medium	Medium-large	Large	Barbary sheep	Gazelle	Equid	Totals
Burnt	GS	2	1	24	4	13	5	1	50
	YS	1	2	11	4	2	1	0	21
Butchered and burnt	GS	0	0	9	0	4	2	0	15
	YS	0	0	2	0	0	0	0	2

Tab. 9.1.7 Counts of burnt bones and butchered and burnt bones for different species and animal-size groups in the S8-GS and S8-YS assemblages.

Unit	ID-Number	P3	P4	M1	M2	M3
	LMUM 25	9.21	12.5	7.3	22.2	29.5
L3	7437					34.4
L14	9083		23.9			
L17	9366			18.1		
L20	9551			23.0		
L29	10361				28.4	
L29	708			17.4		
L29	717			17.1		

Unit	ID-Number	P3	P4	M1	M2	M3
	LMUM 25	9.21	12.5	7.3	22.2	29.5
Y1	10748			16.8		
Y1	924			9.9		
Y1	924		12.8			
Y2	6154	20.5				
Y4	1926			11.8		

Tab. 9.1.8 Crown heights (mm) of lower permanent dentition of Barbary sheep from S8-GS (above) and S8-YS (below) (finds are listed according to unit, beginning with the youngest at the top; the two specimens designated 924 are from the same individual animal).

Unit	ID-Number	P3	P4	M1	M2	M3
L14	9061					23.8+
L22	9714	21.6				
L23	9835				30.9	

Unit	ID-Number	P3	P4	M1	M2	M3
Y1	1101			28.6		
Y1	10755			11.7		
Y1	1026					47.8
Y1	944					39.3
Y1	10387					29.9
Y2	1839				30.0	
Y2	6144					40.4

Tab. 9.1.9 Crown heights (mm) of upper permanent dentition of Barbary sheep from S8-GS (above) and S8-YS (below) (finds are listed according to unit, beginning with the youngest at the top; + indicates the tooth was damaged on the occlusal surface and would have been slightly higher).

all deciduous teeth, including those from very young individuals described in the section on seasonality (see below), were placed into this group.

More difficult was the separation of the permanent dentition of adult Barbary sheep into the "prime" and "old" age-classes, since this assessment requires an approximate age of natural longevity. In captivity, Barbary sheep have been known to live for 20-24 years (Kingdon 1997; Ogren 1965; Weigl 2005) and the oldest specimen in the reference collection of aged zoo animals in Munich had attained 17 years. Natural longevity in the wild is, as far as it is known, much shorter: Gray and Simpson (1983) give an age of 10.5 years for free-ranging Barbary sheep in Texas, whilst Ogren (1965, tab. 6) considered Barbary sheep older than nine years as "very old". In her analysis of cementum rings in the teeth of Barbary sheep from Taforalt, Wall-Scheffler (see **Chapter 9.2**) notes a specimen (an upper M3) from S8 with a mortality age of 12 years, which indicates that at least one individual of Barbary sheep at Taforalt reached a high age.

In the present analysis, the natural longevity of Barbary sheep was placed at 10 years. Thus the boundary between the prime adult and old age-classes can be assigned, according to Lyman's calculation (1994), to about 7 years. Radiographs were taken of some of the mandibles of Barbary sheep from the Munich reference collection, so that heights of the crowns of the teeth could be measured, even though the teeth were embedded in the jaws. One of these mandibles was of an adult individual (LMUM 25) which had died at 6 years and 93 days. This individual is slightly younger than the seven years reckoned for the boundary between "prime" and "old" adults. All of its permanent teeth (P2 – M3) are fully in wear, including the third (posterior) lobe of the lower third molar. The lower M1 has only one infundibulum (one of two deep openings on the crowns of the lower molar teeth) remaining, suggesting a fairly advanced stage of wear. Ogren also describes mandibular teeth with this pattern of wear (1965, tab. 6, stage 12), from a Barbary sheep in his sample of approximately seven years old. Thus by using the crown-heights of the teeth of the Munich specimen as a "bench-mark", crown-heights of permanent lower premolars of Barbary sheep from S8 and S10 could be compared and aged into groups younger and older than approximately 6 years (**tab. 9.1.8**).

The juvenile age-group is poorly represented in the assemblages from S8-GS and S8-YS, and only two maxillae with deciduous dentition and two isolated deciduous teeth were recovered from S8 (see below, on seasonality). Very low numbers of deciduous animal teeth are characteristic of fossil assemblages and have been attributed to the differential preservation of thin-walled milk teeth (Levine 1979). Thus, the rarity of deciduous teeth from juvenile Barbary sheep in these deposits is probably related to processes of deposition, burial, preservation or chance recovery in a small excavation area.

In **table 9.1.8**, the crown heights of isolated permanent lower premolars and molars from S8-GS and S8-YS are listed, together with the comparative recent specimen, LMUM 25. The crown-heights of the Taforalt finds are all higher than those of the Munich specimen, indicating animals younger than six years of age and in their prime adult years. Crown heights of the upper premolars and molars are shown in **table 9.1.9**. Since radiographs of the maxilla of LMUM 25 had not been taken, comparative crown heights of an aged individual for the upper teeth are not available. Even so, the bulk of the teeth in **table 9.1.9** appears to be high-crowned and probably belong to prime-adult individuals. An exception to this is the M3 from S8-L14 (ID-number 9061) which, in comparison to the other upper M3s in the sample from S8, is relatively worn down. Otherwise, very heavily worn teeth, indicative of animals past their prime, are not in evidence in the LSA deposits in S8. Barbary sheep form small family herds with a single male attending several females and their offspring (Kingdon 1997, 445). The ages indicated by the wear on the teeth of Barbary sheep from S8 suggests that herds were hunted, but that adults in their prime were preferred.

	Unit	ID-number	Element	Height	Age in years
S8 GS					
	L24	TAF 10023	$M^{1/2}$	51.8	7-9½
	L29	TAF 364	$P_{3/4}$	73.1	4½-6½
	L29	TAF 11086	$P_{3/4}$	46.7	8¼-10¼
S8 YS					
	Y1	TAF 10708	$P^{3/4}$	73.7+	3-6½
	Y1	TAF 426	$M^{1/2}$	66.0	5½-8
	Y1	TAF 10422	M_2	63.8+	6-7
	Y1	TAF 10811	$P_{3/4}$	47.4	8¼-½

Tab. 9.1.10 Crown heights (mm) of upper and lower dentition and ages of large equids from S8-GS and S8-YS.

Equids

The crown heights of a small number of permanent teeth of equid from S8 (**tab. 9.1.10**) were measured and approximately aged by comparing them with crown measurements given by Levine (1982). By setting the natural longevity at 20 years (Klingel/Klingel 1966) and applying the system of age-classes defined by Stiner (1994) and Lyman (1994), it was possible to define the following groups for the equids: juveniles – between birth and the end of their third year; prime adults – between 4 and 12 years; and old adults – between 12 and 20 years of age. The finds from S8-Y1 have produced some information. There was only one deciduous tooth from this unit, indicating a very low number of juveniles. The crown height of this tooth, a lower dp4 <TAF04-985>, was measured and aged using a technique developed by Bignon (2006; 2008) which established a synthetic frame of reference of dental eruption/replacement based on crown heights using material from recent reference collections. Linear regressions of these data permit an accurate calculation of mortality age. According to Bignon's method, the age of this equid was reckoned at around 13 months at death. Studies (Klingel 1965; 1969a; 1969b) have shown that wild horses occur together in two different types of groups: family groups and bachelor groups. The family group consists mainly of females, accompanied by their young and a single stallion. This group can consist of all age-categories from very young foals to older adults. As its name suggests, the bachelor group comprises only males. Since young males leave the family group at around 2-4½ years of age to join the bachelor groups, the main difference between the groups is the presence of young individuals less than two years of age in the family group. At 13 months of age, the individual from S8-Y1 would probably have been living in a family group. The remaining teeth are all from adult individuals. Crown heights could be measured on only three teeth from S8-GS; these are from animals in their prime years.

Gazelle

Little additional evidence could be derived from the few teeth of gazelle scattered through the units of S8-GS and S8-YS. A mandible with deciduous teeth was present in GS-L6 and an isolated upper dp4 in GS-L24. Permanent molars from adult animals were recovered in GS-L24 (an upper M2 and a lower and an upper M3) and an isolated upper M3 from GS-L23. A well worn lower M2 from an older adult was stratified in S8-Y1 and a small assemblage of deciduous and permanent teeth comprising a lower dp4 from a juvenile and a lower P2 and upper M3 from adult animals in S8-Y2.

The numbers of teeth of Barbary sheep, large equids and gazelle from the S8 deposits was relatively small and could only give a few indications of the age of animals – young, adult, old – hunted by the Iberomaurusians at Taforalt. All age-groups were present, even if represented by only one tooth. Teeth of adult individuals dominate; some are from prime adults.

Seasonality

The age at death of an animal can sometimes be equated with seasonality. Remains of foetal or very young animals (neonate/infantile) play an important role here, since the time of death of young individuals can be pinned down more accurately in terms of months of a year. A prerequisite of seasonal analysis is the identification of the remains of young animals to species. Although foetal bones were recovered from Taforalt, it was difficult to identify these to species and there is a lack of comparative data for ageing foetal bones of Barbary sheep and gazelle. Studies have shown that wild equids in Africa give birth all year round, with a peak in parturition during the rainy season (Levine 1979). Since the age at death of these animals are therefore not particularly useful for defining seasonality, this part of the analysis focussed on stages of eruption and wear of the deciduous dentition of very young individuals of Barbary sheep and gazelle.

The S8-GS Assemblage

Upper deciduous teeth of Barbary sheep from units in the S8-GS provided some information on seasonality. Portions of maxilla with deciduous upper teeth (dp2-dp4) in S8-L7 and S8-L9 respectively, could be identified to this species. On the first specimen <TAF09-8403>, the upper dp4 was still emerging through the jaw, on the second specimen <TAF09-8664>, all the deciduous dentition had emerged. The dentition of neither maxilla showed traces of wear. The upper dp4 of an individual in the Munich collection (LMUM 27) was also emerging from the jaw and the dentition showed no traces of wear. This animal was nine days old when it died, indicating a comparable age for the <8403> specimen. The <8664> individual was very slightly older, but probably less than one month of age at death. These animals probably died between April and May. An upper deciduous premolar (dp4) of Barbary sheep from an older juvenile was recovered in S8-L28 <TAF04-408>. The tooth shows full occlusal wear and exposure of dentine. A specimen from Munich (LMUM 28), aged at death at six months, had a comparative stage of wear on this tooth, suggesting time of death for the individual from Taforalt in the second half of the year, between August and October.

Two remains of gazelle from S8-GS could be approximately aged. They comprise a mandible with lower deciduous dentition (dp2-4) <TAF09-8230> from S8-L6 and a maxilla with upper deciduous dentition <TAF10-10029> from S8-L24. The deciduous teeth of both finds have erupted but are not in wear. In the mandible, wear begins on the dp4 in the first month of life (Munro/Bar-Oz/Stutz 2009, tab. 3) but can stay in this stage until three months of age (ibid., tab. 2). Wear stages are not known for the upper teeth but are probably similar to those of the lower teeth, suggesting the same age for the individual from S8-L24. Both individuals would have died between April and August.

The S8-YS Assemblage

An isolated upper deciduous premolar (dp4; <TAF04-2062>) of Barbary sheep from S8-Y4spit2, has slight traces of wear on the cusps. A young individual (LMUM 14) from the Munich reference collection, showed similar wear on an upper dp4 and had died at around four months of age. According to Kingdon (1997, 445), the rut in Barbary sheep is thought to take place after the autumn rains in October and the young are born following a gestation of 150-165 days, thus placing birth around March-April. The individual from S8-(upper)Y4 probably died between June and July.

First traces of wear on the anterior cusp of a lower deciduous premolar (dp4) of a gazelle indicate this individual from S8-Y2spit5 <TAF04-1568> died at a very early age. According to Munro and others, wear begins on the lower dp4 of mountain gazelle during the first month after birth (Munro/Bar-Oz/Stutz 2009, tab. 3) but the tooth can remain in this stage of wear (ibid., tab. 2, Stage I) for up to three months. Since birthing takes place in the spring (April/May) (Kingdon 1997, 413), the individual from Y2 probably died sometime between April-August.

In summary, evidence of seasonality could be estimated for faunal remains from some of the units in S8-GS and S8-YS. This evidence indicates death of young individuals of Barbary sheep and gazelle in both assemblages mainly from April to August extending into October.

Animal Modification

A tibia from S8-L5 (**tab. 9.1.1**) bears tooth furrows across the *crista tibiae*. This was the only find from the GS deposits with unambiguous traces of carnivore gnawing, suggesting very limited carnivore activity (0.3 %) in the formation of this assemblage. A slightly higher percentage was observed in the S8-YS assemblage where evidence of carnivore attrition was recorded on eleven bones (3.6 %). These modifications comprised tooth furrows mainly located on the shafts of long bones of the limb. A fragment of a long bone in S8-Y2spit3 also bore traces of tooth pits.

On the whole, carnivore modification of the bones was low in both assemblages. Degree of limb circumference was recorded on 180 bone shafts in the S8-GS assemblage. Bunn (1983) sees this as one of the criteria which can be used to differentiate between human-modified and carnivore-modified bone assemblages. Carnivores preferentially gnaw the proximal and distal ends of bones, leaving behind bone 'tubes' with whole tubular circumferences, whereas humans breaking open bones to obtain marrow tend to produce bone debris with less than half or greater than half of the original bone circumference. Some 15.5 % of the bones in the S8-GS assemblage are in Bunn's (1983) stage 3, where the whole tubular circumference is represented. Although this could be interpreted as indications of a stronger carnivore influence on the assemblage, the extremely low counts of visible traces of carnivore gnawing, coupled with the higher incidence of butchery marks, as evidence of human action, suggests this is probably not the case. In contrast, only 9.2 % of 151 bones in the S8-YS assemblage were allocated to stage 3.

Traces of rodent gnawing were recorded on six bones from S8-GS (**tab. 9.1.1**), representing 1.5 % of the assemblage. Rodent gnawing was observed on fragments of three leg bones (metacarpus, S8-L3; radius, S8-L17; tibia, S8-L20) and on three first phalanges (S8-L13 and L17). The metacarpus from S8-L3 also bore traces of cut marks and splitting the bone open to obtain marrow or grease. Rodent gnawing was not observed on any of the remains in the S8-YS assemblage.

The LSA Faunal Remains from Sector 10

General Remarks

The excavation area at S10 is some 2.5 × 2.0 × 0.8 m = 4.8 m³, producing a total of 1,487 faunal finds (**tab. 9.1.11**). They represent the largest assemblage of faunal remains recovered during recent investigations at the Taforalt cave site. In comparison, the S8 aggregate excavated volume has been a little larger but the much greater stoniness (by a factor of perhaps 2-3, S. Collcutt, pers. comm.) means that the abundance of non-human bones in the two sectors is probably not significantly different. Six animal bones from S10 were sampled see **Chapters 4** and **15**) giving dates of 15,101-14,365 to 14,660-14,086 cal BP for the fauna (broadly comparable to the dates from the human bones from S10).

Assemblage	Number of finds recorded	Weight	Indet.	Small	Medium	Medium-large	Large	Butchery traces	Bone tool	Burnt	Carnivore gnawing	Rodent gnawing
Yellow-brown	1346	13835	15	26	165	910	231	232	2	170	11	8
Brown	141	1549	0	3	11	104	23	28	0	63	2	3
Totals	**1487**	**15384**	**15**	**29**	**176**	**1013**	**254**	**260**	**2**	**233**	**13**	**11**

Tab. 9.1.11 Faunal data for the yellow-brown and brown assemblages from S10.

Assem-blage	Barbary sheep	Equid (large)	Gazelle	Large bovine	Alcela-phines	Equid (small)	Red Fox	Jackal	Canid	Rhino-ceros	Bear	Cheetah	Felid	Wild pig	Totals
Yellow-brown	409	74	74	45	12	5	4	1	2	1	1	1	1	1	631
Brown	24	11	4	3	6	1	0	0	0	0	0	0	0	0	49
Totals	**433**	**85**	**78**	**48**	**18**	**6**	**4**	**1**	**2**	**1**	**1**	**1**	**1**	**1**	**680**

Tab. 9.1.12 Number of specimens (NISP) identified to an animal in the yellow-brown and brown assemblages in S10.

As generally observed at Taforalt, faunal preservation at S10 was excellent. In addition, the bones from this sector displayed distinctive patterns of colouration. The bulk of the bones (n = 1,236) is yellow in colour, with patches of brown, giving them a somewhat "speckled" appearance. In addition, three bones from S10 had areas of white colouration, suggesting they had been exposed for some time before final burial. The colour of a further 107 bones could not be described, since the bulk of them (n = 101) showed traces of burning. In this analysis, the yellow-brown bones, the white bones and bones where the colour could not be identified are classified as a single faunal assemblage, comprising a total of 1,346 finds. The remaining bones (n = 141) are brown in colour. The brown bones are treated as a separate assemblage, since there is currently no evidence to indicate whether these finds were deposited at the same time as the rest of the fauna from S10 or otherwise.

As observed in the faunas from S8, remains from the medium-large animal-size group dominate in the yellow-brown assemblage from S10 by 67.5 %, followed by the large (17.1 %), medium (12.2 %) and small (1.9 %) animal-size groups. Exactly the same decreasing order of representation was observed in the brown assemblage, where the medium-large animal-size group dominates (73.7 %), followed by large (16.3 %), medium (7.8 %) and small (2.1 %) animal-size groups.

Butchery traces were observed on 232 bones from the yellow-brown assemblage, representing 17.2 % of these finds. Only two bones show modifications which could be interpreted as resulting from their use as a tool. Various stages of burning were observed on 170 bones (12.6 %). Tooth marks produced during gnawing by carnivores (0.8 %) or rodents (0.5 %) are present, but in very low quantities.

The bones in the brown assemblage also bear traces of butchery, burning and modifications by animals. The percentages show some similarities to those from the yellow-brown assemblage. For example, there is a fairly high percentage (19.8 %) of bones with marks resulting from butchery, but low percentages of carnivore (1.4 %) and rodent gnawing (2.1 %). In contrast to the yellow-brown assemblage, the percentage of burnt bones in the brown assemblage is higher (44.6 %). Bone tools were not identified in the brown assemblage.

Palaeoenvironmental Indications

The numbers of identifiable specimens (NISP) in the two assemblages from S10 are listed in **table 9.1.12**. The fauna in the yellow-brown assemblage from S10 is richer in composition than that from the LSA deposits in S8, and comprises faunal components already identified in S8 such as Barbary sheep, a large equid, Cuvier's gazelle, large alcelaphines, including kongoni or hartebeest (*Alcelaphus buselaphus*) and a rhinoceros. Fragmentary horn cores of a large bovine may belong to either the aurochs (*Bos primigenius*) or the extinct giant buffalo (*Pelorovis antiquus*). In addition, remains of a small equid, probably the wild ass (*Equus africanus*), red fox (*Vulpes vulpes*), common or golden jackal (*Canis aureus*), a bear, cheetah (cf. *Acinonyx jubatus*), and a wild pig (possibly the wild boar, *Sus scrofa*, or bush pig, *Potamocherus larvatus*), along with remains of a medium-sized canid and a medium-large sized felid are present. Despite this range of animals, the identified fauna is dominated once again by Barbary sheep (64.8 %), followed by the equids (total percentage: 12.5 %), gazelle (11.7 %), large bovines (7.1 %) and the alcelaphines (1.8 %). The remaining taxa are represented by very low counts of specimens (between 1 and 4 finds).

Faunal composition in the brown assemblage is similar to that of the yellow-brown assemblage, with dominant Barbary sheep (48.9 %) and equids (24.4 %), gazelle (8.1 %), large bovines (6.1 %) and large alcelaphines (12.2 %) well-represented. However, the absence of the other species does not suggest these animals were not present at Taforalt during the accumulation of the brown assemblage, but simply underlines the very low number of finds from these taxa which were deposited in the cave.

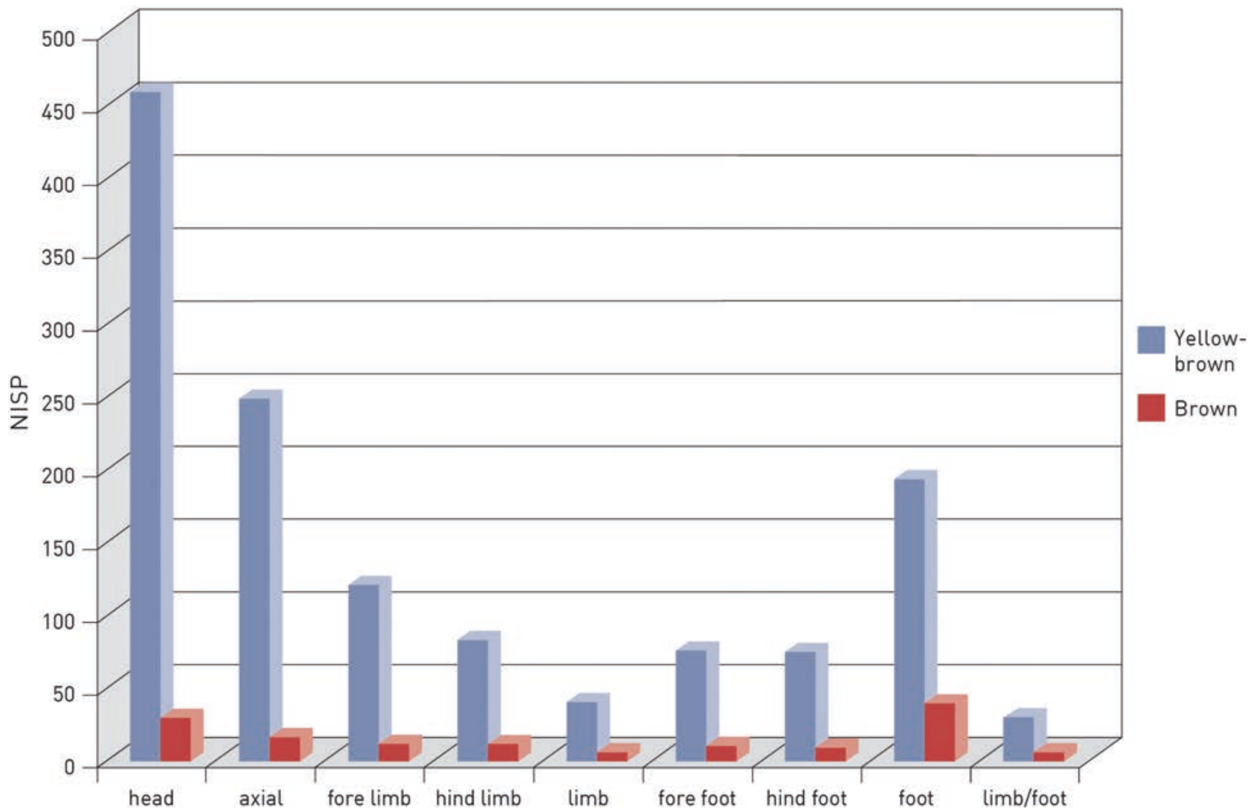


Fig. 9.1.8 Comparative representation of counts of elements (NISP) in anatomical regions in the yellow-brown (n = 1272) and brown assemblages (n = 127) from S10.

Faunal composition in S10 once again suggests regionally open, grassy plains or grassland steppe with parkland, bushland and thickets and stony plateaus and valley slopes in the immediate vicinity of the cave. The presence of wild ass suggests some semi-desert grasslands (Kingdon 1997, 311). Wild boar is indicative of oakwoods, scrub and tamarisk groves (the latter usually on the margins of deserts) (ibid., 329) and bush pig inhabit forests and woodlands, preferring valley bottoms with dense vegetation (ibid., 339).

Bone Assemblage Formation and Skeletal Part Representation

Figure 9.1.8 depicts counts (NISP) of skeletal elements in anatomical regions for the yellow-brown and brown assemblages respectively, thus providing a useful overview of the portions of the bodies of the animals which had accumulated in these assemblages in this part of the cave.

An over-representation of some anatomical regions was observed overall in the faunas from S8 and a similar over-representation is apparent in S10. Elements of the head unit dominate in the yellow-brown assemblage, with a total count of 455 finds. Isolated teeth form a large proportion of this part of the carcass (n = 179; 39.3 %), indicating the preferential survival of large numbers of more robust skeletal elements. However, the remaining 276 finds also comprise a high count of friable elements, such as horn cores and fragments of horn cores (n = 103), suggesting that the differential survival of faunal remains due to attrition and loss was not as pronounced in aggregate as in S8. The axial unit is fairly well represented (n = 241), followed by decreasing counts for bones of the fore (n = 116) and hind limbs (n = 77), fore (n = 68) and hind feet (n = 66), limb (n = 36) and limb/foot (n = 26). The comparatively high count of foot bones not identifi-

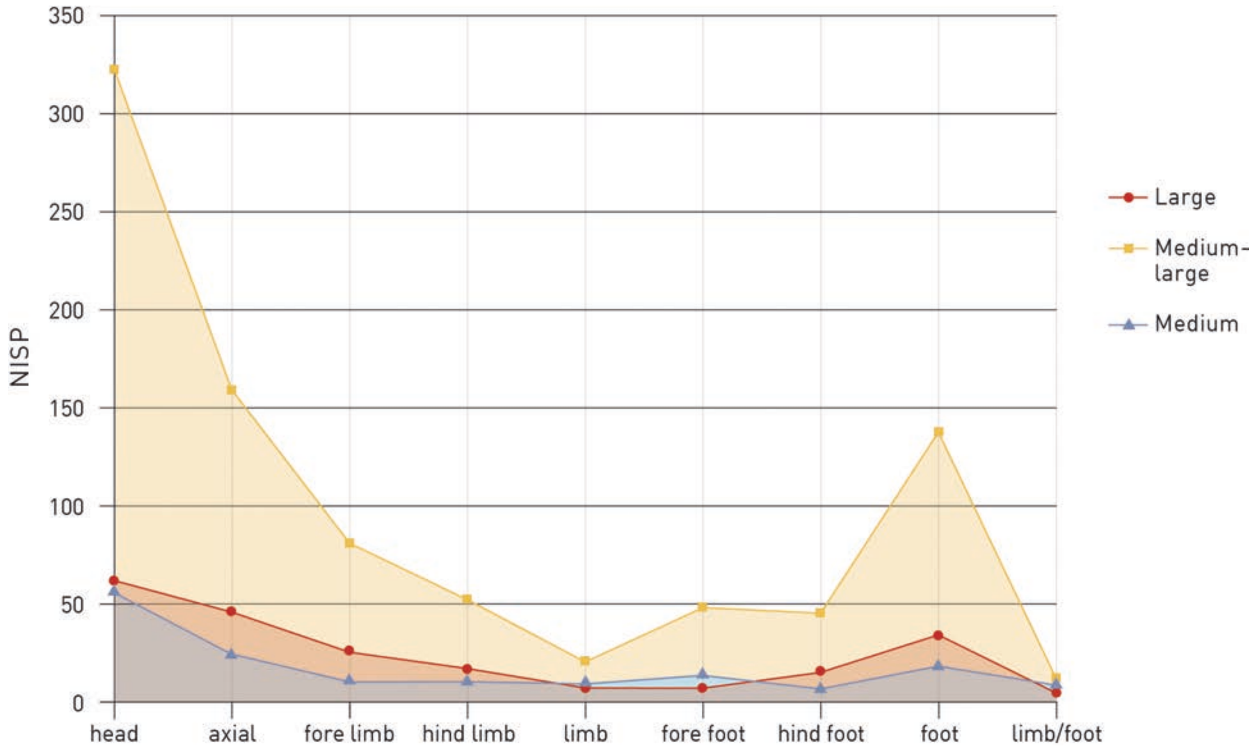


Fig. 9.1.9 Comparative representation (NISP) of anatomical regions of large, medium-large and medium animal-size groups from the yellow-brown assemblage (n = 1242) of S10.

able to fore or to hind feet simply reflects the problems of identifying fragmentary pieces of these elements beyond 'indeterminate metacarpal or metatarsal' and 'indeterminate phalange'. The pattern of representation of anatomical regions was much the same in the brown assemblage, despite the low counts of elements from this assemblage in each part of the carcass.

In general, there was definite evidence of a differential representation of some carcass parts and skeletal elements, where robust elements such as teeth are over-represented. However, the presence of numerous fragments of friable elements, such as horn cores, indicates that conditions in S10 were, on the whole, conducive to good preservation of all types of bone. The general pattern of representation of the anatomical regions in the assemblages shows that both assemblages were subject to similar conditions of deposition and burial.

Figures 9.1.9 and 9.1.10 depict comparative representations of anatomical regions for the large, medium-large and medium size groups in the assemblages. The small animal-size group produced very low overall counts of finds in both assemblages in S10, and is not shown in these figures. Although there are strong differences in terms of counts of elements in the individual carcass units, the pattern of representation of the anatomical regions for the individual animal-size groups is very similar. In the yellow-brown assemblage, the medium-large group has produced the largest counts of finds (fig. 9.1.9). The skeletal representation of this group follows the pattern observed for the whole assemblage very closely (cf. fig. 9.1.8). It is dominated by elements of the head; axial elements are well-represented and there are decreasing amounts of fore and hind limb bones. Counts of hind limb, fore and hind foot bones are almost equal and there is a second peak of not further identifiable elements of the foot. Counts of limb and limb/foot bones are very low. The representation of the carcass parts in the large and medium animal-size groups also follows this pattern to a certain degree with high peaks for the head and foot and lower counts in the remaining regions.

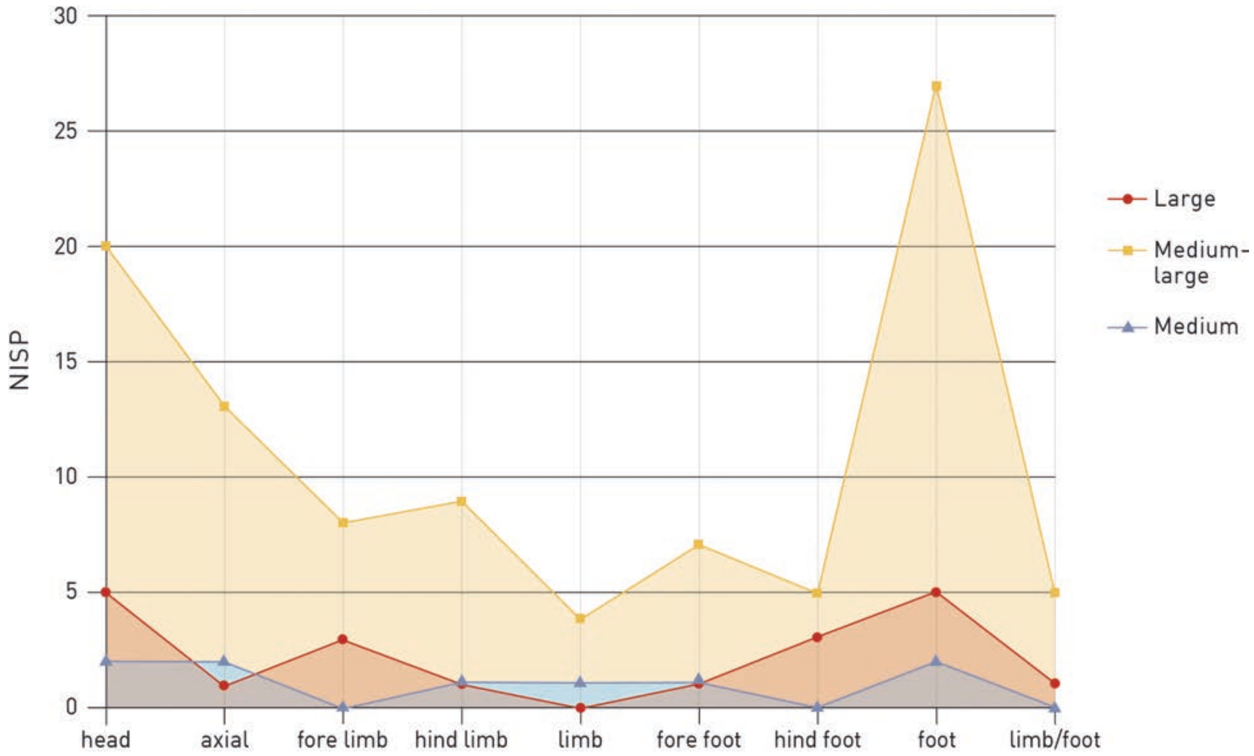


Fig. 9.1.10 Comparative representation (NISP) of anatomical regions of large, medium-large and medium animal-size groups from the brown assemblage (n = 127) of S10.

On the whole, the representation of anatomical regions of the animal-size groups in the brown assemblage shows few differences when compared to that recorded for the yellow-brown assemblage. There is a high peak for the head and peaks for axial, limb and foot bones (**fig. 9.1.10**). Where differences in representation do occur in this assemblage, for example the higher peak for fore foot over the hind foot, a very high peak for the foot in the medium-large group, and a comparatively lower peak for the head in the medium animal-size group, these are probably more likely related to the low numbers of finds in general in each region in this assemblage.

Minimum Number of Individuals and Skeletal Part Representation of the Main Animals

At least twelve individuals of Barbary sheep are represented in the yellow-brown assemblage. This MNI count is based on five lower deciduous third premolars from the right side of the body, which produced the juvenile count, and seven upper second permanent molars from the right body-side, which provide the adult count.

The representation of individual skeletal elements of Barbary sheep (**fig. 9.1.11**) shows that all parts of the skeleton were present in the Sector, except for ribs – generally in a fragmentary state at Taforalt and thus difficult to identify to species – and the patella – a very fragile bone, which probably did not survive. The previous figures (**figs 9.1.8-9.1.10**) show that skeletal representation at Taforalt was dominated in general by elements of the head, mainly reflecting survival of robust skeletal elements, notably teeth. This representation is also apparent for the Barbary sheep, where not only upper and lower isolated teeth but other robust elements such as carpal and tarsal bones and first and second phalanges are well-represented. Unusual in this context, however, is the high count of fragments of crania and horn from this species (n = 118), exceeding that of the teeth. This pattern of representation could result from biasing due to counting large amounts of isolated fragments deriving from only a few horns and crania, be related to the good conditions of bone

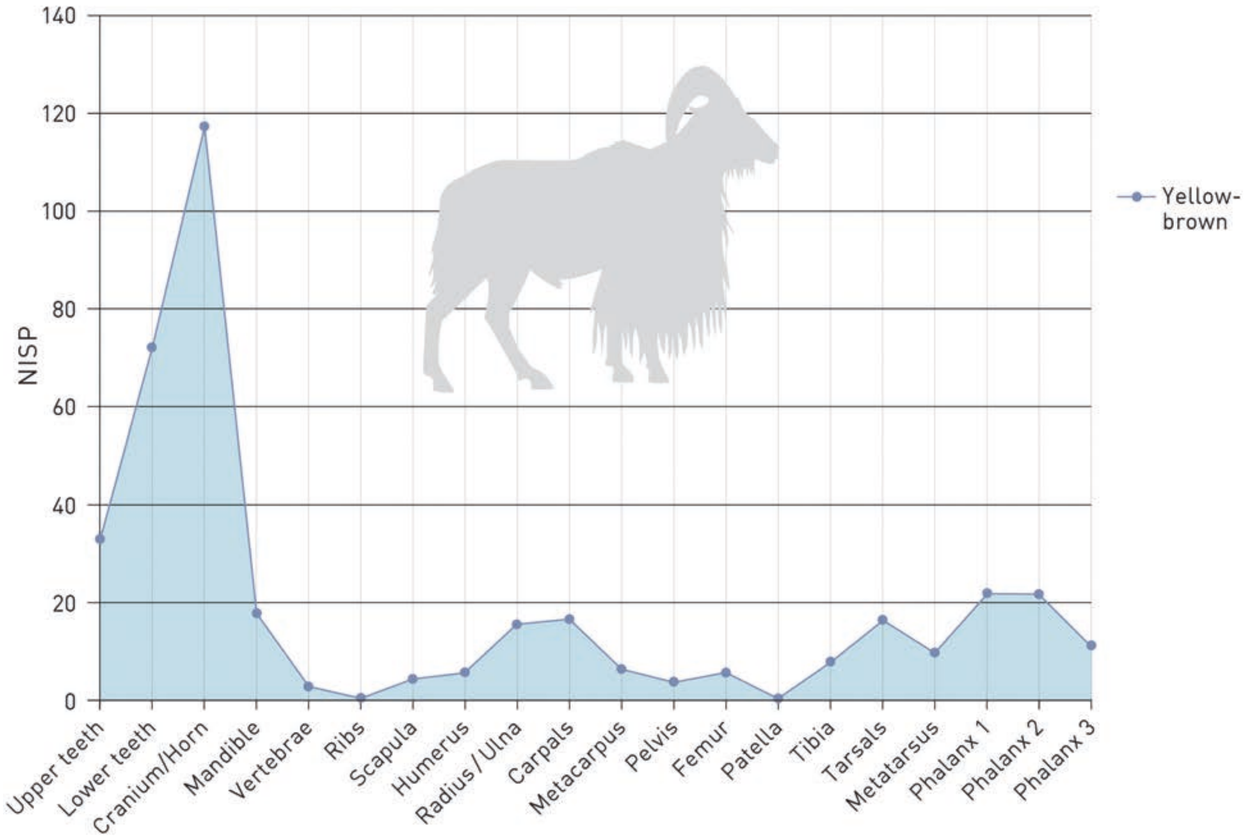


Fig. 9.1.11 Comparative representation (NISP) of skeletal elements of Barbary sheep from the yellow-brown and brown assemblages of S10.

preservation in this part of the cave or reflect social decisions on the part of the human inhabitants of the cave (see below). Although two individuals of Barbary sheep are present in the brown assemblage (counted on two left tarsal bones), its skeletal representation (**fig. 9.1.11**) gives very little additional information, apart from the fact that some remains of this animal are present in this assemblage.

There is a minimum of four large equids in the yellow-brown assemblage. These counts are based on two upper dp2s and two tarsal bones (astragali) from the right side of the body, giving a juvenile and adult count of two individuals respectively. The general pattern of skeletal representation in S10 – high counts for elements of the head and feet – is also present in the representation of individual remains of large equid (**fig. 9.1.12**). Skeletal representation is characterised by high counts of upper teeth and lower counts of lower teeth; cranial bones are absent, but ribs are present. Radius/ulna and carpals are comparatively well-represented, along with tarsals and first phalanges. Scapula, humerus, metacarpus, patella and tibia are missing. Although the absence of scapula and patella can be explained by differential bone survival (these bones or parts of these bones – e. g. blade of the scapula – have low survival potential), there is also a complete absence of more robust long bones such as humerus, tibia and, in particular, metacarpus.

Only 11 bones could be identified to the large equid in the brown assemblage. These comprise limb and foot bones (n = 6), teeth (n = 4) and a single vertebra. One of the finds, a radius, is from a juvenile animal. The remaining bones and teeth demonstrate no more than one adult individual.

Three juvenile (represented by two left lower deciduous fourth premolars) and three adult gazelles (represented by three upper third molars from the left side of the body) are present in the yellow-brown assemblage. The basic pattern of skeletal representation for gazelle is similar to that of Barbary sheep; in particular the representation of elements of the head, where cranium and horn have produced higher counts than

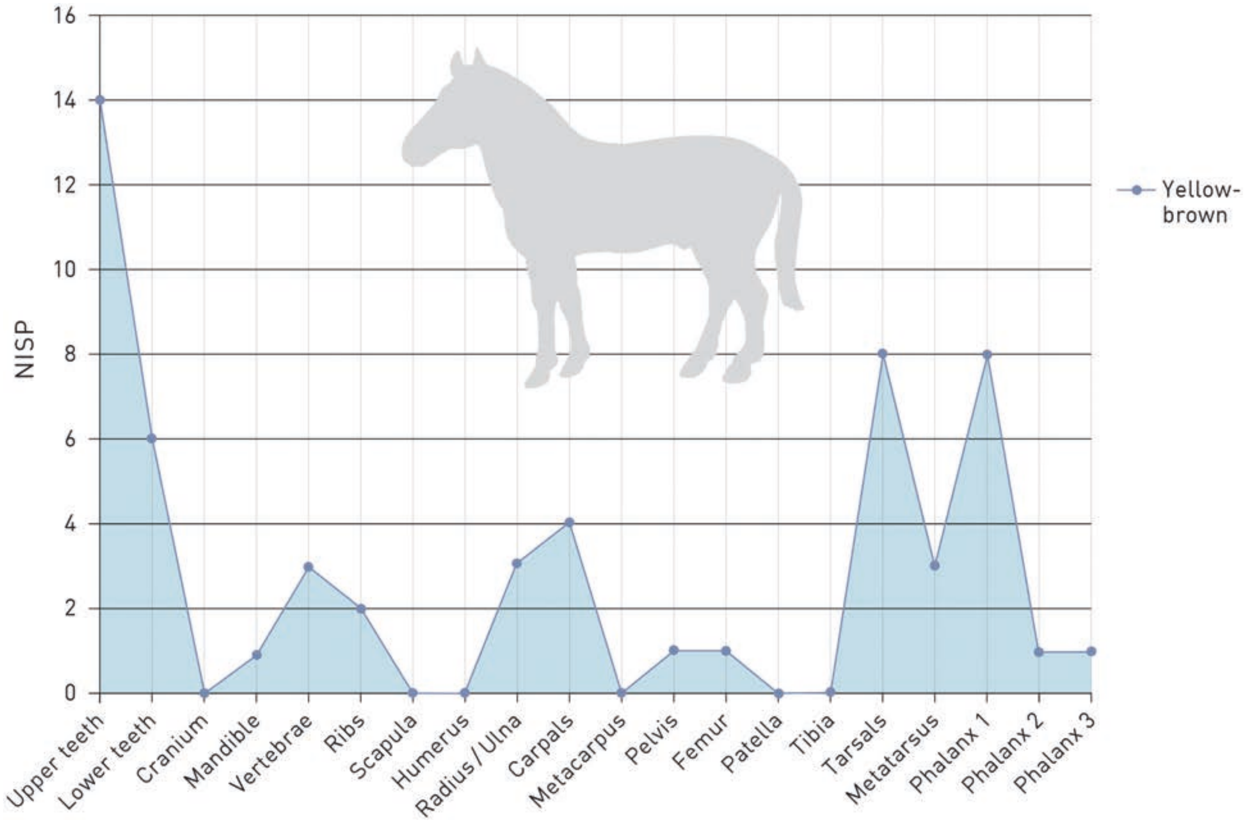


Fig. 9.1.12 Representation (NISP) of skeletal elements of large equid from the yellow-brown assemblage of S10.

teeth (**fig. 9.1.13**). Friable elements such as vertebrae, ribs and patella are absent, as well as robust elements such as humerus, pelvis and femur. The metacarpus is, comparatively speaking, well-represented, as are the first phalanges. Only four elements in the brown assemblage could be identified to gazelle. They comprise two phalanges, a tooth and a fragment of a vertebra. These finds represent one adult individual.

At least two adult large bovines are present in the yellow-brown assemblage. These were counted on two lower third molars from the right side of the body. The skeletal representation of these animals (**fig. 9.1.14**) is comparable to that of Barbary sheep and gazelle, with counts of fragments of cranium and horn higher than counts of teeth. Missing elements show a combination of robust bones such as mandible, pelvis, metatarsus and second phalange and friable elements such as vertebrae, ribs and patella.

Of the four elements identified to large bovine in the brown assemblage, three are from limb and foot bones and there is one fragment of horn. These finds represent a minimum of one individual.

The remaining animals from both assemblages are characterised by low counts of remains (**tab. 9.1.12**) and minimum numbers of one individual. Only the alcelaphines, the medium sized canids and red fox produced a minimum of two individuals respectively.

Figures 9.1.8-9.1.13 show that skeletal representation in general in S10 was mainly determined by differential bone survival, where robust elements, such as teeth, consistently produced high counts and were over-represented, and less robust elements, such as the patella, were consistently under-represented or absent. There are exceptions to this, for example counts of cranial elements, including horn cores, were higher than counts of teeth in Barbary sheep, gazelle and large bovine. In contrast to the excellent state of preservation of animal bone at S10 in general, crania, and in particular horn cores, were comparatively poorly preserved. This is related to the structure of these elements. Thus, numerous fragments from a single

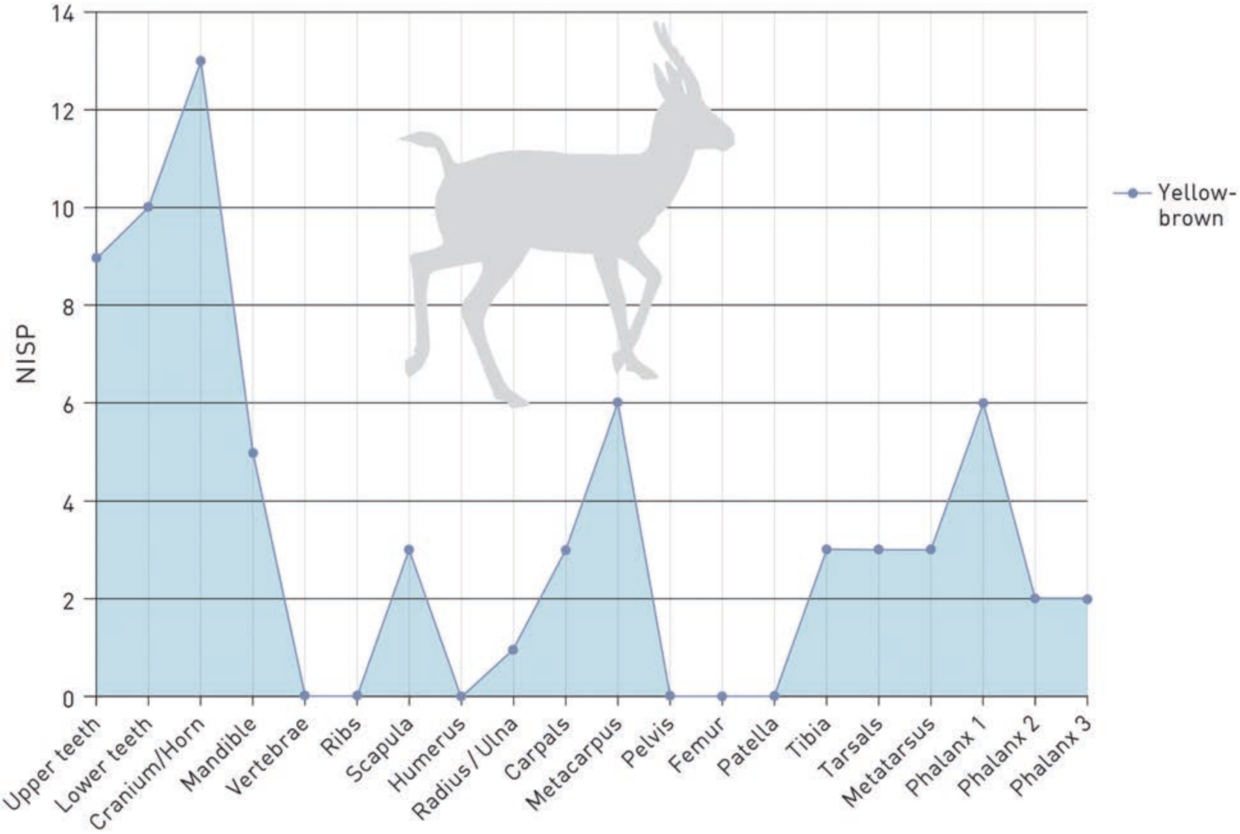


Fig. 9.1.13 Representation (NISP) of skeletal elements of gazelle from the yellow-brown assemblage of S10.

horn and/or skull would probably account for the inflated numbers of these elements. Among the post-cranial remains, some bones also displayed a frequency not fully compatible with their structure or density.

Human Modification

Marks produced during the butchering of animal carcasses were observed on 232 remains from the yellow-brown assemblage and 28 from the brown assemblage (**tab. 9.1.11**). They represent 17.2 % and 19.8 % of the yellow-brown and brown assemblages respectively.

Summaries of the butchery traces on remains identifiable to an animal or those attributed to an animal-size group are given in **tables 9.1.13** and **9.1.14** and illustrated for Barbary sheep and medium-large sized animals in **figure 9.1.15**. Illustrations of these modifications are shown in **figure 9.1.16**. As discussed for S8 (see above), it is likely that the bulk of the bones in the medium-large animal-size group belong to Barbary sheep and the bulk of the remains in the medium-size group belong to gazelle. Butchery marks on animals in the large size group are described together with the butchery marks on the remains of the large bovines.

Butchery in the Yellow-Brown Assemblage

Barbary Sheep and Animals in the Medium-Large Size Group

Some 60 remains of Barbary sheep bore traces of a range of butchering activities, including cut marks deriving from skinning, dismemberment, filleting of meat, removal of periosteum, ligaments and tendons along

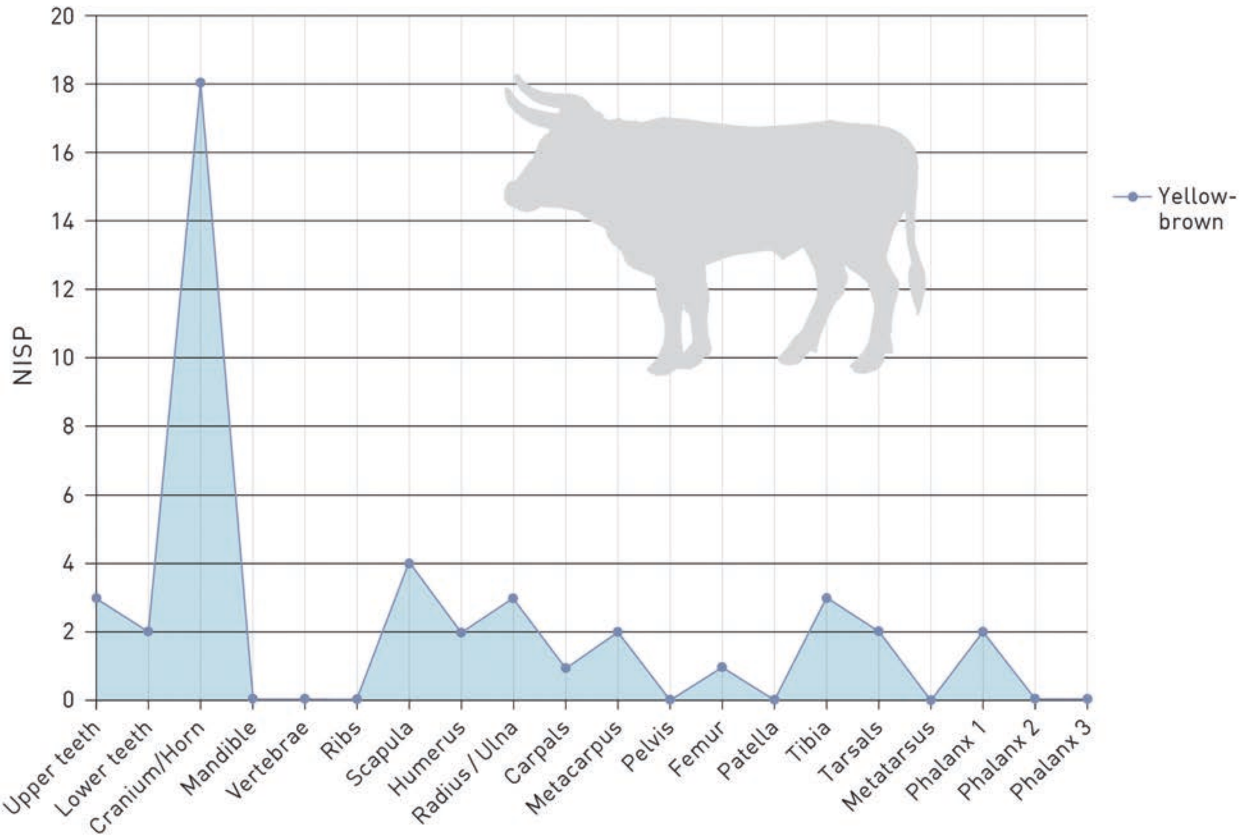


Fig. 9.1.14 Representation (NISP) of skeletal elements of large bovine from the yellow-brown assemblage of S10.

with fracturing of the bones to extract the brain and obtain bone marrow and grease. A larger number of butchered bones, a total of 93 finds, was recorded in the medium-large animal-size group but cut marks indicating skinning have not been observed in this group so far (**tab. 9.1.13**).

– Skinning

Skinning marks were found on four bones from the head of Barbary sheep (**tab. 9.1.13**). One of these finds is the anterior portion of a mandible <TAF10-10672>, bearing short oblique cuts on its basal edge (type M-1, Binford 1981, tab. 4.04; Parkin/Rowley-Conwy/Serjeantson 1986), typically produced during skinning. A set of short cuts on the cranium just below the base of the horn core <TAF09-8697> is also typical of skinning marks. They are the equivalent of Binford's S-4 marks (1991, tab. 4.04) described on the skull of a reindeer, but here in the same position on the skull of Barbary sheep. One of the maxillae bears a set of wide, oblique marks immediately in front of the upper P2 which is, along with most of the upper dental row (the upper M3 is missing), still in the jaw <TAF06-4731>.

– Dismemberment of the Carcass

The bulk of the cut marks on the bones of Barbary sheep (n = 18) was produced during the disarticulation of the carcass. Two sets of oblique cuts on the ventral face of the cranial process of an atlas vertebra <TAF09-8728a>, comparable to Binford's CV-1 (1981, tab. 4.04), indicate separation of the head from the neck.

Cut marks on the fore limb were produced around the elbow joint (distal humerus and proximal radius) as this appendage was separated into its main anatomical portions, comprising the upper and lower leg. Numerous cut marks across the medial and lateral faces of the distal joint of a metacarpus and across the

	Skinning	Dismemberment	Filleting	Periosteum	Ligaments/ tendons	Brain/marrow extraction	Cleaving	Multiple traces	Totals
Barbary sheep	horn core (S-4) cranium & horn core maxilla mandible (M-1)	atlas vertebra (CV-1) distal humerus (Hd-2/Hd-4) (2) proximal radius (RCp-6) carpal (C-1) proximal metacarpus (MCp-1) distal metacarpus (MCd-2/ MCd-3) pelvis (PS-9) proximal femur (Fp-2/Fp-3) (2)* distal tibia (Td-3) tarsal (2) astragalus (TA-2) (2) calcaneus (TC-3) proximal metatarsus (MTp-1) phalange 1	upper P4 mandible (M-3) scapula (S-4) (2) humerus* proximal radius (RCp-6) radiocubitus (2) proximal tibia (Tp-3/ Tp-4)	metacarpus (2) metatarsus (5)*		crania (9) radius (2) radius (longit. split) radiocubitus (opp. notches) metatarsus (longit. split) phalange 1 phalange 1 (longit. split)*	distal humerus distal tibia phalange 2	maxilla (skinning /gingival tissue) mandible (filleting/cleaving) femur (filleting/marrow)	
Sub-totals	*4*	*18*	*9*	*7*	*0*	*16*	*3*	*3*	*60*
Large equid		pelvis (PS-7) astragalus (TA-2) (2) calcaneus (TC-3) (2)*	lower P2 upper P2 upper M2 radiocubitus (RCp-6)	metatarsus	phalange 1 (tendons)	femur		rib (dismembering ribs/evisceration)	
Sub-totals	*0*	*5*	*4*	*1*	*1*	*1*	*0*	*1*	*13*
Gazelle	cranium & horn core mandible		radius distal metacarpus (MCd-4) tibia (3)*	metacarpus (2) metatarsus	phalange 1 (ligaments) phalange 2 (ligaments)	cranium		distal scapula (dismemberment/filleting) (S-1 / S-4)	
Sub-totals	*2*	*0*	*5*	*3*	*2*	*1*	*0*	*1*	*14*
Large bovine	cranium	carpal (C-1) astragalus (TA-2) calcaneus (TC-1)	scapula humerus tibia (2)* long bone			phalange 1 (longit. split)	distal humerus		
Sub-totals	*1*	*3*	*5*	*0*	*0*	*1*	*1*	*0*	*11*
Small equid						phalange 1			
Sub-totals	*0*	*0*	*0*	*0*	*0*	*1*	*0*	*0*	*1*
Canid		mandible							
Sub-totals	*0*	*1*	*0*	*0*	*0*	*0*	*0*	*0*	*1*

	Skinning	Dismemberment	Filleting	Periosteum	Ligaments/ tendons	Brain/marrow extraction	Cleaving	Multiple traces	Totals
Medium-large		cervical vertebra (CV-1/CV-2) thoracic vertebra (TV-5)* rib (RS-3) carpal pelvis (PS-7/PS-9) (4) femur (Fp-2) tarsal (TNC-1/TNE-1) (3)	hyoid (tongue/throat) vertebra vertebra (TV-2) (2) lumbar vertebra (removal of organs in abdomen) rib (2) (removal of organs in chest cavity) rib (14)* scapula (4)* humerus (9)* radius (8) femur (6) tibia (3) long bone (4)	metatarsus (2) metapodial (4)	sesamoid (ligaments) phalange 1 (tendon)	radius metacarpus femur tibia metatarsus	mandible* vertebra proximal radius	thoracic vertebra (rib dismemberment? / cleaving)* rib (evisceration/filleting) humerus (filleting/marrow) radius (filleting/marrow) femur (filleting/cleaved) femur (2) (filleting/marrow) (opp. notches) tibia (2) (filleting/marrow) long bone (filleting/marrow)*	
Sub-totals	*0*	*12*	*55*	*6*	*2*	*5*	*3*	*10*	*93*
Large	cranium maxilla or mandible	atlas? vertebra rib (RS-3)* distal humerus (Hd-2)* distal femur (Fd-5)	rib (RS-1) (5) rib (2) (removal of organs in chest cavity) scapula (S-4) humerus (2) radius femur (2)* proximal tibia long bone (2)	metacarpus (2) metapodial		tibia	proximal tibia	rib (evisceration/filleting/dismembering ribs) scapula (filleting/cleaving) long bone (filleting/marrow)	
Sub-totals	*2*	*4*	*16*	*3*	*0*	*1*	*1*	*3*	*30*
Medium			rib (2) tibia* long bone (3)				lumbar vertebra*	rib (filleting/evisceration)	
Sub-totals	*0*	*0*	*6*	*0*	*0*	*0*	*1*	*1*	*8*
Small		pelvis	rib						
Sub-totals	*0*	*1*	*1*	*0*	*0*	*0*	*0*	*0*	*2*
Totals	**9**	**44**	**101**	**20**	**5**	**25**	**9**	**19**	**232**

Tab. 9.1.13 Summary of butchery marks on the animal bones from the yellow-brown assemblage in S10 (letters in parentheses e.g. (CV-1) denote Binford's (1981) coding system for cut marks; * indicates the bone or one of the bones is from a juvenile individual; longit. split = bone has been split longitudinally; opp. notches = opposing impact notches on bone).

	Skinning	Dismemberment	Filleting	Periosteum	Ligaments/ tendons	Marrow extraction	Cleaving	Multiple traces	Totals
Barbary sheep		metacarpus (MCp-1)						phalange 1 (dismemberment/marrow)	
Sub-totals	*0*	*1*	*0*	*0*	*0*	*0*	*0*	*1*	*2*
Large equid		carpal (C-1) tarsal (TNC-1) astragalus (TA-2)	lower premolar or molar radius*						
Sub-totals	*0*	*3*	*2*	*0*	*0*	*0*	*0*	*0*	*5*
Gazelle					phalange 1 (ligament)				
Sub-totals	*0*	*0*	*0*	*0*	*1*	*0*	*0*	*0*	*1*
Hartebeest						phalange 1			
Sub-totals	*0*	*0*	*0*	*0*	*0*	*1*	*0*	*0*	*1*
Medium-large		vertebra (TV-3?)*	femur humerus radius (2) tibia long bone (2)*	metacarpus (2) metapodial (2)			thoracic vertebra		
Sub-totals	*0*	*1*	*7*	*4*	*0*	*0*	*1*	*0*	*13*
Large			long bone	metapodia		phalange 1		long bone (filleting/ marrow)	
Sub-totals	*0*	*0*	*1*	*1*	*0*	*1*	*0*	*1*	*4*
Medium			rib long bone						
Sub-totals	*0*	*0*	*2*	*0*	*0*	*0*	*0*	*0*	*2*
Totals	**0**	**5**	**12**	**5**	**1**	**2**	**1**	**2**	**28**

Tab. 9.1.14 Summary of butchery marks on the animal bones from the brown assemblage in S10 (letters in parentheses e.g. (MCp-1) denote Binford's (1981) coding system for cut marks; * indicates the bone or one of the bones is from a juvenile individual; longit. split = bone has been split longitudinally; opp. notches = opposing impact notches on bone).

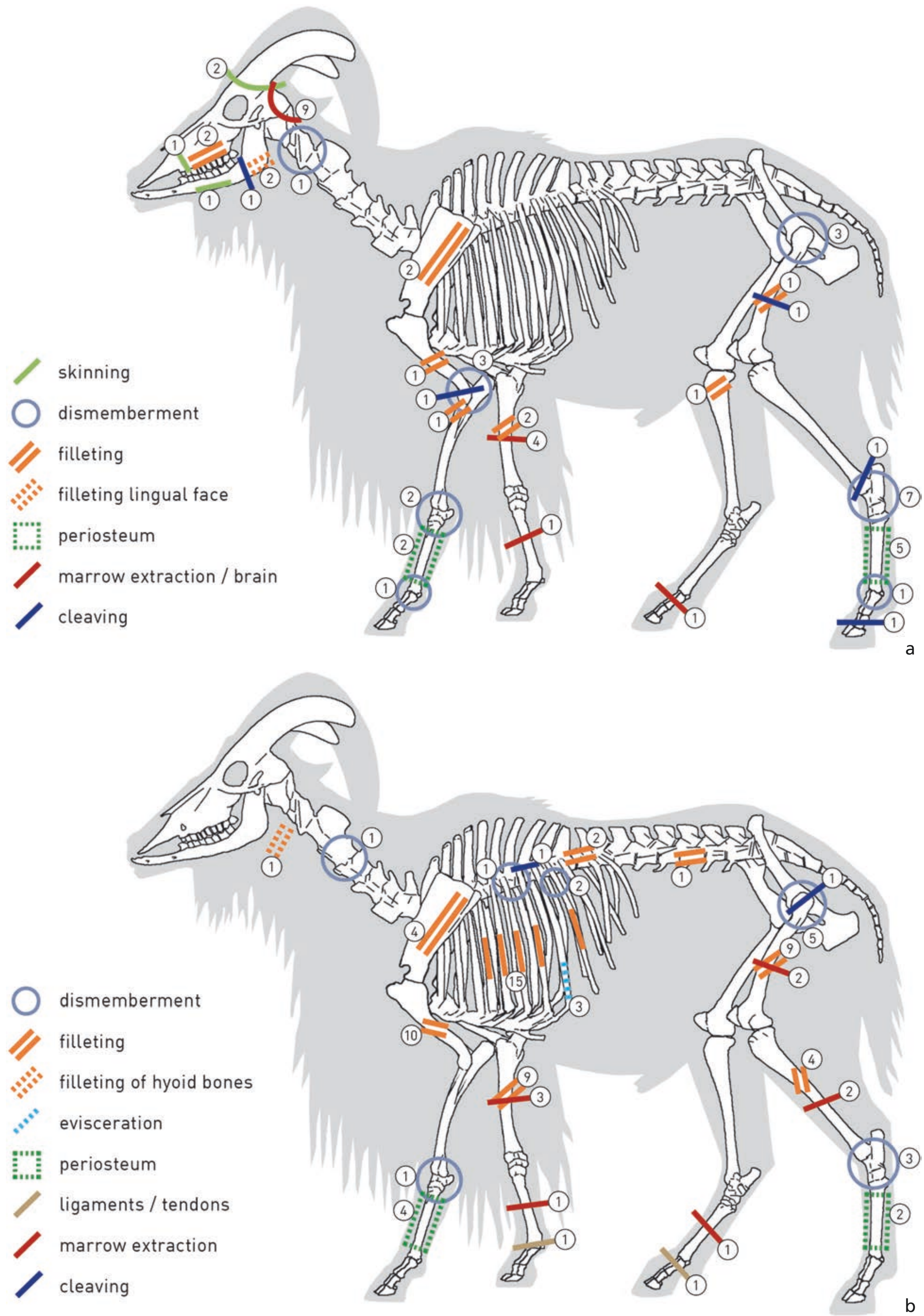


Fig. 9.1.15 Schematic depiction of traces of butchery on the bones of Barbary sheep (**a**) and animals of the medium-large size group (**b**) from the yellow-brown assemblage in S10; numbers in circles indicate the number of times the butchery stage was recorded on a certain bone; note that the position of the traces on the bones does not necessarily reflect the exact position of the marks; unidentifiable shaft fragments ('long bones') not depicted.

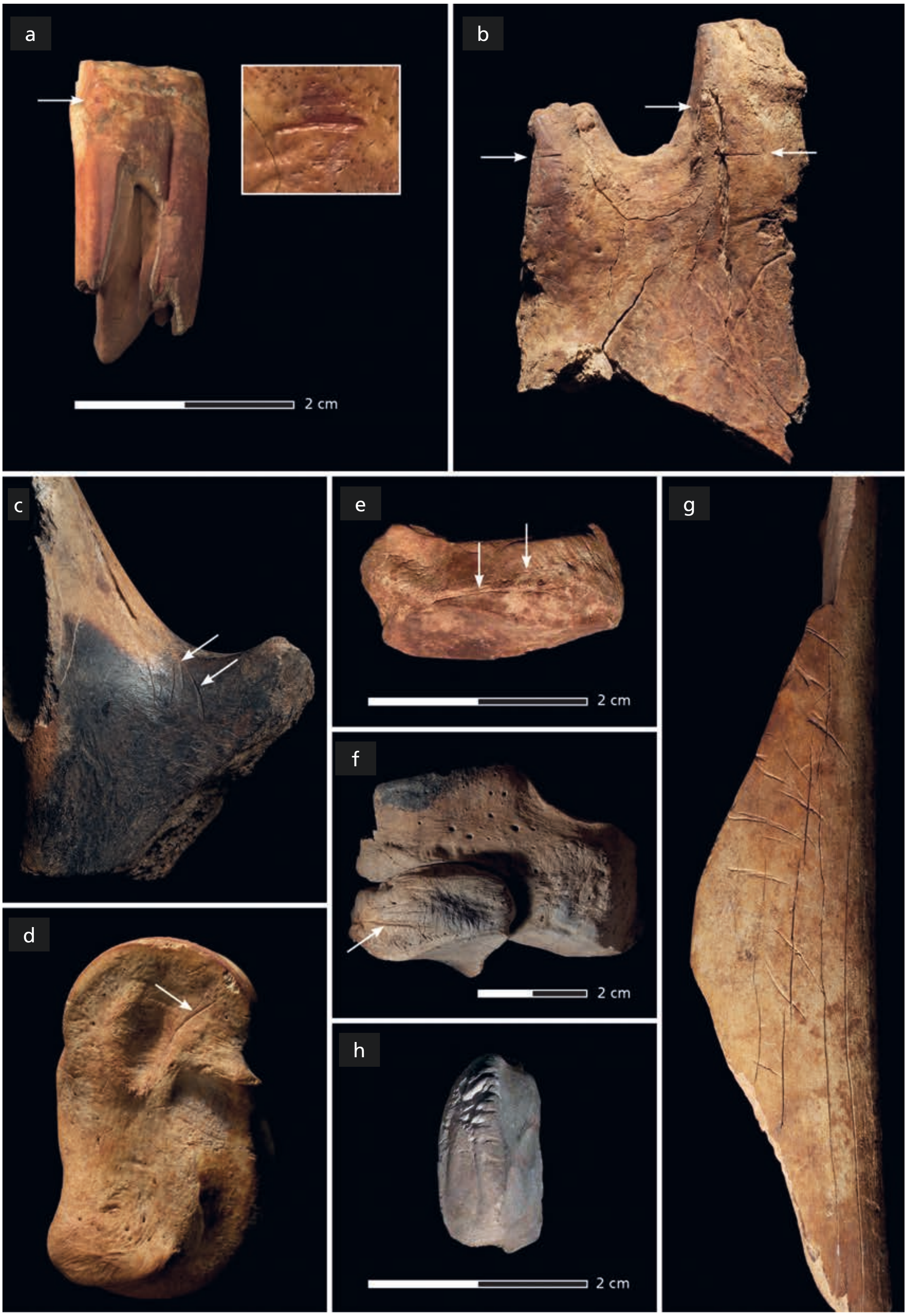


Fig. 9.1.16 Illustrations of traces of butchery on faunal remains from the S10 assemblages: cut marks on the crown of a lower P2 of a large equid (**a**), produced during removal of gingival tissues <TAF06-4204>; dismemberment marks on the cranial fragment of an atlas vertebra (**b**) of a large animal <TAF10-11396>; cut marks produced during dismemberment and burning (**c**) on the pelvis of a medium-large-sized animal <TAF10-9992>; astragalus of Barbary sheep (**d**) displaying cuts on the medial face of the bone produced during dismemberment of the carcass <TAF10-11294>; transverse cut marks produced during dismemberment of the foot bones of medium-large animals (**e-f**) and burning on one find (**f**) (<TAF09-8876> and <TAF10- 9690>); filleting marks on the shaft of a radius (?) of a medium-

large sized animal (**g**) <TAF10-11287>; cut marks on a sesamoid of a medium-large sized animal produced during removal of ligaments (**h**) <TAF09-8638>; filleting marks and burning on the shaft of a humerus of Barbary sheep (**i**) <TAF10-9697>; filleting marks on the lateral face of the proximal end of a rib of medium-large sized animals (**j-k**) (<TAF08-6504> and <TAF10-10637>); radiocubitus of Barbary sheep showing opposing impact notches and conchoidal flakes on the shaft of the bone (**l**) <TAF08-6661>; impact notches and longitudinally split first phalange (**m**) <TAF10-11394> and intact articulating second phalange <TAF10-11318> of a small equid; thoracic vertebra of a medium-large sized animal showing cleaving of the transverse process and the centrum (**n-o**) <TAF10-10565>.

trochlea of this bone <TAF06-4153> indicate removal of distal elements of the fore foot (phalanges). A phalange <TAF04-4701> which could not be identified to either the fore or hind foot also bore transverse cut marks on the proximal end, produced during disarticulation of the distal elements of the foot.

Short, oblique cuts on the ventral edge of the acetabulum of a pelvis <TAF08-6174> and sets of cut marks on the head of a femur <TAF10-10621> and on the proximal end of a femur <TAF13-11899> attest to the removal of this bone from the pelvic girdle. Disarticulation marks were also observed around the ankle joint (distal tibia, tarsals and proximal metatarsus). Disarticulation marks on bones from the same side of the body (humerus, proximal femur, tarsal, astragalus (**fig. 9.1.16d**) indicate that at least two carcasses of Barbary sheep were butchered. Disarticulation marks were also found on the proximal femur of a juvenile animal <TAF10-10621>.

Twelve bones in the medium-large animal-size group bore cut marks attributable to disarticulation. Cut marks at the caudal end of a cervical vertebra <TAF10-10608> were probably inflicted when the neck was cut into sections. Two well-defined cuts close to the caudal end of the centrum of a thoracic vertebra of a young individual <TAF10-10550> are in a similar location to ones described by Binford (1981, tab. 4.04), produced when the ribs are removed. A set of short, transverse cut marks on the ventral-caudal edge of the shaft of a rib, some 57 mm below the proximal head <TAF05-2578>, are the equivalent of Binford's RS-3 marks, also produced when the ribs are removed.

Marks produced when the rear leg was removed from the bony socket of the pelvis are present around the acetabulum and areas adjacent to the acetabulum (**fig. 9.1.16c**) on fragments from four pelves and on the proximal end of a femur. Transverse and oblique cut marks were observed on the external faces of tarsal bones, showing that the ankle had also been dismembered. Three of these bones were from the left side of the body, indicating that portions of at least three carcasses had been butchered. In contrast, only a single bone (a carpal bone) of the fore limb bore traces of cut marks.

– Filleting

Nine marks attributable to filleting are present on the remains of Barbary sheep. Cut marks are present on the buccal face of an isolated upper P4 <TAF09-9002>, produced during removal of gingival tissues. A single, long, transverse cut mark below the M3 on the lingual face of a mandible <TAF15-12921> is comparable to Binford's M-3 mark (1981, tab. 4.04), produced when muscles on the inside of the jaw are cut in order to remove the tongue (Parkin / Rowley-Conwy / Serjeantson 1986). Binford refers this mark to dismemberment, but it is classified here as filleting, since tissue is being removed from the bone. A set of oblique cut marks on the anterior face of the proximal end of a radius <TAF06-4882> and transverse marks on the proximal end of the diaphysis of a tibia <TAF06-3989> also derive from filleting activities. Other filleting marks are located on the blades of two scapulae, on the diaphysis of a humerus from a juvenile individual (**fig. 9.1.16i**) and on the diaphyses of two radiocubiti from adult Barbary sheep.

In contrast to Barbary sheep, where the bulk of the cut marks were produced during dismemberment, the bulk of the cut marks (n = 55) on the bones of animals in the medium-large size group were produced by filleting. The discrepancy between the quantities of cut marks produced during dismemberment and during filleting has already been noted on bones from S8 (see above), where it has been argued that the differences between counts of dismemberment marks and counts of filleting marks on bones of Barbary sheep and the medium-large size group is biased by the location of filleting marks on many fragments of bone shafts undetermined to species (e. g. **fig. 9.1.16g**).

An interesting find from the medium-large size group is a fragment of a bone from the hyoid apparatus <TAF06-4535>, which bears two sets of transverse cut marks. The find was too fragmentary to be definitely identified to a particular hyoid bone. Therefore, these cuts could derive from filleting of the muscles of the tongue or the throat. Cut marks on two vertebrae were produced when the tenderloin was removed (TV-2, Binford 1981, tab. 4.04). Cut marks on the ventral side of a lumbar vertebra and on the medial faces of two ribs were probably produced when major organs were removed from the cavities of the chest and the abdomen (evisceration). But the mass of the filleting marks are located on the lateral faces of ribs (**fig. 9.1.16j-k**), blades of scapulae and on the diaphyses of various long bones from adult and juvenile individuals.

– Periosteum, Ligaments and Tendons

The stripping of the tough, fibrous periosteal membrane and the removal of ligaments and tendons also belong to filleting activities. Two metacarpals and five metatarsals of Barbary sheep, including one from a juvenile individual, bore short, generally oblique, cut marks on their diaphyses, where the periosteum was cut in order to create an opening from which the membrane could be peeled or scraped off the bone. Similar marks were observed on six metapodials from the medium-large size group. Marks pertaining to the removal of ligaments and tendons were not observed on the Barbary sheep remains but were in evidence on bones of the medium-large size group. A series of very deep, oblique cut marks on the lateral edge of a sesamoid bone <TAF09-8638> (**fig. 9.1.16h**) was probably produced when the volar/plantar annular ligament was cut free to remove the flexor tendons (Parkin/Rowley-Conwy/Serjeantson 1986). Three, very deep, transverse cuts on the lateral edge of the plantar face of a first phalange <TAF05-2324>, probably derive from removal of tendons (ibid.).

– Extraction of the Brain, Bone Marrow and Grease

Nine crania or portions of crania of Barbary sheep had been fractured to extract the brain. A large, circular opening had been produced by removing most of the parietal bones at the rear of the skull (**fig. 9.1.21**). Through this opening, the brain could be removed. Crania of red deer from Mesolithic sites in Europe, such as Friesack (David/Casseyas/van der Sloot/Léotard 2016) and Hohen Viecheln (Wild 2019) in Germany also bear the same type of modification, which was probably associated with extraction of the brain. A more detailed description of some of the modified crania from S10 is given below (see funerary artefacts).

Seven bones of Barbary sheep showed marks associated with the fracture of these elements to expose the bone marrow. Impact notches were recorded on two radii and a phalange. Opposing, or reflected, impact notches were observed on the edges of a shaft of a radiocubitus <TAF08-6661>, indicating the bone had been broken open while lying on a hard support (**fig. 9.1.16l**). Three bones, including one from a juvenile animal, had been split open along the longitudinal axis.

A humerus <TAF09-8887>, a tibia <TAF09-8685> and a second phalange <TAF10-9692> are characterised by sharply-defined, straight edges through the distal joints, produced either by fracture of the bone or cleaving (chopping). Fracture of the joint may have been caused indirectly when the bone was broken to obtain marrow, whereas cleaving (chopping) was probably carried out deliberately to break up the joint to obtain bone grease. The lumbar vertebra of a juvenile, medium-large sized animal also appears to have been chopped through the centrum, whether this action was part of bone grease procurement or simply a method of portioning the carcass, is not clear.

– Multiple Butchery Traces

Three bones of Barbary sheep showed traces of carcass preparation which could be attributed to different stages of butchery – skinning, filleting and marrow procurement. A maxilla <TAF15-13069> bears traces of skinning marks and a set of cut marks on the buccal face of the upper P2 above the level of the gum, produced when gingival tissues were cut away. A mandible <TAF06-4790> has filleting marks on the lin-

gual face of the jaw below the M2 and M3 and the ramus has been cleaved or chopped through behind the M3.
Several bones (humerus, radius, femur, tibia and an unidentifiable long bone of a juvenile individual) from medium-large sized animals bore cut marks deriving from filleting and impact notches produced during the opening of the bone to procure marrow. One of the femora <TAF08-5544> has impact notches on both sides of the shaft, suggesting the bone had been laid on a hard support as it was broken to expose the marrow. Cut marks on a thoracic vertebra from a juvenile individual <TAF10-10550> may have been produced when the rib was removed from the backbone. This vertebra had also been cleaved, possibly in association with the removal of the rib, perhaps as part of a rack of meat. Multiple cut marks on both the medial and lateral faces of a rib <TAF10-10249> attest to the removal of large organs from the chest cavity and, presumably later, to the filleting of meat.

Equids
A total of thirteen bones of the large equid bore traces of butchery, including dismemberment, filleting and procurement of bone marrow (**tab. 9.1.13**).

– Dismemberment of the Carcass
Dismemberment marks observed on five bones of the large equid, were produced when the hind limb was removed from the pelvic girdle and the hind foot from the lower leg. The two astragali are from the right side of the body, indicating that portions of at least two adult equids had been dismembered. One of the calcanei is from a juvenile equid.

– Filleting
A single deep, transverse cut mark across the ulna and lateral edge of a proximal radiocubitus, along with very well-preserved sets of short oblique cuts along the lateral portion of the shaft of the radius are similar to Binford's RCp-6 marks (1981, tab. 4.04), produced during filleting meat from the bone. Three cheek teeth have characteristic cut marks on their buccal faces, produced during the removal of gingival tissues at the line of the jaw.
Oblique cut marks on the shaft of a metatarsus were produced during stripping of the periosteum. This find <TAF06-4878> also bears a series of flake removals at one end, consistent with the use of the bone as a tool (see below). Sets of oblique cut marks on the posterior face and lateral edge of the distal joint of a first phalange <TAF08-5481> were produced as tendons were stripped from the bone (Parkin/Rowley-Conwy/Serjeantson 1986).

– Bone Marrow and Multiple Traces of Butchery
Only one bone, a femur, bore impact notches resulting from bone smashing to retrieve marrow. A rib bore cut marks on both the lateral and medial faces of the bone, consistent with dismemberment of the ribs and evisceration.

Gazelle and Animals in the Medium Size Group
Some thirteen bones of gazelle bore traces relating to skinning, filleting, removal of periosteum and ligaments. Traces deriving from dismemberment and the procurement of bone marrow and grease were not observed. Eight bones from the medium size group had been filleted, bore traces of evisceration and had been cleaved (**tab. 9.1.13**).

– Skinning

Sets of longitudinal and transverse cut marks on the lateral side of the cranium at the base of a left horn core of gazelle <TAF15-13770> are comparable with Binford's S-4 marks (1981, tab. 4.04), produced during skinning of the head (**fig. 9.1.18**). The horn also showed distinctive traces of rodent gnawing (see below). Sets of oblique and transverse cut marks on the buccal face of a mandible <TAF10-9680> were also produced during skinning activities.

– Filleting

Five bones of gazelle had been filleted. In the main these were long bones bearing short cut marks on the shaft of the bone, produced as meat was removed from the carcasses of one juvenile and several adult individuals. Oblique cut marks are present above the distal end and on the shaft of a distal portion of a metacarpus <TAF09-8778>. The marks close to the distal joint are comparable with Binford's MCd-4 marks (1981, tab. 4.04), produced on this bone during filleting activities. Marks attributable to removal of the periosteum were located on three metapodials. Cut marks on a first and a second phalange of gazelle were placed in positions relating to the removal of ligaments. Altogether, six bones from the medium size group bore traces of filleting or evisceration.

– Extraction of the Brain

A portion of the cranium attached to a complete horn of gazelle <TAF15-13770> displayed traces of modification similar to those observed on the crania of Barbary sheep and deriving from the opening of the skull to extract the brain.

– Multiple Traces of Butchery

Only one bone, a scapula, had cut marks at the distal joint, deriving from dismemberment. This bone also bore filleting marks on the blade. One bone from the medium size group had been cleaved.

Large Bovine and Animals in the Large Size Group

Eleven bones of large bovines and thirty remains of animals in the large size group bore traces of butchery (**tab. 9.1.13**).

– Skinning

Longitudinal cut marks on the parietal bone of a large bovine <TAF06-4013>, placed some 80 mm from the snout, attest to skinning of the skull. Long cut marks on a cranium and on a fragment of the maxilla or mandible of a large animal can also be referred to skinning activities.

– Dismemberment

Cut marks produced during disarticulation of the feet from the lower part of the limb were observed on a carpal bone and on two tarsal bones of a large bovine. Several sets of transverse and longitudinal cut marks on a vertebra (atlas?) (**fig. 9.1.16b**) <TAF10-11396>, of an animal in the large size group, are likely to have been produced during disarticulation of the neck, as are sets of transverse and oblique cuts just below the proximal end of a rib, on the cranial-ventral face <TAF05-2372>. Short oblique cut marks around the distal joints of the humerus (juvenile individual) and around the distal femur are characteristically produced during disarticulation of the upper and lower fore and rear-leg.

– Filleting

Filleting marks were recorded on the blade of a scapula and four long bones of large bovines. One of these, a tibia, was from a juvenile individual. Sixteen bones with cut marks attributable to filleting were observed in the large size group. The bulk of these are located on the lateral faces of ribs, equivalent to Binford's RS-1 marks (1981, tab. 4.04). Most of the remaining marks were located on the blade of a scapula and on the shafts of long bones, mainly from adult individuals. Two bones, a tibia of a large bovine and the shaft of a long bone from an animal in the large size group, are from juvenile individuals. Two ribs (<TAF05-2778> and <TAF10-9942>) have cut marks on the medial face, produced during clearing of the chest cavity.

Bones of large bovines bearing cut marks in positions relating to the removal of periosteum were not recovered, but three metapodials from animals in the large size group did bear cut marks produced during this activity. Bones with traces deriving from the removal of ligaments and tendons were not observed.

– Bone Marrow, Bone Grease and Multiple Traces of Butchery

Evidence for the procurement of bone marrow and grease is rare. The distal portion of a first phalange <TAF10-11283> of a large bovine had been split longitudinally and the distal joint of a humerus <TAF06-5098> had been cleaved. The large size group also produced two bones, both tibiae, which displayed impact notches and cleaving.

None of the bones identified to a large bovine showed multiple traces of butchery, which were recorded on only three bones from the large size group; they derive from dismemberment, evisceration, filleting, grease and marrow procurement.

Small Equid and Canid

Two impact notches on a first phalange of the small equid <TAF10-11394> derive from marrow procurement (**fig. 9.1.16m**) and are the only evidence of butchery on the few remains of this animal (**tab. 9.1.13**). The mandible of the medium-sized canid has two short cut marks on the ascending ramus, produced when the head was dismembered from the neck.

Butchery in the Brown Assemblage

Barbary Sheep and Animals in the Medium-Large Size Group

Only one bone in this assemblage, a proximal portion of a metacarpus <TAF10-10088>, could be definitely identified to Barbary sheep (**tab. 9.1.14**). A short, transverse cut on the lateral edge of the proximal end of this bone attests to disarticulation of the foot from the lower limb. A first phalange <TAF10-10795> of this species bore dismembering marks and had also been opened to expose the marrow.

A larger quantity of finds with butchery marks were found in the medium-large animal-size group. Oblique cuts across the body of a vertebra from a juvenile individual <TAF10-10795> could indicate dismemberment of the rib, if the vertebra is from the thoracic region of the body. Seven long bones bore filleting marks and four metapodials had traces produced during removal of the periosteum. The body of a second, thoracic, vertebra <TAF10-10565> (**fig. 9.1.16n-o**) had been cleaved.

Equids and Animals in the Large Size Group

Marks produced during dismemberment were recorded on three elements of a large equid, marking the separation of foot bones from both the fore and hind limb (**tab. 9.1.14**). Filleting marks were recorded on the radius of a juvenile animal and cut marks across a lower premolar or molar attest to the stripping of tissues from the jaw (**fig. 9.1.16a**).

Disarticulation marks were not observed on the bones of animals from the large size group. However, marks deriving from filleting and removal of the periosteum were present on two finds. A shaft of an unidentifiable long bone had filleting marks and had been opened to obtain bone marrow.

Gazelle and Animals in the Medium Size Group
The position of short cut marks on the lateral face of a first phalange corresponds to those produced during removal of ligaments (Parkin/Rowley-Conwy/Serjeantson 1986) (**tab. 9.1.14**). This was the only find in the brown assemblage definitely identified as gazelle. A rib and a fragment of the shaft of a long bone in the medium size group had been filleted.

Hartebeest
One of the rare traces of butchery on a bone definitely identified to hartebeest was preserved in this assemblage (**tab. 9.1.14**). The bone is the proximal portion of a first phalange <TAF06-4487>, which bears an impact notch in the centre of its lateral face and had been opened to obtain bone marrow.

Butchery – Summary of Results

Traces of butchery were observed on the bones of Barbary sheep, a large and a small equid, gazelle, large bovine and a canid in the yellow-brown assemblage and on remains of Barbary sheep, a large equid, gazelle and hartebeest from the brown assemblage in S10. Although a range of animals had been butchered, the bulk of these traces in both assemblages were recorded on the remains of Barbary sheep. There were no differences in the treatment of the carcasses of the different animals in the two assemblages and both assemblages produced remains of animals in different size groups with butchery traces, except for the small size group in the brown assemblage.
The location and form of the butchery marks show that the standard techniques of carcass processing identified on faunal remains from the S8-YS and S8-GS units were also employed in S10: carcasses were dismembered at major joints of the carcass and meat, bone marrow and bone grease were procured. Interesting, however, is the appearance of cut marks on animal crania in the S8-GS assemblage (L14) and, in particular, in the S10 assemblage, indicating skinning. Unique to the S10 yellow-brown assemblage is a deliberate opening of the rear of the crania to extract the brain, identified primarily on crania of Barbary sheep, but also on a cranium of gazelle. Whether this action was undertaken to procure the brain as a source of nourishment or as a medium in the tanning of hides, is uncertain. Skinning marks on crania from S10, attesting to the procurement of hides, suggest the latter was a possibility. Ligaments and tendons were removed from the feet and may have been used in a number of ways, as sewing thread for hides to make clothing or containers, but also for making snares, nooses for traps or even nets.

Burning

Counts of unburnt and burnt bones from the S10 assemblages are shown in **table 9.1.15** and illustrated in **figure 9.1.16**. The bulk of the faunal remains showed no traces of burning, and 87.6 % of the bones in the yellow-brown assemblage and 56.5 % in the brown assemblage had not been in contact with fire. Stages of burning were recorded (Stiner 2005; Stiner/Kuhn/Weiner/Bar-Yosef 1995) and show a continuous decline in numbers of bones in the brown assemblage from slightly burned to less than half calcined (stages 1-4) and no heavily calcined bones (stages 5 and 6), which represent the most advanced phases of burning and, in the case of stage 6, are characteristic of the use of bone as a fuel (Costamagno/Théry-Parisot/Brugal/Guibert 2005). The counts observed here suggest bone was not used for purposes of combustion (but see above for discussion). A similar general decline in counts was observed for stages 1-4 recorded on the bones from the yellow-brown assemblage, but with a slight peak for fully black bones (stage 3) and low counts in stages 5 and 6.

Some 170 faunal remains from the yellow-brown assemblage and 63 from the brown assemblage had been burnt (**tab. 9.1.16**). Traces of burning were observed on the remains of several animals and animals in different size groups in both assemblages, but the bulk of the burnt bones are from Barbary sheep and the medium-large animal-size group. A similar pattern of representation is present in the counts of burnt and butchered finds in the yellow-brown assemblage (**tab. 9.1.16**), where the highest counts are from Barbary sheep and medium-large sized animals. There appears to have been no selection of particular skeletal elements for burning. For the Barbary sheep, burning was observed on practically all elements of the skeleton, including crania, horns, vertebrae and ribs, and long bones of the limb and foot. Burning was present on juvenile and adult bones.

In summary, the faunal remains from S10 seem to have had little contact with fire and where burning had occurred, it was not to a great degree. So far, the evidence indicates the burnt bones recovered in the S10 deposits were the results of chance occurrences, perhaps reflecting an *ad hoc* method of disposal of butchery debris or the accidental incorporation of bones into fires, rather than part of a deliberate food processing and cooking strategy.

Informal Bone Tools

A find from the yellow-brown assemblage bears traces of utilisation. It is a portion of the shaft of a third metacarpus of a large equid <TAF06-4847> (**fig. 9.1.17**). There are multiple oblique cut marks across the shaft, deriving from removal of the periosteum. One end of the bone bears a series of removals or hack-like marks, not consistent with either carnivore or rodent gnawing. These may have been produced as the end of the bone was chipped away to form a blunt point or as the bone was utilised.

A second find <TAF05-2568> from S10 also shows damage on the surface of the bone (**fig. 9.1.16**). The find is a shaft of a radius from a medium-large sized animal (probably Barbary sheep). The bone has sets of oblique cuts across the cranial face of the shaft, produced when meat was filleted from the carcass. The cranial face also bears a well-defined area of deep, irregularly-shaped, pit-like features. These pits do not resemble the damage typically left behind on bones used as retouchers to refine or reshape lithic artefacts. The damage may have occurred when the bone was used as a hammer or an anvil.

Age Structures of the Major Species of Game

Barbary Sheep

Only one tooth of Barbary sheep was present in the brown assemblage and assessments of the age-structure of this species therefore focussed solely on data derived from teeth recovered in the yellow-brown assemblage. A total of 17 remains could be designated to juveniles; they comprise six mandibles and one

Fig. 9.1.17 Informal bone tools from the yellow-brown assemblage in S10: shaft of third metatarsus of horse <TAF06-4847> (**a**), with oblique cut marks and a series of removals or hack-like marks at the base of the find (**b**); radius of medium-large sized animal (**c**) displaying area of deep, irregular pit-like features (**d**).

Assemblage	Stage 0	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Stage 6	Totals
yellow-brown	1173	45	34	50	23	8	10	1343
brown	79	25	20	14	4	0	0	141

Tab. 9.1.15 Counts of burnt and unburnt bones in the yellow-brown and brown assemblages from S10.

	Assemblage	Small	Medium	Medium-large	Large	Barbary sheep	Large equid
burnt	yellow-brown	1	12	70	10	50	13
	brown	2	4	24	5	15	6
butchered and burnt	yellow-brown	1	4	14	2	6	1
	brown	1	1	4	3	2	4

(continued)	Assemblage	Gazelle	Large bovine	Alcelaphines	Small equid	Rhinoceros	Totals
burnt	yellow-brown	7	3	2	1	1	170
	brown	2	1	3	1	0	63
butchered and burnt	yellow-brown	1	2	0	0	0	31
	brown	0	0	1	0	0	16

Tab. 9.1.16 Counts of burnt and butchered and burnt bones from the yellow-brown and brown assemblages in S10 according to animal and animal-size groups (0 = not burnt; 1 = slightly burned (less than half); 2 = lightly burned (more than half); 3 = fully burned (black); 4 = less than half calcined; 5 = more than half calcined; 6 = fully calcined).

ID-Number	P3	P4	M1	M2	M3
LMUM 25	9.21	12.5	7.3	22.2	29.5
4212	16.4				
5624	12.2				
6718	11.7				
4054b	7.2				
8594	6.0				
11800			16.4		
10686				41.9	
4790b				28.5	
2816					34.9
4790a					38.3
13436					38.3
2543					32.3

Tab. 9.1.17 Crown heights (mm) of lower permanent dentition of Barbary sheep from the yellow-brown assemblage in S10 (heights marked in grey are older than 6 years of age; specimens <4790a and b> are from the same individual).

ID-Number	P3	P4	M1	M2	M3
9002a		16.2			
4536			33.4		
12041			22.1		
13194			20.4		
13117			18.8		
2846			18.7		
12798			17.8		
12993			15.1		
4394			12.7		
4054a			11.9		
8686				43.8+	
5503				35.6+	
12913				31.5	
11757				31.3	
2846				18.7	
12448				16.3	
4014a				10.2	
11906					43.7
3004					41.9
5805					41.5
6177					37.2
10699					35.2
12547					27.2

Tab. 9.1.18 Crown heights (mm) of upper permanent dentition of Barbary sheep from the yellow-brown assemblage in S10 (+ indicates the tooth was damaged at occlusal surface and could have originally been higher).

ID-Number	Element	Height	Age in years
4202	P_2	56.8	4-5
12869	M^2	75.4	5-6
6720	M^3	65.3	6-7
12937	M^2	72.1	6-7
10613	P^2	17.4	13-14
12721	M_3	24.2	15-16

Tab. 9.1.19 Crown heights (mm) of upper and lower premolars and molars and age of the large equid from the yellow-brown assemblage in S10.

ID-Number	Element	Height
12797	M^3	19.9
2649	M^3	18.4
11388	M^3	17.9
13218	M^3	16.5
13421	M^3	11.3
13263	M^3	7.0

Tab. 9.1.20 Crown heights (mm) of upper third molars of gazelle from the yellow-brown assemblage in S10.

maxilla with deciduous dentition and six lower and four upper isolated deciduous teeth. An MNI of five juveniles was counted on lower dp3s from the right side of the body.
A total of four mandibles, eight maxillae and 50 isolated upper and lower permanent premolars and molars in different stages of wear was identified. The MNI of seven adults was counted on seven upper M2s from the left side of the body. The crown-heights of 35 isolated upper and lower permanent teeth are listed in **tables 9.1.17** and **9.1.18**. The crown heights of ten of the lower teeth were higher than those of the specimen from Munich (LMUM 25) aged at just over six years at death, suggesting the specimens listed here are from adults younger than six years of age. Only two teeth, both third premolars, could be considered as deriving from animals older than six years of age. The range of crown heights measured on the upper M1, M2 and M3 was rather broad and in the absence of a comparative aged individual (from the Munich collection), difficult to assess. For example, heights taken on the upper M1 ranged between 33.4 and 11.9 mm and incorporate specimens with teeth in the first stages of wear (e.g. ID number 4536) deriving from young adults, and worn teeth (e.g. ID number 4054a) from individuals probably well past their prime. Although crown heights of teeth in mandibles and maxillae could not be measured, two of the mandibles (<TAF10-9939>; <TAF10-9950>) and one maxilla <TAF10-9421> were described during recording as "old" due to the heavily worn state of the teeth.

Equids

Eleven deciduous premolars present in the yellow-brown assemblage represent teeth from equids in the juvenile age-group. The MNI of two juvenile equids could be identified, based on two left upper dp2 and two left upper dp4. The crown heights of one lower and six upper deciduous teeth of the large equid were measured and, by applying Bignon's (2006) method, their mortality ages assessed. The youngest individual (upper dp2: <TAF10-9672>) was approximately one year old at death and the oldest juvenile, represented by two teeth (upper dp3 and 4: <TAF05-3559a> and <3559b>), had a mortality age of between 19-21 months. The remaining equids died around 14 months <TAF09-8881> and 16 months (<TAF05-3349>; <TAF10-11408>; <TAF13-12127>).
Seven permanent premolars and molars were identified and the crown heights of six of these teeth could be measured (**tab. 9.1.19**) and approximately aged according to tables given by Levine (1982). Although the dental elements gave an MNI of only one (the two upper M2's are from different sides of the body), it is clear from the crown height data in **table 9.1.19**, that more than one adult was present in the assemblage. Four of these elements are from young or 'prime' adult individuals, between 4-7 years, and two are from older adults, aged at between 13-14 and 15-16 years respectively.

Gazelle

A maxilla and a mandible, both with incomplete deciduous dentition, and three lower and two upper isolated deciduous teeth could be attributed to juvenile gazelles. A total of two juvenile individuals could be reckoned on duplicating elements from the same body side in this group of finds. This count is relatively low (but see the section on seasonality for a slightly higher MNI count). Two mandibles and two maxillae with permanent dentition and fourteen isolated permanent upper and lower premolars and molars represent the remains of the adult gazelles. The MNI of three adults was counted on three left and three right upper M3s. Published data on the ageing of gazelle teeth has focussed on wear stages of lower teeth (Munro/Bar-

Oz/Stutz 2009) or crown heights of lower M3s (Davis 1983). An unworn lower third molar <TAF-12745> is probably from an animal less than 14 months in age according to Munro and others (ibid., tab. 3). A slightly worn lower M3 <TAF-4792>, with a crown height of 20.2 mm, was probably older than c. 15 months at death (Davis 1983). Comparative data on the ages of gazelle for upper teeth have not been published so far. However, in order to glean some information on adult gazelles, crown heights were measured on six upper third molars of this species from S10 (**tab. 9.1.20**). They comprise specimens with little wear <TAF-12797> to heavily worn teeth <TAF-13263>, representing a broad range of animals from young adults to old ones.

Summary

Individuals from all three age-groups of Barbary sheep are present in the yellow-brown assemblage. Adults form the dominant group, based on minimum number of individuals and basic counts of specimens, and the bulk of the adult teeth appears to be from younger adults rather than older ones. A similar pattern of representation of the age-groups, with teeth from juveniles, young adults in their prime and older individuals can also be discerned for the large equids and the gazelles.

Seasonality

In contrast to the sparse evidence from S8, a larger number of finds from S10 was available for assessing seasonality. The finds described here are solely from the yellow-brown assemblage; the brown assemblage did not produce any material relevant to this aspect of the faunal analysis.

A series of mandibles and maxillae with deciduous dentition and isolated deciduous teeth of very young Barbary sheep were recovered from the yellow-brown assemblage in S10. The bulk of these teeth bears no traces or only the first traces of wear. As part of his study of the life history and ecology of a recently introduced game animal, Ogren (1965) devoted special effort to the age determination of Barbary sheep in New Mexico and adjoining States. Radiographs of mandibles of living specimens of Barbary sheep of known age were taken so that he could assess tooth development. He found that at three weeks of age, the deciduous mandibular dentition is complete and by three months, mandibular dp2-4 are fully erupted and wear is visible on dp3 and 4. In the Munich sample, the youngest specimen with traces of wear on lower dp3 and 4 had died at 2.5 months of age (LMUM 21) (Abigail Chipps Smith, pers. comm.; present author's observations), which compares well with Ogren's data.

The youngest individuals from S10 are represented by mandibles with dp2 emerging and no wear on the teeth (<TAF05-3718>; <TAF08-6993>). Using the ageing data described above, these animals appear to have died in the first weeks of life and probably before they reached one month in age. A group of six additional finds comprising isolated lower deciduous teeth (dp3: <TAF05-2458> and <2547>; <TAF08-5462>) and mandibles with deciduous teeth in the jaw (<TAF05-3539>; <TAF06-4054>; <TAF15-13029>) were identified. An upper dp3 <TAF05-2667> and a maxilla with dp2-4 <TAF09-8693> are also present. None of these teeth are in wear and, assuming similar patterns of eruption and wear on both lower and upper teeth of very young individuals, indicate a mortality age of between birth and 2.5 – 3 months for all of these animals. At least four individuals of Barbary sheep are represented in this group of finds by four lower dp3s from the right side of the body (<TAF05-2458> and <2547>; <TAF08-5462> and <6995>). The mortality ages deduced from these finds suggests time of death for several individuals of Barbary sheep in S10 between their birth in March/April and their death in June/July.

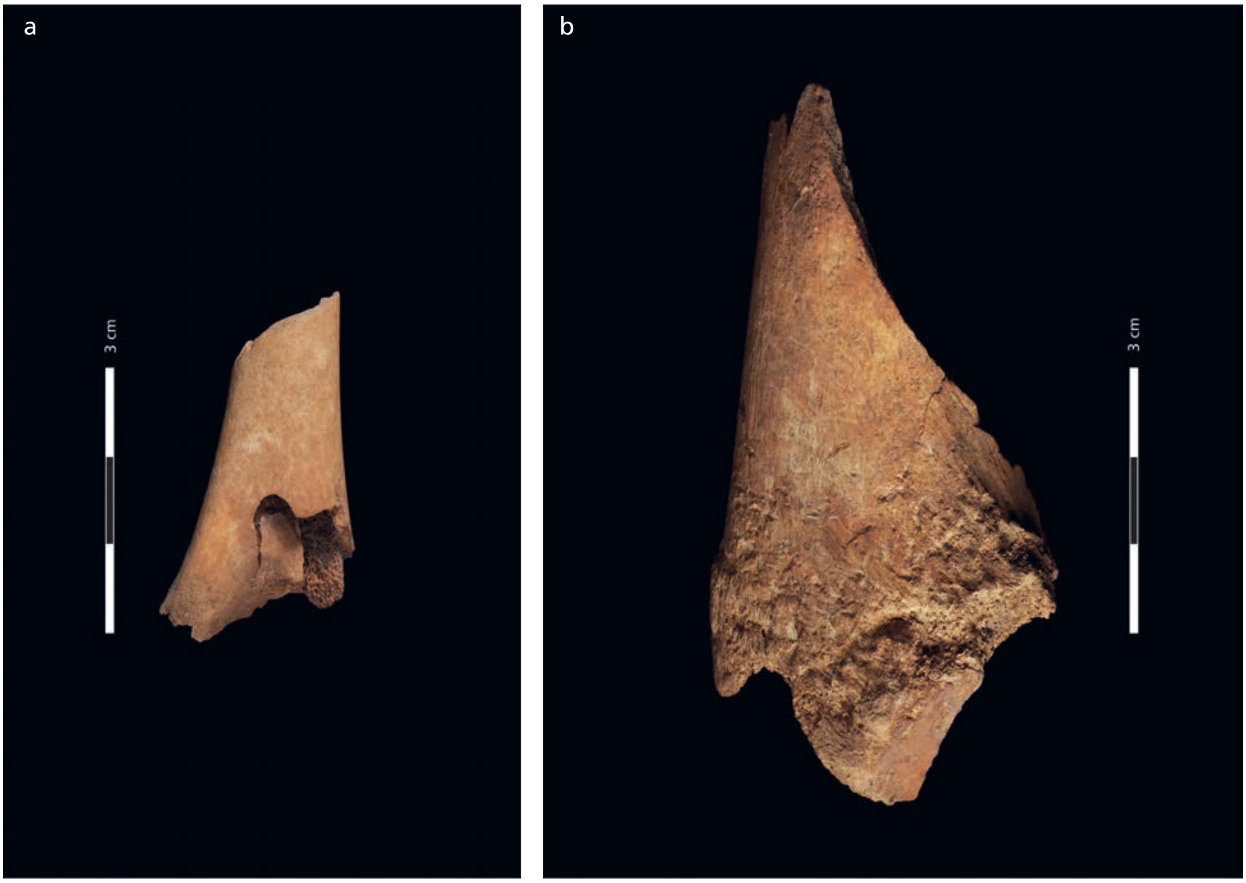


Fig. 9.1.18 Traces of carnivore gnawing on animal bones from the yellow-brown assemblage in S10: tooth notch (**a**) on the distal portion of a diaphysis of a humerus of a juvenile medium-large sized animal, probably Barbary sheep <TAF05-3256>; calcaneus (**b**) of Barbary sheep with gnawing traces on the *processus anterior* <TAF10-10522>.

The gazelle remains considered here comprise two isolated left lower dp4; and a right mandible with lower dp3 and dp4 in the jaw. These finds represent at least three young individuals of gazelle with deciduous fourth premolars in different stages of wear: unworn <TAF 15 12849>, first traces of wear <TAF 15 12575> and full occlusal wear <TAF13-11550>. According to Munro and others, wear can begin on the mandibular dp4 during the first month after birth (Munro/Bar-Oz/Stutz 2009, tab. 2) and expands across the occlusal surface of this tooth up to three months of age (ibid., tab. 2), indicating time of death for the two youngest animals between April and June or July. The lower dp4 in the mandible is already in full occlusal wear, indicating death between 3-7 months of age (ibid., tab. 2) and between July and November for this individual.

In summary, evidence of seasonality for the S10 yellow-brown assemblage could be gleaned from the tooth eruption and wear of young individuals of Barbary sheep and gazelle. The data indicate death of these young animals mainly between March and July, but extending into November.

Animal Modification

Carnivore tooth scores and tooth furrowing were observed on a total of 11 bones in the yellow-brown assemblage (fig. 9.1.18). Remains of Barbary sheep, large bovine and gazelle are amongst those finds with carnivore gnawing which can be identified. Bones from juveniles and adults have been gnawed. Only two finds from the brown assemblage showed tooth scoring from a carnivore. One of these is a radius of a

Fig. 9.1.19 Medial (**a**) and lateral (**b**) views of a horn of gazelle (*Gazella cuvieri*) <TAF15-13770> showing modification of the vault of the skull to remove the brain (**a**), cut marks on the cranium (**b**) and rodent gnawing on the horn (**a** and **b**); from S10.

horse, which shows scoring around the distal end of the bone. The very low counts of carnivore-ravaged bones in both assemblages suggests carnivores did not find the cave attractive for denning or scavenging activities, probably due to the strong and continuing human presence at Taforalt during the deposition of the Grey Series, and despite the presence of large quantities of bone debris.

Assessments of limb fragmentation showed that nine bones (21.4 %) from the brown assemblage and sixty-six (20.6 %) from the yellow-brown assemblage are in Bunn's (1983) stage 3, where the whole tubular circumference is represented. This may indicate a stronger carnivore influence on these assemblages than the visible evidence (carnivore tooth marks) suggests.

Four bones with rodent gnawing recorded in the brown assemblage comprise a tarsal bone of an equid and, from unidentifiable animals, a metacarpus or metatarsus, and fragments of a rib and an indeterminate bone. Typical rodent gnawing was recorded on eight bones from the yellow-brown assemblage. They comprise first and second phalanges of the large equid and Barbary sheep respectively, a metacarpus and scapula of gazelle, a rib and indeterminate fragments of long bones.

One of the most characteristic examples of rodent gnawing from S10 is the left, complete horn core of a gazelle with a portion of the cranium attached <TAF15-13770> (**fig. 9.1.19**). The relatively broad, flat bottomed, multiple grooves (Fisher 1995) encircle the horn some 30 mm above its base, terminating on the lateral face of the find. This find bears cut marks on the cranium, possibly deriving from skinning and shows signs of a deliberate opening of the skull in order to access the brain, as part of the butchery tactics of the human dwellers in the cave.

The LSA Faunal Remains from Sectors 3 and 4 and the S8 Mollusc Column (MMC A23)

General Remarks

Small numbers of faunal remains were recorded and analysed from LSA deposits in two additional sectors (Sectors 3 and 4) and from a profile opened in Sector 8 for column sampling of molluscan remains (MMC in Square A23).

Sector 3

A total of 69 three-dimensionally recorded faunal remains were analysed from earlier LSA deposits (all Yellow Series) investigated in 2008 in this sector. **Table 9.1.21** gives the basic data for these finds (grouped by depths, as recorded in profile AOH 2009; see **Chapter 2**). The bulk of the finds from S3 are in the medium-large animal-size group (n = 37). Some of these finds were identified to taxa, represented by the Barbary sheep (n = 4), gazelle (n = 3), a large equid (n = 1) and a large bovine (n = 1).

The four finds identified as Barbary sheep comprise a first phalange (0-1 cm spit, part of Unit S3-AOH09[5(above datum)-0]), fragments of an upper molar, the diaphysis of a radius (13-14 cm spit, part of Unit S3-AOH09[8-29]) and a fragment of the diaphysis of a tibia (26-28 cm spit, part of Unit S3-AOH09[8-29]). A small number of remains were identified to gazelle. They comprise two first phalanges (1-3 cm spit, part of Unit S3-AOH09[5(above datum)-0]; 5-7 cm spit, part of Unit S3-AOH09[0-8]) and a cervical vertebra (13-14 cm spit, part of Unit S3-AOH09[8-29]). An upper P3 or P4 of an equid was recovered in deposits between 26-28 cm spit, part of Unit S3-AOH09[8-29]. Only one find was identified as large bovine (26-28 cm spit, part of Unit S3-AOH09[8-29]). It is a fragment of the diaphysis of a bone of the foot (metacarpus or metatarsus).

Depth in cm (AOH 2009)	Number of finds recorded	Small size group	Medium size group	Medium-large size group	Large size group	Indet.	Butchery traces	Burnt	Carnivore gnawing	Rodent gnawing
0-1	1	-	-	1	-	-	-	-	-	-
1-3	4	-	1	3	-	-	-	1	-	-
3-5	3	-	1	2	-	-	2	1	-	-
5-7	5	-	1	4	-	-	-	1	-	-
7-9	6	1	1	4	-	-	1	1	-	-
11-13	3	1	1	1	-	-	-	-	-	-
13-14	9	1	3	4	1	-	-	-	-	-
14-16	1	-	-	1	-	-	-	-	-	-
18-19	1	1	-	-	-	-	-	-	-	-
19-21	4	1		-	3	-	-	-	-	-
21-22	5	1	-	3	-	1	-	2		
22-24	5	-	-	4	1	-	1	-	-	-
24-26	3	-	-	3	-	-	-	-	-	-
26-28	12	2	2	6	2	-	2	-	-	-
28-30	6	1	3	-	1	-	-	-	-	-
30-32	1	-	-	1	-	-	-	-	-	-
Totals	**69**	**9**	**13**	**37**	**8**	**1**	**6**	**6**	**0**	**0**

Tab. 9.1.21 Faunal data for Sector 3.

Traces of butchery were observed on the tibia of Barbary sheep. They comprise sets of oblique cuts on the diaphysis of the bone, produced during filleting activities. In addition the find has multiple impact notches resulting from marrow procurement. Two notches are opposing, indicating the bone may have been laid on a hard object as it was smashed. The equid tooth has an oblique cut mark on its buccal face, probably produced when gingival tissues were cut away. Cut marks deriving from filleting were also identified on long bone fragments on medium-sized and medium-large sized animals (3-5 cm spit, part of Unit S3-AOH09 [5(above datum)-0]; 7-9 cm spit, part of S3-AOH09[0-8]; 22-24 cm spit, part of S3-AOH09[8-29]). Traces of butchery were not observed on remains identified as gazelle and large bovine.
A total of six bones showed signs of burning and none of the remains had been gnawed by carnivores or rodents.

Sector 4

A single find was recorded from this sector in S4[47-57], a YS unit which dates from the early part of the LSA. The find comprises a set of articulating lower molars (M1-M3) of a large alcelaphine.

The S8 Mollusc Column (MMC in Square A23)

Eleven faunal remains, recovered from the Grey Series part of the column opened to obtain samples for the analysis of molluscs, were recorded. These finds comprise elements identifiable to Barbary sheep (n = 3), a large equid (n = 3), a large bovine (n = 3) and a large alcelaphine (n = 1). Remains of Barbary sheep were recovered in MMC21 (equivalent to part of S8-L6) and MMC48 (equivalent to a level within the series S8-L16 to S8-L20). They comprise a lower permanent molar (M2) and a tarsal bone (calcaneus) in MMC48 and a mandible with deciduous dentition (dp2-4) in MMC21. The deciduous dentition in the latter find is fully erupted, but not yet in wear, giving an approximate age at death for this individual at around 2-3 months, according to observations made by Ogren (1965) and own observations on mandibles of recent Barbary sheep.
The equid remains comprise an incisor tooth in MMC48 (equivalent to a level within the series S8-L16 to S8-L20) and two upper third or fourth permanent premolars in MMC83 (equivalent to part of Unit S8-L24).
A second phalange (MMC48), a third phalange (MMC20, equivalent to part of Unit S8-L6) and a portion of a metacarpus (MMC48) were identified as large bovine.
A fragment of a long bone of an animal of medium-large size is the only find from the MMC column (the lower stony interval) which shows traces of butchery. Longitudinal cuts were observed on the diaphysis of this piece and may have been produced during filleting activities. Rodent gnawing was also observed on this find. The second phalange of the large bovine from MMC6 (equivalent to part of Unit S8-L3) is the only find from this column showing traces of carnivore gnawing.

Crania of Large Bovines, Barbary Sheep and Other Faunal Remains as Funerary Artefacts

One of the most intriguing aspects of the faunal remains from the LSA deposits in S10 at Taforalt is the placement of crania and other faunal remains alongside the bodies of the deceased or surrounding their graves, indicating the use of these objects as funerary artefacts (Humphrey et al. 2012; Turner/Humphrey/Bouzouggar/Barton 2015) (see **Chapter 15**).

The Grave of Individual 1

The incomplete horns of a large, adult bovine had been deliberately placed in the grave of a male individual. The finds are arranged on either side of the deceased, more or less parallel to each other. They comprise the proximal portions of the left and right horn core with a portion of the skull attached to each horn core. In **figure 15.6** (**Chapter 15**), the find <TAF06-3988> lay (before excavation) to the right of the deceased male and is some 400 mm long and almost 150 mm wide. It comprises the horn core, preserved to a length of approximately 320 mm and a portion of the frontal bone. The find <TAF06-4617> still lying to the left of the deceased in **figure 15.6** (see also **fig. 9.1.20**) is some 410 mm long, the horn core is 360 mm in length and a portion of the parietal is attached. Both finds were highly fragmented and had been crushed *in situ* due to pressure of overlying graves, other finds and/or sediment and rocks.

The frontal bone of the skull on the <3988> find had been fractured in at least two places and both horn cores appear to have been deliberately broken so they would fit into the grave. The horn sheaths must have been removed prior to this action, to ensure the horn cores could be broken at the required length. The lower (proximal) portions of the horn cores were then placed in reverse positions in the grave: the horn on the left is laid with the portion of skull towards the back of the man and the horn on the right with the skull portion towards his feet.

Additional fragments of horn cores of a large bovine were recovered throughout the S10 deposits but two of these finds are of further interest. The finds comprise the middle section <TAF10-10261> of a horn core, located next to the feet of Individual 13, and the tip of a horn core <TAF10-10893>, located alongside the crania of Individuals 13 and 14 (see **Chapter 15**). The mid-section of horn core is 560 mm long and 100 mm wide (**fig. 9.1.20**). The tip of the horn core is preserved to approximately 350 mm in length and is 25 mm wide at the tip (**fig. 9.1.20**). Attempts to refit these finds could not be undertaken due to their very poor state of preservation. However, their close spatial association on site (they are practically laid on top of each other), suggests they may represent the upper portions of a single horn, measuring some 920 mm long. Considering the massive size of all the horns described above, two fossil species of large bovine came into consideration, the aurochs (*Bos primigenius*) and the giant African buffalo (*Pelorovis antiquus*). However, the bovine horn cores from the grave of Individual 1 and close to the graves of Individuals 13 and 14 are fragmentary and show only a few morphological characteristics, so that a definite identification to species is currently not possible. The frontal bone on the <3988> find is smooth, but this is also found in both the giant African buffalo (Klein 1994) and the aurochs. Typical for the two species is the way in which the horn cores are carried – the horn cores of aurochs are borne wide apart at the summit of the crown and curve outwards, forwards and upwards (Cornwall 1956). In contrast, the horns of *P. antiquus* rising behind the orbits were placed transverse to the skull and spanned more than 3 m from tip to tip (Klein 1994) (**fig. 9.1.20**). Unfortunately, the find <TAF06-3988> from the grave was too fragmentarily preserved to ascertain the exact position of the horn to the skull. The horn core of aurochs is massive and has a relatively stout tip. In contrast, the horn cores of *P. antiquus* are comparatively slender and the tip is relatively thin. The tip of the horn core of the large bovine described above is also rather slender.

A single tooth of a large equid was also recovered from the grave of Individual 1 <TAF06-4451>. The find is a left upper second incisor and was recovered in direct contact with the body of this individual. The tooth is in wear, the infundibulum (a deep opening found in the crowns of equid teeth) is long and oval in shape, a stage of wear on incisor teeth indicating a prime adult individual of around 7 years of age (Habermehl 1961, fig. 27). A right mandible of Barbary sheep <TAF06-4790> was also found directly below the pelvis of Individual 1. The mandible is incomplete, but the lower permanent molars (M1-3) are still in the jaw. The


3 cm
a
20 cm
b
3 cm
c
d
e

teeth are in wear, and the mandible appears to be from a prime adult individual, younger than 6 years of age, according to the modern comparative material (**tab. 9.1.17**).

The Grave of Individual 5

Three fragmentarily preserved portions of crania of Barbary sheep, located close together, surround the grave of this female individual. The first find <TAF08-6676> comprises portions of the left frontal and right parietal bones of an adult sheep. The right horn core is still attached to the skull and preserved to a length of 200 mm. The second find <TAF08-6715>, is a well-preserved portion of a skull of a young adult Barbary sheep. The find comprises the frontal bone preserved down to the level of the orbits with the bases of both horn cores still attached to the skull. The uppermost edges of the horns have traces of recent breakage, indicating the horn cores were originally preserved to a greater length than shown in **figure 9.1.21.** Both finds <TAF08-6676> and <6715> show traces of deliberate modification at the back of the vault, resulting in a large opening, through which the brain could be removed (**tab. 9.1.13**). The third find comprises fragments of a horn core and a small portion of the skull (<TAF08 6681> and <6716>). The horn core is preserved to a length of 300 mm. This find and the cranium <6715> are located very close to each other and may have derived from the same skull. If this was the case, then the length of horn core originally attached to the skull would have been quite substantial.

The Grave of Individual 12

An equid tooth <TAF13-11617> had been placed in direct contact with the body of this baby. It is a permanent upper or lower incisor of an adult equid. The lateral end of the infundibulum is not fully closed indicating an age of approximately six and a half years at time of death for this individual, according to Habermehl (1961).

The Grave of Individual 14

Numerous faunal remains were associated with the partly disturbed grave of this individual (see **Chapter 15**). They comprise remains of taxa forming the main components of the S10 faunal assemblage (Barbary sheep, a large equid, a large bovine, hartebeest and a gazelle) but also rarer components, such as remains of the small equid, red fox and a medium-sized canid.

Several faunal remains were recovered from the undisturbed parts of this grave. Two of these, the mandible of a red fox and the mandible of a medium-sized canid, had been placed alongside the body of the deceased. The find from the fox comprises an incomplete left mandible of a young individual <TAF13-12421>, resting directly above the left ankle. The mandible contains some of the permanent dentition, including the

Fig. 9.1.20 Cranium and horn cores of an adult large bovine from the grave of Individual 1 and from deposits surrounding the grave in S10: fragment of cranium (**a**) <TAF06-4617> with frontal bone and base of the horn core found in the grave; fragment of a horn core (**b**) <TAF10-10261> and tip of a horn core (**c**) <TAF10-10893> of large bovine recovered outside the grave of Individual 1; cranium and horn cores of the aurochs (*Bos primigenius*) (adapted from Cornwall 1965) (**d**) and giant African Buffalo (*Pelorovis antiquus*) (adapted from Pomel 1893) (**e**).

lower canine and premolars 1-4. The alveolae for the first and second molars are present, but the teeth have been lost after deposition and burial of the find. The mandible is broken in the region of the alveola of the third molar; this tooth is also missing. Since the replacement of the deciduous dentition by the permanent teeth in the red fox occurs over a short period of time from around two and a half months to six months (Habermehl 1961), fully developed permanent teeth, as in this specimen, should be present at six months of age, thus providing an approximate age at death for this animal.
The second mandible was located close to the hand and pelvis of the deceased. The find <TAF10-11398> comprises an incomplete left mandible of a medium-sized canid. The incisors are missing; the canine and most of the lower permanent dentition (P1-P4 and M1-2) are still in the jaw. The M3 was originally present, but loose, and was taken for sampling (O18 and Sr analysis, results pending). The teeth are all very worn, indicating an old individual. The upper portion of the ascending ramus has been broken recently and is missing. In contrast to the mandible of fox, which shows no traces of human modification, this canid mandible bears two sets of short, transverse cut marks across the ascending ramus. Cut marks in this position are consistent with removal of the jaw from the head. The taxonomic status of this specimen is unclear but still under study.
A fragment of a skull (os nasale) of a large animal, possibly a large bovine, was located close to the shoulder of Individual 14. Remains of Barbary sheep were also recovered in close association with the body of this individual. A cranium of Barbary sheep <TAF10-11286> was found next to the right knee. This find comprises a portion of the right frontal bone and the base of the horn core. Parts of the skull are still attached to the left horn core, which is preserved to a length of 120 mm. The horn cores are robust and derive from an adult (possibly male) individual. The cranium shows the same type of modification of the rear of the skull, described above on crania of Barbary sheep associated with grave 5. A fragment of a maxillary bone with upper M2 and M3 (12280) was laid next to the right elbow of Individual 14. The find is from an adult Barbary sheep, but bore no traces of human modification. Three fragmentary horn cores of this species (<TAF13-12183>, <TAF 15 13560>=HC1; <TAF13-11950>, <TAF13-11955>, <TAF15-13558>=HC2; <TAF13-12409>=HC3) were stacked above the left foot. The find <11950> had been burnt.

Discussion

At Taforalt, mammalian remains were recovered in close spatial association with the graves of the Iberomaurusian (Humphrey et al. 2012; Turner/Humphrey/Bouzouggar/Barton 2015). Crania or portions of crania played an important role and were probably specifically selected as funerary artefacts due to their size and or appearance. Regardless of whether the cranium of a large bovine in grave 1 is from aurochs or giant buffalo, both species have large, imposing skulls and horns. Close spatial associations of crania and fragments of the horns of Barbary sheep indicate the horn cores of this species were probably intact when the finds were deposited. The current state of preservation of Barbary sheep crania from the site gives little idea of how imposing these horns could have been at the time of their deposition close to the graves (**fig. 9.1.21**). Although two adult individuals of large bovine at S10 could be identified from duplicating dental elements, the fragmentary bovine horn cores currently give little additional information on numbers of individuals. In contrast, crania of Barbary sheep are in abundance, and in two instances, multiple crania of sheep were grouped together on the edges of the graves (graves of Individuals 5 and 14). There was also a large stack of at least seven horn cores of Barbary sheep associated with the grave of Individual 13 (see **Chapter 15**). The difference in the way crania of large bovines and Barbary sheep were utilised in their role as funerary artefacts may stem from the hunting tactics and economic activities of the Iberomaurusian. Barbary sheep

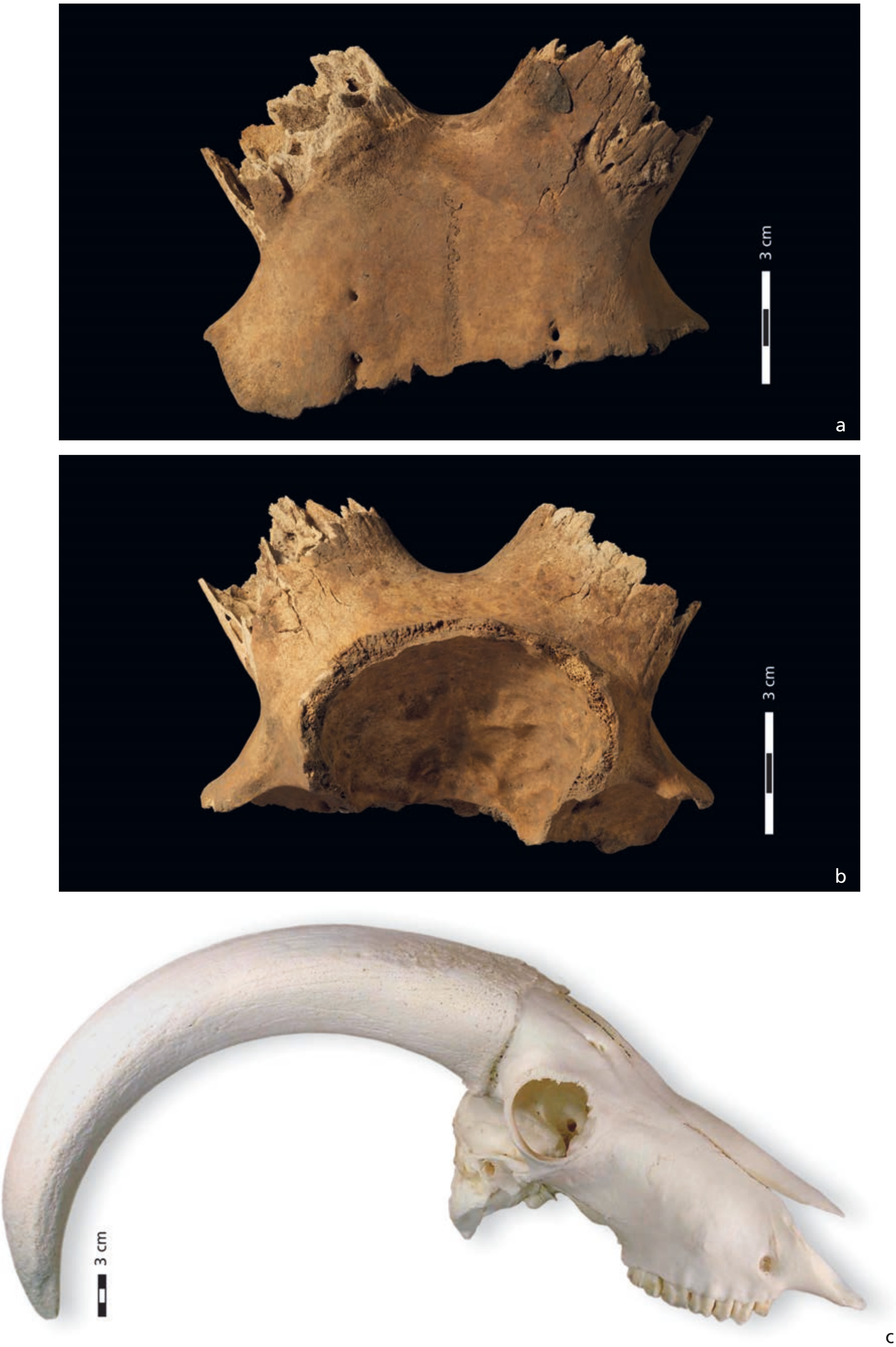


Fig. 9.1.21 Crania and horn cores of Barbary sheep <TAF08-6715> from S10: frontal view, with bases of recently damaged horns (**a**); occipital view (**b**) showing evidence of a deliberate opening of the brain case; (**c**) modern specimen (LMUM 26).

would have inhabited the rocky slopes and valleys immediately surrounding the cave and the evidence from S8 and S10 shows that this animal was the species of game preferentially hunted by the Iberomaurusians, probably due to its local abundance. This is reflected in the large amounts of remains from all parts of the body of Barbary sheep, together with high numbers of individuals and intensive traces of butchery on sheep bones in the assemblages from S10.

Large bovines would not have inhabited the steep, rocky terrain near the cave, but would have been encountered in the plains below the cave. It would have been necessary to transport their remains from a kill-site, presumably some distance away. Long transportation distances coupled with economic decisions may account for the low counts of post-cranial remains from at least two individuals of large bovine in S10 and for a predominance of fore and rear limb and foot bones of large bovines, resulting from a selection at the kill-site of smaller portions of the meatier parts of the carcass for transportation. These results are even more interesting when one considers that the cranium of one large bovine was deemed important enough to be transported to the cave, despite its weight and cumbersome form. Although the cranium of a large bovine would provide some meat and the brain, the choice to transport this portion back to the cave seems to be a departure from a purely rational decision to produce maximal returns in terms of food consumption. It appears to underline the importance of this particular skull, perhaps the equivalent of a modern-day 'trophy'?

The crania of Barbary sheep in S10 can be interpreted as the end-products of mundane hunting and butchery processing (extraction of the brain for consumption or for tanning hides), some of which had a secondary function as extraordinary artefacts commonly laid in or close to graves.

The remains of canids are rare elements in the Taforalt faunas, and the mandibles of the fox and the larger canid may also have been deliberately chosen because of the unusual form of the jaw and the sharp teeth. Cut marks across the ascending ramus of the mandible are consistent with removal of the jaw from the head but whether the mandible was deliberately separated from the head to be specifically laid in the grave or whether the cut marks were the result of more mundane butchery activities is uncertain.

Conclusions

The mammalian remains described in this chapter derive from two different zones in the cave at Taforalt. The deposits in Sector 8 (including the MMC series and with the nearby exposures in Sectors 3 and 4) comprise many units spanning a range in time from 20,894-21,430 to 12,566-12,713 cal BP. They incorporate an important boundary at c. 15,000 cal BP, marked by a distinct change in sedimentation between the yellow cave loams of the Yellow Series and the grey, ashy deposits of the Grey Series. The animal remains from Sector 8 are potentially useful in identifying diachronic changes in faunal representation and utilisation, in particular immediately before and after the boundary between the YS and GS units. In contrast, the larger numbers of faunal remains from Sector 10 give more detailed insights into the procurement and utilisation of animals between 15,101-14,365 to 14,660-14,086 cal BP.

This analysis has revealed the remains of several taxa in the LSA cave deposits. In both zones the faunas are typified by the appearance of five 'main' taxa, Barbary sheep, a large equid, a large bovine, gazelle and large alcelaphines, of which Barbary sheep is by far the dominant species. This dominance is also reflected in the presence of large quantities of medium-large sized animals in both zones, which are considered to augment the remains of Barbary sheep. The dominance of Barbary sheep in the faunas is undoubtedly associated with the location of the cave in a region of stony plateaus and valley slopes, the favourite habitat of this species where they would have occurred in abundance, a situation that the Iberomaurusians at Taforalt fully exploited. Radical changes in faunal composition in the assemblages were not observed at around 15,000 cal BP and the main taxa are present in the youngest unit of S8-YS (Y1) and appear again in the oldest deposits of S8-GS (L29). Barbary sheep is present throughout the younger deposits of the Grey Series; the other animals occur sporadically. This pattern of faunal representation may be due to fluctuating changes in climate and environment associated with regional occurrence/absence of some species, may reflect an increasingly selective procurement of Barbary sheep by the human occupants of the cave or may simply be a reflection of decreasing numbers of faunal remains surviving in general in younger units of the Grey Series. On the whole, the presence of varying quantities of skeletal elements of taxa and animal-size groups in the assemblages in S8 and S10 could be mainly attributable to differential bone survival in the cave, where fragile skeletal elements did not survive and were under-represented and robust skeletal elements did survive and were over-represented. Against this background, the richer remains in the yellow-brown assemblage in S10 provided information on the parts of the carcasses of taxa transported to and deposited in the cave. Almost all elements of large equid, large bovine and gazelle had been brought to the cave, even if in very low quantities. Interesting is the representation of the large equid at S10. This is the only taxon in S10 which has produced remains of all elements of the axial region (vertebrae; ribs; pelvis) and, together with fragments of ribs of large sized animals in S8-GS, indicates that axial elements from large animals were occasionally transported back to the cave. This is, however, not the case for the large bovine in S10, where the axial portion of the carcass is absent and, in this aspect, the skeletal representation of the large bovine from S10 resembles that of the much smaller gazelle. In contrast, all body parts of Barbary sheep, except the ribs, seem to have been deposited in the cave, sometimes in high quantities, where taphonomic processes led to a loss of more fragile elements.

Marks produced during butchery were observed on the bones of Barbary sheep, large and small equids, large bovines, alcelaphines, including hartebeest, gazelle and a medium-sized canid, but the bulk of the butchery traces on bones from the LSA deposits in S8 and S10 were found on the remains of Barbary sheep and animals in the medium-large size group. Standardised techniques of butchering were employed on the remains of animals in the assemblages in both sectors and on animals of different size. Major differences in butchery techniques were not observed between bones in the S8-YS assemblages and in the S8-GS assemblage. In the main, carcasses were dismembered at major joints and meat, bone marrow, bone grease and sinews (ligaments and tendons) were procured. These techniques of carcass processing were present throughout most of the phases of the LSA represented by the S8 and S10 deposits.

In contrast, higher percentages of butchery marks in the assemblage from the S8-GS deposits appear to reflect a more thorough processing of animal carcasses during the accumulation of the GS unit. Indeed, after indexing with sedimentation rates, both butchery and burning show a doubling, on top of the tripling in simple numbers, when comparing the GS with the YS. Evidence of skinning is present on crania of Barbary sheep, gazelle, large bovine and unidentifiable large animals from S10 and on the cranium of a gazelle in S8-GS. A deliberate opening of the rear of the crania to extract the brain was observed primarily on crania of Barbary sheep, but also on a cranium of a gazelle in the yellow-brown assemblage from S10. The brain may have served as a source of nourishment or could have been used specifically as a medium in the tanning of hides or both. Skinning marks on crania from S10, attesting to the procurement of hides, suggest that hides were likely tanned at Taforalt. Ligaments and tendons, removed from the feet, may have been used in a number of ways, including thread to sew clothing or make containers out of hides. Sinews would also have been useful items in binding, making snares, nooses or even nets.

Two long bones, a metacarpus of a large equid and a radius, probably from a Barbary sheep, bore traces indicating these remains may have been used as informal tools. But perhaps the most intriguing aspect of the faunal remains from the LSA deposits in S10 at Taforalt is the placement of crania and other faunal remains alongside the bodies of the deceased or surrounding their graves, indicating the use of these objects as funerary artefacts. Whereas the crania of Barbary sheep in S10 can be interpreted as the end-products of mundane hunting and butchery processing (extraction of the brain for consumption or for tanning hides), some of which had a secondary function as extraordinary artefacts commonly laid in or close to graves, the choice to transport the heavy, cumbersome cranium of an adult large bovine seems to underline the importance of this particular skull, perhaps the equivalent of a modern-day 'trophy'.

The bulk of the faunal remains in the S8-YS and GS units and in the assemblages from S10 showed no traces of burning, although there is still an appreciable increase in the GS. This result was rather surprising, since the S8-GS and S10 deposits are characterised by high quantities of ash and, in the former, the presence of several hearths. The bulk of the burnt bones are from Barbary sheep or animals in the medium-large size group. There was no apparent selection of particular skeletal elements and bones from both juvenile and adult animals had been burnt. Although low counts of calcined bones in the units in S8 and S10 suggest that bones were not used as fuel at Taforalt, the susceptibly of calcined bone to fragmentation and loss may have distorted these results. So far, the evidence from the LSA levels at Taforalt indicates that bones had little contact with fire and, where burning had taken place, had not taken place to a great degree. This does not appear to reflect a deliberate food processing and cooking strategy where bones were roasted over fires, but rather an *ad hoc* method of disposal of butchery refuse or the accidental incorporation of bone refuse into fires.

The age, or mortality, structures of three of the main species at Taforalt, Barbary sheep, equids and gazelle, gave insights into the hunting and procurement tactics of the Iberomaurusian. Only scanty information could be gleaned for gazelle in the S8-YS and GS deposits, where isolated teeth of juveniles, adults and one old adult were recovered. Teeth of mainly prime adult individuals of equid were also scattered through the same deposits, but in low numbers. The age-structure of Barbary sheep from S8 is characterised by very low numbers of deciduous teeth, several teeth of prime adult individuals and an isolated tooth from an older adult. More information was available from the yellow-brown assemblage in S10, where individuals of Barbary sheep from all three age-groups are present. Teeth of adult individuals form the dominant group and the bulk of these are from young, probably prime adults, rather than older ones. Similar patterns of age-group representation can be recognised for the large equids and gazelle in this assemblage, suggesting that, although the Iberomaurusians appear to have hunted all age-groups, young adults (prime adults) seem to have been preferentially taken.

Evidence of seasonality could be estimated for faunal remains from some of the units in S8-YS and S8-GS and indicate death of young individuals of Barbary sheep and gazelle in assemblages from this sector mainly between April to August and extending into October. Similar evidence was gleaned from young individuals of these species for the S10 yellow-brown assemblage. The data indicate death of these animals between March and July, but also extending into November. It was not possible to judge in this analysis when adult Barbary sheep and gazelle died due to the lack of comparative crown height data for permanent teeth (see Chapter 9.2).

Very low numbers of bones bearing gnawing marks in the assemblages in S8 and S10 suggest carnivores did not find the cave an attractive place to den or to scavenge, even though a stronger carnivore influence could perhaps be discerned in the results of limb fragmentation analyses. Rodent gnawing was only observed on a few bones. In particular, the lack of carnivore signatures on the faunal elements supports the idea of a strong human presence in the cave.

C. M. WALL-SCHEFFLER

9.2 SEASONALITY OF SITE USE AND AGE STRUCTURE OF *AMMOTRAGUS LERVIA* FROM DENTAL CEMENTUM

Introduction

A useful means of assessing the complexity of hominin behaviour comes from the reconstruction of subsistence strategies, including the patterns of use of seasonally available resources (Pike-Tay/Cosgrove 2002; Wall 2005; Wall/Wall 2006; Wall-Scheffler 2007; Wall-Scheffler/Foley 2008). The high resolution analysis of seasonality studies, such as those that use cementum banding patterns of prey (Burke 1995), isotopic analysis (Richards et al. 2008), or microwear patterns of hominin teeth (Henry/Brooks/Piperno 2014), offer the clues to what allows some populations to move into novel niches and out-compete resident groups, as well as the strategies some hominin populations might employ over long-term visits to the same site(s) (Lieberman/Shea 1994; Wall-Scheffler 2007). Here, we investigate the seasonal use of Taforalt, at a time when numerous other north African sites are also being populated (Close 1977; 1986; Close/Wendorf 1990; Barton et al. 2013), and when many of those sites share both technology (i. e. Iberomaurusian) and a dominant ungulate prey (i. e. Barbary sheep, *Ammotragus lervia*).
We consider *A. lervia* from Iberomaurusian layers of Sectors 8 and 10 that can be dated from roughly 21,000-14,600 cal BP (see **Chapter 4**). We compare our analysis with that of the seasonality of site use and age profiles of the LSA assemblage at Haua Fteah (Libya). A better understanding of the potential seasonality shifts in faunal use between the comparable LSA at Haua Fteah and Taforalt could provide a better understanding of *H. sapiens* dispersals and patterns of innovation in slightly different niches.

Materials and Methods

Ammotragus lervia teeth from Sectors 8 and 10 were collected in order that an analysis of the luminance properties of dental cementum bands could be accomplished. Eighteen teeth (12 from S8 and 6 from S10) were chosen as potential specimens for cementum analysis. Five of these teeth were processed initially to test for diagenesis (see below). As none showed complete diagenesis, the rest of the sample was processed. Of the eighteen teeth, seven from S8 and five from S10 showed no damage to the outer edge after processing and are used in the analysis. The rest of the sample showed clear damage to the outer edge, so only gave a minimum possible age and no season of death (**tab. 9.2.1**).

Dental Cementum Preparation

Each tooth was embedded in resin, sliced longitudinally down the centre and each cut-face was polished. Each half was then adhered to a frosted slide with more of the same resin (Buehler Epo-thin epoxy) and left to dry overnight. Once dry, the remaining tooth was sliced off and the thin section ground down and polished to 70 µm ± 10 µm (for more details, see Wall 2004; Wall-Scheffler/Foley 2008).
Upon slide completion, each thin section was viewed using a polarising microscope. Polarising light microscopes which utilise transmitted light are regarded as superior to reflected light microscopes, as they allow

Age	Season	Sector	Specimen	Layer	
	Damaged Edge	8	10387		
	Damaged Edge	8	1635		
	Damaged Edge	8	1859		
>2	Outer edge damaged	8	1026	Y1	
>3	Outer edge damaged	8	2152	Y4spit2	Lowest Yellow
6	Winter	8	9061	L14	Grey Series
9	Winter	8	9835	base L23	
3	Winter	8	10361	L29	Lower Grey
1	Winter	8	717	L29 (G100)	
12	Late Summer	8	944	Y1	Upper Yellow
3	Winter	8	1101	Y1	
4	Winter	8	1839	Y2spit5	Lower Yellow
	Damaged Edge	10	6177		
2	Late Summer	10	5503		Contemporary with Lower Grey Series of Sector 8
4	Winter	10	8686		
9	Winter	10	10699		
2	Winter	10	10686		
7	Winter	10	4014		

Tab. 9.2.1 The age and season of death of *A. lervia* from Taforalt, from dental cementum analysis.

finer histological details to be seen (Hillson 1986); in addition, previous researchers have had problems using a reflected light microscope for the analysis of dental cement (McCullough 1996). Reflected light reveals superficial detail whilst polarised light transmitted through the specimen is being scattered by the structural properties of the cementum, thus revealing more detail than the reflected light microscope (see further description in Burke 1993). Furthermore, a polarising set-up is crucial for Palaeolithic zooarchaeologists in assessing the appearance of diagenetic samples among faunal remains (Stutz 2002).

The microscope used for this research is a Leica DM EP with 10X and 20X objectives and a rotating stage that can be used to align the sample with the polarising lenses. The optical properties of cementum can vary depending upon the orientation of the sample to the polarisers (for a detailed explanation, see Stutz 2002). To create consistency in the optical properties of each sample, the protocol consisted of lining each sample up to one of the perpendicularly oriented polarisers, so the first cementum band after the layer of Tommes (adjacent root dentine) would appear as a high luminance (HL) band (Lieberman 1994). Under polarising microscopes, HL bands of this population represent summer, or fast-growth periods, while low luminance (LL) bands represent winter, or slow-growth periods. The entirety of cementum tissue on each tooth was assessed for areas of complete cementum (e.g. no damage to the outer edges) which also exhibited high contrast between HL and LL bands.

Diagenesis Analysis

The use of dental cementum to assess the season of death of faunal remains has been shown to be successful in Palaeolithic archaeology, once a detailed analysis of the appearance of diagenetic samples (e.g. any effect of post-mortem chemical and physical changes that might alter banding patterns) has been accomplished (Stutz 2002). Following Stutz (2002), an analysis of diagenesis was undertaken; the samples used for this analysis and the appearance of unusable (due to the loss of the outer edge) individual teeth are listed in **table 9.2.1**.

Age Analysis

In order to look at patterns between assemblages and seasons, age cohorts will be utilised for some analyses. The age cohorts are defined similar to those in Cassinello (1997) and comprise Calves (0-11 months), Yearlings (12-23 months), Juveniles (2 years - 2 years 11 months), Sub-adults (3 years - 3 years 11 months), Prime / Adults (4 years - 7 years 11 months) and Post-prime (greater than 8 years old). The cohort decisions from Cassinello (1997) are based on data from body size, horn size, teeth maturation and dominance relationships.

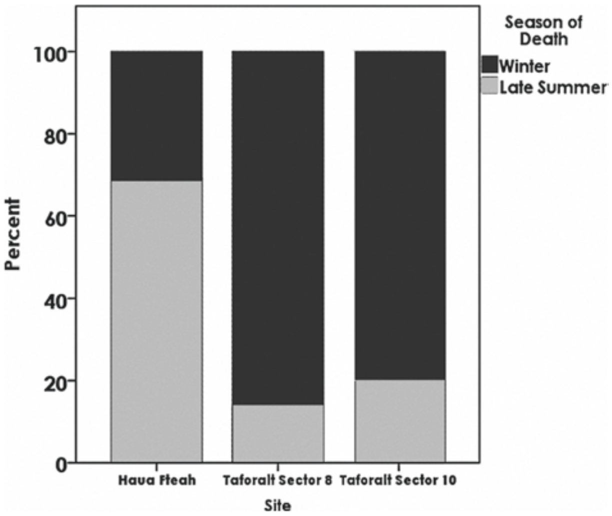


Fig. 9.2.1 The percentage of summer versus winter deaths of *A. lervia* within Iberomaurusian assemblages at the Haua, and the two sectors of Taforalt, from dental cementum analysis.

Results

The results show that the majority of *A. lervia* specimens studied were taken during the winter months (83 % across the Iberomaurusian assemblages; **fig. 9.2.1**), and that these animals were generally in their prime (mean = 4.3 years for Sector 8 and 5.5 years for Sector 10) (**fig. 9.2.2**). The individuals taken in the late summer were either old (12 years for Sector 8) or young (2 years for Sector 10).

Discussion

Though the sample size used here for the dental cementum analysis is currently small, the striking pattern of winter deaths sets the Taforalt Iberomaurusian apart from the comparable LSA of Haua Fteah (Wall-Scheffler 2007, fig. 1), which was dominated by late summer usage of *A. lervia*. That being said, the *A. lervia* remains at the Haua also showed a much broader range of age-at-death among the summer months than winter months, which is clearly true of this limited dental cementum sample from Taforalt as well, given the young and old ages found in the summer deaths. Initially it was unclear if the increased summer age range at the Haua might simply be due to the larger number of individuals accumulated during the summer (given that most of the deaths at the Haua were from the summer

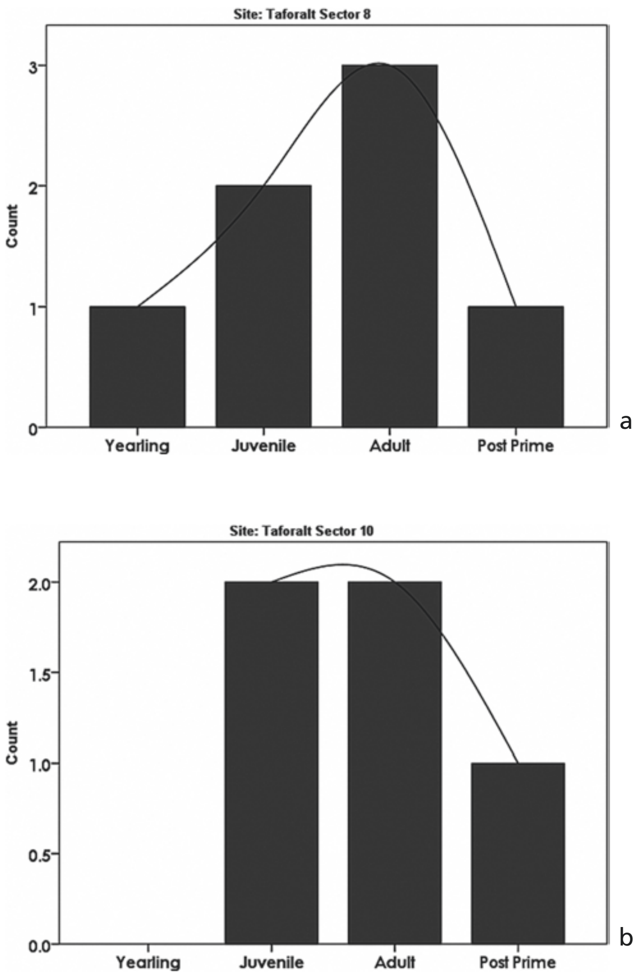


Fig. 9.2.2 The age profiles of Taforalt *A. lervia*, from dental cementum analysis; **a** Sector 8, **b** Sector 10.

months) but, given the findings from this Taforalt sample, it seems possible that use of *A. lervia* during the summer in the LSA did include a broader age range and represents a seasonally different strategy (Wall-Scheffler 2007). It should further be noted that the only post-prime individual found at the Haua came from the Holocene Libyco-Capsian assemblage, and not the Pleistocene LSA (Wall-Scheffler 2007), although Close (1977; 1986) has argued for a gradual shift between these two populations. Clearly, analysis of a larger *A. lervia* sample should be considered, in order to get a clearer understanding of how this prey species was used by the populations at Taforalt.

J. H. COOPER

10. THE LATE PLEISTOCENE AVIAN ASSEMBLAGES FROM SECTORS 8 AND 10

10.1 INTRODUCTION

Modern Morocco boasts an extremely rich avifauna, thanks to its complex topography, Mediterranean and Atlantic coastlines, wide diversity of habitats and also its location on a major bottleneck on the Europe-Africa migration route. Some 452 bird species have been recorded, of which 209 (46 %) breed regularly as either residents (140 species) or summer migrants (69 species), with 15 further occasional breeding species. The present avifauna includes a small number of full species endemic to the Maghreb region and also nearly 20 subspecies endemic to Morocco. During the 20th century, 13 regular breeding species have become extinct in Morocco, with a further 21 species currently threatened at country level (Thévenot / Vernon / Bergier 2003). 15 species are regarded as Globally Threatened by the IUCN, five of which are considered Critically Endangered or Endangered (BirdLife International 2016).
The biogeographic affinities of the Moroccan avifauna are complex. Considered part of the West Palearctic region, the majority of species now present are of Holarctic or Mediterranean origin, with a minority of Saharan species. However, a significant number of tropical species with origins in sub-Saharan Africa also occur, more so than in other countries of the Maghreb.
Thanks to its diverse avian communities, Morocco has attracted the interest of ornithologists from the mid-1800s onwards. Consequently, the recent ornithological history of the country is now well documented (see Thévenot / Vernon / Bergier 2003). By contrast, relatively little is known about the ancient avian communities of Morocco, or indeed of the Maghreb in general. Only five Moroccan sites were listed in the comprehensive Palearctic Pleistocene catalogue of Tyrberg (1998) with only a further two added in the online revision of 2008 (Tyrberg 2008). Between these sites, which span from Middle to Late Pleistocene, only four avian taxa have been identified, dominated by Ostrich *Struthio* sp. recorded from all seven (Tyrberg 1993; 2008). The Pleistocene and Holocene avifauna of further Moroccan cave sites, including El Harhoura 2 and Guenfouda are presently under review (cf. Aouraghe et al. 2010; Steele 2012).
The fossil avifaunas from the Grotte des Pigeons therefore represent the first Late Pleistocene specimens available for eastern Morocco and are also the most diverse Pleistocene or Holocene Moroccan fossil bird assemblages yet documented.

10.2 MATERIALS AND METHODS

The Grotte des Pigeons is located at approximately 720 m above sea level in the mountains of the Beni Snassen region of eastern Morocco. The Beni Snassen range reaches a maximum elevation of some 1530 m and forms part of a mountainous boundary complex lying between lowland plains to the north reaching the coast some 40 km distant and arid high plateaux to the south. At present, the slopes of the Beni Snassen are characterised by thermo-Mediterranean scrub and woodland, with a further characteristic of the region near the Grotte des Pigeons being deep, often verdant gorges. Although the region is now recognised as a SIBE (*site d'intérêt biologique et écologique*) preserving a wide range of native species, there has been significant human ecological alteration of the area in recent centuries, which more recently has included dedicated efforts to restore floral and faunal communities (see **Chapter 1** for a regional review).

The assemblages examined here originate from the series of excavations from 2005-2010, for which comprehensive analysis of the avifaunal finds has been completed, including individual finds recorded *in situ*, remains isolated during sieving in the field and remains recovered during post-excavation fine picking of bulk sediment samples.

Most of the assemblages were kindly made available for analysis in the UK, enabling the majority of specimens to be identified by direct comparison with the recent avian osteological collection of the Natural History Museum, held at Tring. A number of the larger finds were examined and identified in the field or at INSAP, Rabat, using reference photographs as necessary. The entire collection is now deposited at INSAP. All specimens not from the Order Passeriformes were identified as precisely as possible, as was material from larger Passeriformes such as Family Corvidae (crows). Due to the high degree of conservatism in their osteological morphology, detailed taxonomic identification of remains from smaller passerines was restricted to humeri and occasional cranial or mandibular elements, which are more diagnostic. As these elements are comparatively robust and survive well, this approach is a useful method of establishing the diversity of a small passerine assemblage (cf. Cooper 1999; 2012a; 2012b).

The taxonomic treatment used here follows Thévenot / Vernon / Bergier (2003).

10.3 RESULTS

A total of 161 avian remains were recovered from the LSA levels in Sectors 8 and 10 respectively, including 107 non-passerine and 54 passerine remains. Between these two Sectors, a total of 16 distinct taxa were recovered. It should be noted that a significant quantity of avian material was also recovered from MSA levels at the site, which will be described separately in due course.

Sector 8

Sector 8 yielded the less numerous avian assemblage, with 46 remains recovered, of which only five were identifiable to genus or species level (**tab. 10.1**). Despite the low number of avian finds, the identifications are informative.

Taxon	Common name	Current status	NISP	MNI
Alectoris barbara	Barbary Partridge	RB	3	1
Upupa epops	Hoopoe	PM, BM, OW	1	1
cf. *Pyrrhocorax*	probable Chough	RB	1	1
Passeriformes indet.	Passerine	-	20	-
Aves indeterminate	Bird	-	21	-

Tab. 10.1 A summary of avian remains from Sector 8 (abbreviations indicating present status in Morocco are: RB = resident breeder; FB = former breeder; BM = breeding migrant; PM = passage migrant; OW = overwinters; WV = winter vagrant; AV = accidental visitor).

Taxon	Common name	Current status	NISP	MNI	Modified
Struthio sp.	Ostrich species	FB	1	1	1
Aquila sp.	Eagle species	RB, AV, FB	1	1	1
Alectoris barbara	Barbary Partridge	RB	18	2	
cf. *Alectoris*	probable partridge		2	1	
Otis tarda	Great Bustard	RB	24	4	9
Columba cf. *livia*	Pigeon, probable Rock Dove	RB	1	1	
Columba livia/oenas	Rock/Stock Dove	RB, WV	3	1	
cf. *Columba*	probable pigeon		1	1	
Columbidae	Pigeon family		1	1	
Strix aluco	Tawny Owl	RB	1	1	
Apus sp.	Swift species	RB, PM, BM, OW	1	1	
Pyrrhocorax pyrrhocorax	Red-billed Chough	RB	1	1	1
Aves indeterminate	Bird (non-passerine)	-	42	-	
Passeriformes indet.	Passerine	-	17	-	

Tab. 10.2 A summary of avian remains from Sector 10 (abbreviations as in **tab. 10.1**).

The most noteworthy find was the proximal carpometacarpus of Hoopoe *Upupa epops*, from Unit Y2, the only record of this taxon from the site.

Sector 10

The LSA deposits of Sector 10 yielded the most remarkable avian finds yet discovered at the site. Overall 114 bird remains were identified, in 14 distinct taxa (**tab. 10.2**). Similarly to other areas of the cave, the assemblage from this sector includes low numbers of identifiable remains from a reasonably wide range of small taxa. However, this Sector's signature is the presence of a significant number of remains from very large taxa, including a damaged distal phalanx of Ostrich *Struthio* sp., a fragmentary proximal scapula from an eagle *Aquila* sp. but, most importantly, over twenty remains of Great Bustard *Otis tarda*. Also notably abundant in this sector was Barbary Partridge *Alectoris barbara*, with 18 remains recovered, representing two or more individuals.

Amongst the less common taxa, several stand out as being of interest. A distal tibiotarsus of Tawny Owl *Strix aluco* adds a significant predator to the assemblage.

Remarkably, the most abundant taxon present, both in terms of number of identified remains and minimum numbers of individuals (MNI) was Great Bustard *Otis tarda*, represented by 24 remains, including at least four individuals (three adults and one juvenile) but probably more. In terms of skeletal element representation, the assemblage is dominated by elements from the trunk including coracoid, furcula, sternum and synsacrum (**tab. 10.3**). Additionally, although a limb bone, the femur also forms part of the core body mass, being embedded within the significant muscle complex at the hip. Also well represented, indeed forming the basis for the adult MNI, were distal humeri, three each of left and right. A damaged humerus shaft was also found. Other parts included two bill fragments, a damaged juvenile ulna and a damaged tarsometatarsus.

The osteology of Family Otididae is distinctive, making initial identification of bustard relatively straightforward and the large size of the Taforalt remains considerably narrowed the field for candidate taxa. Bustards are believed to have evolved on the African continent, and it remains the centre of their diversity, though the history of the distribution and evolution of the modern taxa remains relatively poorly known (Collar 1996). At present, several large species occur south of the Sahara, including the very large Kori Bustard

Element	Entire	Proximal	Distal	Other
Cranium				
Premaxilla			1	
Mandible				1 fragmentary
Vertebrae	2			
Sternum	1			2 fragments
Furcula	1			
Coracoid	1			
Scapula				
Synsacrum				2 fragmentary
Humerus			6	1 shaft
Ulna	1			
Radius				
Carpometacarpus				
Manus phalanges				
Femur			2	
Tibiotarsus				
Tarsometatarsus				1 shaft
Pedal phalanges				

Tab. 10.3 Great Bustard *Otis tarda* skeletal element representation in Sector 10.

Ardeotis kori (adult males up to 19 kg; all masses from Collar 1996) and somewhat smaller Denham's Bustard *Neotis denhami* (adult males up to 10 kg). The substantial Arabian Bustard *Ardeotis arabs* (adult males up to 10 kg) now has a Sahelian range immediately south of the Sahara, with a probably extinct subspecies *A. arabs lynesi* formerly present in North Africa, including Morocco where it was last recorded in the 1990s (Hume/Walters 2012).

Great Bustard (adult males up to 18 kg) is primarily a Eurasian species but a small population occurs at present in Morocco, marking the southernmost limited of its global range.

Notably, modern ranges of the largest bustards do not overlap; where more than one species of bustard occurs, they appear to be generally organised in size guilds. Nevertheless, there remains the possibility that palaeogeographic ranges may have shifted due to climatic and habitat alterations, replacing one large bustard with another over time. Identification of the larger bustards may also potentially be complicated by their great sexual dimorphism, with males up to 50 % larger than females, which can result in significant overlapping of size ranges. The bustard remains from Grotte des Pigeons were directly compared to skeletal specimens of *Otis tarda*, *Ardeotis kori* and to skins and x-rays of *Ardeotis arabs lynesi* held at the NHM, Tring. A range of comparative measurements of Great Bustard was also obtained from the avian osteological collection held at the Naturhistoriches Museum, Vienna (NHMW).

The Grotte des Pigeons assemblage was identified as Great Bustard on the basis of morphology and measurements. Morphologically, finds of a premaxilla, a fragmentary mandible and a damaged tarsus are particularly noteworthy. Great Bustard has a proportionately short bill and short tarsus, whereas the large southern African species share the features of a long bill and long tarsus; although damaged, the Taforalt finds are clearly proportionately short. In terms of morphometrics, *A. a. lynesi* could additionally be ruled out on the basis of size, being significantly smaller than Great Bustard overall. It was immediately apparent that the size range of the Grotte des Pigeons assemblage exceeded the range of the limited number of comparative specimens available at Tring, but that a number of specimens nevertheless fell into two distinct groups of larger and smaller individuals. Measurements of the extended comparative sample at NHMW both clarified the separation of male and female sizes and expanded the modern size range. From this, a number of the

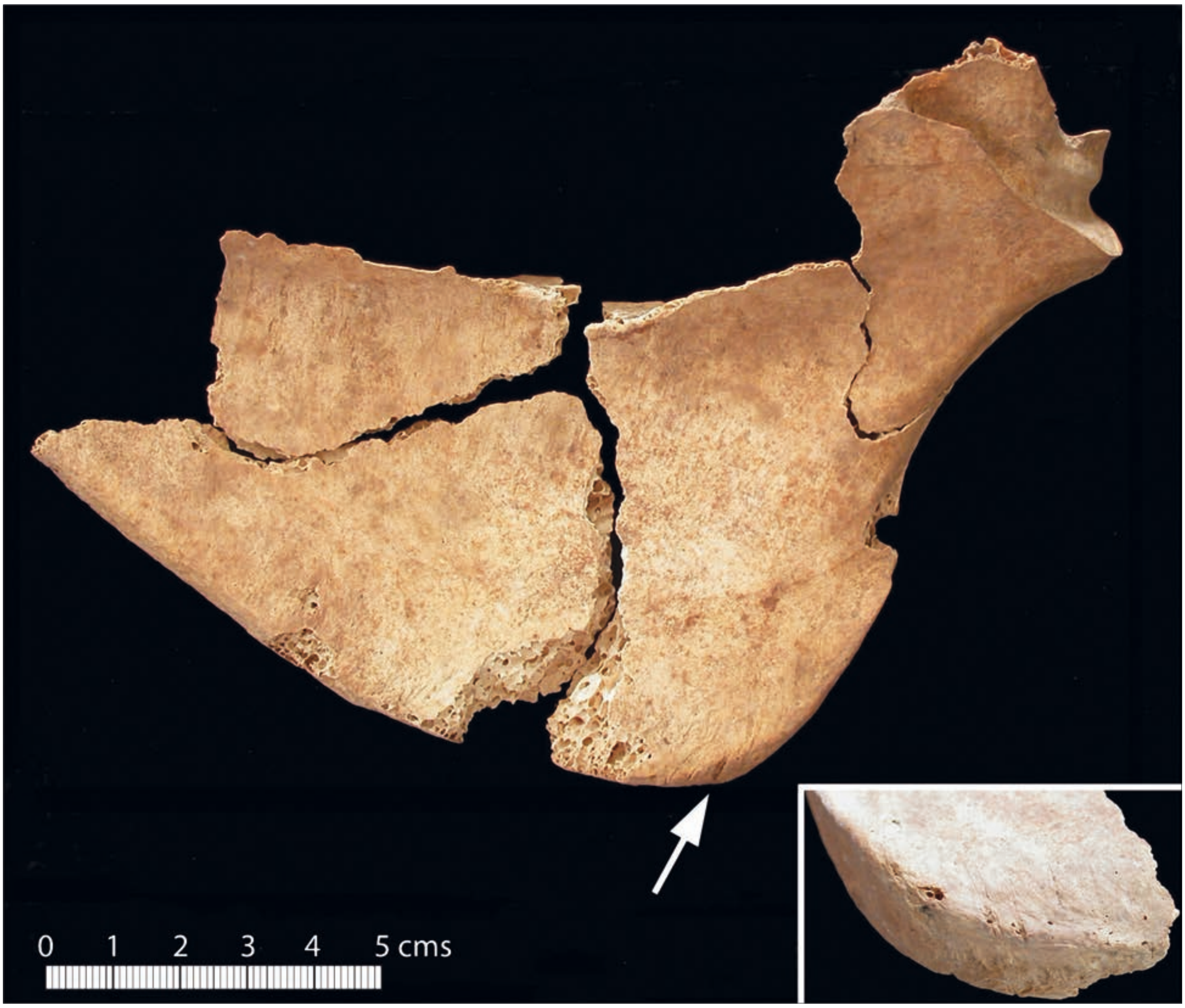


Fig. 10.1 Great Bustard *Otis tarda* fragmented sternum <11389>; inset: cut-marks to keel. – (Photo J. H. Cooper).

present finds can be confidently sexed, confirming that adult male and female individuals are present, with remains of at least one juvenile also preserved. However, the largest of both male and female remains also exceeded the maximum size range of the Vienna collection. Nevertheless, the largest supposed female fossil finds were still below the size of the smallest modern males.

Great Bustard remains were found across the excavated area of Sector 10 and throughout the burial stacks but, due to the complex cross-cutting of the burials, it is difficult to determine clear associations between bustard finds and individual burials. No articulated remains were found but at least two individual bustards, represented by fragmented sterna, were definitely associated with Burial 14 (see below), recovered during the first season of excavation of this individual burial. The most complete of these sterna <11389> is a very large male (**fig. 10.1**). Further sterna fragments <11315-11316> are probably also associated with this burial, but cannot be confirmed as representing additional individual bustards, though this is certainly possible. A damaged tarsometatarsus was unearthed within Burial 5, adjacent to one forearm. However, this may represent disturbance of a previous burial when Individual 5 was deposited. One distal humerus <11348> was found in the midst of Individual 13, but is likely to represent intrusive disturbance. The remaining finds were found throughout the Sector, including in the 'blue stone' burials area and main burial stacks (cf. **Chapter 15**), but with no clear associations to any other individuals.

Fig. 10.2 Ostrich *Struthio* sp. terminal phalanx <4054>, with modern comparative specimen. – (Photo J. H. Cooper).

10.4 MODIFICATIONS

Cut-marks were recorded on numerous bird bones from Sector 10 (**tab. 10.2**). In addition to appearing on many of the Great Bustard bones, discussed in more detail below, cut-marks were also discovered on the eagle scapula fragment <11360> and on the isolated premaxilla of a Red-billed Chough *Pyrrhocorax pyrrhocorax* <11358>. These latter marks may show sawing, being particularly deep with evidence of multiple strokes into the bone (**fig. 10.3**). Unfortunately, though recovered from the area between Individuals 13 and 14, neither eagle nor chough find showed a clear association with a specific burial.

Evidence of further potential modification comes from the single ostrich phalanx, recovered with general finds from the burial stack of Individuals 1-4. This has significant damage to its proximal part (**fig. 10.2**). This is a relatively small but extremely robust element, which might be considered resistant to most natural damage. Additionally, in life, the phalanx would be sheathed by a very strong toenail almost hoof-like in form, with the rest of the digit covered in an extremely tough scaly skin. To penetrate these defences to inflict the damage observed would appear to have required some determination. It seems reasonable to suggest that this damage may have been deliberate.

Within the Great Bustard assemblage, cut-marks are present on nine of the remains, including on the large sternum <11389> and humerus <11853> in Burial 14 and all six distal humeri recovered from the site.

On the sternum, a small group of near vertical fine cuts is apparent on the apex of the keel, passing across its right margin and onto its right side (**fig. 10.1**). On a complete carcass, this is the deepest part of the

Fig. 10.3 Red-billed Chough *Pyrrhocorax pyrrhocorax* cut-marked premaxilla <11358>, with comparative skin specimen. – (Photo J. H. Cooper).

chest, with the maximum depth of breast muscles lying to either side of the keel. Based on personal practical experience of preparing large modern comparative osteological specimens, including Great Bustard, it is worth noting that the edge of the keel itself is not buried very deep in tissue and its apex can make a useful starting point for filleting away the breast muscles from the keel.

The most abundant Great Bustard elements, distal humeri, and also the entire humerus, are also the most cut-marked. All seven displayed cut-marks to a greater or lesser extent, primarily small groups of fine, largely parallel cut-marks on the dorsal and/or caudal surfaces and some isolated cuts to the distal articulation. The extent of the surviving shaft also shows a strong degree of consistency, with several specimens retaining approximately one-third of the original overall length of the humerus.

No charring was observed on the recovered Great Bustard remains.

10.5 DISCUSSION

Origins of the Assemblage

The accumulation of the avian assemblage at Grotte des Pigeons can be attributed to a combination of natural and human agencies. Remains deposited by the latter, all associated with the activities of Sector 10, are considered in more detail below. These include the bustards, ostrich, eagle, some Red-billed Chough and possibly some partridge.

While human use of the cave has changed considerably over time, natural processes of accumulation are still very much in evidence. Observations made during several excavation seasons of birds and their behaviour, in and around the site, provide useful indications of likely past use of the cave. Indeed, many of the same species still occur at the site or in the local area (personal observations).

The simplest, most direct source of birds is death on site. Several species presently use the cave or cliffs for nesting; including Rock Doves and Pallid Swifts *Apus pallidus*. Various other species forage in the cave, particularly for insects and their larvae, or around its entrance. Any of these may potentially die on site and be incorporated. Modern remains of a Rock Dove found towards the entrance of the cave may represent this route. It is striking that in Sector 10, once the species clearly linked with human activities are excluded from the assemblage, the remaining taxa are almost all known occupants of the cave, strongly suggesting the incorporation of the occasional inhabitant.

However, this does not provide a satisfactory explanation for the entire assemblage, given the presence of non-cave dwellers, including woodland and matorral species. Again, the modern cave may provide the answer. Towards the rear of the site, remains of recent birds were being accumulated very effectively at the base of a well-used owl roost on a small, raised pillar-like rock. Feathers and droppings indicated its recent use and also identified the predator as a Tawny Owl *Strix aluco*. Beneath the roost was a significant accumulation of small bird and mammal remains, having apparently been incorporated into the cave sediment as regurgitated pellets decomposed. A full analysis has yet to be completed but the bird remains included numerous small passerines, amongst them significant numbers of hirundines. One find of Tawny Owl was recovered from Sector 10, confirming its presence in the local LSA palaeocommunity.

Tawny Owl is a medium-sized owl, but with a wide prey range for its size, capable of taking birds from the tiny Goldcrest *Regulus regulus* up to adult Mallard *Anas platyrhynchos*. Both Rock Dove (both Sectors) and Woodcock (Sector 8) are known prey, whilst Hoopoe (Sector 8) and Barbary Partridge (both Sectors) are within the prey size range; the additional presence of small but unidentified passerines is also worth noting. Although not described in detail here, it is notable that many of the taxa identified in the site's MSA avian assemblage are also known prey of this owl. Altogether, based on the modern evidence of its activity on site and the taxon's prey profile, it seems reasonable to suggest that Tawny Owl was probably also a key contributor to the fossil avian assemblage.

Overall, the natural sources of birds appear to have provided a sampling of the avifauna of the cave and its local environs. Based on modern home ranges (i.e. the hunting range) of Tawny Owl, this might suggest a sampling area of less than 1 km^2 for possible owl contributions (Mikkola 1983).

Archaeological Significance

Only four taxa provide clear evidence of human activity, all from Sector 10; a large eagle, Red-billed Chough, Ostrich and Great Bustard. Each of these exploited taxa has its own distinct archaeological signature and is considered below. Other taxa may potentially have been utilised, but as yet this cannot be confirmed as no further cut-marks or other modifications have been identified to date. In the case of Barbary Partridge, with 18 (possibly 20) confirmed remains, it is second only in abundance in Sector 10 to Great Bustard. This abundance, which is well in excess of any inhabitant or possible Tawny Owl prey species, combined with its status as a non-cave dweller, may well indicate that its presence is also connected with human activity. The skeletal element distribution of Barbary Partridge (**tab. 10.4**), includes elements from the trunk, legs and proximal wings, but distal wing elements are absent. While a proportional absence of wing elements has been used to suggest human involvement in accumulation (cf. Ericson 1987), it should be noted that some owl species detach wings at the humerus before consuming their prey, which could result in a similar bias (cf. Stronach/Cooper 2010). Considering the present evidence, human activity may be suspected then, but not confirmed. Barbary Partridge is likely to have been abundant locally, then as now, and if it was hunted by humans could have been obtained using ground-based traps or snares made from twigs, sticks and plant-fibre twines (cf. Wadley 2010).

Element	Entire	Proximal	Distal	Other
Cranium				
Premaxilla				
Mandible				
Vertebrae				
Sternum				1 fragment
Furcula				
Coracoid		3		
Scapula	3			
Synsacrum				1 fragment
Humerus	1		1	
Ulna				
Radius				
Carpometacarpus				
Manus phalanges				
Femur	1	2		
Tibiotarsus			2	
Tarsometatarsus	1		1	

Tab. 10.4 Barbary Partridge *Alectoris barbara* skeletal element representation in Sector 10.

Ostrich *Struthio* sp.

For the skilled hunter-gatherer, ostriches should potentially represent a unique resource, providing not only substantial quantities of food, in terms of meat, fat and eggs, but also additional raw materials of feathers, leather, sinews, eggshell and bone. However, while ostrich eggshell is widely recorded in North African Palaeolithic sites, finds of ostrich bone remain extremely limited (cf. Tyrberg 1998; Merzoug 2011). It is possible that the large bones, particularly if heavily damaged by processing, may be going unrecognised in sites. The rarity of ostrich bone in archaeological sites has also been attributed to an inability to hunt adult birds successfully. While this may indeed be true in some areas, a wide range of traditional hunting techniques recorded in the mid-19th to 20th centuries across Africa suggests that ostriches are not as invulnerable as might be supposed (de Mosenthal/Harting 1879; Davies 2002). Even without using arrows, ostrich may be ambushed at the nest or near waterholes; stalked by hunters wearing gazelle or ostrich skins; lassoed; trapped in pits; driven into ambushes; rounded up and killed in a co-operative circle hunt. However, as adult ostrich are large, wary, fast, potentially aggressive and prefer extremely open habitats, they are noted as difficult quarry; indeed in some cultures, success in ostrich hunting carried considerable prestige (de Mosenthal/Harting 1879).

Based on comparisons with 19th century accounts, it seems possible that ancient ostrich kills may have been largely processed in the field for ease of transport and that only a small proportion of the carcasses was returned to hunters' dwellings. One traditional method of field dressing removed the prized skin as a first step, followed by rendering the fat (which may approach 20 litres) into bags made from the intact skin of the thighs tied off at the lower end (de Mosenthal/Harting 1879). The meat may then be divided amongst the hunters. The main meat mass on an ostrich is carried around the thighs and upper shin; it is possible that, as with the anatomically similar moa of New Zealand, relatively little of the rest of the carcass was exploited for meat and was discarded (cf. Berentson 2012). Consequently, even where ostriches might have been exploited, relatively little evidence of the actual birds may have survived to be preserved on sites, having been converted in the field into perishable products.

Currently, only one find of Ostrich bone has been confirmed at the Grotte des Pigeons, a substantial distal phalanx <4054>, heavily damaged at its proximal end (**fig. 10.2**), which unfortunately cannot be associated with a specific burial. Ostriches have only two digits, a reduced outer toe and a large inner toe carrying an extremely robust, almost hoof-like claw. This is triangular in section and gently curved along its length, which may be over 100 mm. Depending on wear, the tip may be blunt or somewhat pointed. It is these heavy claws that make the ostrich's defensive attack of kicking a highly effective and indeed dangerous deterrent.

Bird claws have been, and indeed still are, used very widely across human cultures as objects of cultural significance (Serjeantson 2009). It seems highly likely that this ostrich claw was an ornament of some kind, possibly hung as a pendant by binding the proximal end of the claw. Given the apparent cultural and ritual significance to the people of the Grotte des Pigeons of large animals, including at least one species of bird, the probably highly valuable practical and perhaps also cultural status of ostrich and the likely difficulty of obtaining a claw like this, it seems reasonable to suggest this was some form of trophy, perhaps conferring status upon its owner.

Ostrich Eggshell

Robust and readily recognised, ostrich eggshell (OES) fragments are widespread in North African archaeological sites, frequently noted where other bird remains have not been described (Tyrberg 1998; Steele 2012). In Morocco OES has been recovered from the MSA at Rhafas, Dar-es Soltan 1, Irhoud and El Harhoura 1 and 2 (Steele 2012), and also at the mid-Holocene Bizmoune Cave (Fernandez/Bouzouggar/Collina-Girard/Coulon 2015).

At the Grotte des Pigeons, OES fragments have been recovered throughout Sectors 8 and 10, with 39 and 22 fragments recovered up to 2010 from each sector respectively. Roche (1963) reported 994 OES fragments across the majority of his levels, with the highest number (733) recovered in the outer cave. However, more fragments may not equate to more eggshell but simply more breakage, for example from trampling, as might be expected in the outer cave.

Ostrich eggs are the largest of any modern bird, averaging about 159 × 131 mm in overall size, weighing (with contents) about 1500 g with eggshell thickness approximately 2 mm (Folch 1992). It is worth noting that with a surface area of some 5800 mm^2 (cf. Paganelli/Olszowka/Ar 1974; Muir/Friedman 2011), a single egg can potentially be shattered into a surprisingly large number of fragments. For example, even a generous fragment size of 40 mm^2, similar dimensions to the fragment figured by Roche (1963, fig. 25), would result in a total of 145 fragments. A more detailed analysis of the total area of recovered eggshell could provide a more refined estimate of the potential number of eggs present, but it would seem that the complete Grotte des Pigeons OES assemblage, as recovered (that is, not allowing for any collection bias in the early excavations or for any other taphonomic effects), could represent less than ten eggs.

This may at first appear to be a high figure, however it must be considered that, unlike the adult birds, eggs can be obtained relatively easily. Ostrich lay large communal clutches, which often number over 25 eggs (an example of over 70 in a single nest has been recorded) (Folch 1992). Brooding adults may spend periods away from the nest, allowing eggs to be collected with relative ease (Folch 1992; Davies 2002). Potentially only a very few encounters with ostrich nests would have been necessary to obtain the quantity of eggs apparently present at the site.

Ostrich eggs are likely to have been desirable objects for the people of the Grotte des Pigeons, being not only nutritionally valuable, yielding the equivalent volume of some 28 hens' eggs, but also having a further practical value as containers, which could be drilled, stoppered and used for water. Ostrich eggshell may also be broken down and manufactured into flat, often disc-shaped, beads, leaving characteristic waste (Serjeantson 2012). Roche (1963, 57 and fig. 25) recorded one scratched fragment and one perforated OES fragment which he interpreted as a broken, unfinished bead. However, this perforation might have been the hole in an egg drilled as a container. As yet no further evidence of other modification has been confirmed at Grotte des Pigeons. With further detailed analysis to examine possible refitting to reconstruct broken flasks or modifications to edges or surfaces that might indicate drilling or decoration, it may eventually be possible to determine precisely how ostrich eggshells were being utilised, or even curated, at this site.

Eagle, Golden / Imperial / Steppe Group *Aquila* sp.

Respected and feared for their hunting prowess, powerful flight, keen eyesight and fierce appearance, eagles carry great symbolic importance across many cultures, both geographically and temporally. Consequently, human use of eagle parts, especially feathers, is common and often carries magical significance, seen as imbuing the user with some of the eagle's power and skill (Serjeantson 2009).

Only one fragment from this taxon, similar in size to Golden Eagle *Aquila chrysaetos*, was recovered, a robust proximal right scapula <11360>, carrying cut-marks. In life, the proximal scapula is enclosed deep within the muscle mass of the shoulder, in articulation with the coracoid, furcula and humerus. Damage to the articular surface of the scapula may be associated with disarticulation, possibly suggesting removal of the wing, though in this case the association is not definitive.

Neanderthal exploitation of raptor and also corvid wing feathers has been suggested at several Gibraltar cave sites (Finlayson et al. 2012; Blasco et al. 2016). Clear evidence of systematic processing of *Aquila* eagle corpses for wing removal has been demonstrated at the Epipalaeolithic site of Wadi Jilat 22 in eastern Jordan, with a peak period between c. 14,700-16,600 BP (Martin / Edwards / Garrard 2013), while the burial of an elderly Natufian lady in the Levant included part of an articulated eagle wing (Grosman / Munro / Belfer-Cohen 2008).

In the absence of any further eagle material from the Grotte des Pigeons at present, it is not possible to say whether or not similar processing or curating of eagle parts was definitely being carried out here. However, given the evidence of systematic exploitation on site of at least one other large bird species for ritual purposes, it seems plausible that eagle remains – wings, feathers and possibly more – may also have been symbolically significant, but perhaps utilised less frequently and in a different manner.

Red-Billed Chough *Pyrrhocorax pyrrhocorax*

The smallest of the archaeologically significant species, Red-billed Chough, is represented by two remains, including a cut-marked premaxilla <11358>. An inhabitant of cliffs and crags in open country, Red-billed Chough was probably a familiar sight in the Grotte des Pigeons region during the Last Glacial Maximum and is still common in the Beni Snassen hills today (Thévenot / Vernon / Bergier 2003). It is a striking bird with all black plumage and bright crimson legs and strong, downward curved beak (**fig. 10.4**). In the Taforalt find, the deep cuts, which show multiple parallel strokes, are located above the nostrils on the dorsal surface, just at the point where in a complete specimen there is a visible junction between the feathers and the ramphotheca (**fig. 10.3**). While this may have been where an attempt was made to detach the beak, the actual break occurred along the relatively weak pre-frontal hinge between the premaxilla and the cranium, possibly

Fig. 10.4 Red-billed Chough *Pyrrhocorax pyrrhocorax* in flight. – (Photo © Mark Adams).

due to the pressure exerted during cutting. Given the location of the cut-marks, detachment of the beak from, rather than removing the beak as part of, a skin seems to have been the objective; with the latter, no damage to this part of the beak would be necessary as the beak could have been detached from the skull from within the skin, i.e. from the cranium side of the pre-frontal hinge.

Along with feet and claws, beaks are also highly prized across many cultures in time and space, widely used as ornaments, amulets or included in artefacts such as medicine bundles or rattles (Serjeantson 2009). Frequently, the species of bird used has symbolic significance. One strong reason why this chough beak was removed is likely to be its original deep crimson colour in life. Along with black and white, red is one of the most important colours in human cultural history, with use of red iron ochre dating back to about 160 ka BP in Africa and about 200 ka BP in Europe (Roebroeks et al. 2011). Symbolically, in prehistoric cultures red appears to be frequently associated with blood and life, and red pigments have a strong association with burials, including finds of ochre at the Grotte des Pigeons (cf. Chapter 14). The bright red beak of the Red-billed Chough against its black plumage may have made it a significant species for the people of Grotte des

Pigeons, with this beak removed and curated for some purpose. The shape of the beak would have lent itself well to use as a toggle or perhaps more likely as a striking ornament, for example through an earlobe, septum or other piercing.

Great Bustard *Otis tarda*

The most remarkable component of the avian archaeological assemblage is the collection of remains from Great Bustard, overall 24 finds representing a minimum of four individuals, at least three adults, male and female, and one juvenile. One further piece was found in Sector 2, recovered within the fill of a recent porcupine burrow; however, given the known bone collecting behaviour of Crested Porcupine *Hystrix cristata* (cf. Kibii 2009), at present this specimen is best considered intrusive. This is a highly significant collection, both in terms of its evidence for ancient human use of the species but also for its biogeographic implications for the history of the taxon in North Africa, which will be discussed in more detail below.

Great Bustard is a very large bird of primarily terrestrial habits, strongly associated with open steppe and plains habitats. It exhibits pronounced sexual dimorphism, with adult females standing approximately 0.8 m tall, with a wingspan of up 1.9 m and reaching a weight of between 3.3-5.3 kg, while adult males stand over 1 m tall, have a wingspan of some 2.5 m and may reach a weight of 5.8-18 kg, placing them amongst the world's heaviest flying birds (Collar 1996). There are some suggestions of historic records of even heavier birds, reaching in excess of 24 kg (Collar 1996). Despite their great size, they are capable of strong flight, though very large males may struggle to take off, particularly in spring when at their peak weight prior to the breeding season. Great Bustards have a lekking mating system, where males perform a spectacular display to advertise their presence to females. At the height of his display, puffed up and with wings inverted and fanned to expose their white undersides, a normally well-camouflaged male may be visible for several kilometres (Collar 1996). The taxon has a very broad distribution across Eurasia, though is declining steadily across its range and is ranked as a globally vulnerable species. There is a very small, rapidly declining population in Morocco, with only some 50 individuals remaining (Alonso et al. 2016). The present population is restricted to the northwest of the country, on the Tangier peninsula and adjacent floodplains (Thévenot et al. 2003; Alonso et al. 2016). Given the strong preference of Great Bustard for steppe or plains habitats, it seems likely that the hunters of Taforalt probably obtained them on the open plains lying to the north and south of the Beni Snassen range, possibly in a dedicated hunt. Precisely how the Grotte des Pigeons bustards were secured cannot be determined but ethnographic evidence from modern and historic hunter gatherers proves that, although large bustards are an extremely wary quarry, they are nevertheless vulnerable to a range of traditional hunting techniques, including trapping, stalking and ambush, not dissimilar to those used on ostrich (see above and cf. Collar 1996; Ziembicki 2010). It is possible that the hunting parties may have taken advantage of the birds' gregarious habit of forming droves, hence the presence of multiple individuals within one burial. While the methods of hunting them must remain speculation, the assemblage does provide considerable information about the butchery and subsequent use of the birds.

The preservation on-site of both trunk and some distal extremities, in the form of beak parts and a tarsometatarsus, suggests that some birds at least were returned largely whole to the cave for butchery, with some heads and feet removed on site. Further carcass dismemberment is evident from the six distal humeri, which appear to represent systematic detachment of wings. From the consistency of the surviving portion of the bones, this often appears to have been done at roughly the point where the meaty muscles of the upper wing taper off to thinner slips inserted on the distal epiphyses. This would leave the proximal humerus *in situ* and the meat of the shoulder and breast intact on the substantial butchered carcass.

The core carcass of an adult male Great Bustard measures approximately 300 mm long, 200 mm wide and 200 mm deep, carrying the massive main muscle mass of the breast on the sternum (itself potentially over 100 mm deep) and, if retaining proximal humeri and femora, also the muscle masses of the shoulders and upper legs. It would represent one of the largest and heaviest bird carcasses available to the hunters of Grotte des Pigeons. Remains of trunks from at least three adult Great Bustard were recovered within the site, one from near the 'blue stone' burials area and at least two from the burial of Individual 14. These latter finds provide clear and exceptional evidence of the use of Great Bustards as part of the funerary rituals of the Grotte des Pigeons human population.

Excavation of the burial of Individual 14 commenced in 2010, revealing an extremely complex assemblage of human and faunal remains and artefacts, the excavation of which continued over subsequent seasons. This discussion only considers the Great Bustard remains from that first season; full analysis of the entire burial is still in progress so a full description of the complete Great Bustard assemblage is not yet feasible.

In 2010, Great Bustard remains were found both undisturbed in the base of the Individual 14 burial and also in extremely close association with the burial. The key undisturbed find was the fragmented, cut-marked sternum of an extremely large adult male bustard <11389>, amongst which was discovered a fragment from a second sternum. Further fragments, which may have derived from either of these sterna were unearthed nearby. Additionally, the burial yielded an intact furcula close to the main sternum.

The sternum with associated breast muscles would comprise a portion very similar to the 'crown' joint now popular for the modern western Christmas domestic turkey *Meleagris gallopavo* (another very large, ritually important bird species). Arguably the choicest part of the prepared carcass and being from an extremely large bird, the deposition of such a portion is likely to have represented a significant offering, certainly of high value and perhaps reflecting a high status for the buried individual. This suggestion of linking Great Bustard with high status is also supported by the overall complexity of this burial, which comprises numerous other faunal remains and artefacts (cf. **Chapters 9, 12** and **15**). It may also be significant that the key Great Bustard find in the burial derives from a very large male bird and that Individual 14 was a young adult male of clearly high standing. However, it is difficult to be certain how intact this offering was at deposition and whether the bustard remains with Individual 14 are the leftovers of a funerary feast. Cut-marks across the margin of the preserved keel and up onto its side strongly suggest that at least part of the breast meat was removed prior to deposition. Additionally, the placement at the feet of the human burial seems considered and deliberate. The initial assessment of the bustard assemblage from the burial therefore gives the strong impression of a careful selection of the best part of the bustard, rather than a general collection of waste parts. The cut-marks over the keel may indicate that a part of this prime offering was divided between the living and the dead, perhaps for significant living members of the community to share a final meal with the deceased.

In Sector 10 overall, there seems to be a general absence of other meaty parts of bustard, with large, robust elements such as femora, proximal humeri and tibiotarsi relatively scarce. It may be that these lesser portions contributed to a wider funeral feast and were mostly disposed of in a different part of the cave, perhaps including being removed altogether from the site.

Even with the interpretation of the Great Bustard assemblage at a relatively early stage, it is clear that this taxon was ritually important to the people of Grotte des Pigeons. Large bustards worldwide have not only a long history of being exploited (in many cases, over-exploited) as desirable game species, but have also become the focus of complex cultural beliefs, laws and traditions. In Botswana, the Kori Bustard *Ardeotis kori*, similar in size to Great Bustard, is depicted in the rock art and dances of the San, suggesting a ritual relationship of considerable antiquity in addition to its practical value as quarry. Kori Bustard meat may be subject to strict taboo and is associated with the male initiation rites of the |Gui dialect group (Tanaka / Sugawara

1993). Beyond Africa, the large Australian Bustard *Ardeotis australis* is also both prized game and a highly important cultural and spiritual animal for many Aboriginal groups, again the subject of much mythology and complex systems of totem and taboo laws (Ziembicki 2010).

The presence of other modified remains from apparently valued bird species, including ostrich, Red-billed Chough and eagle, appears to suggest that, while Great Bustards may have been especially important, the people of the Grotte des Pigeons had a cultural relationship with a diverse range of taxa, some aspects of which may have been shared widely across the Mediterranean region over an extended period of time.

Environmental Significance

Most of the taxa identified within the fossil assemblage still occur in the local area or in the wider Beni Snassen region, at present, even some of the scarcer modern Moroccan species, such as Hoopoe (which the author personally observed at Tafoughalt village). Additional species, including Ostrich and Great Bustard, remain part of the wider Moroccan avifauna, albeit in very limited numbers. In general, though, the fossil assemblage provides a solid signal for open woodland habitats and mattoral, not dissimilar to the present day local habitats. However, at the risk of stating the obvious, flighted birds are highly mobile and would definitely have an altitudinal response to moderate environmental shifts in this altered local terrain, probably without much time lag, making them less sensitive indicators in the present context. Ostrich and Great Bustard are indicative of open plains environments, and, as both species have a clearly anthropogenic presence at the cave, probably represent habitats some distance from the site, most likely to be plains beyond the mountains to the north or south.

Biogeographic Significance

European fossil Mediterranean avifaunas have been well-studied and their biogeographic implications discussed on both local and regional scales (e. g. Covas / Blondel 1998; Holm / Svenning 2014). Of particular research interest have been the occurrence of northern irruptive species and the presence of refugia areas. However, while North Africa has been identified as a refugium region, its Pleistocene fossil record seems to have been largely ignored in Mediterranean syntheses, possibly having been regarded as too sparse to be helpful, with the assemblage of the Haua Fteah, Libya, an exception. Although it is only one relatively small site with a fairly limited avifaunal assemblage, the Grotte des Pigeons has yielded the most diverse late Pleistocene avifauna yet described from Morocco, therefore adding valuable data to the North African fossil record, and providing a number of important biogeographic insights.

In general, with its overall similarities to the modern Moroccan avifauna, particularly that of the Beni Snassen region, the fossil avifauna of the Grotte des Pigeons appears to demonstrate a certain persistence, or indeed resilience, in the region's core avian communities, despite significant environmental changes over time. However, it is the impact of humans on the biogeography of the region's avifauna that is highlighted most clearly by the Grotte des Pigeons fossil assemblage. In particular, with the preservation of remains of Great Bustard and Ostrich, the assemblage records a formerly widespread ancient terrestrial avian megafauna that has now largely been eradicated from the Maghreb region, with the probably extinct Moroccan subspecies of Arabian Bustard *Ardeotis arabs lynesi* another member of this lost avian megafaunal community.

Evidence of Ostrich is common and widespread across numerous Holocene and Late Pleistocene Maghreb sites, particularly in Algeria and Tunisia (cf. Tyrberg 1993; also Merzoug 2011). Physical remains largely consist of eggshell fragments, with bones relatively rare, but depictions of ostrich are also well documented in Neolithic and Capsian rock art (Rahmani/Lubell 2005). However, while the ancient presence of *Struthio* is well-attested and the causes of its extinction in the region are well understood (e.g. Kinzelbach 2003), much remains to be discovered about the dynamics of the taxon's origin and subsequent development across North Africa.

Ostrich is now extinct as a breeding species in Morocco but occurred historically in the Saharan regions of the country, including on the high plateaux and Saharan Atlas regions directly south of the Beni Snassen and Monts d'Oujda ranges, where it persisted into the early 20th century. Ancient records of ostrich at Taforalt, Rhafas and various other archaeological finds in Morocco, e.g. from 1950s excavations at the Neolithic site of Kheneg Kenadsa, also in northeastern Morocco (Merzoug 2011), clearly demonstrate its wider, more northerly ancient distribution across the region. Ostrich still remained abundant in southern Morocco into the 1950s, but the population continued to decline steeply until it disappeared as a breeding species in the 1970s. Only occasional vagrants have subsequently been recorded, though an attempt is underway to reintroduce the species to reserves in southern Morocco. A similar pattern has occurred across the wider region of northern Africa, with formerly abundant populations reduced to limited, critically endangered remnants. The primary cause of these catastrophic declines is human over-exploitation, for meat, eggs and feathers, with the latter a particular focus for hunting in the mid-19th century until ostrich farming became established in southern Africa (Folch 1992; Kinzelbach 2003).

While ostrich has effectively been eradicated as an established part of Morocco's avifauna, Great Bustard continues to cling on as a critically endangered species, with a population of only around 50 individuals in northwest Morocco (Alonso et al. 2016). Bustards as a family have an uneasy relationship with humans. Collar (1996, 259) goes as far as to comment that "bustards and human beings are largely incompatible" and, indeed, almost all bustard species are presently in decline, largely due to human activities. In Morocco, the crucial modern threat to Great Bustard is now collision of flying birds with power-lines, replacing hunting as the primary major threat during the last decade (Alonso et al. 2016). Recent molecular studies have shown the Moroccan Great Bustard population to be genetically distinctive from the Iberian population (Horrero et al. 2014). Although there is clearly some gene flow into Morocco from Iberian vagrant birds, the genetic diversity of the Morocco population is overall highly restricted, partly due to the species' decline on both sides of the Strait increasing the isolation of the Morocco population. The genetic diversity of the Moroccan birds has been interpreted to suggest an historical colonisation from Iberia "thousands of years ago" (Alonso et al. 2009, 387). Based on radiocarbon dates available for human and animal bones in Sector 10, the Great Bustard remains at the Grotte des Pigeons corroborate the DNA evidence and demonstrate that the species was clearly well established in Morocco by at least 15,000 years ago (Humphrey et al. 2014). Additionally, the Taforalt finds are more than 300 km distant from the modern population, now confined to a small region in the Tangier Peninsula, indicating a considerably more extensive ancient range. Remains of large bustards have also been recovered from the Neolithic levels of the Haua Fteah, and also in Egypt and Algeria (MacDonald 1997); identifications have favoured *Ardeotis* species but reviews of these finds could reveal an even wider former distribution for Great Bustard. Overall, it seems highly likely that Great Bustard undertook a southerly range shift in response to environmental changes during the last glaciation, taking advantage of a reduced crossing of the Strait of Gibraltar and colonising the expanded arid steppe habitats available in the Maghreb during this period (cf. Barton et al. 2005).

10.6 CONCLUSIONS

The Late Pleistocene archaeological and palaeontological sites of Morocco are currently the focus of unprecedented levels of research interest based around developments in prehistoric human culture and palaeoenvironmental change. However, while mammalian remains are being reported upon, avian faunal analyses which could also make a significant contribution to these and other lines of enquiry, are unfortunately under-represented at present. This absence is likely to be due in part to the need for potential avian researchers to build up experience with modern comparative specimen collections, which may not be readily available. Although describing an assemblage of relatively modest scale, it is hoped that the present report may demonstrate some of the potential of Morocco's Pleistocene avifaunas to encourage further research across additional sites.

The present LSA avifauna from the Grotte des Pigeons represents the first stage in documenting the most diverse avian assemblage yet recorded from the Pleistocene of Morocco. Comprising 161 remains representing at least sixteen distinct taxa, eight of them first recorded fossil occurrences for Morocco, the LSA avian assemblage provides biogeographic, ecological and archaeological evidence, relevant not only to understanding ancient environments and their human inhabitants but also valuable to modern ornithological science and conservation.

The Grotte des Pigeons assemblage is dominated by taxa strongly associated with cliffs and rocky scrub habitats, typified by Barbary Partridge, Red-billed Chough, probable Rock Dove, a swift and an eagle. Two further taxa, Tawny Owl and Hoopoe contribute an indication of local open woodland habitats. Most of these taxa may be observed locally at the present time, which on the one hand may suggest long-term stability but may equally suggest resilience in these avian communities to environmental change and potentially be indicative of positive results of the restoration efforts in the Beni Snassen region. In either case, the modern occurrence of a suite of taxa that has been occupying the region (albeit with possible interruptions) for in excess of 15,000 years, may well strengthen a case for elevating its reserve status.

Reflecting habitats outwith the immediate area but accessible to LSA human inhabitants, Great Bustard and Ostrich represent the terrestrial faunal communities of the arid plains beyond the mountains, brought to the Grotte des Pigeons by human hands. It is telling that both of these taxa are, by human agency rather than environmental change, either recently extinct or critically endangered as breeding species of Morocco; the history of interaction between these birds and humans is demonstrably ancient.

It is the evidence of this interaction that forms the basis for the most striking avian discoveries at the Grotte des Pigeons thus far, with exploitation of a range of species demonstrating not only resourceful hunting practices but also complex cultural values, with birds utilised for both food and creating objects. Of the archaeological assemblage, it is the Great Bustard remains that are of outstanding importance and the key signature avian discovery from this site.

The Great Bustard assemblage of 24 remains from at least four individuals, male, female and immature, suggests that the taxon was widespread and apparently relatively abundant in Morocco by at least 15,000 years ago. Amongst the archaeological avian assemblage, the finds uniquely demonstrate unequivocal use of a bird for ritual purposes, primarily feasting and offerings associated with the human burials of Sector 10, and establish a record of human exploitation that appears to have continued to at least 2005 in the form of trophy hunting adult male bustards (Alonso et al. 2005).

Unfortunately, both hunting pressure and habitat changes have contributed to the rapid disappearance of the Great Bustard in Morocco, to the point that, at current rates of decline, the extinction of this genetically distinctive population is predicted within 20 years (Palacín et al. 2016). It is therefore to be keenly hoped that the proof of Great Bustard's ancient origin in the country and also its importance to the LSA people of the Grotte des Pigeons may raise the profile of this species and give it a new cultural significance that will help inspire modern Moroccans to back conservation efforts to secure the species' future in North Africa.

11. OTHER FAUNAL REMAINS

THE EDITORS

11.1 MICROMAMMALS

The micromammal collections from the recent excavations are still under study and will be published on a later occasion. However, Simon Parfitt has already reported (Bouzouggar et al. 2008) the presence of the Barbary ground squirrel (*Atlantoxerus getulus*) from the basal units of the Grey Series (S8-G100 to G99). This suggests only relatively scattered tree cover in the vicinity at this time, as these animals shelter in burrows and prefer rocky habitats with isolated trees (Kingdon 1997). Kowalski/Rzebik-Kowalska (1991) reported that their distribution at that time was restricted to the extreme west of Algeria, with a northern limit of around 33° N, which would imply slightly greater aridity at this level at Taforalt. However, this ground squirrel is reported in Aulagnier/Cuzin/Thévenot (2017; reference kindly supplied by. E. Stoetzel) in the vicinity and south of Taforalt today, although, as with most wildlife in North Africa, it is unclear how much this fast-breeding animal may have modified its range (still usually employing at least locally rocky areas) in response to more recent human activity, in this case by extension due to the attraction of domestic crops, especially fruits, to supplement a flexible (normally omnivorous) diet (cf. Rihane et al. 2018). Parfitt has also identified *Meriones* sp. (jirds) from Units Y4, Y2 and Y1 in Sector 8 (reported in Jeffrey 2016), an animal associated with largely open and sparsely vegetated environments, usually with a tendency towards a degree of aridity.

The microfauna reported from the Roche excavations is not available for study and we must therefore assume that the most likely reason for the presence in the cave of the majority of the taxa mentioned was accumulation by non-human predators, especially large owls or small carnivores. Under the circumstances, it is perhaps best not to rely upon the majority of these early identifications. However, it is of note in the 1950s collections that lagomorphs (a more reliably identified group) were recorded to have been concentrated towards the back of the cave, perhaps more in the upper two-thirds of the sequence of the Grey Series; whilst some carnivores may well have taken such game, it seems likely that humans also exploited this resource.

Our own excavations in Sector 8 have recovered microvertebrate bone fragments from the mollusc column (MMC units), as shown in **figure 8.5**. After adjustment for sedimentation rates, the counts (plausibly dominated by micromammals, although some smaller bird, reptile and amphibian remains will be included) show a two- to threefold decrease from the Yellow Series to the Grey Series, suggesting an overall tendency towards avoidance of man, probably by most microfaunal species and their non-human predators.

C. GLEED-OWEN with R. N. E. BARTON

11.2 AMPHIBIANS AND REPTILES

Methods

The herpetofaunal material was picked by Cath Price from bulk sample sieve residues. Each sample was one litre of finer matrix, unless indicated otherwise. Herpetofauna was removed from the 4 mm, 2 mm and 1 mm fractions and sorted by eye and low power microscope. The material was studied by CGO using a binocular reflected-light microscope with x5 to x32 magnifications. These samples all come from Sector 8. Although they are relatively restricted in number, they provide a representative selection from each of the main units excavated. Abundance is expressed on a three point scale only, using large empirical discontinuities in the count data (mirrored in the taxa numbers), remembering that the samples have not been normalised for stone content or likely time interval. Not all of the samples taken were processed.

Results and Discussion

These samples show a very low presence of herpetofaunal bone in the Grey Series. Only a few specimens were recovered in any one of these units, representing an equally low diversity of identified species (1-2 for most units) (**tab. 11.2.1**). A number of taphonomic factors may explain the scarcity of material, which has also been noted in the avifaunal and micromammalian assemblages from the GS. First, sedimentological data and the radiocarbon dating models presented in earlier chapters indicate the GS sequence of deposits accumulated extremely rapidly (at an estimated average rate of 1.8 m/kyr), thus allowing little time for incorporation of microfaunal remains. Indeed, the deposits are almost entirely anthropogenic in origin, consisting of thick accumulations of burnt stone, wood ash and fragments of burnt shell, burnt large mammal bone and lithic artefacts. There is relatively little evidence of burning of the herpetofaunal bone (except in Unit S8-G99), which implies that these smaller animals were infrequent visitors to the cave or that any potential predators were relatively uncommon while humans were there. It is also clear, for these same reasons, that most palaeoenvironmental signal would have been swamped by the human activity and that, in any case, the samples are too small to gain much additional information, apart from noting the presence of some species which are found in the area even today. The one exception to this pattern is provided by the lowest sample from S8-G100, which plausibly contains a physical mix of material brought up by human activity from the Yellow Series below. One may also mention here a reptile taxon not represented in the assemblage studied by the present author, namely, the tortoise, *Testudo* sp. One burnt femur has been recovered during the present campaign from S8-L3 and identified by Elaine Turner (pers. comm.) as the relatively small species, *T. graeca*, still present in the general vicinity. However, Arambourg (in Roche 1963, chapter 16) recorded "*Testudo* sp." (unfortunately with no counts) from every single one of Roche's *Niveaux I-VIII*, the only ubiquitous reptile, all others, even though identified only to family level, appearing in no more than two of these units; whilst the basis of the determinations is not given, it seems likely that many of them were made on scute fragments, one of the more easily recognisable (and anatomically numerous) remains of the tortoise.

More reliable palaeoenvironmental information is available for samples from the underlying Yellow Series sediments (**tab. 11.2.2**). Here it is interesting to point out that the decrease in herpetofaunal specimens in Unit S8-Y3 may also correspond to a particularly strong signal of anthropogenic activity and a correspond-

TAF ref. no.	Layer	Spit	Abund	Species diversity
TAF03/200	G88		+	Lacertidae, Sauria
TAF03/203	G89	2	+	*Tarentola mauritanica*, Colubridae
TAF03/204	G90	1	+	Sauria
TAF03/212	G92	2	+	Lacertidae
TAF03/213	G92	3	+	*Coronella girondica*
TAF03/214	G93	1	+	Sauria
TAF03/217	G93	2	+	*Ophisaurus koellikeri*
TAF03/224	G95	3	+	Lacertidae, Sauria
TAF03/36	G98		+	*Tarentola mauritanica*
TAF03/63	G98	4	+	*Coronella girondica*
TAF03/58	G98	4	+	Colubrinae, Sauria
TAF03/61	G98	4	+	*Coronella girondica*, Colubrinae
TAF03/73	G98	4	+	Colubrinae
TAF03/89	G98	5	+	Colubrinae
TAF03/90	G99		+	*Tarentola mauritanica*, Scincidae, Sauria, *Coronella girondica*
TAF03/100	G99		+	Lacertidae, *Coronella girondica*, Colubridae
TAF03/109	G99	base	+	Serpentes
TAF03/108	G99	base	+	Lacertidae, Colubrinae
TAF03/118	G100		+	Sauria, Serpentes
TAF04/719	G100		++	*Pelophylax* sp., *Ophisaurus koellikeri*, Lacertidae, *Chalcides* sp., Sauria, *Coronella girondica*, Colubrinae

Tab. 11.2.1 Herpetofauna from Grey Series sediments (in stratigraphic order) (abundance of specimens: + low (1-25); ++ medium (26-125)).

Taf ref. no.	Layer	Spit	Abund	Species diversity
TAF04/887	Y1		+	*Sclerophrys mauritanica*, Lacertidae, Sauria, *Coronella girondica*, Colubrinae
TAF04/888	Y1		++	Anura, *Acanthodactylus erythrurus*, Lacertidae, *Chalcides* sp., Sauria, *Coronella girondica*, Colubrinae
TAF04/1051	Y1		+	Sauria, *Coronella girondica*, Colubrinae
TAF04/894	Y1	hearth	+	*Acanthodactylus erythrurus*, Lacertidae, Sauria, *Malpolon monspessulanus*, *Hemorrhois hippocrepis*, Colubrinae
TAF10/10823	L30 = (Y1)		++	*Discoglossus* sp., Lacertidae, *Chalcides* sp., Sauria, *Coronella girondica*, *Telescopus* sp.?, Colubrinae
TAF04/1175	Y2		++	*Acanthodactylus erythrurus*, Lacertidae, Scincidae, *Trogonophis wiegmanni*, Sauria, *Coronella girondica*, Colubrinae, *Natrix maura*
TAF10/10849	L31 = (Y2)		+++	Anura, Lacertidae, *Chalcides* sp., Sauria, *Coronella girondica*, Colubrinae
TAF04/1838	Y3		+	*Acanthodactylus erythrurus*, Lacertidae, Sauria
TAF04/1895	Y3		+	*Ophisaurus koellikeri*, Lacertidae, *Trogonophis wiegmanni*, Sauria
TAF04/1901	Y4	1	+++	*Discoglossus* sp., *Pelophylax* sp., Anura, *Chameleo* sp., *Ophisaurus wiegmanni*, Lacertidae, *Chalcides* sp., Sauria, *Coronella girondica*, Colubrinae
TAF04/2140	Y4	2	+++	*Chamaeleo chamaeleon*, *Ophisaurus wiegmanni*, *Acanthodactylus erythrurus*, Lacertidae, *Chalcides* sp, Sauria, Colubrinae
TAF04/2105	Y4	3	+	Lacertidae, Sauria, Colubrinae
TAF05/2170	Y4	4	++	*Chamaeleo chamaeleon*, Lacertidae, Scincidae, Sauria, Colubrinae
TAF05/3228	Y4	4	+	*Chalcides* sp., Sauria, *Coronella girondica*, Colubrinae

Tab. 11.2.2 Herpetofauna from Yellow Series sediments (in stratigraphic order) (abundance of specimens: + low (1-25); ++ medium (26-125); +++ high (126-350)).

ing temporary rise in sedimentation rate in that unit. It may be relevant that the only example of a burnt herpetofaunal bone (of Moroccan glass lizard, *Ophisaurus koellikeri*) in the YS also comes from this unit and may be linked to deliberate exploitation of this lizard for food. Some of the largest samples of herpetofauna were recovered near the top of S8-Y1, and in S8-Y2 and S8-Y4. The presence of certain species in these units suggests that some areas outside the cave must have been well vegetated. For example the occurrence of chameleon in S8-Y4 indicates the presence of small bushes and trees, whilst, also recorded in this layer, the Moroccan glass lizard (*Ophisaurus*) is indicative of humid and vegetated habitats. Relatively warm humid conditions are also indicated by the occurrence of amphibians such as the Berber toad (*Sclerophrys mauritanica*), painted frog (*Discoglossus pictus*) and other frogs (water frog *Pelophylax* sp., indet. Anura) in this unit and in S8-Y1 and S8-Y2. The same is true of the presence of various snakes, such as the Montpellier snake (*Malpolon monspessulanus*), the horseshoe whipsnake (*Hemorrhois hippocrepis*), which favour humid conditions, and a viper (Viperidae indet.). Notably absent from any of these YS units is the Moorish gecko (*Tarentola mauritanica*), an indicator of dry conditions today. All of the YS deposits mentioned here relate to the period of Iberomaurusian occupation, including the upper part of Unit S8-Y4, spits 1 and 2.
Unit S8-Y4spit4 contains only MSA artefacts. There is a relatively high reptile abundance but the herpetofauna overall does not differ significantly from the higher (LSA) intervals of the Yellow Series.
The sedimentation rates in S8-Y4spit4 and in S8-Y4spit2 and above are demonstrably significantly higher than that in the intervening S8-Y4spit3, the latter having the lowest rate yet observed in the cave. However, this subunit has hardly any reptile bones compared to their relative abundance in the faster-accumulating spits above and below, perhaps suggesting a local 'squeeze' rather than a major faunal change. The interesting thing about this low mountainous area is that it seems to retain traces of most creatures, more or less no matter what the regional 'climate', presumably due to the wide range of persistent habitats (accidented topography and altitudinal range), as well as persistent predators.

Conclusions

If any environmental signal has survived the difficult taphonomic conditions within the cave and the habitat mosaic buffer likely represented by the local highlands, it is difficult to discern in the present samples. With respect to the Grey Series, the almost complete lack of amphibians (in theory, suggesting water stress) needs to be balanced against the risk of interpreting negative evidence (absence) in such small samples. Perhaps more reliable as a marker of slightly drier conditions is the single-specimen presence of the Moorish gecko, *Tarentola mauritanica*, towards the base (G99 and G98) and top (G89) of the Series. Slightly damper conditions would seem to be indicated in the bulk of the Yellow Series samples (containing a variety of lizards, snakes, frogs and toads requiring reasonable humidity and vegetation cover), also remembering the interval of apparent environmental constriction in S8-Y4spit3 and the fact that the suspected cool dry interval, in contorted sediment towards the top of Y2 (see **Chapter 2**), had not been recognised at the time of sampling. Such environmental conclusions must nevertheless remain speculative.
With respect to taphonomy, whilst a few species might have frequented the cave itself (cf. the amphisbaenian, *Trogonophis wiegmanni*, which is very obviously present today), most herpetofaunal remains will have been the result of predation, with occasional digestion, crunching and toothmarks showing on material from both the Grey and Yellow Series. The signs of burning in S8-G99 (as well as on the tortoise bone from S8-L3) and S8-Y3 are perhaps evidence of human predation. The numbers of specimens are much larger in the Yellow Series and the present, preliminary analysis could usefully be augmented by further comparative material study to extract more specific diagnoses.

12. LATER STONE AGE LITHIC ARTEFACTS

J. HOGUE · A. BOUZOUGGAR

12.1 RAW MATERIALS

The raw materials described come from Sectors 8 and 10, which provided the majority of finds from the Iberomaurusian units. The descriptions of the raw materials are given in **table 12.1**. Those in Sector 8 are grouped into four different successive phases separated on techno-typological criteria (Upper, Middle, Mixed/transitional and Lower); these are treated separately from the finds in Sector 10 (**tab. 12.1**).

In total, the lithic artefacts described here comprise mainly microcrystalline and crypto-crystalline rocks classified as cherts (Luedtke 1992). There are also moderate amounts of limestone and a few other raw materials including small quantities of quartzite, silicified limestone and a metamorphic rock similar to basalt (**tab. 12.1**).

The cherts form the largest group and were sub-divided according to colour. A major group consisted of grey to brownish coloured cherts (Munsell colours 5YR 6/1 – 10YR 3/6), that were extremely fine-grained with excellent fracture properties for knapping. They often had pale grey inclusions that gave the material a slightly mottled appearance. A second group, also of high quality for knapping, consisted of light grey to brown col-

	Upper Phase	Middle Phase			Transitional/ Mixed Phase	Lower Phase	Sector 10	Total
		GS	YS	Total				
Chert	8605	1002	1697	2699	470	1980	2377	16,131
	83.7 %	89.8 %	95.6 %	93.4 %	92.2 %	96.6 %	94.1 %	88.4 %
Black	10	4	11	15	1	24	12	62
Dark grey	14	6	4	10	2	7	9	42
Grey/light grey	28	2	17	20	7	13	27	94
Greyish brown	27	16	35	51	7	21	40	146
Pale brown/yellowish brown	165	58	101	159	44	177	76	621
Brown/strong brown	108	25	68	93	26	114	122	463
Reddish brown	15	9	20	29	5	5	12	66
Dusky red/weak red	18	9	12	21	1	3	2	45
White	16	5	15	20	3	9	39	87
Intermediate/unclassified	8204	868	1413	2281	375	1606	2038	14,504
Limestone	1665	114	77	191	40	59	144	2099
	16.2 %	10.2 %	4.3 %	6.6 %	7.8 %	2.9 %	5.7 %	11.5 %
Basalt	0	0	0	0	0	4	0	4
	-	-	-	-	-	0.2 %	-	>0.1 %
Quartzite	5	0	1	1	0	7	3	16
	0.1 %	-	0.1 %	>0.1 %	-	0.3 %	0.1 %	0.1 %
Other	1	0	0	0	0	0	1	2
	>0.1 %	-	-	-	-	-	>0.1 %	>0.1 %
Total	10279	1116	1775	2891	511	2050	2525	18,256
	100.0 %			100.0 %	100.0 %	100.0 %	100.0 %	100.0 %

Tab. 12.1 Absolute and relative frequencies of raw materials.

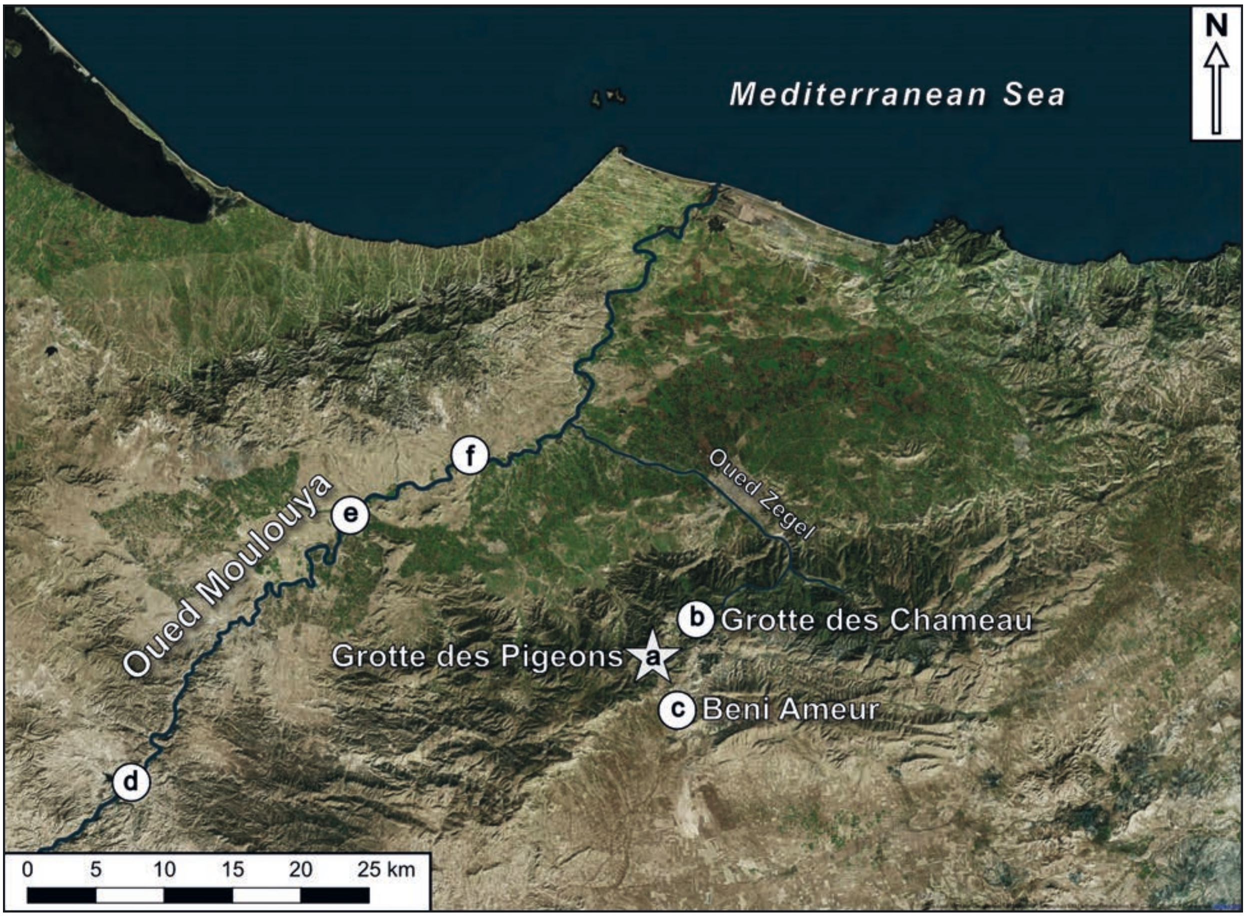


Fig. 12.1 Raw material sources in relation to Taforalt (**a**); silicified black limestone in side valley near Grotte du Chameau (**b**); Domerian limestone at Beni Ameur (**c**); grey to brownish cherts sampled at various locations in the Oued Moulouya (**d-f**).

oured cherts (Munsell colours 7.5YR 7/1 – 6/4). Although there was a noticeable overlap in colour with the first group, the second did not contain many inclusions. A third group was made up of good quality white to grey cherts (Munsell colours White N 9.5 – Grey 2 6/1), which included at one end of the spectrum a translucent material akin to chalcedony. A small number of artefacts of a silicified black limestone were also recovered, as well as a grey lithographic limestone. All of the cherts range in size from a few centimetres to 10 cm in maximum dimension. Most of them display a smooth outer rind which is often stained, weathered and showing the typical chatter-marked alteration seen on water transported material. There are no obvious examples with true cortex as typical of material gathered from near primary sources just below geological outcrops.

Since the great majority of the raw material used at the site is derived from waterworn pebbles and cobbles, modern exploration was undertaken of the surrounding river valley systems for possible sources (fig. 12.1). The streambed of the Zegzel valley below the cave was searched upstream and as far downstream as Tghasroutte (fig. 1.6) but failed to produce any significant quantities of cherts or quartzites. However, it is possible that that now more deeply buried deposits with these materials were once available closer to the surface. A more obvious source of raw material is that of the Moulouya River which at its closest point lies 16.7 km from Taforalt as the crow flies. The river covers an enormous catchment area in keeping with its status as the second largest river system in North Africa. The main valley lies north and west of Taforalt and cuts through Jurassic rocks that contain cherts and quartzites (Bartz et al. 2018). Our searches revealed a heterogeneous range of coloured and textured cherts along its gravel banks (fig. 1.12d-f), although these gravels are today overlain and, in most locations largely obscured, by up to c. 10 m of fine over-bank deposits that formed during the Holocene (Ibouhouten et al. 2010). The raw material recovered from the gravel banks is similar to that classified as 'Moulouya Brown' and 'Moulouya White' by Linstädter et al. (2015), utilised in the Ibero-maurusian levels at Ifri Oudadane. The Brown contains brownish to greyish varieties that fall within our first and second groups of chert and the White is a more homogeneous chert probably akin to our third group. In addition Linstädter et al. (2015, 161) note that their Moulouya Brown sometimes has a reddish tinge and can be translucent which is also typical of the Taforalt lithics.

Of the other raw materials represented at Taforalt, the nearest source of silicified black limestone comes from near Grotte du Chameau, about 5 km downstream from Taforalt in a tributary of the Zegzel (**fig. 1.12b**). Here large boulders of local bedrock contain small pebbles of the raw material and also dark grey cherts, dull and opaque in colour (Munsell N4) with a thick outer cortex. The chert contains numerous internal fissures making it hard to knap. The majority of these raw materials were found embedded in the rock and extraction of anything sizeable was near impossible despite the aid of a modern rock hammer. The grey lithographic limestone used for knapping at Taforalt could have come from Domerian outcrops which include a source at Beni Ameur, 5 km southeast of Taforalt (**fig. 1.12c**). It is also possible that other outcrops were exploited within the Zegzel valley and just downstream of the cave (see **Chapter 2**). We note that the 'calc-limestone' rocks used in the pyrolithics is of similar material to the Domerian and would suggest, on grounds of sheer volume, that this mostly derived from within a short distance of the cave. Finally, it should be remembered that the cave deposits themselves could have been mined for raw materials. It is certainly plausible that knappable cherts were grubbed up from the floor of the cave and re-used (see below).

J. HOGUE with R. N. E. BARTON

12.2 METHODOLOGY

This study is mainly based on the long archaeological sequence in Sector 8 with additional observations on the artefacts from Sectors 3 and 9. Sector 10 is treated separately, partly because at present it cannot be correlated directly with the main stratigraphic sequence. Standard non-parametric statistical tests (Krukal-Wallis Test and Fisher's Exact Test) were used throughout to analyse the assemblages.

All lithic finds discussed in this chapter come from the 2003-2010 phase of the excavations. Due to some minor disparities in excavation methods between these sectors (particularly with Sector 10), the lithic assemblages were first size-sorted to create a level of standardisation, with material dry-sieved through a 4 mm mesh and artefacts less than this size omitted from classification. The largest collection of artefacts is from Sector 8 (S8) and consists of 12,709 lithic artefacts from 44 stratigraphic units of the Grey and Yellow Series (**tab. 12.2** and see **Chapter 2**). Techno-typological criteria were used to separate them into four Phases in S8 (see below and **tab. 12.2**). The 191 lithic artefacts from Sector 3 were excavated from 22 spits, grouped into two intervals (0-29 cm and 29-44 cm on the AOH 2008 log), broadly equivalent to the two lower Phases in Sector 8. The 1263 lithic artefacts from Sector 9 come from three units (U1, U2 and U3) that are believed to broadly correlate with the Lower Phase in Sector 8 (**tab. 12.2**). The 2526 lithic artefacts from Sector 10 are treated as a single assemblage that derives mainly from the Grey Series. However, it should be noted that the artefact taphonomy is likely to be complex since the origin of these Grey Series sediments is thought to be largely secondary, being imported from other parts of the cave, and there is also the possibility of localised mixing with the underlying deposits.

	Sector 3	Sector 8			Sector 9(W)[b]
		2003-08	2009-10 L-units	2009-10 MMC[a]	
Upper Phase		G88-96	L2-L27	MMC1-c. MMC96	
Middle Phase		G97-Y1	L28-L30	c. MMC97-MMC110	
Intermediate/Mixed Phase	0-6 cm	Y2spit1	L31-L32	MMC111-MMC114	
Lower Phase	6-44 cm	Y2spits2-5 Y3-Y4spits1-2		MMC115-MMC130	U1-U3

Tab. 12.2 Stratigraphic contexts assigned to artefact Phases.
[a] lithic assemblage from mollusc column not included in study by Hogue (2014).
[b] After Ward 2007.

The method for categorising finds is based principally upon that devised by Tixier (1963) and later expanded by Inizan/Reduron-Ballinger/Roche/Tixier (1999). A "flake" is any removal with a length to width ratio of <2:1. A "small flake" is a flake measuring between 10-20 mm that retains its butt. The term "blade/let" is used to refer to all blanks with length at least twice the width. Here the distinction between blades and bladelets is seldom made, but when utilised follows the criteria outlined by Tixier (1963). The term "debris" has been used to refer to fragments and smaller knapping flakes (<20 mm) and larger chunks (≥20 mm). The core typology follows that outlined by Close (1977, 54-55), with the addition of the term "core-on-flake" (after Olszewski/Schurmans/Schmid 2011). All splintered pieces have been categorised separately, as these objects were originally thought to be intentional retouched tools (Tixier 1963) but have also been interpreted as the exhausted remnants of bipolar reduction (Olszewski/Schurmans/Schmidt 2011).
Retouched tools have been classified following the terminology of Tixier (1963) and Inizan/Roche/Tixier (1992), with some slight modifications. For convenience, all of the laterally backed and retouched material in the Taforalt collection has been grouped under the category of "microlithic and related forms" (**fig. 12.2**). This covers a spectrum of retouched forms ranging from true microliths (those made using the microburin technique) to small backed or retouched bladelets with their butts present. Within this broad grouping are identified sub-categories such as non-geometric backed bladelets (types 45-71) and geometric forms (types 82-100), and the term "microlithic fragment" has been used to classify other objects too fragmentary to be identified to a specific type (types 66 & 72). '*Mèches de foret*' or 'drill bits' (type 16) have been classified within microlithic forms to reflect observed technological similarities (e.g. backing, manufacture on blades, etc.); in contrast, Tixier (1963, 63-66) originally grouped this type, with a diverse range of other types, as perforators, based on assumed function. In a further divergence from Tixier, the term "pointed straight-backed bladelets *sensu lato*" has been used to refer to an amalgamation of his type 45 (all pointed straight-backed bladelets *sensu stricto*) and his types 46-52 (seven sub-variants identified by the morphology of the base and/or additional retouch). In addition, the term "convex-backed bladelet *sensu lato*" has been used to merge his type 56 (convex-backed bladelets *sensu stricto*) with types 57-59 (variants identified by the morphology of the base). A distinction has also been made between typical convex-backed bladelets *sensu stricto* (type 56a) and those tending towards the form of a typical segment (type 56b), which, although not reflected in his formal type-list numbers, follows observations made by Tixier (1963, 104).
Tixier (1963, 103-104. 110) also defined specific types with partial backing (e.g. bladelets with a convex-backed end [type 55], shouldered bladelets [type 64]), but also used the general term 'partially backed bladelets' (type 63) to refer to a diverse variety of other forms not included within these more specifically defined types. In describing the Taforalt microlithic forms, a new subdivision has been introduced between partially backed bladelets with an acutely pointed truncation at one end (type 63a) and other partially backed forms lacking a truncation (type 64b). In addition, a scalene bladelet (type 68) is defined as a blade-

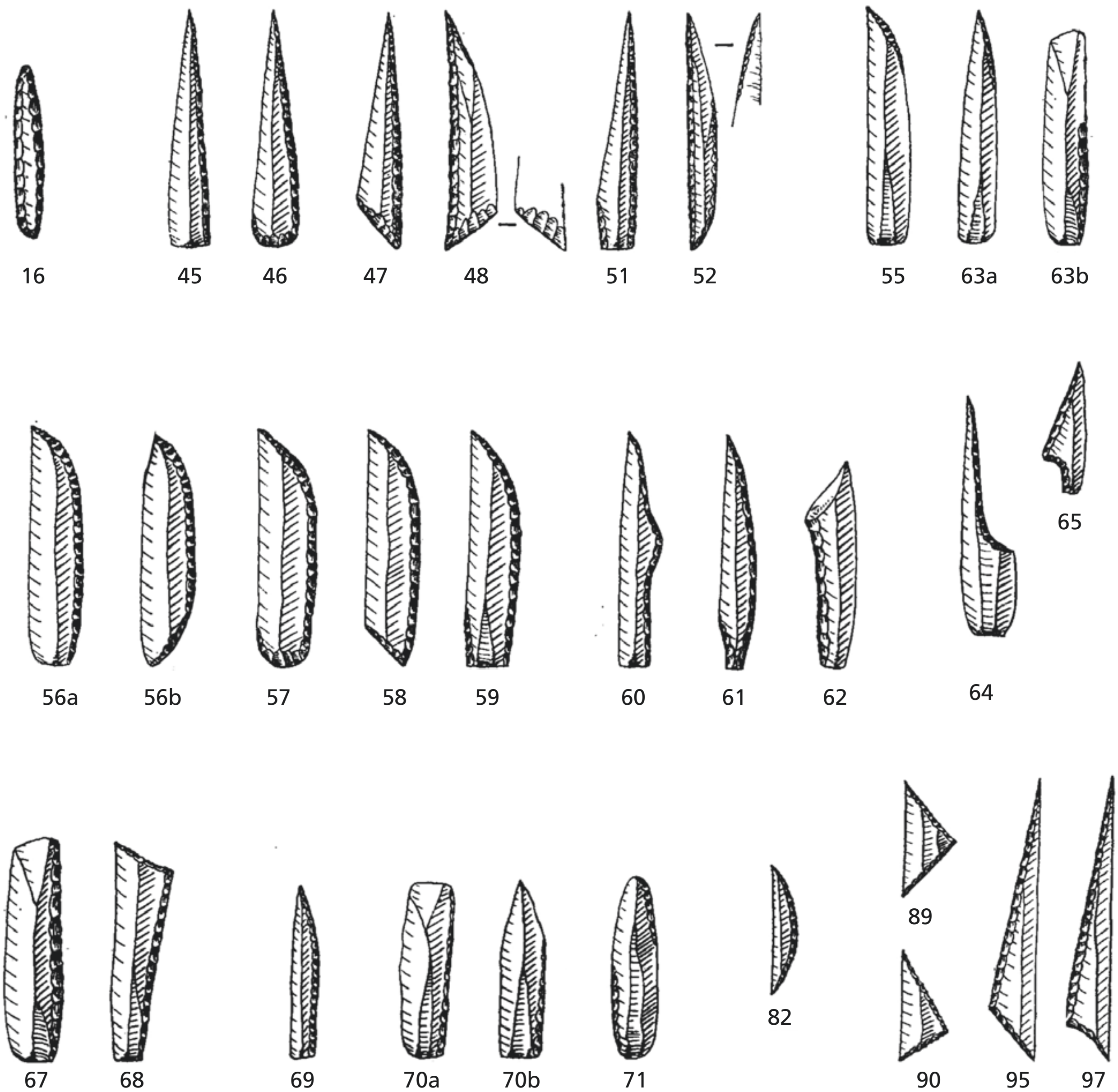


Fig. 12.2 Microlithic and related types at Taforalt (modified after Tixier 1963): **16** Drill bit; **45** Pointed straight-backed bladelet; **46** Pointed straight-backed bladelet with rounded base; **47** Pointed straight-backed bladelet with truncated base; **48** Mechta el-Arbi point; **51** Pointed straight-backed bladelet with retouched base; **52** *Aïn Kéda* point; **55** Bladelet with convex backed end; **56a** Convex backed bladelet; **56b** Convex backed bladelet tending towards segment; **57** Convex backed bladelet with rounded base; **58** Convex backed bladelet with truncated base; **59** Convex backed bladelet with retouched base; **60** Backed bladelet with gibbosity; **61** Backed bladelet with narrowed base; **62** *La Mouillah* point; **63a** Partially backed bladelet with pointed ends; **63b** Partially backed bladelet with unmodified ends; **64** Shouldered bladelet; **65** Shouldered point; **67** Obtuse ended backed bladelet; **68** Scalene bladelet; **69** Pointed bladelet with Ouchtata retouch; **70a** Ouchtata bladelet retouched along entire lateral margin; **70b** Ouchtata bladelet retouched on proximal portion of one edge; **71** Bladelet with Ouchtata retouch; **82** Segment or semi-circle; **89** Isosceles or equilateral triangle; **90** Scalene triangle; **95** Elongated scalene triangle with short truncation; **97** Elongated triangle with concave short truncation.

let with one continuously retouched margin and an oblique truncation removing either the distal end or butt (after Close 1977, 27-38) (**fig. 12.2**).

Finally, there has been some confusion over the use of the term "Ouchtata retouch". Tixier used it specifically to describe a distinctive form of fine, marginal retouch, usually found along one edge of a bladelet, leaving the butt intact and tending to weaken towards the distal end leaving the latter unmodified (Tixier

1963, 115). These he termed bladelets with Ouchtata retouch or 'Ouchtata bladelets' (type 70) (Tixier 1963, 115-116). Unfortunately, the term Ouchtata bladelet has also been used elsewhere to refer to a more variable group of tools rather than a single type (e.g. Olszewski/Schurmans/Schmidt 2011). To reflect this variability, in this volume Ouchtata bladelets are subdivided into those with retouch down the entirety of one margin (type 70a) and those with partial retouch restricted to the proximal portion of one edge (type 70b). In passing, it should be stated that a conscious decision was made by JH, the main author of this chapter, not to refer directly to the earlier work on the lithic assemblages by Roche (1963). This was partly because it was based on a microlithic tool typology that was at odds with the versions used here but also due to perceived problems over his interpretation of the main chronostratigraphic units (**Chapter 2**). In hindsight, some of the insights provided by Roche in fact strongly support our findings and are referred to briefly later in this chapter.

12.3 DEFINITION OF ASSEMBLAGE GROUPS IN THE IBEROMAURUSIAN SEQUENCE

Preliminary examination of the lithic assemblages revealed broad technological and typological trends. Based on initial observations in Sector 8 (the richest and most complete Iberomaurusian sequence in the cave), three sub-divisions were identified by JH (Barton et al. 2013):

IB1 (Yellow Series Units Y2 to Y4) – microburins were uncommon throughout and the toolkit consisted principally of types not requiring the use of microburin technique (e.g. obtuse-ended backed bladelets and Ouchtata bladelets);

IB2 (Yellow Series Unit Y1) – microburins were prolific at the top of the YS and associated with novel tool forms (e.g. *La Mouillah* points);

IB3 (Grey Series) – microburins were relatively underrepresented, although the toolkit consisted of types generally produced using the microburin technique (e.g. curved-backed bladelets).

Subsequent more detailed analysis of the lithics showed that this division needed to be more nuanced (Hogue 2014). Going back to the full set of units as excavated, the process involved systematic pairwise comparisons of the original assemblages in order to examine variation in the attribute and metrical data. Stratigraphic units were systematically collapsed where limited variation was observed, respecting basic stratigraphic principles. In total, three or possibly four groups emerged from these analyses, which were most different from each other, whilst minimising in-group variation. Firstly, the basal GS deposits S8-L28-L29 (and equivalents) were distinct from the upper GS deposits, in the proliferation of the microburin discards and details in the toolkit (e.g. occurrence of *La Mouillah* points) and, as such, on techno-typological grounds were more like the uppermost S8-Y1. Secondly, S8-Y2spit1 did not fit within the initially observed trends: specifically it included a relatively high frequency of microburins technologically similar to those observed in Y1 but a toolkit broadly consistent with that of the underlying Y2spits2-5 and Y3-Y4spits1-2. Interestingly, the sedimentological evidence from S8-Y2spit1 shows plastic deformation consistent with wetness and possible transient ground freezing, which is likely to have resulted in displacement of artefacts and mixing of finds from older and younger levels. Nevertheless, it is conceivable (yet considered very unlikely) that this grouping represents a genuine transition. Due to these factors, the groups were refined and a revised nomenclature is adopted here. Four instead of three Phases could be recognised in the main Sector 8 sequence (and for the equivalents in other Sectors; see also **tab. 12.2**):

Lower Phase (Yellow Series: Y4spits2-1, Y3, Y2spits5-2, MMC130-MMC115)

Transitional/Mixed Phase (Yellow Series: Y2spit1, L32-L31, MMC114-MMC111)

Middle Phase (lower Grey and upper Yellow Series: Y1-G97, L30-L28, MMC110-c. MMC97)

Upper Phase (Grey Series: G96-G88, L27-L2, c. MMC96-MMC1)

A further series of systematic pairwise comparisons were undertaken, comparing attribute occurrence (e.g. butt types) using Fisher's Exact Test and metrical variables (e.g. blank size) using Mann-Whitney U Tests, on artefacts in adjacent stratigraphic units within each recognised group; none showed consistent in-group variation. In part, this may have been a factor of sample size, with many of the units yielding few artefacts, increasing the chance of statistical indeterminacy. Nonetheless, given the available information, there was little evidence to suggest that these broad groups could be further sub-divided. As such, this archaeological phasing was adopted and formed the basis of subsequent analysis. A description of each Phase is given in the following section.

12.4 DESCRIPTION OF LITHIC ASSEMBLAGES

Lower Phase

The Lower Phase assemblage consists of 2050 lithic artefacts, of which a relatively low frequency is undiagnostic knapping debris (51.5 %). Of the classifiable artefacts, small flakes and flakes are most common (58.1 %), but there are also relatively high proportions of blade/lets (20.2 %), low proportions of cores (1.7 %) and core-trimming elements (1.1 %), infrequent microburin products (1.0 %) and moderate numbers of tools (17.4 %) (**tab. 12.3**). The productivity in total artefacts (that is, estimated abundance in a standard sediment volume, weighted by estimated sedimentation rate) is 260 in the Lower Phase, which is the lowest of any Phase (**tab. 12.4**; see table caption for a full explanation of this effectively dimensionless productivity metric).

Cores

In total, 17 cores and core fragments have been recovered. Single platform cores are prevalent (**fig. 12.3a-c**) followed by opposed platform cores (**fig. 12.3d-e**). However, a strict distinction between these types seems to be misleading, as often only a couple of removals have been struck from the opposing striking platform and many of the cores seem to have been abandoned soon after being rotated (see Discussion). There is little evidence for the concurrent exploitation of two or more striking platforms. One multidirectional core has been identified. One discarded tested nodule is recorded, which would have been suitable for further working. There are also three core fragments (**tab. 12.5**).

Most cores are made of chert, although one is made of limestone. All the cores and core fragments retain elements of the original outer surfaces (see raw materials), whereas, in the later Phases, many of the cores are entirely 'decorticated'. Half the cores have recognisable blade/let removals, with the remainder having either mixed removals or solely flake removals (**tab. 12.6**).

Overall, the sizes of cores are not significantly different from those of the later Phases (**tab. 12.7**). However, one is a particularly large core, and is an outlier in terms of length, width and thickness. It is a multidirectional flake core made of limestone, is approximately twice the size of the average core, and measures 57.1 × 47.4 × 30.2 mm.

	Upper Phase	Middle Phase			Transitional/ Mixed Phase	Lower Phase	Sector 10	All sectors
		GS	YS	Total				
Small flake	833	105	192	297	54	352	202	1738
	37.5 %	25.9 %	25.2 %	25.5 %	24.1 %	35.4 %	13.3 %	28.4 %
Flake	533	106	168	274	58	226	642	1733
	24.0 %	26.1 %	22.1 %	23.5 %	25.9 %	22.7 %	42.2 %	28.3 %
Blade	274	61	129	190	45	201	295	960
	12.3 %	15.0 %	17.0 %	16.3 %	20.1 %	20.2 %	19.4 %	16.4 %
Core-trimming elements	47	11	17	28	3	11	50	139
	2.1 %	2.7 %	2.2 %	2.4 %	1.3 %	1.1 %	3.3 %	2.3 %
Microburins & related products	11	47	103	150	20	10	25	216
	0.5 %	11.6 %	13.5 %	12.9 %	8.9 %	1.0 %	1.6 %	3.5 %
Cores	56	20	29	49	6	17	74	202
	2.5 %	4.9 %	3.8 %	4.2 %	2.7 %	1.7 %	4.9 %	3.3 %
Splintered pieces	4	1	1	2	0	4	20	30
	0.2 %	0.3 %	0.1 %	0.2 %	-	0.4 %	1.3 %	0.5 %
Tools	462	55	122	177	38	173	215	1065
	20.8 %	13.6 %	16.0 %	14.2 %	17.0 %	17.4 %	14.1 %	17.4 %
Subtotals	2220	406	761	1167	224	994	1523	6128
	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %
Chips	(7592)	(651)	(945)	(1596)	(261)	(1015)	(713)	(11,177)
	(73.9 %)	(58.3 %)	(53.2 %)	(55.2 %)	(51.1 %)	(49.5 %)	(28.2 %)	(61.2 %)
Chunks	(467)	(59)	(69)	(128)	(26)	(41)	(289)	(951)
	(4.5 %)	(5.3 %)	(3.9 %)	(4.4 %)	(5.1 %)	(2.0 %)	(11.5 %)	(5.2 %)
Overall Totals	10279	1116	1775	2891	511	2050	2525	18,256

Tab. 12.3 Absolute and relative frequencies of artefact classes. (Counts in brackets contribute to "Overall Totals" on the bottom line but not to previous "Subtotals" involving only better classified pieces.)

Fig. 12.3 Lower Phase cores: **a-c** single platform cores; **d-e** opposed platform cores.

		Volume	Sedim Rate	Debris			Debitage			Tools			Total		
		m³	m/^{14}C cal ka	n	/m³	prod	n	/m³	prod	n	/m³	prod	n	/m³	prod
Upper Phase		1.67	1.65	7445	4458	7356	1595	955	1576	432	259	427	9472	5672	9359
Middle Phase	GS	0.41	4.00	710	1732	6928	351	856	3424	55	134	536	1116	2723	10892
	YS	0.47	0.17	1014	2157	367	639	1360	231	122	260	44	1775	3777	642
	Total	0.88	0.67	1724	1959	1313	990	1125	754	177	201	135	2891	3285	2201
Intermediate/ Mixed Phase		0.28	0.17	287	1025	174	186	664	113	38	136	23	511	1825	310
Lower Phase		1.34	0.17	1056	789	134	821	613	104	173	129	22	2050	1530	260
Overall		4.17	-	10512	2520	-	3592	861	-	820	197	-	14924	3579	-

Tab. 12.4 Lithic artefact productivity. The objective of this table is to show estimates of lithic artefact productivity ("productivity") based upon counts (excluding lithics from MMC001-056). – Bulk density is given as number/cubic metre. Most bulk densities have been calculated using estimated volumes for the total volume of sediment (with varying proportions of mineral sands, stones, ash, etc.) excavated. Estimated volumes have been calculated in the QGIS software package using 3D data recorded in the field and digitised section/profile drawings. In the case of MMC080-130, the volume of sediment was measured in the field and has been used instead of estimated volumes when calculating bulk densities. No data are available for the volumes of sediment recovered from MMC001-056 or from Sector 10. – Bulk density on its own is not a sufficient proxy for productivity, since the sediment matrix of the different Phases accumulated at different rates. Thus, sedimentation rate estimates (see **Chapter 2**, relying heavily upon Sector 8) have next been used (in thickness metres per calibrated radiocarbon millennia) to weight the bulk density calculations. The resulting productivity figures ("prod" in the table, expressed as effectively a dimensionless but approximately linear metric) are still only estimates (due to differences in sediment, such as variations in texture/composition, that still constrain the possible lithic numbers) but the figures are considered sufficiently reliable at least to indicate gross contrasts between Phases. Note that "overall productivity" has not been calculated, since the lithostratigraphic representation in different sectors is too disparate to allow a meaningful estimate of average LSA-period sedimentation rate.

	Upper Phase	Middle Phase			Transitional/ Mixed Phase	Lower Phase	Sector 10	Total
		GS	YS	Total				
Single platform	18	8	12	20	1	7	22	68
	32.1 %	40.0 %	41.4 %	40.8 %		41.2 %	29.7 %	33.7 %
Opposed platform	12	3	5	8	2	5	19	46
	21.4 %	15.0 %	17.2 %	16.3 %		29.4 %	25.7 %	22.8 %
90° platform	3	0	0	0	0	0	2	5
	5.4 %	0.0 %	0.0 %	0.0 %		0.0 %	8.1 %	2.5 %
Multiplatform	4	4	2	6	0	1	6	17
	7.1 %	20.0 %	6.9 %	12.2 %		5.9 %	2.7 %	8.4 %
Discoidal	1	0	1	1	0	0	1	3
	1.8 %	0.0 %	3.5 %	2.0 %		0.0 %	1.4 %	1.5 %
Core-on-flake	6	1	2	3	0	0	8	17
	10.7 %	5.0 %	6.9 %	6.1 %		0.0 %	10.8 %	8.4 %
Prepared/tested	0	2	1	3	1	1	1	6
	0.0 %	10.0 %	3.5 %	6.1 %		5.9 %	1.4 %	3.0 %
Fragment	12	2	6	8	2	3	15	40
	21.4 %	10.0 %	20.7 %	16.3 %		17.6 %	20.3 %	19.8 %
Total	56	20	29	49	6	17	74	202
	100.0 %			100.0 %	100.0 %	100.0 %	100.0 %	100.0 %

Tab. 12.5 Absolute and relative frequencies of cores.

	Upper Phase	Middle Phase			Transitional/ Mixed Phase	Lower Phase	Sector 10	Total
		GS	YS	Total				
Flake	26	8	15	23	5	5	36	95
	52.0 %	42.1 %	57.7 %	51.1 %		31.3 %	58.1 %	53.4 %
Blade	0	0	0	0	0	0	2	2
	-	-	-	-	-	-	3.2 %	1.1 %
Bladelet	19	9	10	19	0	8	19	65
	38.0 %	47.4 %	38.5 %	42.2 %	-	50.0 %	30.7 %	36.5 %
Mixed	5	2	1	3	0	3	5	16
	10.0 %	10.5 %	3.9 %	6.7 %	-	18.8 %	8.1 %	8.9 %
Total	50	19	26	45	5	16	62	178
	100.0 %			100.0 %	100.0 %	100.0 %	100.0 %	100.0 %

Tab. 12.6 Absolute and relative frequencies of diagnostic scars on cores.

	Length (mm)	Width (mm)	Thickness (mm)	Weight (g)
Upper Phase				
N	44	44	44	44
Mean	27.4	19.7	14.0	9.7
Std. Deviation	5.2	5.2	5.2	5.2
Minimum	16.5	10.4	7.2	3.5
Maximum	40.8	34.7	31.3	22.0
Median	27.6	18.8	12.6	8.8
Middle Phase				
N	41	41	41	41
Mean	26.3	21.1	15.1	11.1
Std. Deviation	5.5	5.8	4.2	6.1

Tab. 12.7 Dimensions of cores.

	Length (mm)	Width (mm)	Thickness (mm)	Weight (g)
Minimum	17.8	11.4	8.7	2.5
Maximum	43.2	38.5	24.6	32.6
Median	26.8	19.6	14.0	9.4
Transitional/Mixed Phase				
N	4	4	4	4
Mean	31.2	21.5	13.4	11.1
Std. Deviation	12.3	5.8	3.0	7.2
Minimum	23.0	14.5	10.5	5.0
Maximum	49.6	27.9	17.5	21.4
Median	26.2	21.8	12.8	8.9
Lower Phase				
N	14	14	14	14
Mean	31.4	22.5	16.3	18.8
Std. Deviation	10.3	9.6	6.0	26.2
Minimum	18.0	10.9	8.1	3.2
Maximum	57.1	47.4	30.2	105.7
Median	29.4	19.5	14.6	10.2
Sector 10				
N	59	59	59	59
Mean	33.7	25.0	17.3	24.6
Std. Deviation	8.0	8.8	7.5	50.3
Minimum	19.6	15.2	8.4	4.9
Maximum	69.3	68.8	58.0	386.9
Median	33.1	22.5	15.9	14.1

Tab. 12.7 (continued)

Debitage

In total, 201 blade/lets including fragments have been recovered. All the blade/lets are made of chert and the overwhelming majority have no outer rind (**tab. 12.8**). Most have unidirectional dorsal scars and relatively few have bidirectional opposed dorsal scars (**tab. 12.9**). An overwhelming number have punctiform/linear butts and the other butt types are found only in small numbers (**tab. 12.10**). None is a blade *sensu stricto*, all being bladelet-sized. On average the blade/lets are relatively narrow and thin in comparison to the Middle and Upper Phases (**tab. 12.11**).

A total of 578 small flakes and flakes have also been recovered. Most are made of chert (93.8 %), with smaller frequencies made of limestone (4.7 %), quartzite (1.0 %) and basalt (0.5 %). All complete and almost complete flakes have been selected for further attribute analysis (n = 134). Around a third have no outer rind (**tab. 12.12**). Just over half have unidirectional dorsal scars and over a quarter have multidirectional dorsal scars (**tab. 12.13**). Around two fifths have plain butts and those with 'cortical' butts also make up a strong proportion of the assemblage (**tab. 12.14**). Overall, the average size of flakes is not significantly different from that in the Transitional/Mixed Phase (**tab. 12.15**).

Eleven core-trimming elements have been recovered from the Lower Phase. All are made on chert. Most are crested pieces, relating to the initial shaping of a blade or bladelet core in which a crest, or ridge, is formed that is then used to guide subsequent blade removals. The two faces of a crest are known as versants. In the Lower Phase the crested pieces include eight crested blade removals with one prepared versant, one crested blade removal with both versants prepared and two fragments. The median dimensions are 26.0 × 8.6 × 3.8 mm (**tab. 12.16**). There is also one example measuring 14.7 × 8.1 × 2.7 mm.

	Upper Phase	Middle Phase			Transitional/ Mixed Phase	Lower Phase	Sector 10	Total
		GS	YS	Total				
None	43	16	35	51	15	53	75	237
	43.0 %	69.6 %	60.3 %	68.2 %	68.2 %	73.6 %	49.7 %	55.6 %
Less than 25 %	27	4	13	17	7	8	46	105
	27.0 %	17.4 %	22.4 %	21.0 %	31.8 %	11.1 %	30.5 %	24.7 %
Between 25-50 %	20	1	6	7	0	6	15	48
	20.0 %	4.3 %	10.3 %	8.6 %	0.0 %	8.3 %	9.9 %	11.3 %
More than 50 %	7	2	4	6	0	3	12	28
	7.0 %	8.7 %	6.9 %	7.4 %	0.0 %	4.2 %	8.0 %	6.6 %
Complete	3	0	0	0	0	2	3	8
	3.0 %	0.0 %	0.0 %	0.0 %	0.0 %	2.8 %	2.0 %	1.9 %
Total	100	23	58	81	22	72	151	426
	100.0 %			100.0 %	100.0 %	100.0 %	100.0 %	100.0 %

Tab. 12.8 Absolute and relative percentage of outer rind retained on the dorsal surface of blade/lets.

	Upper Phase	Middle Phase			Transitional/ Mixed Phase	Lower Phase	Sector 10	Total
		GS	YS	Total				
Unidirectional	117	37	65	102	27	111	150	507
	60.6 %	74.0 %	64.4 %	67.6 %	79.4 %	73.4 %	66.1 %	67.1 %
Bidirectional opposed	50	10	18	28	3	19	41	141
	25.9 %	20.0 %	17.8 %	18.5 %	8.8 %	12.6 %	18.1 %	18.7 %
Bidirectional crossed	6	1	9	10	0	12	8	36
	3.1 %	2.0 %	8.9 %	6.6 %	0.0 %	8.0 %	3.5 %	4.8 %
Multidirectional	20	2	9	11	4	9	28	72
	10.4 %	4.0 %	8.9 %	7.3 %	11.8 %	6.0 %	12.3 %	9.5 %
Total	193	50	101	151	34	151	227	756
	100.0 %			100.0 %	100.0 %	100.0 %	100.0 %	100.0 %

Tab. 12.9 Absolute and relative frequencies of diagnostic dorsal scar patterns on blade/lets and blade/lets fragments.

	Upper Phase	Middle Phase			Transitional/ Mixed Phase	Lower Phase	Sector 10	Total
		GS	YS	Total				
'Cortical'	9	1	6	7	0	5	9	30
	6.8 %	5.0 %	9.7 %	8.5 %	0.0 %	4.6 %	4.8 %	5.7 %
Plain	52	8	24	32	4	16	82	186
	39.4 %	40.0 %	38.7 %	39.0 %	21.1 %	14.7 %	44.1 %	35.2 %
Dihedral	5	0	1	1	1	2	7	16
	3.8 %	0.0 %	1.6 %	1.2 %	5.3 %	1.8 %	3.8 %	3.0 %
Faceted	22	2	1	3	0	0	5	30
	16.7 %	10.0 %	1.6 %	3.7 %	0.0 %	0.0 %	2.7 %	5.7 %
Puncti-form/ Linear	44	9	30	39	14	86	83	266
	33.3 %	45.0 %	48.4 %	47.5 %	73.7 %	78.9 %	44.6 %	50.4 %
Total	132	20	62	82	19	109	186	528
	100.0 %			100.0 %	100.0 %	100.0 %	100.0 %	100.0 %

Tab. 12.10 Absolute and relative frequencies of diagnostic butt types on blade/lets and blade/let fragments.

	Length (mm)	Width (mm)	Thickness (mm)	Weight (g)
Upper Phase				
N	67	101	101	67
Mean	27.3	10.1	4.0	1.4
Std. Deviation	6.7	3.2	1.8	1.3
Median	27.0	9.6	3.7	1.1
Minimum	16.9	4.1	1.1	0.2
Maximum	45.1	18.2	8.8	5.6
Middle Phase				
N	45	81	81	45
Mean	27.0	9.7	3.7	1.4
Std. Deviation	6.6	2.8	1.7	1.1
Median	26.1	9.5	3.1	1.3
Minimum	15.1	4.5	1.2	0.1
Maximum	40.7	16.8	8.6	3.9
Transitional/Mixed Phase				
N	16	22	22	16
Mean	30.3	9.7	3.3	2.2
Std. Deviation	11.7	5.6	2.1	4.9
Median	29.4	8.1	3.0	1.0
Minimum	18.0	4.7	1.4	0.1
Maximum	66.8	31.0	10.9	20.2
Lower Phase				
N	53	72	72	53
Mean	25.0	8.7	3.0	0.9
Std. Deviation	7.1	2.8	1.2	0.9
Median	24.0	8.1	2.7	0.6
Minimum	13.2	4.6	1.2	0.1
Maximum	43.4	16.6	5.7	4.4
Sector 10				
N	117	158	158	117
Mean	34.0	12.5	4.4	2.7
Std. Deviation	8.2	3.6	1.7	2.5
Median	33.8	12.2	4.2	2.1
Minimum	17.0	5.0	1.3	0.2
Maximum	62.6	25.9	11.4	17.0

Tab. 12.11 Dimensions of blade/lets by Phase.

	Upper Phase	Middle Phase			Transitional/ Mixed Phase	Lower Phase	Sector 10	Total
		GS	YS	Total				
None	89	19	26	45	9	41	114	298
	29.9 %	31.7 %	30.6 %	31.0 %	23.7 %	30.6 %	29.4 %	29.7 %
Less than 25 %	70	17	16	33	12	35	115	265
	23.5 %	28.3 %	18.8 %	22.8 %	31.6 %	26.1 %	29.6 %	26.4 %
Between 25-50 %	43	6	15	21	6	22	58	150
	14.4 %	10.0 %	17.7 %	14.5 %	15.8 %	16.4 %	15.0 %	15.0 %
More than 50 %	54	8	13	21	7	16	58	156
	18.1 %	13.3 %	15.3 %	14.5 %	18.4 %	11.9 %	15.0 %	15.6 %
Complete	42	10	15	25	4	20	43	134
	14.1 %	16.7 %	17.7 %	17.2 %	10.5 %	14.9 %	11.3 %	13.4 %
Total	298	60	85	145	38	134	388	1003
	100.0 %			100.0 %	100.0 %	100.0 %	100.0 %	100.0 %

Tab. 12.12 Absolute and relative frequencies of diagnostic dorsal rind* on flakes. * Includes natural exterior surfaces on limestone flakes.

	Upper Phase	Middle Phase			Transitional/ Mixed Phase	Lower Phase	Sector 10	Total
		GS	YS	Total				
Unidirectional	78	15	33	48	16	49	111	350
	48.4 %	41.7 %	60.0 %	52.7 %	61.5 %	51.6 %	44.2 %	
Bidirectional opposed	17	4	3	7	0	10	24	65
	10.6 %	11.1 %	5.5 %	7.7 %	0.0 %	10.5 %	9.6 %	
Bidirectional crossed	10	2	2	4	1	8	27	54
	6.2 %	5.6 %	3.6 %	4.4 %	3.8 %	8.4 %	10.6 %	
Multidirectional	56	15	17	32	9	28	89	246
	34.8 %	41.7 %	30.9 %	35.2 %	34.6 %	29.5 %	35.5 %	
Total	161	36	55	91	26	95	251	715
	100.0 %			100.0 %	100.0 %	100.0 %	100.0 %	

Tab. 12.13 Absolute and relative frequencies of diagnostic dorsal scar patterns on flakes.

	Upper Phase	Middle Phase			Transitional/ Mixed Phase	Lower Phase	Sector 10	Total
		GS	YS	Total				
'Cortical'*	64	15	17	32	5	27	92	220
	24.8 %	28.9 %	22.1 %	24.8 %	17.2 %	23.5 %	26.4 %	25.0 %
Plain	146	28	36	64	13	49	178	450
	56.6 %	53.9 %	46.8 %	49.6 %	44.8 %	42.6 %	51.2 %	51.1 %
Dihedral	9	4	8	12	5	12	22	60
	3.5 %	7.7 %	10.4 %	9.3 %	17.2 %	10.4 %	6.3 %	6.8 %
Faceted	26	4	10	14	3	10	27	80
	10.1 %	7.7 %	13.0 %	10.9 %	10.3 %	8.7 %	7.7 %	9.1 %
Punctiform/Linear	13	1	6	7	3	17	30	70
	5.0 %	1.9 %	7.8 %	5.4 %	10.3 %	14.8 %	8.6 %	8.0 %
Total	258	52	77	129	29	115	349	880
	100.0 %			100.0 %	100.0 %	100.0 %	100.0 %	100.0 %

Tab. 12.14 Absolute and relative frequencies of diagnostic butts types on flakes. * Includes natural exterior surfaces on limestone flakes.

	Length (mm)	Width (mm)	Thickness (mm)	Weight (g)
Upper Phase				
N	223	295	298	223
Mean	24.5	21.2	5.1	4.4
Std. Deviation	8.8	7.9	3.2	9.5
Median	22.6	19.9	5.2	2.2
Minimum	12.1	9.3	1.3	0.1
Maximum	77.3	59.1	24.4	105.0
Middle Phase				
N	119	145	145	119
Mean	23.9	19.3	5.8	3.9
Std. Deviation	5.9	6.0	2.6	6.9
Median	22.9	19.3	5.5	2.3
Minimum	12.8	9.3	1.3	0.5
Maximum	52.7	45.1	16.8	64.0
Transitional/Mixed Phase				
N	31	38	38	31
Mean	25.0	20.4	5.4	3.6

Tab. 12.15 Dimensions of flakes.

	Length (mm)	Width (mm)	Thickness (mm)	Weight (g)
Std. Deviation	7.4	7.4	3.3	4.6
Median	23.1	18.1	4.7	1.9
Minimum	14.0	10.6	1.7	0.6
Maximum	41.4	41.2	15.1	19.9
Lower Phase				
N	117	134	134	117
Mean	24.2	19.6	5.6	3.3
Std. Deviation	6.4	6.7	3.1	4.2
Median	23.1	19.1	4.9	1.9
Minimum	11.4	7.1	1.1	0.3
Maximum	50.8	39.6	19.2	27.0
Sector 10				
N	319	398	398	319
Mean	28.5	22.7	6.7	6.5
Std. Deviation	9.4	8.9	3.5	13.4
Median	26.5	20.7	6.0	3.3
Minimum	11.6	10.1	1.3	0.5
Maximum	74.4	78.4	27.8	159.4

Tab. 12.15 (continued)

	Length (mm)	Width (mm)	Thickness (mm)	Weight (g)
Upper Phase				
N	14	25	25	14
Mean	27.5	10.6	5.7	1.6
Std. Deviation	7.2	3.8	2.1	1.3
Minimum	17.1	5.6	3.0	0.4
Maximum	37.9	17.9	10.6	4.5
Median	29.0	9.5	5.1	1.0
Middle Phase				
N	8	15	15	8
Mean	30.5	10.1	5.6	2.2
Std. Deviation	4.9	4.2	2.2	2.2
Minimum	24.6	3.9	3.3	0.3
Maximum	37.5	16.8	11.9	7.3
Median	28.9	8.0	5.4	1.6
Transitional/Mixed Phase				
N	1	2	2	1
Mean	41.3	12.0	5.7	4.5
Std. Deviation		2.5	0.6	
Minimum	41.3	10.3	5.2	4.5
Maximum	41.3	13.8	6.1	4.5
Median	41.3	12.0	5.6	4.5
Lower Phase				
N	5	7	7	5
Mean	27.4	8.9	3.9	0.7
Std. Deviation	5.6	1.2	0.9	0.2
Minimum	19.9	7.6	2.6	0.5
Maximum	34.7	10.9	5.5	0.9
Median	26.0	8.6	3.8	0.6

Tab. 12.16 Dimensions of crested pieces.

	Length (mm)	Width (mm)	Thickness (mm)	Weight (g)
Sector 10				
N	26	35	35	26
Mean	40.0	13.5	7.5	4.2
Std. Deviation	9.4	3.8	2.1	2.4
Minimum	26.2	7.6	3.9	0.8
Maximum	60.8	24.4	12.6	8.3
Median	41.6	13.4	7.2	3.8

Tab. 12.16 (continued)

	Upper Phase	Middle Phase			Transitional/ Mixed Phase	Lower Phase	Sector 10	Total
		GS	YS	Total				
Left	4	35	74	109	12	2	20	147
		77.8 %	74.2 %	75.7 %	60.0 %		80.0 %	72.4 %
Right	1	10	25	35	8	7	5	56
		22.2 %	25.3 %	24.3 %	40.0 %		20.0 %	27.6 %
Total	5	47	99	144	20	9	25	203
			100.0 %	100.0 %	100.0 %		100.0 %	100.0 %

Tab. 12.17 Absolute and relative frequencies of diagnostic microburin retouch lateralisation.

	Upper Phase	Middle Phase			Transitional/ Mixed Phase	Lower Phase	Sector 10	Total
		GS	YS	Total				
Distal	2	35	75	110	7	2	21	148
		77.8 %	75.8 %	76.4 %	35.0 %		84.0 %	72.9 %
Proximal	3	10	24	34	13	7	4	55
		22.2 %	24.2 %	23.6 %	65.0 %		16.0 %	27.1 %
Total	5	45	99	144	20	9	25	203
					100.0 %		100.0 %	100.0 %

Tab. 12.18 Absolute and relative frequencies of diagnostic microburin location.

	Length (mm)	Width (mm)	Thickness (mm)
Upper Phase			
N	5	5	5
Mean	9.4	7.0	2.3
Std. Deviation	3.8	2.4	0.8
Median	7.8	7.2	2.4
Minimum	5.7	3.7	1.2
Maximum	15.3	10.3	3.4
Middle Phase			
N	148	148	148
Mean	18.1	10.7	3.8
Std. Deviation	5.4	3.5	1.3
Median	17.5	10.2	3.6
Minimum	8.1	4.1	1.5
Maximum	32.3	22.6	8.1

Tab. 12.19 Dimensions of microburins.

	Length (mm)	Width (mm)	Thickness (mm)
Transitional/Mixed Phase			
N	20	20	20
Mean	19.9	10.2	3.9
Std. Deviation	6.4	2.7	1.3
Median	18.2	10.0	3.5
Minimum	10.1	6.2	2.1
Maximum	32.9	15.0	6.4
Lower Phase			
N	9	9	9
Mean	11.6	6.9	2.4
Std. Deviation	4.4	1.8	0.8
Median	11.0	6.7	2.1
Minimum	5.5	4.3	1.2
Maximum	18.9	10.0	3.4
Sector 10			
N	25	25	25
Mean	24.6	13.5	5.0
Std. Deviation	7.4	3.4	2.1
Median	23.8	13.6	4.6
Minimum	9.3	7.2	2.0
Maximum	40.5	21.2	10.1

Tab. 12.19 (continued)

	Upper Phase	Middle Phase			Transitional/ Mixed Phase	Lower Phase	Sector 10	Total
		GS	YS	Total				
End-scrapers	13	7	2	9	2	4	33	61
	2.8 %	12.7 %	1.6 %	5.1 %	5.3 %	2.3 %	15.4 %	5.7 %
Perforators	0	0	0	0	0	0	1	1
	-	-	-	-	-	-	0.5 %	0.1 %
Backed flakes and blades	3	0	0	0	0	0	8	11
	0.7 %	-	-	-	-	-	3.7 %	1.0 %
Composite tools	1	0	0	0	0	0	1	2
	0.2 %	-	-	-	-	-	0.5 %	0.2 %
Microlithic and related	199	25	66	91	21	57	105	473
	43.1 %	45.6 %	54.1 %	51.4 %	55.3 %	33.0 %	48.8 %	44.4 %
Microlithic fragments	201	17	42	59	11	91	43	405
	43.5 %	30.9 %	34.4 %	33.3 %	29.0 %	52.6 %	20.0 %	38.0 %
Notches and denticulates	14	1	1	2	2	8	17	43
	3.0 %	1.8 %	0.8 %	1.1 %	5.3 %	4.6 %	7.9 %	4.0 %
Truncations	7	1	2	3	1	5	2	18
	1.5 %	1.8 %	1.6 %	1.7 %	2.6 %	2.9 %	0.9 %	1.7 %
Varia	24	4	9	13	1	8	5	51
	5.2 %	7.3 %	7.4 %	7.3 %	2.6 %	4.6 %	2.3 %	4.8 %
Total	462	55	122	177	38	173	215	1,065
	100.0 %			100.0 %	100.0 %	100.0 %	100.0 %	100.0 %

Tab. 12.20 Absolute and relative frequencies of tool classes.

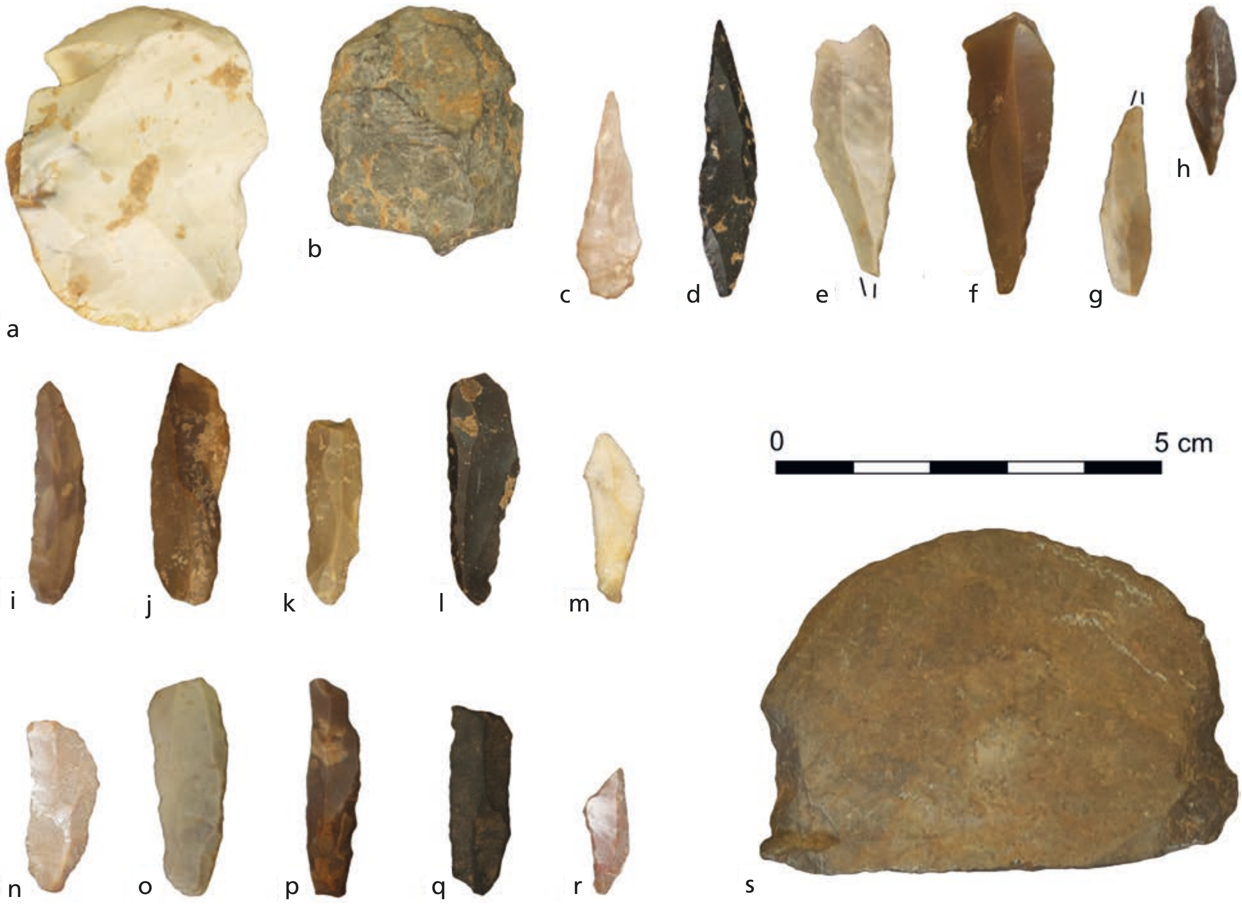


Fig. 12.4 Lower Phase retouched tools: **a** end-scraper on retouched flake; **b** fragment with end-scraper retouch; **c-e** pointed straight-backed bladelets; **f-h** partially backed bladelets with pointed ends; **i** convex-backed bladelet; **j** partially backed bladelet with unmodified end; **k** obtuse-ended backed bladelet; **l-p** Ouchtata bladelets; **q-r** scalene bladelets; **s** large strangulated piece.

Microburins and Related Products

One Krukowski microburin and nine true microburins have been recovered from the Lower Phase. The Krukowski is an accidental by-product of retouch, as opposed to a true microburin which is a deliberate waste product of microlith manufacture. Of the latter, most have been detached from the proximal end of the blank and have the notch on the left side (**tabs 12.17-12.18**). In general, the microburins are relatively restricted in size, indicating that a short section has been removed from relatively narrow, thin blades/lets (**tab. 12.19**).

Retouched Tools (**fig. 12.4**)

The Lower Phase assemblage includes 173 retouched tools. These are dominated by microlithic and related forms, with relatively few other tool-types (**tab. 12.20**).

End-Scrapers

An end-scraper on a flake, an end-scraper on a retouched flake (**fig. 12.4a**), a denticulated end-scraper and a fragment of an end-scraper have been recovered from the Lower Phase. All are made on chert flakes apart

	Upper Phase	Middle Phase			Transitional/ Mixed Phase	Lower Phase	Sector 10	Total
		GS	YS	Total				
16. Drill (*Mèche de foret*)	1	0	0	0	0	0	0	1
	0.5 %	-	-	-	-	-	-	0.2 %
34. Backed flake	2	0	0	0	0	0	0	2
	1.0 %	-	-	-	-	-	-	0.4 %
45. Pointed straight backed bladelet	13	2	0	2	0	8	11	34
	6.5 %	8.0 %	-	2.2 %	-	14.0 %	10.5 %	7.2 %
46. Pointed straight backed bladelet with rounded base	3	0	0	0	0	1	0	4
	1.5 %	-	-	-	-	1.8 %	-	0.9 %
47. Pointed straight backed bladelet with truncated base	9	1	0	1	0	0	13	23
	4.5 %	4.0 %	-	1.1 %	-	-	12.4 %	4.9 %
48. Mechta el-Arbi point	0	0	0	0	0	0	1	1
	-	-	-	-	-	-	1.0 %	0.2 %
51. Pointed straight backed bladelet with retouched base	1	0	0	0	0	0	1	2
	0.5 %	-	-	-	-	-	1.0 %	0.4 %
52. *Aïn Kéda* point	4	0	0	0	0	0	1	5
	2.0 %	-	-	-	-	-	1.0 %	1.1 %
55. Bladelet with convex backed end	4	0	0	0	0	2	1	7
	2.0 %	-	-	-	-	3.5 %	1.0 %	1.5 %
56. Convex backed bladelet								
a. typical	50	6	11	17	1	3	24	95
	25.1 %	24.0 %	16.7 %	18.7 %	4.8 %	5.3 %	22.9 %	20.1 %
b. tending towards segment	44	2	11	13	1	0	13	71
	22.1 %	8.0 %	16.7 %	14.3 %	4.8 %	-	12.4 %	15.0 %
57. Convex backed bladelet with rounded base	2	0	2	2	0	2	4	10
	1.0 %	-	3.0 %	2.2 %	-	3.5 %	3.8	2.1 %
58. Convex backed bladelet with truncated base	26	2	5	7	1	0	22	56
	13.1 %	8.0 %	7.6 %	7.7 %	4.8 %	-	21.0 %	11.8 %
59. Convex backed bladelet with retouched base	4	1	1	2	0	0	1	7
	2.0 %	4.0 %	1.5 %	2.2 %	-	-	1.0 %	1.5 %
60. Backed bladelet with gibbosity	1	0	1	1	0	0	0	2
	0.5 %	-	1.5 %	1.1 %	-	-	-	0.4 %
61. Backed bladelet with narrowed base	5	0	0	0	0	0	2	7
	2.5 %	-	-	-	-	-	1.9 %	1.5 %
62. *La Mouillah* point	0	4	22	26	2	0	2	30
	-	16.0 %	33.3 %	28.6 %	9.5 %	-	1.9 %	6.3 %

Tab. 12.21 Absolute and relative frequencies of microlithic and related types.

	Upper Phase	Middle Phase			Transitional/ Mixed Phase	Lower Phase	Sector 10	Total
		GS	YS	Total				
63. Partially backed bladelet								
a. with pointed end	0	0	2	2	0	6	0	8
	-	-	3.0 %	2.2 %	-	10.5 %	-	1.9 %
b. with unmodified end(s)	0	1	0	1	1	2	2	6
	-	4.0 %	-	1.1 %	4.8 %	3.5 %	1.9 %	1.3 %
64. Shouldered bladelet	0	0	0	0	0	1	0	1
	-	-	-	-	-	1.8 %	-	0.2 %
65. Shouldered point	0	0	1	1	0	0		1
	-	-	1.5 %	1.1 %	-	-		0.2 %
67. Obtuse backed bladelet	1	0	2	2	4	7		14
	0.5 %	-	3.0 %	2.2 %	19.1 %	12.3 %		3.0 %
68. Scalene bladelet	1	2	1	3	1	5		10
	0.5 %	8.0 %	1.5 %	3.3 %	4.8 %	8.8 %		2.7 %
69. Pointed bladelet with Ouchtata retouch	6	0	0	0	0	2	0	8
	3.0 %	-	-	-	-	3.5 %	-	1.7 %
70. Ouchtata bladelet								
a. retouched along entire lateral margin	1	0	1	1	6	9	0	17
	0.5 %	-	1.5 %	1.1 %	28.6 %	15.8 %	-	3.6 %
b. retouched on proximal portion of one edge	0	0	2	2	3	5	1	11
	-	-	3.0 %	2.2 %	14.3 %	8.8 %	1.0 %	2.3 %
71. Bladelet with Ouchtata retouch	5	0	3	3	1	1	1	11
	2.5 %	-	4.6 %	3.3 %	4.8 %	1.8 %	1.0 %	2.3 %
82. Segment or semi-circle	10	3	0	3	0	0	1	14
	5.0 %	12.0 %	-	3.3 %	-	-	1.0 %	3.0 %
89. Isosceles or equilateral triangle	2	1	0	1	0	0	0	3
	1.0 %	4.0 %	-	1.1 %	-	-	-	0.6 %
90. Scalene triangle	3	0	0	0	0	1	0	4
	1.5 %	-	-	-	-	1.8 %	-	0.9 %
95. Elongated scalene triangle with short truncation	0	0	0	0	0	0	1	1
	-	-	-	-	-	-	1.0 %	0.2 %
97. Elongated scalene triangle with concave short truncations	0	0	0	0	0	0	1	1
	-	-	-	-	-	-	1.0 %	0.2 %
112. *Varia*	1	0	1	1	0	1	0	3
	0.5 %	-	1.5 %	1.1 %	-	1.8 %	-	0.6 %
Total	199	25	66	91	21	57	105	473
	100.0 %			100.0 %	100.0 %	100.0 %	100.0 %	100.0 %

Tab. 12.21 (continued)

	Upper Phase	Middle Phase			Transitional/ Mixed Phase	Lower Phase	Sector 10	Total
		GS	YS	Total				
Continuous	196	24	64	88	16	39	102	442
	98.5 %	96.0 %	97.0 %	96.7 %	76.2 %	68.4 %	97.2 %	93.3 %
Partial	3	1	2	3	5	18	3	32
	1.5 %	4.0 %	3.0 %	3.3 %	23.8 %	31.6 %	2.8 %	6.8 %
Distal	2	0	0	0	0	6	0	8
Mesial	0	1	0	1	1	0	0	2
Proximal	1	0	2	2	4	12	3	22
Total	199	25	66	91	21	57	105	474
	100.0 %			100.0 %	100.0 %	100.0 %	100.0 %	100.0 %

Tab. 12.22 Absolute and relative frequencies of retouch distribution on microlithic and related types.

	Upper Phase	Middle Phase			Transitional/ Mixed Phase	Lower Phase	Sector 10	Total
		GS	YS	Total				
Left	109	19	49	68	7	21	56	261
	61.9 %	76.0 %	81.7 %	80.0 %	33.3 %	36.8 %	57.1 %	59.7 %
Right	66	6	11	17	14	36	42	175
	37.5 %	24.0 %	18.3 %	20.0 %	66.7 %	63.2 %	42.9 %	40.1 %
Both	1	0	0	0	0	0	0	1
	0.6 %	-	-	-	-	-	-	0.2 %
Total	176	25	60	85	21	57	98	427
	100.0 %			100.0 %	100.0 %	100.0 %	100.0 %	100.0 %

Tab. 12.23 Absolute and relative frequencies of diagnostic retouch lateralisation on microlithic and related types.

from the last that is on a limestone flake. A couple have been retouched distally (including one with retouch extending down the right edge), one has been retouched at the proximal end, and one has been retouched at an indeterminate end. Excluding the fragment, the medium size is 31.2 × 29.5 × 8.7 mm.

Microlithic and Related Forms

This category is prolific, only exceeded in number by microlithic fragments. A diverse range of microlithic types has been identified and the assemblage is largely distinct from those found in the later Phases in the dominant forms recorded (**tab. 12.21**).

The most frequent type is the Ouchtata bladelet (type 70) in which the butt is retained. Ouchtata bladelets (**fig. 12.4l-p**) with retouch along the entire lateral margin (subtype 70a) are almost twice as common as those with only partial retouch (subtype 70b). The former are morphologically similar, differing only in the extent of retouch, to the obtuse-ended backed bladelets (type 67), which also occur in relatively high proportions in the Lower Phase.

Pointed straight-backed bladelets (types 45-52) also make up a relatively strong proportion of the tools (**fig. 12.4c-e**). Most have been classified as pointed straight-backed bladelets *sensu stricto* (type 45). A few of this type have marginal retouch along one edge that becomes more intensive towards the tip producing a tapered outline. These tapering forms are largely similar to the partially backed bladelets with a pointed end (type 63a), differing only in the extent of retouch along the edge. Partially backed bladelets with pointed ends (**fig. 12.4f-h**) also account for a relatively high proportion of microlithic types from the Lower Phase.

	Upper Phase	Middle Phase			Transitional/ Mixed Phase	Lower Phase	Sector 10	Total
		GS	YS	Total				
Ouchtata	12	0	3	3	8	17	2	42
	6.0 %	-	4.6 %	3.3 %	38.1 %	29.8 %	1.9 %	8.9 %
Direct	114	19	53	72	10	38	62	296
	57.3 %	76.0 %	80.3 %	79.1 %	47.6 %	66.7 %	59.1 %	62.6 %
Inverse	1	0	0	0	0	0	1	2
	0.5 %	-	-	-	-	-	1.0 %	0.4 %
Direct/crossed	30	3	3	6	2	1	22	61
	15.1 %	12.0 %	4.6 %	6.6 %	9.5 %	1.8 %	21.0 %	12.9 %
Inverse/crossed	0	1	0	1	1	0	0	2
	-	4.0 %	-	1.1 %	4.8 %	-	-	0.4 %
Crossed	37	2	6	8	0	1	18	64
	18.6 %	8.0 %	9.1 %	8.8 %	-	1.8 %	17.1 %	13.5 %
Alternating	5	0	1	1	0	0	0	6
	2.5 %	-	1.5 %	1.1 %	-	-	-	1.3 %
Total	199	25	66	91	21	57	105	473
	100.0 %			100.0 %	100.0 %	100.0 %	100.0 %	100.0 %

Tab. 12.24 Absolute and relative frequencies of diagnostic retouch type on microlithic and related types.

	Upper Phase	Middle Phase			Transitional/ Mixed Phase	Lower Phase	Sector 10	Total
		GS	YS	Total				
None	4	0	5	5	15	25	3	50
	2.0 %	-	7.6 %	5.5 %	71.4 %	40.3 %	2.9 %	10.6 %
Single	126	19	47	66	5	31	86	314
	63.3 %	76.0 %	71.2 %	72.5 %	23.8 %	54.4 %	81.9 %	66.4 %
Distal	89	18	36	54	3	23	65	234
Proximal	22	1	7	8	2	8	15	55
Intermediate	15	0	4	4	0	0	6	25
Double	69	6	14	20	1	3	16	109
	34.7 %	24.0 %	21.2 %	22.0 %	4.8 %	5.3 %	15.2 %	23.0 %
Total	199	25	66	91	21	57	105	473
	100.0 %			100.0 %	100.0 %	100.0 %	100.0 %	

Tab. 12.25 Absolute and relative frequencies of points on microlithic and related types.

	Length (mm)	Width (mm)	Thickness (mm)
Upper Phase			
N	78	199	199
Mean	21.5	7.1	3.4
Std. Deviation	5.3	1.6	1.0
Median	20.9	7.0	3.3
Minimum	11.7	3.5	1.4
Maximum	41.2	12.3	7.2
Middle Phase			
N	39	91	91
Mean	22.2	6.6	3.5
Std. Deviation	3.8	1.1	0.9

Tab. 12.26 Dimensions of microlithic and related types.

	Length (mm)	Width (mm)	Thickness (mm)
Median	21.6	6.5	3.3
Minimum	16.3	4.6	1.4
Maximum	31.3	9.6	6.0
Transitional/Mixed Phase			
N	9	21	21
Mean	29.3	8.2	3.2
Std. Deviation	5.9	2.2	1.3
Median	30.8	7.7	2.8
Minimum	19.9	5.8	1.8
Maximum	38.7	15.8	6.9
Lower Phase			
N	38	57	57
Mean	26.6	8.5	3.0
Std. Deviation	5.4	2.2	0.9
Median	27.0	8.1	3.0
Minimum	14.8	4.8	1.3
Maximum	39.5	14.4	5.6
Sector 10			
N	48	105	105
Mean	25.9	7.1	3.5
Std. Deviation	5.4	1.4	1.0
Median	25.2	6.8	3.5
Minimum	16.4	4.5	1.8
Maximum	40.4	13.2	6.5

Tab. 12.26 (continued)

Scalene microliths (type 68) are relatively well-represented compared to the later Phases (**fig. 12.4q-r**). A relatively irregular-shaped scalene triangle (type 90) was also recovered from the Lower Phase. Beyond this irregular scalene triangle, no other 'geometrics' have been recorded in the Lower Phase.

One of the most notable features is that convex-backed bladelets *sensu lato* (types 56-59) make up only a relatively small proportion of the assemblage from the Lower Phase (**fig. 12.4i**). None of the other microlithic forms is well represented.

Most of the microlithic and related forms are retouched along the entirety of one edge, although a relatively high proportion are only partially retouched (**tab. 12.22**). Just less than two thirds are retouched along the right edge (**tab. 12.23**). The majority have been modified by direct semi-abrupt/abrupt retouch, but a relatively high proportion have been modified by marginal (so-called Ouchtata) retouch (**tab. 12.24**). A notable proportion have not been modified to form a point(s) and instead retain the butt and distal termination (**tab. 12.25**). Overall, the microliths and backed blade/lets are significantly longer and wider, yet thinner, than in both the Middle and Upper Phases (**tab. 12.26**).

	Upper Phase	Middle Phase			Transitional/ Mixed Phase	Lower Phase	Sector 10	Total
		GS	YS	Total				
Left	89	8	24	32	2	22	16	161
	61.4 %	61.5 %	64.9 %	64.0 %	22.2 %	26.5 %	53.3 %	50.8 %
Right	56	5	13	18	7	61	13	155
	38.6 %	38.5 %	35.1 %	36.0 %	77.8 %	73.5 %	43.3 %	48.9 %
Both	0	0	0	0	0	0	1	1
	-	-	-	-	-	-	3.3 %	0.3 %
Total	145	13	37	50	9	83	30	317
	100.0 %			100.0 %	100.0 %	100.0 %	100.0 %	100.0 %

Tab. 12.27 Absolute and relative frequencies of diagnostic retouch lateralisation on microlithic fragments.

Microlithic Fragments

Microlithic fragments are the most common retouched tools in the Lower Phase. As with the classifiable microlithic forms, the overwhelming majority are retouched along the right edge (**tab. 12.27**) and have been modified by marginal (so-called Ouchtata) or direct semi-abrupt/abrupt retouch (**tab. 12.28**). A relatively high proportion, just over a quarter, retain the butt (**tab. 12.29**). It does not appear that they were deliberately segmented.

Notches and Denticulates

Five notched blades/lets, a notched flake, a notched or denticulated piece with additional retouch, and a large strangulated or notched piece (**fig. 12.4s**) have been recovered from the Lower Phase. Only one is complete, with one being a fragment and the others broken laterally. Some might have broken as a result of manufacturing failures and microburin mishits. The objects in this class are retouched along the right edge in half the cases, the left edge in one instance, both lateral margins in two cases, and at the distal end in one case. These tools are quite varied in size, the largest measures 38.1 × 17.0 × 4.6 mm. The laterally

	Upper Phase	Middle Phase			Transitional/ Mixed Phase	Lower Phase	Sector 10	Total
		GS	YS	Total				
Ouchtata	4	2	2	4	4	45	6	63
	2.0 %	11.8 %	4.9 %	6.9 %	36.4 %	49.5 %	13.6 %	15.8 %
Direct	127	13	33	46	6	44	28	251
	64.5 %	76.5 %	80.5 %	79.3 %	54.6 %	48.6 %	65.1 %	62.8 %
Inverse	4	0	0	0	0	1	0	5
	2.0 %	-	-	-	-	1.1 %	-	1.3 %
Direct/crossed	12	0	2	2	1	0	1	16
	6.1 %	-	4.9 %	3.5 %	9.1 %	-	2.3 %	4.0 %
Inverse/crossed	0	0	0	0	0	0	0	0
	-	-	-	-	-	-	-	-
Crossed	44	2	4	6	0	1	6	57
	22.3 %	11.8 %	9.8 %	10.3 %	-	1.1 %	14.0 %	14.3 %
Alternating	6	0	0	0	0	0	2	8
	3.1 %	-	-	-	-	-	4.7 %	2.0 %
Total	197	17	41	58	11	91	43	400
	100.0 %			100.0 %	100.0 %	100.0 %	100.0 %	100.0 %

Tab. 12.28 Absolute and relative frequencies of diagnostic retouch types on microlithic fragments.

	Upper Phase	Middle Phase			Transitional/ Mixed Phase	Lower Phase	Sector 10	Total
		GS	YS	Total				
Yes	25	1	8	9	1	24	3	62
	12.4 %	5.9 %	19.1 %	15.3 %	9.1 %	26.4 %	7.0 %	15.3 %
No	176	16	34	50	10	67	40	343
	87.6 %	94.1 %	80.9 %	84.8 %	90.9 %	73.6 %	93.0 %	84.7 %
Total	201	17	42	59	11	91	43	405
	100.0 %			100.0 %	100.0 %	100.0 %	100.0 %	100.0 %

Tab. 12.29 Absolute and relative frequencies of microlithic fragments retaining the butt.

broken examples have widths of 7.4-62.6 mm and thicknesses of 2.5-17.1 mm. One of these is a distinctive strangulated or notched piece made on limestone, measuring ≥44.4 × 62.6 × 17.1 mm.

Truncations

There are five truncations. Each is made of chert, retouched distally, and broken. Most appear to have been made on small bladelets, but one is more substantial and may have originally been part of a larger blade *sensu stricto*. The latter has additional inverse Ouchtata retouch along the left edge. The sizes ranged for width between 7.8-16.0 mm and thickness 2.2-4.2 mm.

Varia

This group consist of eight non-standardised retouched pieces all made of chert. There are three made on blades, a couple on flakes, one made on a core-trimming element and a couple on indeterminate debitage. The four unbroken tools range in length from 23.6-46.5 mm, in width from 7.3-20.1 mm and in thickness from 2.7-6.4 mm.

Transitional / Mixed Phase

The Transitional/Mixed Phase is a relatively small assemblage. It consists of 511 lithic artefacts, of which 56.2 % are undiagnostic knapping debris. Most of the classifiable assemblage is made up of small flakes and flakes (50.0 %), but also contains blade/lets (20.1 %), low proportions of cores (2.7 %) and core-trimming elements (1.3 %), high numbers of microburin products (8.9 %) and moderate numbers of tools (17.0 %). Overall, the assemblage is most like the Lower Phase, although the relative proliferation of microburin products and presence of *La Mouillah* points would be more consistent with the Middle Phase (**tab. 12.3**). The productivity in artefact numbers is 310 in the Transitional/Mixed Phase, a relatively similar metric (showing only about a 20 % increase) to that identified in the Lower Phase (**tab. 12.4**; see table caption for a full explanation of this productivity metric).

Cores

There are only six cores: a single platform flake core, two opposed platform flake cores, a tested nodule, and a couple of core fragments (**fig. 12.5a-b**). Each is made of chert. Five retain rind on their exteriors. Median size values are given in **table 12.7**.

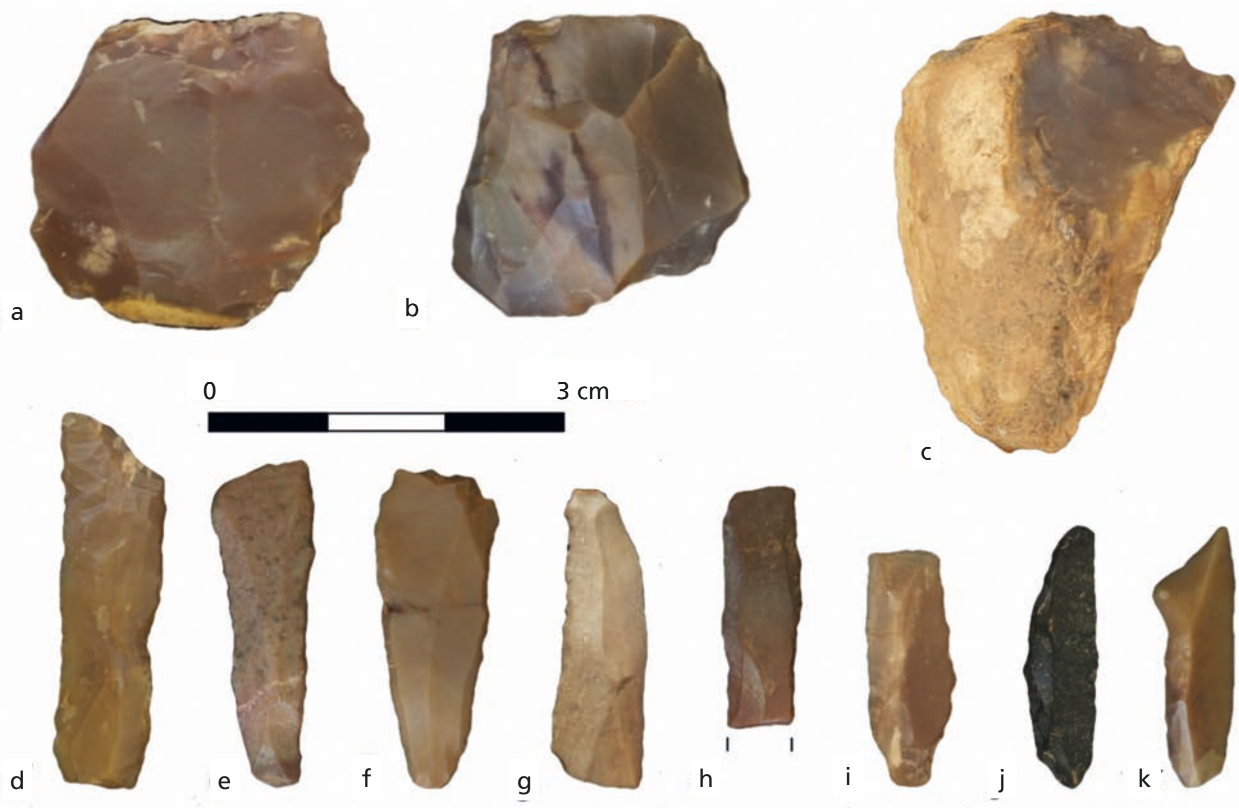


Fig. 12.5 Transitional/Mixed Phase debitage and retouched tools: **a** single platform core; **b** opposed platform core; **c** denticulated end-scraper; **d-f** obtuse-ended backed bladelets; **g-i** Ouchtata bladelets; **j** convex-backed bladelet; **k** *La Mouillah* point.

Debitage

In total, 45 blade/lets including fragments have been recovered (**tab. 12.3**). The blade/lets closely resemble those from the Lower Phase. All are made on chert, generally lacking rind (**tab. 12.8**), most frequently with unidirectional dorsal scars (**tab. 12.9**) and with small punctiform/linear butts (**tab. 12.10**). One is a blade *sensu stricto*, but the others are all bladelet-sized (**tab. 12.11**).

Of the 112 small flakes and flakes, most are made of chert, with only three made of limestone. The majority of the whole flakes (n=38) retain outer rind (**tab. 12.12**), have unidirectional dorsal scars (**tab. 12.13**) and plain butts (**tab. 12.14**). The median size values are presented in **table 12.15**.

The core-trimming elements recovered include a couple of primary crests with a single prepared versant and a platform rejuvenation flake. One of the crested pieces is unbroken and measures 41.3 × 10.3 × 6.1 mm (**tab. 12.16**).

Microburins and Related Products

Twenty true microburins, accounting for a relatively high proportion of the diagnostic artefacts, have been recovered from the Transitional/Mixed Phase. The majority of microburins are proximal examples with the notch on the left side (**tabs 12.17-12.18**). They are generally substantial in size, with a relatively long section of the blank having been removed using the microburin technique (**tab. 12.19**). In general, the morphology and size of the microburins are broadly consistent with those from the Middle Phase.

Retouched Tools

The Transitional/Mixed Phase comprises only 38 tools, but at a similar relative frequency to that observed in the Lower Phase. The retouched tools are dominated by microlithic and related forms (55.3 %) and fragments (29.0 %). The other tool classes occur infrequently (**tab. 12.20**).

End-Scrapers

Only two end-scrapers have been recovered: an end-scraper on a flake (36.4 × 35.7 × 15.2 mm) and a denticulated end-scraper (37.2 × 30.3 × 10.2 mm) (**fig. 12.5c**). Both are made on chert flakes and retouched distally.

Microlithic and Related Forms

This tool class (**fig. 12.5d-l**) consists of 21 tools, accounting for 55.3 % of the tool assemblage. There is a diversity of microlithic or related types (**tab. 12.21**). As is the case in the Lower Phase, the most frequent objects are Ouchtata bladelets (type 70). Often these have retouch along the entire lateral margin (subtype 70a) and they are twice as common as those retouched towards the butt (subtype 70b). The obtuse-ended backed bladelets (type 67) also occur in relatively high proportions in this Phase.

The convex-backed bladelets *sensu lato* (types 56-58) are slightly more common than in the underlying units but, nevertheless, are relatively infrequent in comparison to the later Phases. *La Mouillah* points (type 62) make up a relatively high proportion of the microliths and are found only elsewhere in substantial numbers in the Middle Phase. This point type, illustrated in **figure 12.6**, often shows abrupt backing down one edge with a microburin facet at the distal end. Other microlithic types are uncommon in this Phase.

Like the Lower Phase, most microlithic and related forms are retouched along the entirety of one edge, although partially retouched forms are still relatively common (**tab. 12.22**). Most are retouched along the right edge (**tab. 12.23**), and are typically modified by marginal (so-called Ouchtata) or direct semi-abrupt/abrupt retouch (**tab. 12.24**). Many have retained an unmodified distal termination (**tab. 12.25**). The median dimensions are most like those of the Lower Phase (**tab. 12.26**).

Microlithic Fragments

This is the largest category after classifiable microlithic types, accounting for 29.0 % of the tool assemblage. Most fragments are retouched along the right edge (**tab. 12.27**) and have been modified by Ouchtata or direct semi-abrupt/abrupt retouch (**tab. 12.28**). There are relatively few retaining the butt (**tab. 12.29**).

Notches and Denticulates

This class includes only two tools: a mesial fragment with the remnants of a retouched notch at the left margin (type 74) and a fragment with a single-blow notch at the left edge and additional inverse retouch along the right lateral margin (type 79).

Truncations

There is one bladelet, with an irregular, slightly oblique, truncation removing the distal end (type 80). It measures 31.4 × 11.8 × 1.6 mm.

Varia

A single tool has been assigned to this tool class. It is on an unusually thick blank with abrupt preparation forming a 'retouched' margin (cf. type 55). It measures 52.1 × 8.4 × 8.8 mm.

Middle Phase

The Middle Phase consists of 2891 lithic artefacts, of which 59.6 % are unclassifiable knapping debris. An internal breakdown of the assemblage into the YS (Y1) and GS (G100-G97) components shows that that there are increasing frequencies of indeterminate knapping debris associated with the GS units. Nevertheless, there is little difference across the important YS/GS boundary in the frequencies of the diagnostic artefact classes. Overall, the assemblage is dominated by small flakes and flakes (49.0 %), relatively moderate numbers of blade/lets (16.3 %), high proportions of cores (4.2 %) and core-trimming elements (2.4 %), numerous microburin products (12.9 %) and relatively low frequencies of retouched tools (14.2 %) (**tab. 12.3**). The average productivity in total artefact numbers is 2201 in the Middle Phase, although an internal breakdown of these figures highlights differences between the YS and GS components (**tab. 12.4**; see table caption for a full explanation of this productivity metric): there is notably higher productivity in the basal GS units (10892) than in the YS units (642) associated with the Middle Phase. An important point here is that the increase in unclassifiable knapping debris across the YS/GS boundary is a real effect and not simply caused by pieces being rendered unclassifiable by burning. Thus, at least in S8, the GS starts with greater concentrations of knapping debris.

Beyond the differences in artefact productivity and the numbers of classifiable objects, few differences are observable in the lithic technology of the subdivided YS and GS Middle Phase assemblages. As such, in the following the overall characteristics of the Middle Phase are described and only where relevant are internal differences between YS and GS components highlighted.

Cores

In the Middle Phase, single platform cores are prevalent and opposed platform cores are the second most common (**figs 12.7-12.8**). There are a relatively high proportion of multidirectional cores and a discoidal core. A small number of cores-on-flake has also been recorded for the first time in this Phase. Discarded tested nodules suitable for further working are observed in similar frequencies to those in the Lower Phase. A few core fragments are also recorded (**tab. 12.5**).

All of the cores are made of chert. Around a fifth of cores and core fragments are entirely 'decorticated' (in contrast to the typical retention of some outer surface rind in the Lower Phase). Just over half the cores have recognisable flake removals, although blade/let removals are also observed in significant numbers (**tab. 12.6**). Many of flake cores are heavily reduced and might once have been blade/let cores where the negative scars have subsequently been obliterated. Overall, the length, width and thickness values of the cores are not significantly different from the other Phases (**tab. 12.7**). However, looking at the weight statistics there is an observable trend showing a steady decrease in mean core weights up the whole sequence which might reflect an increasingly economic use of raw material, reaching its peak in the upper GS (**tab. 12.7**).

Debitage

In total, 190 blade/lets including fragments have been recovered from the Middle Phase, which accounts for a moderate proportion of the assemblage (**tab. 12.3**). All the blade/lets are made of chert and the majority have no outer rind, although there is a slight increase in the proportion retaining outer rind compared to

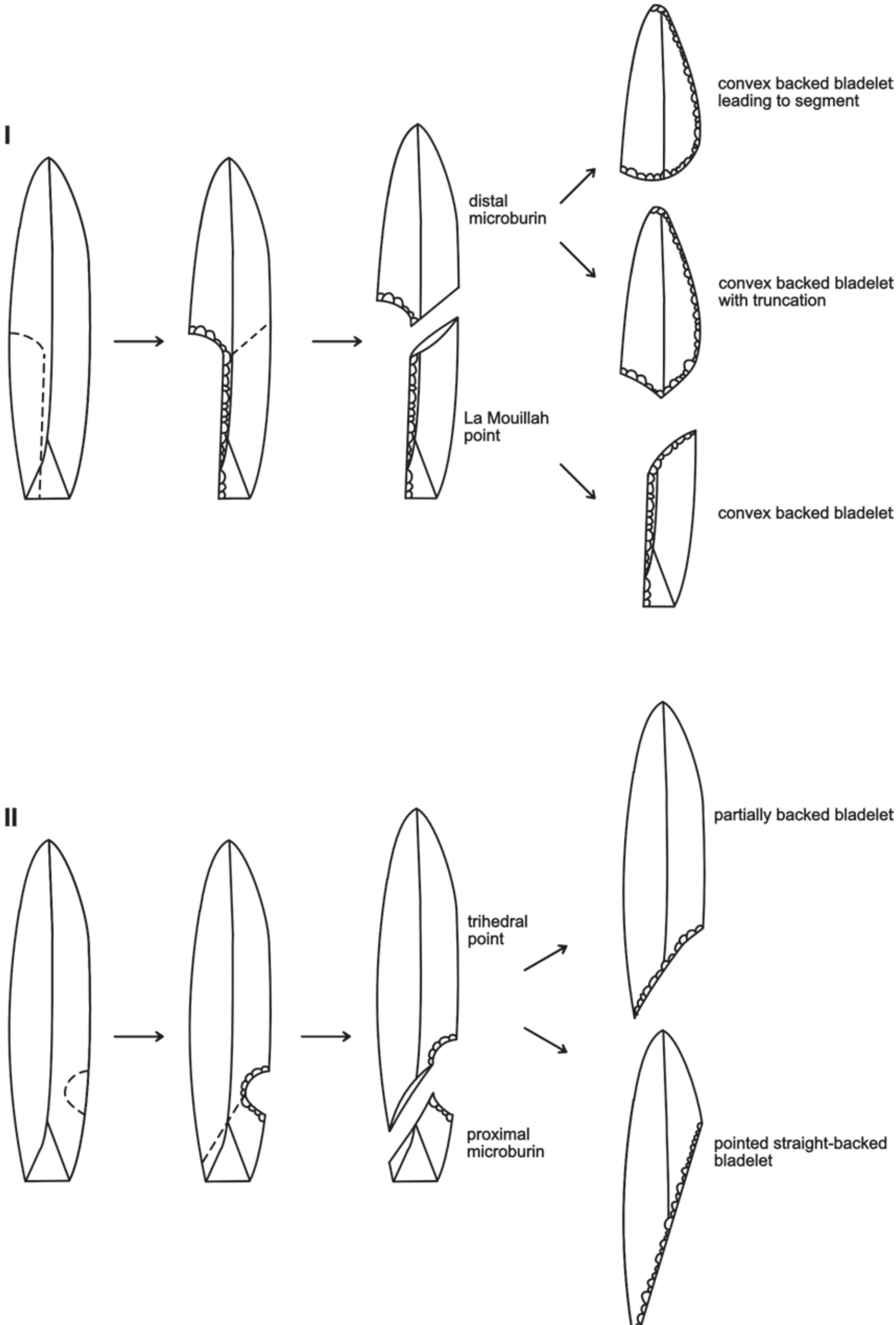


Fig. 12.6 Different ways of sectioning bladelets using the microburin technique; **Method I** is most commonly utilised for the manufacture of *La Mouillah* points (type 62) and subsequent retouch into convex backed bladelets (types 56-59) in the Upper and Middle Phases; **Method II** is thought to be more commonly associated with the manufacture of pointed straight-backed bladelets (type 45) and pointed partially backed bladelets (type 63a) in the Lower Phase.

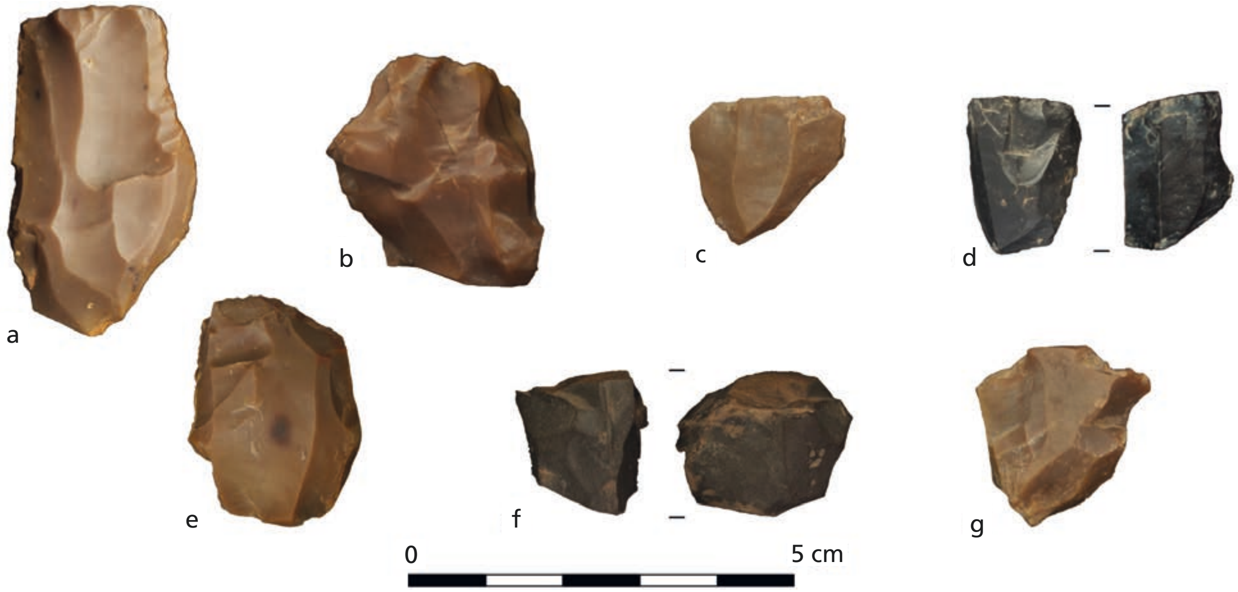


Fig. 12.7 Middle Phase Grey Series cores: **a-d** single platform cores; **e** opposed platform core; **f-g** multiple platform cores.

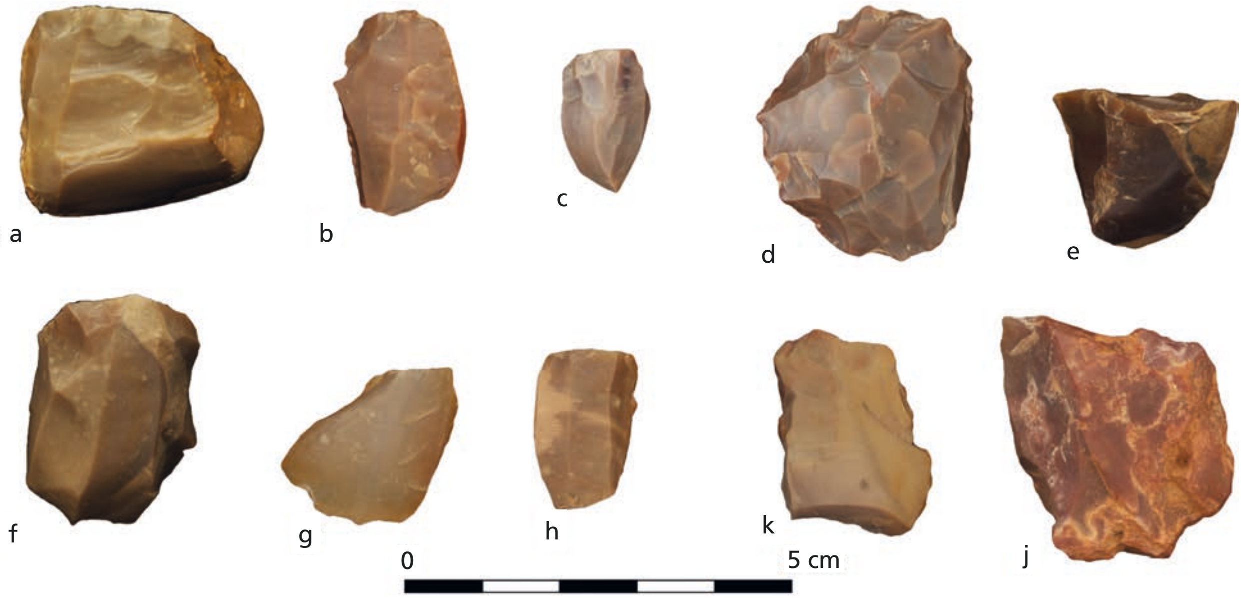


Fig. 12.8 Middle Phase Yellow Series cores: **a-c** single platform cores; **d** discoidal core; **e** multiplatform core; **f-h** opposed platform cores; **j** core-on-flake; **k** splintered piece.

the earlier levels (**tab. 12.8**). Most have unidirectional dorsal scars, although there is a small, yet significant, increase in the proportion with bidirectional opposed dorsal scars (**tab. 12.9**). Those with punctiform/linear butts are most frequent; however, there are twice as many with plain butts compared to the underlying levels (**tab. 12.10**). There are no blades *sensu stricto*, with all these pieces being bladelet-sized. On average the blade/lets are relatively wide and thick compared to the Lower Phase (**tab. 12.11**).
In total, 571 small flakes and flakes have also been recovered. Most are made of chert (95.7 %), with a smaller frequency made of limestone (4.4 %). All whole flakes have been selected for further attribute analysis (n = 145). The flakes closely resemble those from the other Phases, generally retaining outer rind (**tab. 12.12**). Those with unidirectional dorsal scars are dominant, multidirectional scars also being com-

mon amongst the 'decorticated' flakes (**tab. 12.13**), and many have plain or 'cortical' butts (**tab. 12.14**). Overall, the average size of flakes is not significantly different from that in each of the other Phases (**tab. 12.15**).

Twenty-eight core-trimming elements were recovered, twice the frequency found in the Lower Phase (**tab. 12.3**). All are made of chert. Most are crested pieces, including ten primary first removals with one prepared versant, four first removals with both versants prepared, one secondary removal and seven fragments. The median dimensions are 28.9 × 8.0 × 5.4 mm (**tab. 12.16**). There are also two platform rejuvenators or core tablets. One is complete and measures 16.0 × 18.9 × 4.3 mm. There are also four *flancs de nucléus* with median dimensions of length, width, and thickness, respectively, of 28.5 mm (range 15.7-35.8 mm), 21.7 mm (range 20.2-29.5 mm) and 9.0 mm (range 5.0-11.3 mm).

Microburins and Related Products

A total of 148 true microburins, one trihedral point (bladelet fragment with a microburin facet) and one Krukowski microburin have been recovered. Of the true microburins, the majority are distal examples notched on the left side (**tabs 12.17-12.18**). This contrasts with the Transitional/Mixed and Lower Phases where the microburins are generally proximal examples with the notch of the left side.

Retouched Tools

End-Scrapers

This class (**figs 12.9-12.10**) comprises nine tools: four single end-scrapers on flakes, two denticulated end-scrapers, a double end-scraper, an end-scraper on a retouched flake and a fragment of an end-scraper. Each was made on a chert flake. Most are retouched distally (including one with retouch extending down the right edge), with only one retouched at the proximal end (which also has retouch extending down the right edge) and one retouched at both ends. Excluding the fragment, the median size is 30.9 × 25.4 × 9.9 mm.

Microlithic and Related Forms

This tool class (**figs 12.9-12.10**) is the most prolific. It consists of 91 microlithic and related forms, accounting for 51.7 % of the tool assemblage. There is a diversity of types representing a clear departure from the Transitional/Mixed and Lower Phases (**tab. 12.21**).

The most common types, accounting for just less than half of this category, are convex-backed bladelets *sensu lato* (types 56-59). There are broadly similar proportions of typical convex-backed bladelets (subtype 56a) and those tending towards segments (subtype 56b). Each of the convex-backed bladelet *sensu lato* subtypes have been found in smaller frequencies, although convex-backed bladelets with truncated bases (type 58) make up a relatively strong proportion.

One of the most distinctive features is the presence and relatively high proportions of *La Mouillah* points (type 62) (**fig. 12.6**), which account for a third of the microlithic forms from the Middle Phase (**fig. 12.10m-s**). In contrast, this form is absent in both the Upper and Lower Phases.

None of the other microlith forms is particularly well represented in the Middle Phase (**tab. 12.21**).

The microlithic forms in the Middle Phase are overwhelmingly retouched on the entirety of one lateral margin (96.7 %; **tabs 12.22-12.23**), which is usually the left edge (**tab. 12.23**). This is in contrast to the

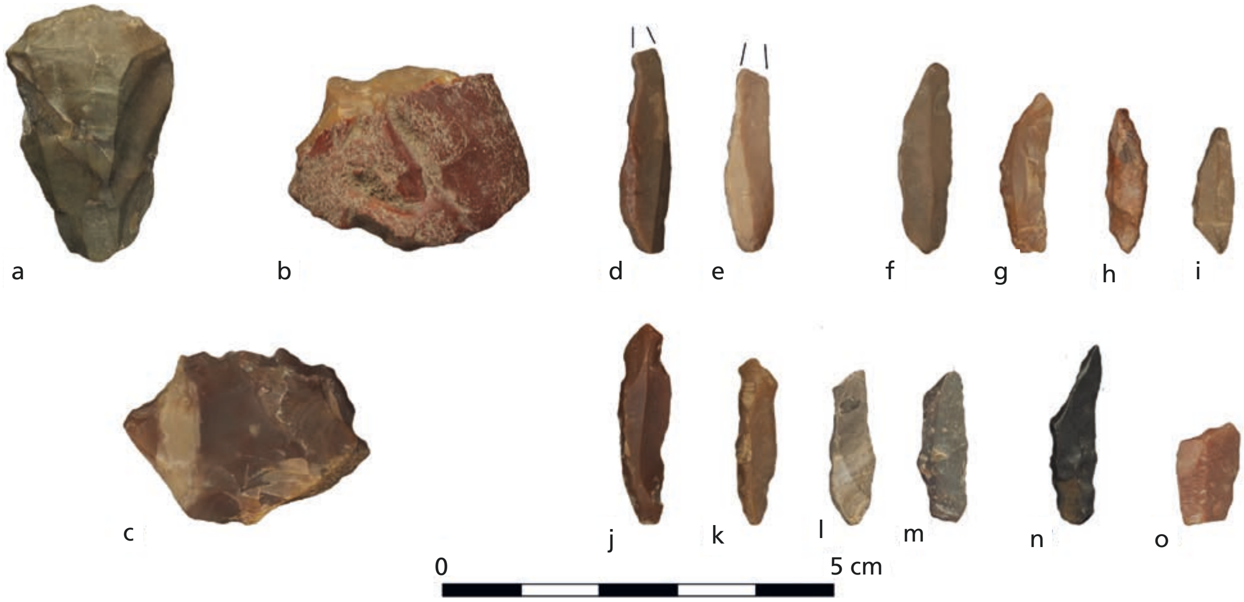


Fig. 12.9 Middle Phase Grey Series retouched tools: **a-b** single end-scrapers on flakes; **c** denticulated end-scraper; **d-e** pointed straight-backed bladelets; **f-g** convex-backed bladelets; **h** convex-backed bladelet with truncated base; **i** convex-backed bladelet tending towards segment; **j-m** *La Mouillah* points; **n** scalene bladelet; **o** truncation.

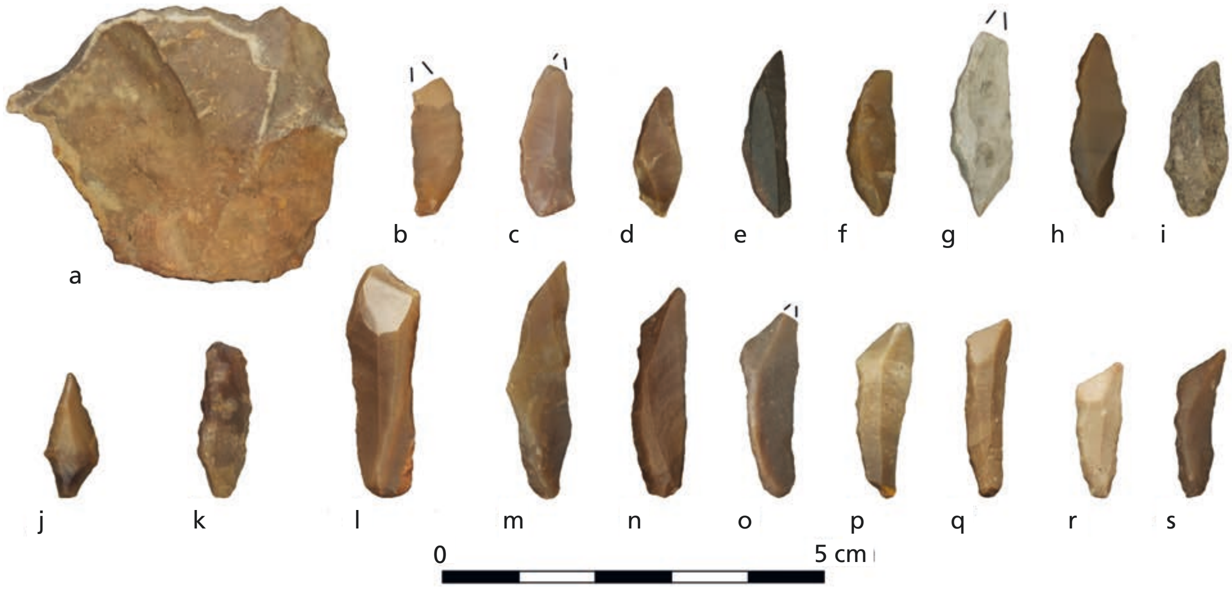


Fig. 12.10 Middle Phase Yellow Series retouched tools: **a** denticulated end-scraper; **b-d** convex-backed bladelets; **e-f** convex backed bladelets tending towards segments; **g-h** convex-backed bladelets with truncated bases; **i** convex-backed bladelet with retouched base; **j** shouldered point; **k** obtuse-ended backed bladelet; **l** Ouchtata bladelet; **m-s** *La Mouillah* points.

Lower Phase where only 68.4 % have continuous retouch and 31.6 % are partially retouched (**tabs 12.22-12.23**). The retouch is typically direct semi-abrupt/abrupt, largely to the exclusion of other types of retouch (**tab. 12.24**), and most pieces are truncated to form a point(s) (**tab. 12.25**). On average, the tools are significantly shorter and narrower, yet thicker, than in the Lower Phase (**tab. 12.26**).

Microlithic Fragments

This is the most common category after classifiable microlithic types, accounting for 33.5 % of the tool assemblage in the Middle Phase (**tab. 12.20**). As with the classifiable microlithic forms, most fragments are modified along the left edge, with direct semi-abrupt/abrupt retouch (**tabs 12.27-12.28**) (see later discussion on lateralisation). Few microlithic fragments retain the butt (**tab. 12.29**).

Notches and Denticulates

This class includes only two tools: a bladelet (31.7 × 10.9 × 5.5 mm) with a retouched notch on the right edge (type 76) and a denticulated flake (29.9 × 15.4 × 4.9 mm) with contiguous notches along the entire left and partly along the right edge (type 75).

Truncations

There are four truncations, accounting for 2.3 % of the tool assemblage in the Middle Phase. Each is made of chert. A couple are retouched at the distal end, one is retouched at an indeterminate end, and another is retouched at both ends. A couple are made on indeterminate debitage, one is made on a flake, and another is made on a bladelet. Median size values are 18.5 mm (range 12.9-19.8 mm), 9.3 mm (range 8.1-21.4 mm) and thickness 3.5 mm (range 1.9-9.9 mm).

Varia

This group consists of 12 non-standardised retouched pieces. All are made of chert. Half are made on indeterminate blanks, with two of each made on blades *sensu stricto*, bladelets and core-trimming elements. Many are complete (41.7 %), with smaller numbers of laterally broken (33.3 %) and other fragments (25.0 %). The median size values are length 27.0 mm (25.0-39.4 mm, n = 5), width 13.5 mm (range 6.5-21.1 mm, n = 9) and thickness 5.4 mm (range 1.7-9.2 mm, n = 9).

Upper Phase

A total of 10,279 lithic artefacts were recovered from the Upper Phase, of which a very high proportion (78.4 %) consisted of undiagnostic knapping debris. Most of the classifiable assemblage is made up of flakes and small flakes (61.5 %), with relatively low proportions of blade/lets (12.3 %), moderate proportions of cores (2.5 %) and core-trimming elements (2.1 %), low frequencies of microburin products (0.5 %) and a relatively high percentage of retouched tools (20.8 %) (**tab. 12.3**). The average productivity in total artefact numbers is 9359 in the Upper Phase (**tab. 12.4**; see table caption for a full explanation of this productivity metric); as an average, this is a little lower than for the Middle Phase but, since approximately half of the Upper Phase is composed of extremely stony, clast-supported, sediment, the bulk density figure for the upper, finer-grained portion would be much over-estimated, such that the real productivity in lithic artefact numbers in this portion is probably very much higher (perhaps by as much as 50 %), certainly making this upper interval the most productive in the whole LSA sequence. In passing, we can discount trampling (cf. lack of stoniness in half this deposit) and burning as the only, or even the dominant, causes of the proliferation of small debitage; in large part, the increase is very likely also to reflect the more exhaustive core reduction processes including the 'heavier' retouching of tools in these layers.

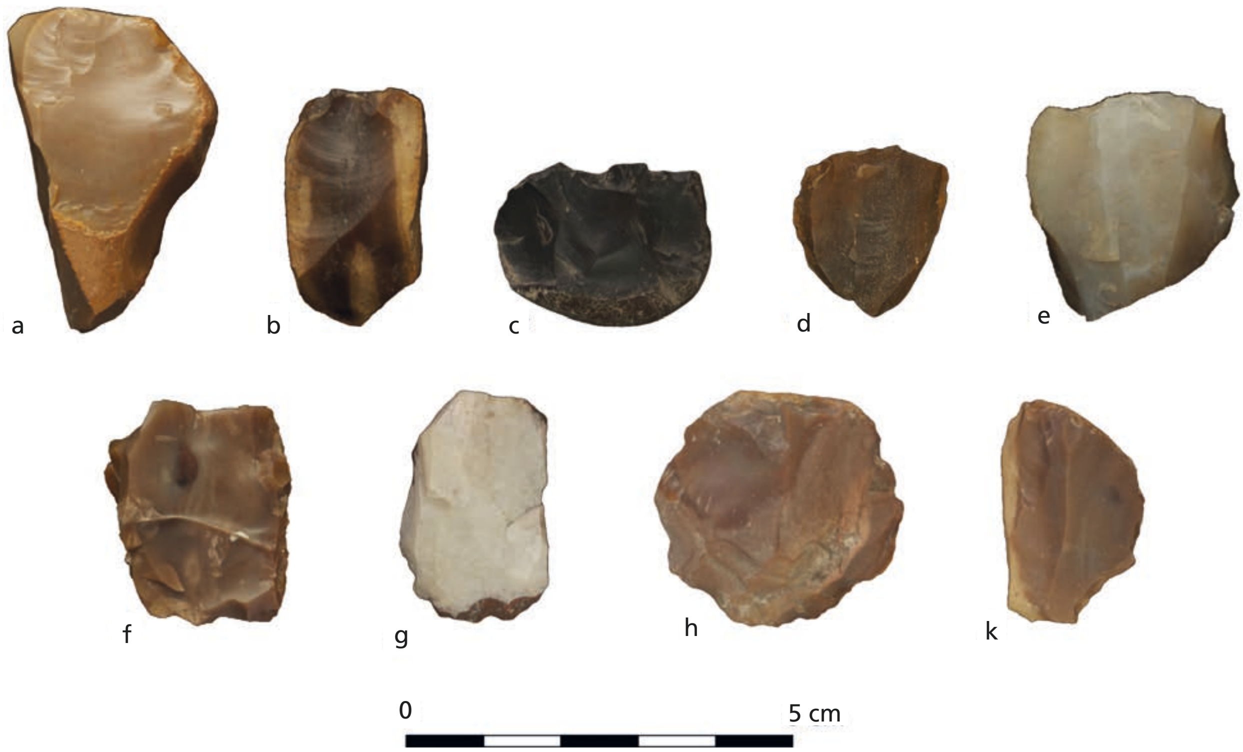


Fig. 12.11 Upper Phase cores: **a-d** single platform cores; **e-g** opposed platform cores; **h** discoidal core; **k** core-on-flake.

Cores

In total 56 cores and core fragments have been recovered from the Upper Phase. Most common are single platform cores (**fig. 12.11a-d**) but these are found in relatively small numbers in comparison with the earlier Phases. A relatively moderate frequency of opposed platform cores (**fig. 12.11e-g**) has also been recorded and, for the first-time, cores with 90° platforms are found in small frequencies. Evidence for the exploitation of two or more striking platforms is also attested by multidirectional cores and a single discoidal core (**fig. 12.11d**). There is an increase in the frequencies of cores-on-flake (**fig. 12.11k**), which contribute their highest proportion in the Upper Phase. No tested nodules are present. A notable presence of core fragments has also been recorded (**tab. 12.5**).

All cores are made of chert. Around four fifths of cores and core fragments retain outer rind, as in the Middle Phase. Just over half have flake removals, although those with blade/let removals are still found in significant numbers (**tab. 12.6**). Again, a strict distinction between cores with blade/let, flake and mixed removals, is misleading. Overall, the size (linear dimensions) of cores is not significantly different from the other Phases (**tab. 12.7**), although mean weights show a decrease in value from the Middle Phase (see the comment on this matter in the section on cores from the Middle Phase).

Debitage

In total, 273 blade/lets including fragments have been recovered, accounting for a relatively small proportion of the assemblage (**tab. 12.3**). All blade/lets are made of chert and relatively few are entirely 'corticated' (**tab. 12.8**). Most have unidirectional dorsal scars, although there is a relatively high proportion with bidirectional opposed dorsal scars (**tab. 12.9**). Most commonly the blade/lets have plain butts or punctiform/linear butts, as in the Middle Phase. A notable proportion have faceted butts, a situation which has rarely been recorded elsewhere (**tab. 12.10**) and might be connected to a special technique of knapping 90° cores which also have faceted platforms. None of the blanks is a blade *sensu stricto*. On average, the blade/lets are broadly similar in size to those from the Middle Phase, but significantly wider and thicker than those in the Lower Phase (**tab. 12.11**).

In total, 1366 small flakes and flakes were recovered. Most are made of chert (87.0 %), with smaller frequencies of limestone (12.7 %), quartzite (0.2 %) and basalt (0.1 %). All whole flakes have been selected for further attribute analysis (n = 298). These flakes closely resemble those from the earlier Phases, generally retaining outer rind (**tab. 12.12**), with unidirectional and multidirectional dorsal scars patterns most common (**tab. 12.13**), and significant frequencies with plain or 'cortical' butts (**tab. 12.14**). Overall, the flakes are of similar size to those from the earlier Phases (**tab. 12.15**).

In total, 47 core-trimming elements have been recovered from the Upper Phase. Each is made of chert. Most are crested pieces, including 22 primarily first removals with one prepared versant, four first removals with both versants prepared, one secondary removal and eight fragments. The median dimensions are 29.0 × 9.5 × 5.1 mm (**tab. 12.16**). There are also five platform rejuvenations, with median dimensions for length 21.6 mm (range 17.7-25.3 mm, n = 3), width 21.6 mm (range 15.5-24.5 mm, n = 3) and thickness 8.3 mm (range 4.8-11.6 mm, n = 3). There are also eight *flancs de nucléus* with median dimensions of length, width and thickness of, respectively, 26.1 mm (range 20.5-38.0 mm, n = 5), 18.0 (range 11.8-28.1 mm, n = 5) and 8.2 mm (range 6.5-10.1 mm, n = 5).

Microburins and Related Products

A total of 5 microburins and 6 Krukowski microburins were recovered from the Upper Phase. Of this very small group of true microburins, three are from the proximal end and two from the distal end. All but one of the microburins have the notch on the left edge (**tabs 12.17-12.18**). In general, the microburins are restricted in size, indicating that they were detached from relatively narrow, thin microlith blanks (**tab. 12.19**).

Retouched Tools

End-Scrapers

There are 13 artefacts in this class (**fig. 12.12**): five single end-scrapers on flakes, an end-scraper on a retouch flake, a core-like scraper, a denticulated end-scraper, a double end-scraper (**fig. 12.12b**) and four fragments with end-scraper retouch. All but one are made on chert flakes and the last is made of quartzite. Eight have the scraper formed at the distal end (including one with retouch extending down the right edge), one is formed at the proximal end, one is retouched at both ends, a couple have retouch extending around most of the margin, and one is made at an indeterminate end. Excluding the fragments, the median size is 21.5 × 18.3 × 10.0 mm. The end-scraper made on a quartzite flake has a well-defined convex scraping-end and is particularly large measuring 41.9 × 32.4 × 10.5 mm.

Fig. 12.12 Upper Phase retouched tools: **a** end-scraper on a flake; **b** double end-scraper; **c** combination tool; **d** pointed straight-backed blade; **e-f** pointed straight-backed bladelets; **g-h** pointed straight-backed bladelets with truncated base; **i** pointed straight-backed bladelet with rounded base; **j** pointed straight-backed bladelet with retouched base; **k** *Aïn Kéda* point; **l-o** convex-backed bladelets; **p** convex-backed bladelet with truncated base; **q** convex-backed bladelet with rounded base; **r** convex-backed bladelet with retouched base; **s-u** convex-backed bladelets tending towards segments; **v-x** segments; **y** equilateral triangle; **z** denticulated flake.

Backed Flakes and Blades

This class only includes three tools. One is a distinctive straight-backed blade (type 35) with backing along the right edge; it would have had a point at the distal end, but the tip has been broken, leaving measurements of >47.3 × 14.5 × 7.7 mm. In addition, there are two burnt backed blade fragments (type 42) made of chert, one retouched along the right edge and the other retouched on an indeterminate edge.

Composite Tools

This class includes a single end-scraper/burin (type 44). It is made on a partially 'corticated' flake. It has a convex distal scraping end, with retouch continuing onto and extending down the entirety of both margins (**fig. 12.12c**). The burin, with a single facet, is on a break. It is probable that the break and burin spall might have occurred spontaneously during use when hafted. The piece measures 31.4 × 20.5 × 10.7 mm.

Microlithic and Related Forms

A total of 199 classifiable tools were recovered from the Upper Phase (**tab. 12.21**). The dominant forms are convex-backed bladelets *sensu lato* (types 56-59), which account for around two fifths of the microlithic and related types (**fig. 12.12l-u**). These are divided between broadly similar proportions of typical convex-backed bladelets (subtype 56a) and those tending towards segments (subtype 56b). Each of the other types of convex-backed bladelets *sensu lato* is found in lesser frequencies with a notable presence of convex-backed bladelets with truncated bases (type 58).

As a group, pointed straight-backed bladelets *sensu lato* (types 45-52) account for a relatively strong proportion of the tools, which is also the case in the Lower Phase. Nonetheless, there are some striking differences in the expression of this form. In contrast to the Lower Phase, there is greater internal variability in the range of formal types represented. It is plausible that this is due to the larger assemblage size of the Upper Phase. However, the pointed straight-backed bladelets *sensu lato* also appear comparatively well-made, with relatively intense, semi-abrupt to abrupt, retouch, creating a regular backed edge (**fig. 12.12d-f**). There is also a relatively high proportion of types with additional retouch (**fig. 12.12g-j**). Most often this is expressed in the forms with acutely truncated bases (type 47). A few *Aïn Kéda* points (type 52) have also been found (**fig. 12.12k**), with a distinctive form of inverse retouch at the tip (see **fig. 12.2**); so far in S8, this type has only be found near the top of the Upper Phase.

Few other microlithic types occur in very large frequencies, although geometric segments (type 82) are overall notably more common in the Upper Phase (**fig. 12.12v-x**). These differ only in the straightness of the unmodified edge and symmetry of retouched margin from the convex-backed bladelets tending towards segments (subtype 56b) (**fig. 12.12s-u**). A few isosceles, equilateral (**fig. 12.12y**), and scalene triangles (types 89-90) have also been recorded, and, together with segments, these 'geometric' microlithic (types 82-100) occur in relatively high frequencies in the Upper Phase (7.5 %) compared to the Middle and Lower Phases (4.4 % and 1.8 %, respectively).

None of the other microlithic forms is well represented in the Upper Phase. Many of the forms that dominated in the underlying units are notably absent or only contribute a tiny proportion in the Upper Phase, such as *La Mouillah* points, partially backed bladelets, Ouchtata bladelets and obtuse backed bladelets (**tab. 12.21**).

Overall, tools in this category are almost exclusively retouched along the entirety of one lateral margin (**tab. 12.22**). Most often they have been modified along the left edge by direct semi-abrupt/abrupt retouch, although these include fairly frequent examples with abrupt direct/crossed and crossed 'anvil' retouch (**tabs 12.23-12.24**). Nearly all the microlithic forms are retouched into (a) point(s) (**tab. 12.25**). On average, they are similarly-sized to those from the Middle Phase, but significantly shorter and narrower, yet thicker, than in the Lower Phase (**tab. 12.26**). This could be linked to a greater use of cores on flakes.

Microlithic Fragments

This is the most frequent category, with a total of 201 microlithic fragments (**tab. 12.20**). As with the classifiable types, the left edge is most commonly modified (**tab. 12.27**) and usually with direct semi-abrupt/abrupt retouch, although abrupt direct/crossed and crossed 'anvil' retouch are also found in relatively high frequencies (**tab. 12.28**). Around one in eight microlithic fragments retain the butt (**tab. 12.29**).

Notches and Denticulates

There are 14 tools in this class. These primarily consist of notched blade/lets, followed by denticulated blade/lets and denticulated flakes. All but one are made of chert, with the last of limestone. Half are broken laterally, one is a partial fragment, and the remainder are whole. Due to their size, a few may be manufacturing failures or microburin mishits. Most commonly the retouch location cannot be determined (35.7 %), with lower frequencies of retouch along the right edge (21.4 %), left edge (14.3 %), both edges (14.3 %), left edge and distal end (7.1 %) and proximal end (7.1 %). These tools are quite varied in size. The median size values are length 29.4 mm (range 18.6-81.1 mm, n = 6), width 14.1 mm (range 5.0-64.3 mm, n = 13) and thickness 4.7 mm (range 1.9-16.4 mm, n = 13). One of the pieces is particularly distinctive and is a denticulated flake made of limestone (**fig. 12.12z**). It is on a flake with a natural surface with four contiguous notches along the left edge that increase in size towards the distal termination; it has ochre covering the dorsal surface and is especially large measuring 81.1 × 64.3 × 16.4 mm. In contrast, the longest object made on chert measures only 47.6 mm.

Truncations

There are only seven truncations in the Upper Phase. Each of the truncations is made of chert. Five are made on blade/lets, one is made on a flake, and one is made on an indeterminate fragment. One is whole, with the remainder laterally broken. One more has the truncation at the proximal end than at the distal end. The median size values are length 15.9 mm (n = 1), width 9.0 mm (range 5.8-16.8 mm, n = 7) and thickness 4.0 mm (range 2.0-4.9 mm, n = 7).

Varia

This group consists of 24 non-standardised retouched pieces. All but one of the pieces are made of chert, the last being of limestone. Most are made on indeterminate blanks (34.8 %), with smaller percentages on blades (13.0 %) and bladelets (26.1 %), and flakes (26.1 %). The majority are laterally broken (65.2 %), with smaller numbers of partial fragments (30.4 %). Only a couple are unbroken. The median size values are length 22.1 mm (range 16.1-28.1 mm, n = 2), width 15.9 mm (range 7.2-36.2 mm, n = 16) and thickness 4.0 mm (range 2.0-14.8 mm, n = 16).

Sector 10

A total of 2526 lithic artefacts have been recovered from Sector 10. It should be emphasised that these do not come from a contiguous set of stratigraphic units but from the area that has produced burials and where sediments from other parts of the cave may well have been introduced (see **Chapter 2**). Overall, 39.7 % of the assemblage consists of unclassifiable knapping debris, which is significantly less than in any

Fig. 12.13 Sector 10 cores: **a-e** single platform cores; **f-h** opposed platform cores; **i** core-on-flake; **j** discoidal core; **k-l** multiple platform cores.

of the other assemblage groups from nearer the front of the cave. This is hard to explain in simple terms. For instance, even though total recovery methods were not used in the early seasons (only dry sieving was employed) we doubt that this had a significant 'winnowing effect' on the sample. Thus, some 60 % of the chips (pieces up to 2 cm in max dimension) would need to be missing to bring the figures up to that of S8 GS Phases. Moreover, there are far too many small flakes (1-2 cm) present in S10 to make this seem possible (for alternative suggestions see discussion below). Of the classifiable artefacts, small flakes occur relatively infrequently (13.3 %) and instead flakes are the most common (42.2 %). A high proportion of blade/lets (19.4 %), strong proportions of cores (4.9 %) and core-trimming elements (3.3 %), low frequencies of microburin products (1.6 %) and a relatively low percentage of retouched tools (14.1 %) have also been recorded in Sector 10 (**tab. 12.3**). There are insufficient spatial and sedimentation rate data available to calculate the lithic artefact productivity in the very complex setting of Sector 10.

Cores

In total 74 cores and core fragments have been recovered, accounting for 4.9 % of the assemblage. Single platform cores (**fig. 12.13a-e**) are most common and slightly more frequent than opposed platform cores (**fig. 12.13i**). Two 90° platform cores have also been recorded. This is a rare type only found so far in the Upper Phase. Further evidence of the exploitation of two or more striking platforms is provided by multidirectional cores (**fig. 12.13k-l**) and a single discoidal core (**fig. 12j**). There is a relatively high frequency of cores-on-flakes (**fig. 12.13i**), which occur in Sector 8 from the Middle Phase upwards. Only one tested nodule has been recorded from Sector 10. A fifth of the cores are unclassifiable fragments (**tab. 12.5**).
All but two of the cores are made of chert, with the others made of limestone and a dark grey and olive banded mudstone. Around one in eight are entirely 'decorticated'. The majority have flake removals, although blade/let removals contribute around a third of the recognisable negative scars (**tab. 12.6**). Median size values are shown in **table 12.7**, as are the mean weight values for cores which show that they were on average even larger in size than the cores from the Middle and Lower Phases.

Debitage

In total, 295 blade/lets including fragments have been recovered, accounting for 19.4 % of the assemblage (**tab. 12.3**). All the blade/lets are made of chert. Around half are entirely 'decorticated', but blade/lets retaining outer rind are nevertheless still relatively common (**tab. 12.8**). Of those with identifiable dorsal scars, around two thirds have unidirectional scars, followed by moderate numbers with bidirectional opposed and multidirectional dorsal scars, and only a small number have bidirectional crossed dorsal scars (**tab. 12.9**). Blade/lets and fragments retaining plain or punctiform/linear butts are found in roughly equal proportions and dominate the assemblage (88.5 %) (**tab. 12.10**). On average, the blade/lets are significantly longer, wider and thicker than from anywhere else in the cave (**tab. 12.11**).
In total, 844 small flakes and flakes have been recovered. Most were made of chert (93.0 %), with a smaller frequency made of limestone (7.0 %). All the complete or mostly complete flakes have been selected for further attribute analysis (n = 398). These flakes closely resemble those from all of the other Phases, generally retaining outer rind (**tab. 12.12**), with unidirectional dorsal scars prevalent, followed by strong numbers with multidirectional dorsal scar patterns (**tab. 12.13**), and most often having plain butts, but 'cortical' butts also being common (**tab. 12.14**). Nonetheless, the flakes are significantly longer, wider and thicker than those recovered from elsewhere at the site (**tab. 12.15**).
In total, 50 core-trimming elements have been recovered from Sector 10. Each is made of chert. Most are crested pieces, including 23 first removals with a single prepared versant, 10 first removals with both versants prepared, 2 second removals, and 2 fragments. The median dimensions are 41.6 × 13.4 × 7.2 mm (**tab. 12.16**). There are also six platform rejuvenations, with median dimension for length 19.6 mm (range

16.4-38.4 mm, n = 5), width 21.4 mm (range 11.2-31.2 mm, n = 5) and thickness 6.2 mm (range 3.3-8.5 mm, n = 5).

Microburins and Related Products

Twenty-five true microburins have been recovered from Sector 10. Most often these are distal examples with the notch on the left hand side (**tabs 12.17-12.18**), similar to the Middle Phase. These include larger examples as also seen in the Middle Phase (**tab. 12.19**).

Retouched Tools

Sector 10 has produced 217 tools. The tool sample is dominated by microlithic and related forms (48.8 %). There are relatively few microlithic fragments. For example referring to **table 12.20** it can be shown that there are about 1.6 times fewer fragments than in any S8 Phase (with the exception of the Mixed/Transitional Phase which is anomalous). This may indicate less trampling damage. End-scrapers account for a relatively high proportion of the tools from Sector 10 (15.4 %). Other classes occur only infrequently, accounting for 0.5-2.3 % of the tool assemblage (**tab. 12.20**).

End-Scrapers

This class (**fig. 12.14a-e**) comprised 33 tools: 13 end-scrapers on flakes, 7 denticulated end-scrapers, 2 nosed end-scrapers, 1 circular scraper, 1 end-scraper on a retouched flake, 1 end-scraper on a blade, 1 double end-scraper and 7 fragments. All are made of chert. All but four are made on flakes, with only a couple made on blades; two are also made on indeterminate fragments. Most are retouched distally (22, including one with additional retouch along the right edge and two with additional bilateral retouch), five are retouched proximally (including one with retouch extending down the left edge and one with retouch extending along the right edge), three are retouched at an indeterminate end, a couple are retouched at both ends (including one with retouch along the right edge), and one has retouch extending around the entirety of the perimeter. Excluding fragments, the median size is 30.8 × 23.7 × 8.7 mm.

Perforators

Only a single perforator has been recovered, which is made on the left edge of a small flake (13.1 × 23.6 × 4.1 mm).

Composite Tools

This is a rare tool class throughout the site. This sector contains a single end-scraper/backed blade made on a 'non-cortical' chert blade. It has backing along the entirely of the left edge and a well-formed convex end-scraper at the proximal end, removing the butt. It measures 47.3 × 15.7 × 4.9 mm.

Backed Blades and Flakes

There are eleven artefacts in this category (**fig. 12.14h-j**). All are made of chert. Most have direct semi-abrupt/abrupt retouch, with only a couple with mixed abrupt/crossed retouch. Just less than half are retouched along the left edge, whilst three are retouched along the right edge and three are retouched along an indeterminate lateral edge.

A couple of pieces are particularly distinctive and elongated artefacts. One is a bi-pointed straight backed bladelet with extremely regular backing along the right edge (**fig. 12.14f**). It measures 55.7 × 6.4 × 4.7 mm. The other is a convex backed blade with mixed direct/crossed forming a convex margin (**fig. 12.14g**). It measures 53.9 × 9.0 × 5.7 mm. Each of these delicate objects seemingly required an exceptional skill to attain a suitable blank and subsequently to form the back without breakage occurring. It is possible given their unusual nature that they were intentionally placed with one of the burials from this Sector.

Microlithic and Related Forms

Of the 105 classifiable microlithic forms, convex-backed bladelets *sensu lato* (types 56-59), account for around three fifths of the backed category (**fig. 12.14m-z**). There are relatively substantial numbers of typical convex-backed bladelets (subtype 56a) in contrast to those tending towards segments (subtype 56b). Each of the other types of convex-backed bladelets *sensu lato* is found only in small frequencies, although convex-backed bladelets with truncated bases (type 58) are relatively common. The range of types is similar to those found in the Middle and Upper Phases (**tab. 12.21**).

As a group, pointed straight-backed bladelets *sensu lato* (types 45-52) also make up a strong proportion of the microlithic types. The pointed straight-backed bladelets *sensu lato* broadly resemble in morphology those from the Upper Phase, rather than those from the Lower Phase. An *Aïn Kéda* point (type 52) was amongst this group (**fig. 12.14l**) and this type is found elsewhere only in the Upper Phase.

No other microlithic types have been found in very large frequencies in Sector 10. Many of the forms that dominate in the YS levels are absent or only contribute a tiny proportion in Sector 10, such as *La Mouillah* points, partially backed bladelets, Ouchtata bladelets and obtuse backed bladelets.

The microlithic and related forms are overwhelmingly retouched along the entirety of one lateral margin (**tab. 12.22**). Most have retouch along the left edge (**tab. 12.23**) and this tends to be direct semi-abrupt/abrupt, although there are significant proportions with relatively abrupt direct/crossed and crossed 'anvil' retouch (**tab. 12.24**). Most have been truncated into a point (**tab. 12.25**). Median figures for the microliths are 25.2 × 6.8 × 3.5 mm (**tab. 12.26**).

Microlithic Fragments

Even though the second most common tool category is that of unclassified microlithic fragments, there are relatively few examples in contrast to other excavated areas, with a total of 43 fragments from Sector 10. Most are modified along the left edge (**tab. 12.27**) most frequently with direct/semi-abrupt retouch, although abrupt crossed 'anvil' retouch is also relatively common (**tab. 12.28**).

Notches and Denticulates

There are 17 artefacts in this class (**fig. 12.14ab-ad**). These primarily consist of denticulated blade/lets, followed by denticulated flakes, and a variety of other forms. All are made of chert. Three are broken laterally, four are partial fragments, and the remainder are whole. Some may be manufacturing failures or microburin mishits. Most commonly the retouch location is along the left edge (35.3 %) or both lateral margins (35.3 %). A few have retouch along the left edge, others on the distal end (11.8 %), or along the right edge (17.6 %). Overall, median length, width and thickness values are, respectively, 32.2 mm (range 18.5-53.9 mm), 17.0 (range 12.6-17.9 mm) and 4.2 mm (3.8-7.2 mm).

Truncations

There is only one truncated piece. It is made of chert and has a slightly concave truncation at the distal end. It measures 28.4 × 15.0 × 5.6 mm.

Fig. 12.14 Sector 10 retouched tools: **a** end-scraper on a flake; **b** circular scraper; **c** denticulated end-scraper; **d** nosed end-scraper; **e** end-scraper on a blade; **f** straight-backed blade; **g** convex-backed bladelet; **h-j** straight-backed bladelets; **k** Mechta el-Arbi point; **l** *Aïn Kéda* point; **m-s** convex-backed bladelets; **t-v** convex-backed bladelets with truncated cases; **w** convex-backed bladelet with rounded base; **x** convex-backed bladelet with retouched base; **y-z** convex-backed bladelets tending towards segments; **aa** segment; **ab** notched blade; **ac-ad** notched flakes; **ae** fragment of a side-scraper.

Varia
This group consists of five non-standardised retouched pieces. All are made of chert and are extremely fragmentary, so that the original blank form could not be distinguished. In addition, there is one formal tool, a fragment of a side-scraper, made of chert (**fig. 12.14ae**). It has scraper retouch along the left edge and distal end. It is typical of forms observed in the MSA and may be intrusive.

In summary, the assemblage from Sector 10 looks slightly different from those from other areas of the cave and is thus difficult to subsume within any of the defined Phases. Stratigraphically, it should be closer to the Middle or very base of the Upper Phase. However, the cores on average weigh even more than the heaviest cores in Sectors 3, 8 and 9 (Lower Phase), the bladelets and flakes are also significantly longer, wider and thicker than from anywhere else in the cave. The artefacts in general are less heavily fragmented and this may indicate that the area was not excessively trampled. One further anomaly is that the Sector 10 assemblage includes large microburins (typical of the Middle Phase) but only sparse *La Mouillah* points, though the most common microlith types are convex-backed bladelets that are possible products of the same reduction process and may account for the near absence of the *La Mouillah* types. All in all, the arefacts in Sector 10 should perhaps be treated as a 'special' deposit made up of a combination of lithics and objects transferred in sediments to this sector as well as items deliberately selected for inclusion with the burials.

12.5 DISCUSSION

Lithic Raw Material Variance

In **Section 12.1**, the question was asked as to whether there is any interpretable information in the distribution of lithic raw materials through the observed stratigraphic range.
With the caveat that natural and inadvertent mechanical flakes are difficult to differentiate from simple (deliberate) artefacts in limestone, the complete datasets in **table 12.1** suggest that this raw material was used more commonly in the GS than in the YS, and increasingly so upwards in the GS (see also Section on 'Expedient Tool Manufacture' below). It is felt that this raw material should be treated as a 'local' resource and, given this special association, it has been removed from the further numerical analysis below, so as not to obscure any procurement patterns in other raw materials. The very large number of unclassified cherts have also been removed, a step which effectively gives much more importance to the non-chert raw materials, although the latter, always being rare, make no significant difference to the conclusions reached below. The data in **table 12.1** can therefore be reduced to the smaller set shown in **table 12.30**.
The columns of data for the total (GS + YS) Middle Phase and for the (Transitional/) Mixed Phase have been placed in small italic print in **table 12.30**, since these data may also obscure any trends in the best stratified assemblages. In fact, these data are 'intermediate' in exactly the way one would expect, given their respective components (either grouped, transitional or mixed).
A variance index has been calculated using the formula given at the foot of the table. The basic principle in the analysis is the comparison of observed percentages against a theoretical uniform distribution (one with 8.3 % of material in each of the 12 raw material categories). A perfectly uniform distribution would give a variance of zero; a rising figure indicates an increasing departure from uniformity, with the maximum possible figure representing a case with all material in only one of the raw material categories. Translating this into more archaeologically relevant terminology, a low figure suggests procurement of a broad range

	Sector 8 Upper Phase	Sector 8 Middle Phase			*Sector 8 Mixed Phase*	Sector 8 Lower Phase	Sector 10
	GS	GS	YS	*Total*	YS	YS	GS
	407	**134**	**284**	***418***	***96***	**384**	**343**
Chert							
Black	10 (2.4 %) [2.9]	4 (3.0 %) [2.3]	11 (3.9 %) [1.6]	*15 (3.6 %) [1.8]*	*1 (1.0 %) [4.4]*	24 (6.3 %) [0.3]	12 (3.5 %) [1.9]
Dark grey	14 (3.4 %) [2.0]	6 (4.4 %) [1.3]	4 (1.4 %) [4.0]	*10 (2.4 %) [2.9]*	*2 (2.1 %) [3.2]*	7 (1.8 %) [3.5]	9 (2.6 %) [2.7]
Grey / light grey	28 (6.9 %) [0.2]	2 (1.4 %) [4.0]	17 (6.0 %) [0.4]	*19 (4.5 %) [1.2]*	*7 (7.3 %) [0.1]*	13 (3.4 %) [2.0]	27 (7.9 %) [0.0]
Greyish brown	27 (6.6 %) [0.2]	16 (11.9 %) [1.1]	35 (12.3 %) [1.3]	*51 (12.2 %) [1.3]*	*7 (7.3 %) [0.1]*	21 (5.4 %) [0.7]	40 (11.7 %) [1.0]
Pale brown / yellowish brown	165 (40.5 %) [86.4]	58 (43.3 %) [102.1]	101 (35.6 %) [62.1]	*159 (38.0 %) [73.5]*	*44 (45.8 %) [117.2]*	177 (46.1 %) [119.1]	76 (22.2 %) [16.1]
Brown / strong brown	108 (26.5 %) [27.6]	25 (18.7 %) [9.0]	68 (23.9 %) [20.3]	*93 (22.2 %) [16.1]*	*26 (27.1 %) [29.5]*	114 (29.7 %) [38.2]	122 (35.6 %) [62.1]
Reddish brown	15 (3.7 %) [1.8]	9 (6.7 %) [0.2]	20 (7.0 %) [0.1]	*29 (6.9 %) [0.2]*	*5 (5.2 %) [0.8]*	5 (1.3 %) [4.1]	12 (3.5 %) [1.9]
Dusky red / weak red	18 (4.4 %) [1.3]	9 (6.7 %) [0.2]	12 (4.2 %) [1.4]	*21 (5.0 %) [0.9]*	*1 (1.0 %) [4.4]*	3 (0.8 %) [4.7]	2 (0.6 %) [4.9]
White	16 (3.9 %) [1.6]	5 (3.7 %) [1.8]	15 (5.3 %) [0.8]	*20 (4.8 %) [1.0]*	*3 (3.1 %) [2.3]*	9 (2.3 %) [3.0]	39 (11.4 %) [0.8]
Basalt	0 (0.0 %) [5.7]	0 (0.0 %) [5.7]	0 (0.0 %) [5.7]	*0 (0.0 %) [5.7]*	*0 (0.0 %) [5.7]*	4 (1.0 %) [4.4]	0 (0.0 %) [5.7]
Quartzite	5 (1.2 %) [4.2]	0 (0.0 %) [5.7]	1 (0.4 %) [5.2]	*1 (0.2 %) [5.5]*	*0 (0.0 %) [5.7]*	7 (1.8 %) [3.5]	3 (0.9 %) [4.6]
Other	1 (0.2 %) [5.5]	0 (0.0 %) [5.7]	0 (0.0 %) [5.7]	*0 (0.0 %) [5.7]*	*0 (0.0 %) [5.7]*	0 (0.0 %) [5.7]	1 (0.3 %) [5.3]
Variance*	**139.4**	**139.1**	**108.6**	***115.8***	***179.1***	**189.2**	**107.0**

Tab. 12.30 Selected lithic raw material variance. *Σ (observed% – uniform%)^2/n, where n = 12, uniform% = 8.3 %; individual cell variance contributions shown in square brackets.

of materials, whilst a high figure suggests greater specialisation in fewer raw material types. It should be remembered that this variance index is effectively dimensionless and that it has meaning here only in a comparative sense. Nevertheless, it is important to note that none of the observed values is 'absolutely low', such that a combination of choice (for technological and / or aesthetic reasons) and of regional availability have clearly caused a general tendency towards selection of particular cherts throughout the LSA at Taforalt.

Looking first at the lowest YS (Lower Phase), the result (index of 189.2) suggests a relatively narrow range of raw materials (in comparison with other columns, by far the narrowest in the available samples), favouring the two most common (overall) material types (accounting for over 75 % of this Lower Phase sample). In the upper part of the YS (the lower part of the Middle Phase), the index has dropped radically (to 108.6), suggesting a considerable broadening of the raw material range (one of the two widest in the available samples). The two columns from the GS show very similar indices, suggesting an intermediate but relatively broad raw material range. Note that the 'variance' index involves a power relationship (to take account of moduli); it is therefore here confirmed that these figures (139.1 and 139.4) are closer to the 'wide' end of the spectrum observed in the Taforalt data than to the 'narrow' end.
Whilst these results are not, of course, determinative in their own right, and whilst the sample sizes are rather small (and the indeterminate/unclassified counts very high), it may be permissible to suggest factors plausibly contributing to the procurement patterns observed. The earliest visits to the cave may have involved a 'narrow' raw material range, perhaps reflecting short visits in a 'procurement round'. The 'wide' pattern in the latest YS perhaps reflects more deliberate source assay, possibly even including the need, or conscious objective, to acquire more local knowledge. In the GS, the pattern narrows a little to what one assumes was the 'best' source balance available (remembering also the incremental addition of limestone artefacts).
Sector 10 gives a 'wide' index value (107.0), the widest in the available samples. However, whilst the variance index is similar to that for the latest YS, the actual distribution of raw materials used is very different – indeed, the Sector 10 sample is also markedly different from both of the other GS samples (remembering also that S10 has a relatively low limestone artefact presence). Material selection in S10 appears to have favoured the stronger-coloured cherts, at the expense of paler or greyer material. It therefore seems plausible to suggest that different material selection criteria (presumably associated with the burial function of this Sector) were persistent enough to overcome any tendency towards 'homogenisation' that may have arisen due to the bulk import from other parts of the cave of GS sediment into Sector 10 (proposed in **Chapter 2**).

Lithic Artefact Productivity

The concept of productivity here is based on bulk density of artefacts (counts per standard unit of volume) weighted with estimated sedimentation rates (nominal thickness per standard unit of time). The resulting productivity figures (**tab. 12.4**) provide gross contrasts between Phases; this is a comparative metric, effectively dimensionless, but broadly linear in nature (a larger figure indicates a larger productivity). Thus major differences in productivity can be seen between the Upper Phase (9359 overall and perhaps as high as 14,000 for the upper (finer-grained and slower-accumulating) half of this Phase), the Middle Phase (2201) and the Lower Phase (260). It is possible that the estimate for the uppermost part of the Upper Phase is exaggerated due to higher rates of breakage and burning but the observed changes in productivity by artefact number appear broadly consistent with the idea that, increasingly through time, inhabitants were walking over and digging into earlier surfaces, creating more hearths, and/or clearing knapping waste into hearths, processes consistent with a more concentrated use of the cave.
Perhaps the most noteworthy change in average productivity is that seen abruptly across the Yellow Series/Grey Series boundary, from 642 to 10892, a 17-fold increase. A breakdown of the assemblage into unidentified knapping debris, debitage (including cores, core-trimming elements, microburins) and tools, shows interesting trends (**tab. 12.4**; see table caption for a full explanation of this productivity metric). The productivities in debitage in the Upper and Middle Phases (1576 and 754, respectively) are about an order

of magnitude greater than those observed in the Lower Phase (104). A similar pattern is also reflected in the productivity of retouched tools from the Upper and Middle Phases (427 and 135, respectively) in comparison with the Lower Phase (22). In fact, as with the average productivity for all lithics, the principal abrupt change in all artefact categories shown in **table 12.4** is within the Middle Phase, at the Yellow Series/Grey Series boundary.

Overall, it seems reasonable to suggest that the higher productivities in numbers of lithic artefacts may be an index of a gross rise in activity within the cave. There is a steady, but modest, increase within the Yellow Series, the Transitional/Mixed Phase showing intermediate values for this parameter too, perhaps an indication that mixing is indeed at least a strong contributor to the overall nature of the lithic assemblage in this Phase. Significantly, after the beginning of the Middle Phase, there then appears to be a massive jump in productivity, plausibly reflecting the shift from dominantly natural to dominantly anthropogenic sediment accumulation and presumably also indicative of greater on-site knapping activity. In addition, allowing for the differential stoniness within the Upper Phase, it seems likely that this upward trend in productivity in lithic artefact numbers continues through time, with perhaps a 40 % increase even within the time-span of the Grey Series itself. The one caveat that must be borne in mind here is that the observed changes in productivity may be highly localised and the product of sampling strategy during the current excavation campaign, although it is considered unlikely that this could be the sole or dominant factor in the pattern observed, given the very magnitude of the changes noted (principally in Sector 8) and the other changes in the material culture thought to be indicative of greater activity levels and the possibility of increased sedentism (see **Chapter 18**).

Artefact Condition

Analysis of the lithic assemblages indicated some interesting changes in the frequencies of diagnostic artefact classes and undiagnostic knapping debris (i.e. chips and chunks). Overall, 33.6 % of the assemblage can be attributed to diagnostic artefact classes. The relative frequencies of total diagnostic artefacts vary dramatically between the Phases, with 21.6 % in the Upper Phase, 40.4 % in the Middle Phase, and 48.9 % in the Lower Phase.

In Sector 8, around 49.3 % of the assemblage shows evidence of burning, which includes discoloration and fracturing (**tab. 12.31**). Overall there is a steady increase in percentage burning upwards through the 'standard' YS to GS sequence with significantly more burnt artefacts in the Upper Phase (71.9 %), than in the Middle (36.8 %) or Lower Phases (23.1 %). Despite the otherwise strongly rising 'productivity' in burnt artefacts, there appears to be a slight fall off in values in the Upper Phase (**tab. 12.4**) which might be attributable to multiple fracturing of larger artefacts into smaller pieces not counted in this analysis. In the GS, there are also high levels of burning of the faunal, molluscan, and botanical remains, and of the sediments, all presumably anthropogenic in origin (see **Chapter 2**). There is no evidence for the use of heat treatment as a preparation for knapping. If anything, the burning is less often associated with the cores than the other classes. In fact, rates of burning are slightly higher amongst the retouched tools in all but the Lower Phase, which might imply that the tools were being discarded close to active hearths, whilst primary knapping took place further away from such features. To test this hypothesis, further horizontal excavations will be necessary. Even though the high levels of burning have somewhat obscured evidence of the reduction process, several prominent changes in lithic technology were recorded in the course of the sediment sequence. The comparatively high percentage of burnt artefacts in Sector 10 (64.5 %) may at first glance offer parallels with the Upper Phase but we would qualify this by noting that Sector 10 probably includes matrix trans-

		Burnt		Unburnt		Total
		n	%	n	%	n
Upper Phase		829	71.9	324	28.1	1153
Middle Phase	GS	125	49.0	130	51.0	255
	YS	148	30.5	338	69.5	486
	Total	273	36.8	468	63.2	741
Intermediate/ Mixed Phase		50	33.3	100	66.7	150
Lower Phase		127	23.1	423	76.9	550
Sector 10		703	64.5	387	35.5	1090
Overall		1982	53.8	1702	46.2	3684

Tab. 12.31 Lithic artefact burning traces. Burning frequencies of larger artefacts excluding debris, small flakes and flake fragments.

ferred in from the outer cave. If the material subsequently transferred was originally produced at more or less the same time, this does of course beg the question as to what kinds of activity (funerary feasting?) may have taken place nearer the entrance to have produced such a burning phenomenon.

One further point worth making here concerns the varying quantities of breakage amonst the microlithic tools. For example, it is only in the Lower Phase that microlith fragments markedly outnumber more or less whole microliths (91:57). In the Middle Phase, the ratio is the other way around (59:91), whilst the two classes have almost the same numbers (201:199) in the Upper Phase. It is clear from our analyses that in the Upper Phase the breakage must have been to some extent influenced by the high degree of burning but the same cannot be the case in the Middle and Lower Phases. Although we have no definitive explanation for the variation in breakage patterns, is it possible that retooling in the Lower Phase involved more replacement with ready made (imported) microliths. If this were the case, it might also suggest that relatively more tools were made in this part of the site in the Middle Phase. Such speculation must of course be weighed up against the relatively restricted areas sampled by our excavations. This is something that could eventually be tested against Roche's data although he only includes broken counts of some tool classes.

Reduction Sequences

Microlithic Toolkit Production

All of the lithic assemblages identified can be described as 'microlithic' and there are a number of similarities in reduction strategies throughout. In all Phases, small chert cobbles were selected primarily for the manufacture of blade/let blanks for microlithic tools and were likely sourced from the gravel banks of the Moulouya River catchment. Based on the 'cortical' elements, it appears that pebbles were brought to the cave whole, without first being 'decorticated'. In all Phases, the most common types of core are single platform examples (32.1-41.2 %), followed by slightly lower frequencies of opposed platform cores (21.4-29.4 %). It would be misleading to draw a sharp distinction between these types, as many of the opposed platform cores have only one heavily exploited platform, with the other probably serving to correct knapping mistakes. Most often, the additional platform only has a couple of removals and the core was usually abandoned soon afterwards. Thus, in many cases the discarded opposed platform cores appear to be indicative of a failed effort to regulate the core or a last-ditch attempt to maximise the number of removals towards the end of the reduction sequence. There is only a little evidence to indicate regular rotation of the core and/or concurrent exploitation of two or more striking surfaces. Forty-one (18 %) of bladelets show bidirectional opposed scars.

Even though there are broad similarities between Phases, subtle temporal changes are suggested in the methods of core reduction. In particular, there appears to have been an increasing reliance on certain techniques for maximising the available raw material towards the top of the sequence. For instance, there is a very slight increase in the numbers of cores-on-flakes, from a total absence at the base of the Lower Phase, to moderate frequencies in the Middle Phase (6.1 %) and relatively high frequencies in the Upper Phase (10.7 %). This may be connected with a way of extending material in the manufacture of microlith tool blanks. At Grotte des Contrebandiers on the Atlantic coast of Morocco, Olszewski/Schurmans/Schmid (2011) have suggested that cores-on-flakes, along with *pièces esquillées* (i.e. splintered pieces), show a deliberate process to maximise the use of raw materials. It is certainly the case that cores-on-flakes might indicate a more economic use of raw material at Taforalt but, unlike Contrebandiers, the use of the bipolar technique for reducing flakes does not seem to have been habitually practiced (this may be linked to differences in quality of raw material between the two sites); splintered pieces account for only a very small proportion of the diagnostic artefacts from the three major Taforalt Phases (0.2-0.4 %). The low, yet sustained, numbers of tested and early abandoned cores in the Lower and Middle Phases (5.9 % and 6.1 %, respectively), contrasts with a complete absence in the Upper Phase, perhaps suggesting a more extended use of the raw materials near the top of the sequence. Alternatively, Bouzouggar has noted that some of the cores in the lower part of the Grey Series (equivalent of the Middle Phase) were deliberately left with large stepped removals, a practice that changed further up the sequence; he believes they may have functioned as planing tools (‘*rabots*’). Such ideas could be tested by use-wear studies.

Evidence from the core-trimming elements also suggests some changes in core-shaping strategies through time. An increasing proportion of such elements has been recorded upward through the sequence. In relative terms, core-trimming elements in the Upper and Middle Phases (2.1 % and 2.4 %, respectively) are broadly twice as common as in the Lower Phase (1.1 %). In each Phase, crested blades are the most common core-trimming elements. Most often these have only been prepared along one versant, occasionally with outer surface preserved on the other margin. In addition, from time to time, minor adjustments were made to the angle of platforms by the removal of small rejuvenation flakes, which are rarely large enough to be described as true core tablets. In the Upper and Middle Phases, *flancs de nucléus* are also recorded in small numbers, indicating another method of core rejuvenation, focused on refreshing the whole of the flaking face. No *flancs de nucléus* have been recorded in the Lower Phase, although the overall sample size is relatively small and the use of this technique cannot be excluded.

In every part of the sequence, the primary objective of core reduction seems to have been the manufacture of small blade/lets and elongated flakes. There were higher frequencies of blade/lets in the Lower Phase (20.2 %) than in the Middle Phase (16.3 %) and even fewer in the Upper Phase (12.3 %). This might be taken at first glance to indicate a drop in the prevalence of blade/let production in favour of flake manufacture. However, several features of the assemblage tentatively indicate that the reduced frequencies reflect a more rigorous use of available blade/let blanks in the upper parts of the stratigraphic sequence.

First, the relative frequencies of ‘cortical’ and ‘non-cortical’ elements amongst the flakes remained stable, but there were more ‘cortical’ blade/lets towards the top of the sequence, suggesting that, rather than an increase in the manufacture of flake blanks, more ‘non-cortical’ blade/lets are being utilised (and removed) from the assemblage towards the top.

Second, a more exhaustive use of available blade/lets is supported by the ratios of these items to retouched tools. In the Upper Phase the ratio of blade/lets to tools was 1:1.69, which means that retouched tools were more common than blade/lets. However, in the Middle and Lower Phases, the ratios were respectively 1:0.93 and 1:0.85, which means that retouched tools were here less common than unmodified blade/lets. An almost two-fold increase in the number of blade/lets retouched into tools would account for the relatively low numbers of 'non-cortical' blades and high proportions of tools in the Upper Phase. The ratio of flakes to tools remains relatively low and consistent across the Upper, Middle and Lower Phases (1:0.34, 1:0.31 and 1:0.30, respectively), which suggests little change in the selection and retouching of flakes into tools. It seems likely that a reduction in the relative frequencies of blanks can be interpreted as an index of the degree of blank use. Thus, the recorded drops in the frequencies of blade/lets would suggest that raw materials were being utilised more exhaustively towards the top of the sequence, especially in the Upper Phase.

One potential caveat is that the signal of blade/let manufacture and use is potentially masked by the increased levels of burning, which may have led to greater fragmentation of blade/lets and bias against the blade/let recognition in the more heavily burnt components of the assemblage. However, the frequencies of artefacts classified as blade/lets and their fragments remain relatively stable throughout and suggest limited changes in the fragmentation of blade/lets regardless of levels of burning. Of the blade/lets, around three quarters are broken fragments in the Upper, Middle and Lower Phases (75.4 %, 76.3 %, and 73.4 %, respectively).

There were a few subtle changes in the morphology of blade/lets over time, which indicate that, in addition to the increased utilisation of available blade/lets, there were also changes in their manufacture. Even though bladelets dominate throughout and there is limited evidence for the manufacture of blades *sensu stricto*, there are significant differences in size of surviving bladelets through time, with progressively wider and thicker values towards the top of the sequence giving a statistically significant result. It is plausible that this is simply a result of the increase in 'corticated' elements, although the dimensions of the microlithic tools suggest otherwise (see below). A subtle change has also been observed in the length of bladelets, with progressively longer blanks towards the top of the sequence.

There is some subtle variation in the morphology of striking platforms on blade/lets that might be indicative of changes in manufacturing technique (see **tab. 12.10**). For example, there are significantly fewer blade/lets with punctiform/linear butts in the Upper Phase (33.3 %) than in the Middle (47.5 %) and Lower Phases (78.9 %). At first glance this might imply greater attention to the preparation of butts lower down in the sequence but the appearance of blanks with faceted and dihedral butts in the Upper and Middle Phases would appear to contradict this. The use of hard hammer technique does not appear to have been prevalent in any of the Phases.

Microburin Technique

It appears that some of the most marked differences in reduction occurred at the stage of transforming blade/lets into retouched tools, including differences in the utilisation of the microburin technique for sectioning blanks. Evidence of the use of the microburin technique has been recorded from each of the major Phases. However, there are significant differences observed in the frequencies of microburin discards, along with changes in tool forms, which suggest that the nature and use of the technique fluctuated considerably through time.

In the Upper Phase, very few microburin discards have been recovered, yet most of the microlithic forms from this interval are thought to have been made using the microburin technique, such as convex-backed bladelets *sensu lato* (types 56-59). A general lack of microburin discards may indicate that sectioning of blanks and retouching of microliths was conducted elsewhere in the cave. Alternatively, the limited number of microburin discards might reflect the retouching of microburins themselves into microliths (**fig. 12.4**), as has been suggested in relation to roughly contemporary industries in the Near East (Neeley/Barton 1994).

Throughout the Middle Phase (YS and GS), a notable feature of the assemblage is the abundance of microburin discards, which were found alongside relatively high numbers of *La Mouillah* points (type 62). A *La Mouillah* point retains a microburin facet at one end and has a backed margin. This type is quasi-absent elsewhere in the site. There is some question as to whether *La Mouillah* points represent an intermediate stage in the manufacture of other microlithic forms (e.g. convex-backed bladelets *sensu lato*, segments) or final tool forms in and of themselves. Judging by the lack of macroscopic wear, it seems plausible that *La Mouillah* points were an intermediate stage in microlith manufacture. If this is the case, then the high discard rates of these 'unfinished tools' might indicate a liberal use of raw material during the Middle Phase. In this Phase, the microburins were often relatively large (another possible indication of the abundance of raw material).

In the Lower Phase, few microburin discards have been recovered and, additionally, microlithic forms retaining their bulbs are common, such as obtuse-ended backed bladelets and Ouchtata bladelets. Thus, the relatively limited number of microburins may genuinely reflect a rarity in the utilisation of the microburin technique in the Lower Phase. There is also some slight evidence here for differences in the use of the microburin technique. In contrast to the Transitional/Mixed Phase, the microburins mainly removed the butt of the blade/let, the notch was most often formed on the right margin, and only a relatively short section of the blank was removed.

Although no detailed comparative analysis of microburins from earlier excavations has yet been made, it can be noted that some of the general stratigraphic distributional trends seen here are remarkably similar to those observed by Roche (1963, 147). In particular, he recognised a decreasing upward pattern in the GS microburin proportions; his data also show that the pattern was geographically consistent across the interior, middle and exterior zones of the cave. An additional feature is that, at each level, the lowest numbers of microburins occurred towards the exterior, with the highest numbers towards the interior.

Microlithic Typology and Lateralisation

Major differences have been recorded across the sequence in the most common microlithic forms.

The Upper Phase assemblage is dominated by convex-backed bladelets *sensu lato*, followed by moderate numbers of pointed straight-backed bladelets *sensu lato*. A relatively high proportion of the convex-backed bladelets *sensu stricto* tend towards typical segments. A small number of true 'geometric' segments have also been recorded and, together with the other 'geometric' forms, make up a relatively strong proportion of the tool assemblage.

The Middle Phase is similarly dominated by convex-backed bladelets *sensu lato*, although there is only a low proportion of pointed straight-backed bladelets *sensu lato.* In contrast, there are relatively strong numbers of *La Mouillah* points in the Middle Phase, which, as noted above, might represent an intermediate stage in microlithic tool manufacture (**fig. 12.6**). None of the other microlithic forms is particularly well-represented, but several forms more commonly found at the base of the sequence have been recovered here too in small numbers (e.g. obtuse-ended backed bladelets, Ouchtata bladelets).

The Lower Phase differs substantially from the other two Phases. Convex-backed bladelets *sensu lato* make up only a small proportion of the assemblage and *La Mouillah* points are entirely absent. In contrast, the most common forms are Ouchtata bladelets, whilst obtuse-ended backed bladelets (differing mainly from the former in the thickness of the retouched edge) are also relatively common. Even though pointed straight-backed bladelets *sensu lato* are recorded in broadly comparable relative frequencies as in the Upper Phase, differences are noticeable in their morphology. In the Lower Phase, the pointed straight-backed bladelets *sensu lato* tend to have more marginal retouch, which is relatively irregular. In addition, some of these forms resemble the partially backed bladelets with pointed ends, differing only in the extent of the retouch along the edge, and this last form also only occurs in notable frequencies in the Lower Phase. The highest frequency of scalene bladelets is also recorded here. None of the other types is well-represented in the Lower Phase.

The length of microlithic forms also differs significantly across the sequence, with shorter examples, on average, recorded in the Upper and Middle Phases. Neeley/Barton (1994) have suggested that a reduction in microlith size relative to blank size might be symptomatic of a shift towards the manufacture of more than one microlith from a single blank. Given that blank length remains relatively stable throughout the sequence this could explain the shift towards shorter forms at Taforalt. Further evidence for producing more than one microlith from a single blank is also suggested by the changing application of the microburin technique in the Upper Phase, which we tentatively suggest allowed manufacture of microliths from both the microburin and the corresponding blade/let section with a trihedral point. However, in the Middle Phase, there is strong counter-evidence, indicating that typically only a single tool was manufactured from each blank, as evidenced by the numerous surviving long microburin discards.

It is generally assumed due to their size that microliths normally served as replaceable inserts or tips in hunting projectiles. However, it is equally possible that they were hafted in handles for other uses such as "[…] plant-gathering, harvesting, slicing, grating, plant-fibre processing for lines, snares, nets and traps, shell openers, bow-drill points and awls [… and] fish hooks […]" (Clarke 1976, 476). There is little direct evidence for hafting methods in the North African record, although a sickle haft retaining three microlithic backed inserts was recovered from a later Epipalaeolithic level at Columnata (Cadenat 1960). No such evidence is available from the preceding LSA/Iberomaurusian but some indication that at least a proportion of these tools were used as projectile tips comes from a preliminary study of diagnostic macro-fractures patterns on microlithic forms from Tamar Hat, eastern Algeria (Merzoug/Sari 2008; Sari 2014). At Taforalt, observations tentatively indicate that some of the microliths were components of composite tools. There is also a slight shift temporally from damage initiating laterally along one edge to damage initiating from the end of the tools, which might be indicative of changes in hafting configuration and/or use (pers. obs. J. Hogue). More experimental data are required better to understand and reconstruct the hafting methods and uses of such tools during the LSA. Nonetheless, it is tempting to speculate that changes in techno-typological attributes may reflect a progressive shift in the function of microlithic forms through the sequence.

As well as the changes mentioned above, there is significant variation in retouch lateralisation. In the Upper and Middle Phases there is an overwhelming tendency towards retouching the left margin (61.9 % and 80.0 %, respectively), in contrast to the percentage of such examples in the Lower Phase (36.8 %). A similar observation was also made in the retouch lateralisation on the microburin discards. Some authors have argued that retouch lateralisation reflects the handedness of the knapper (e. g. Conneller 2006; Peresani/Miolo 2012). However, other studies have consistently shown that, whilst there may be some subtle variation in handedness, based on geographical and ethnic differences, about 90 % of all people are right-handed (McManus 2009 but see Stock et al. 2013 for a discussion of variability in this characteristic).

An alternative suggestion by Close (1977; 1978; 1989) is that retouch lateralisation is functionally neutral and, as such, reflects 'stylistic' traditions for manufacturing tools by different socio-cultural groups (cf. Sackett 1977). Another possibility is that style might lie with the haft, i. e. determining how the microliths are inserted (A. Roberts, pers. comm.). Close has recorded the dominance of right lateral backing on microlithic forms from the Iberomaurusian sites of Rassel and Tamar Hat (eastern Algeria). Based on this and other similarities in the lithic assemblages, she concluded that they were created by a single, diachronic, social group. Existing and recently obtained AMS radiocarbon dates indicate that Rassel and Tamar Hat seem to overlap in age and, as noted above, right lateral backing was also dominant in the Lower Phase at Taforalt, which suggests some level of commonality with the assemblages from eastern Algeria. However, our study has included younger assemblages falling outside the timeframe examined by Close. Thus, left lateral backing was most common in both Upper and Middle Phases at Taforalt, which at leasts suggests there was a shift in retouch lateralisation through time at this site.

Based on the proposition that retouch lateralisation is 'stylistically' determined, and bearing in mind the other changes in lithic technology, it is tempting to speculate that the shift in retouch lateralisation might be linked to a change in socio-cultural group. It is interesting to note a dominance of tools retouched along the left margin has also been observed at Afalou Bou Rhummel (Hachi 2003) and Columnata (Sari 2012; 2014) in Algeria, sites that are broadly contemporary with the Upper and Middle Phases at Taforalt. This shift seems to challenge the existing notion that all microlithic assemblages from this region dating from the latest Pleistocene (i.e. Iberomaurusian) were the product of only one extended socio-cultural grouping (*contra* Close 1989; 1978; 1977; Sari 2012; 2014).

Expedient Tool Manufacture

In addition to the prevailing use of fine-grained chert probably from gravels of the Moulouya River catchment, there are also low background levels of a 'lithographic' limestone throughout the sequence, which is much coarser than the chert but is not as coarse as the actual bedrock of the cave. It appears that this material was locally available outside and below the cave (see **Chapter 2**) and was utilised for tool manufacture in a relatively *ad hoc* fashion. Most of the flakes in this material are relatively large, often retaining their original exterior surfaces, and have probably been struck using hard-hammer percussion, with little if any preparation of the edge of the striking platform. Only a few of the flakes of the limestone have been made into retouched tools, most often notches and denticulates. There was probably little time investment needed to produce tools of this sort, as the technology is basic, and the inhabitants of the site had a ready supply of limestone to hand. Even though there are low background levels of this material throughout the sequence, there is a significant increase in the quantity of limestone in the Upper Phase. There may be another reason why limestone was freely available actually on site: we have noted that enormous quantities were brought into the cave in the Grey Series period for pyrolithic reasons (**Chapter 2**).

It is also worth reiterating here that the majority of chert (and quartzite) artefacts originated from pebbles 2-10 cm long and were simply too small to produce the larger and heavier tools. This may also explain rocks sourced close to the cave such as limestone where the size was not so restricted. Furthermore, the latter is relatively isotropic and experiments have shown that it exhibits surprisingly reliable flaking properties, with good conchoidal fracture and unlike dolomitic limestone, for example, is able to hold an edge with not too much crushing.

While no detailed work has yet been undertaken on the Roche lithic artefact collections, it can be noted that similar trends in the distribution of the large (limestone) tools can be seen in his excavations (1963, 150). For example, the vertical increase in limestone is clearly apparent from his descriptions and seems to hold true for all three inner, middle and outer zones of the cave.

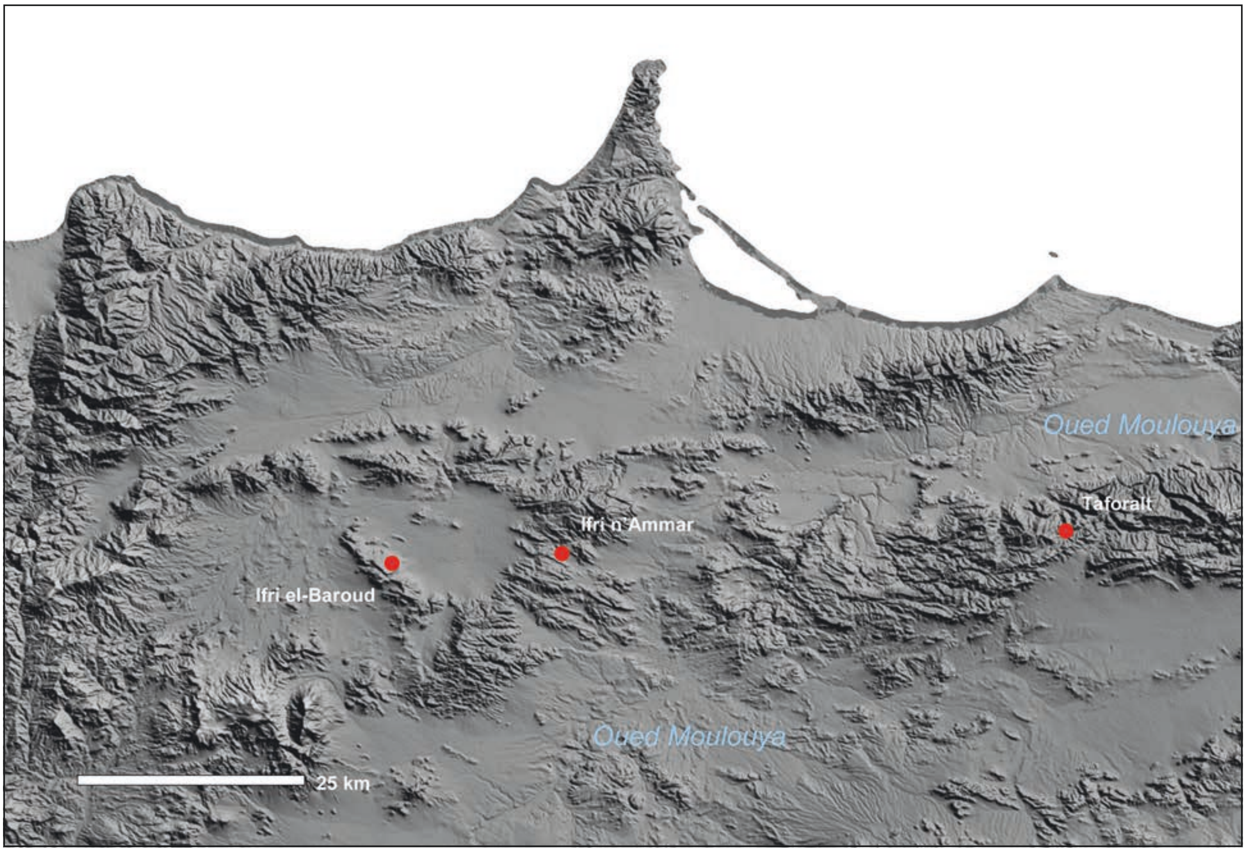


Fig. 12.15 Map showing Iberomaurusian sites of Ifri el-Baroud and Ifri n'Ammar in relation to Taforalt. – (Background image courtesy of NASA, SRTM).

Wider Regional Comparisons with Iberomaurusian Assemblages

Previous authors have applied different models for categorising variation in the Iberomaurusian, which have tended to be based on fluctuations in major tool groups (such as end-scrapers, burins, backed bladelets, etc.) (e.g. Balout 1955; Camps 1974; Lubell/Sheppard/Jackes 1984). In contrast, this study has found little evidence for variation in the major tool group frequencies at Taforalt and we therefore see little utility in using this method here (Hogue 2014). Instead, changes in the *chaîne opératoire* and nature of the microlith toolkit are far more useful for dividing the assemblages. Evaluation of the published literature suggests that several of the changes identified at Taforalt might have wider regional parallels. However, it has been difficult to apply the method uniformly because of the general lack of comparative information from other sites, so most of the comparisons are based primarily on tool counts with some general observations on the manufacturing techniques.

Lower Phase

There are few assemblages of comparable age to those from the Lower Phase at Taforalt. However, a coherent set of radiocarbon ages dating from ~20 to 11-10 ka cal BP has been published from the nearby site of Ifri el-Baroud (**fig. 12.15**), located in the *Rif Oriental* (Morocco) (Görsdorf/Eiwanger 1999). Those lithic assemblages have currently only been described according to broad lithostratigraphic divisions (e.g. *escar-*

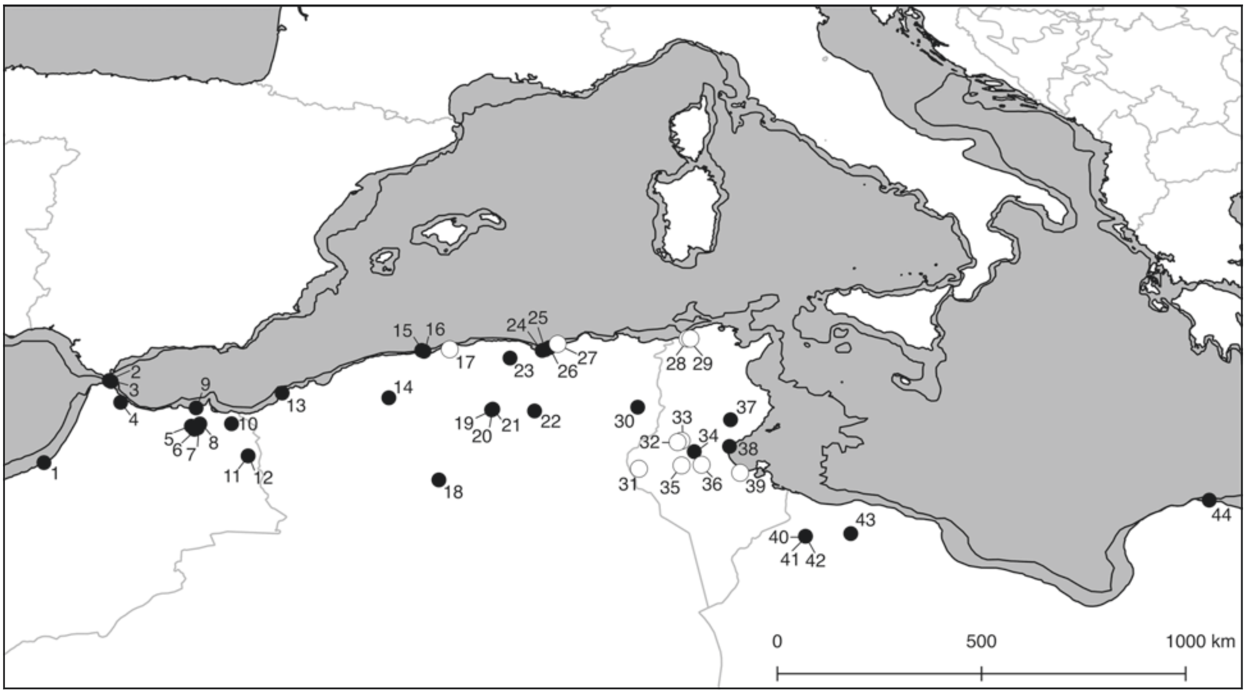


Fig. 12.16 Distribution of Iberomaurusian and related microlithic assemblages: **1** Contrebandiers; **2** Kehf That el Ghar; **3** Ghar Cahal; **4** Kehf el Hammar; **5** Taghit Haddouch; **6** Hassi Ouenzga open air site; **7** Ifri el-Baroud; **8** Ifri n'Ammar; **9** Ifri Armas; **10** Grotte des Pigeons Taforalt; **11** Chaâba Bayda site 1; **12** Chaâba Bayda site 2; **13** Oued Guettara II; **14** Columnata; **15** Rolland; **16** Rassel; **17** Oued Kerma; **18** El Haouita; **19** El Hamel; **20** El Onçor; **21** Es Sayar; **22** M'Doukal; **23** Gueldaman 1; **24** Tamar Hat; **25** Afalou Bou Rhummel; **26** Taza I; **27** Djidjelli; **28** Ouchtata *rive gauche*; **29** Ouchtata *rive droite* localities; **30** Wadi Mezeraa; **31** Grotte Velozzo; **32** Sidi Mansour; **33** Lalla; **34** Bir Oum Ali; **35** Menchi; **36** Ain el Atrouss; **37** Rammadiya El Oghrab; **38** Fadh el Nadhour 1; **39** Mareth; **40** SJ-00-55 West; **41** SJ-00-55; **42** SJ-00-55 East; **43** SG-99-41; **44** Haua Fteah.

gotière and *couche rouge*) (Nami 2007), which makes it difficult to tease out finer-grained chronological differences. Nonetheless, there are some observable similarities between lithic assemblages from the *couche rouge* and the Lower Phase at Taforalt, with a small assemblage, containing pointed straight-backed bladelets (type 45), partially backed bladelets (type 63), obtuse-ended backed bladelets (type 67) and Ouchtata bladelets (type 70), having been described from *sondage II*. The available radiocarbon ages for the *couche rouge* suggest a broadly equivalent age to the Lower Phase at Taforalt, with the el-Baroud dates ranging from between 20,488-20,003 cal BP (Bln-4774, 16,777 ± 83 BP) to 16,287-15,826 cal BP (Bln-4745, 13,359 ± 72 BP) (Görsdorf/Eiwanger 1999; Nami 2007, 228).

There is also some evidence for techno-typological similarities between Taforalt and assemblages elsewhere in the Maghreb. New AMS radiocarbon ages indicate occupation between ~25 to 20-19 ka cal BP at the site of Tamar Hat, situated on the *Golfe de Béjaïa* (eastern Algeria), and the lithic assemblages from there are also characterised by the careful production of blade/lets from single platform cores using a soft-hammer technique, with resulting blanks often being transformed into pointed straight-backed bladelets (type 45) and partially backed bladelets (type 63), as well as into more marginally retouched Ouchtata bladelets (type 70). A notable feature which also offers comparison is in the lateralisation of retouch, with a preference for modification on the right edge of blanks at both localities (Hogue 2014; Hogue/Barton 2016).

Evident similarities are also observable amongst assemblages in Tunisia (**fig. 12.16**). Gragueb (1983) has re-analysed assemblages from across the country and records a series of early assemblages with high proportions of bladelets with Ouchtata retouch, obtuse-ended backed bladelets, and scalene backed bladelets, as well as predominance of right lateral retouch (>70 %) and low proportions of abrupt crossed retouch

(<25 %) on backed bladelets *sensu lato*. This appears broadly in keeping with material from the Lower Phase at Taforalt. None of the Tunisian assemblages is well dated, but an age estimate, based on correlation with a local aeolianite stratigraphic member, of at least ~21 ka cal BP has been suggested for some of the assemblages located in the vicinity of Ouchtata itself in northern Tunisia (ibid., 16). Currently there are no available radiocarbon determinations on bone or charcoal for sites in southern Tunisia, although an age of (C-3569) 17,470 ± 315 BP (21,945-20,325 cal BP) is available on ostrich eggshell from Bir Oum Ali (Vernet / Aumassip 1992). This may indicate the broadly contemporary appearance of LSA technology in southern Tunisia, but associated assemblages have not yet been fully described.

Transitional / Mixed Phase

Some scope for comparison may occur with the site of Ifri n'Ammar (**figs 12.15-12.16**), in the Moroccan *Rif Oriental* (Mikdad / Eiwanger 2000; Moser 2003). A gradual shift from marginally retouched Ouchtata bladelets at the base of the sequence in *enlèvement* [spit] 28 (as yet undated) to high concentrations of *La Mouillah* points (type 62) and numerous microburins in *enlèvements* 25-23 has been noted. An age of (UtC-6180) 13,590 ± 70 (16,651-16,148 cal BP) from *enlèvement* 26 gives a *terminus ante quem* for the inception of the Ouchtata bladelet-rich assemblages, which falls towards the end of the timeframe for the Lower Phase at Taforalt. It is easy to see parallels between the successive industries at Ifri n'Ammar and Taforalt and yet the replacement of assemblages rich in Ouchtata bladelets by those rich in *La Mouillah* points seems more gradual at Ifri n'Ammar. A mixture of Ouchtata bladelets and numerous microburin discards has also been recorded in the Transitional / Mixed Phase, although there were few *La Mouillah* points. Unlike Taforalt however, the assemblage from Ifri n'Ammar might suggest the possibility of a genuine gradual transition between industries comparable to those of the Lower and Middle Phases at Taforalt. It is difficult to evaluate fully this hypothesis, as there is strong evidence of bioturbation at Ifri n'Ammar in most levels of the *couche rouge* (i. e. the 70 cm thick Unit B, below the 'grey snail' Unit A) (cf. Klasen et al. 2018). Moreover, excavations at Ifri n'Ammar involved the use of horizontal spits and it is certainly plausible that the *enlèvements* cut across distinct sediment boundaries, as is suggested by the available stratigraphic profiles. If so, each *enlèvement* might include a mixture of lithic materials from a relatively broad time-range and time-averaging between stratigraphic units could explain what appears to be a relatively gradual change in the retouched components when compared with the sequence at Taforalt.

Middle Phase

Evidence for similar assemblages to those in the Middle Phase at Taforalt is less persuasive. Setting aside the stratigraphic caveats mentioned above, there is some evidence for comparable assemblages at the nearby site of Ifri n'Ammar, with high concentrations of *La Mouillah* points (type 62) and numerous microburins in *enlèvements* 25-23, which date from ~16.4-16.2 ka cal BP (Moser 2003).

A lithic assemblage including relatively high frequencies of *La Mouillah* points and numerous microburins has also been described from the open-air site of Es Sayar, located at the eastern edge of the *Hauts Plateaux* in northern Algeria (Amara 1977). A single radiocarbon age on ostrich eggshell of (Gif-4349) 13,100 ± 250 BP (16,491-14,955 cal BP) also suggests that the assemblage is broadly contemporary with the Middle Phase at Taforalt.

No other sites with radiocarbon ages show clear affinities with the Middle Phase at Taforalt. However, a couple of particularly important caves were excavated in the early-19th century by Barbin (1910; 1912; Pallary 1909) along the margins of the Oued Mouillah, c. 5 km north of Maghnia in western Algeria, which showed a proliferation of "*lames à dos et* «*piquant trièdre*»" (now known as *La Mouillah* points). Interestingly, the sites of *La Mouillah* provided the type-assemblage for the Iberomaurusian (Pallary 1909) as well as the namesake of the *La Mouillah* point (Tixier 1963). Unfortunately, the collections from these sites were largely divided up between different institutions and there do not appear to have been any subsequent excavations at the caves. Nonetheless, the high numbers of *La Mouillah* points is of interest, given that it is one of the defining characteristics of the Middle Phase at Taforalt.
If the timeframe for the Middle Phase (c. 15,615-14,453 cal BP; cf. Chapter 4) at Taforalt is anything to judge by, then this technological repertoire was relatively short-lived, which may help explain the scarcity of comparable assemblages from other sites. A limited occurrence of such technology, but over a slightly longer period, is also suggested at the site of Ifri n'Ammar, with 37 *La Mouillah* points recorded in spits 28-18 (Moser 2003, 75) and covering a maximum potential age range of 16,651 cal BP (spit 26) to 14,378 cal BP (spit 18) (Moser 2003, 101). Beyond any genuine chronological patterning in the use of this technology, major difficulty in detecting similar occurrences is perhaps linked to the tendency of researchers in the region to describe assemblages by broad groups associated with *escargotières* (as an undifferentiated whole) and an underlying *couche rouge* (again often poorly differentiated into component stratigraphic units), as at Ifri el-Baroud (Nami 2007). Given that our work indicates the continuation of technological strategies across sedimentary boundaries, as well as significant changes in lithic assemblages without marked shifts in sediment type, *a priori* division of assemblages simply by gross sediment type is only likely to mask further variation within the Iberomaurusian. Although spit excavation may sometimes be the only logistical option, excavations of well-stratified sites using fine-grained approaches are needed to test whether similar assemblages exist at other sites.
In terms of yet wider connections, high proportions of convex-backed bladelets *sensu lato*, the prevalence of *La Mouillah* points and extensive use of the microburin technique have been used in the past to link the Iberomaurusian with the Mushabian of the Negev and the Sinai Peninsular (Bar-Yosef 1987). The Mushabian is now known to date between ~16.7-12.9 ka cal BP (Maher/Richter 2011; Maher/Richter/Stock 2012), which means that, at least in chronological terms, the possibility raised by Bar-Yosef (1987) of the Mushabian being ancestral to the Iberomaurusian remains an open question. Given the shared cultural markers (e.g. *La Mouillah* points), albeit in smaller proportions, in preceding assemblages of both regions, it is difficult to exclude the alternative hypothesis of independent development of homologous industries in each region. A separate development of these industries is also supported by the lack of similar assemblages in the intermediate zone between the Maghreb and the Levant.

Upper Phase

Based on the techno-typological characteristics of the assemblages, there is some evidence for continuity in the microlithic tool forms between the Middle and Upper Phases at Taforalt, with convex-backed bladelets *sensu lato* dominating in both Phases. Furthermore, there is also some suggestion of 'stylistic' continuity (e.g. functionally neutral, learned patterns of behaviours) in the form of retouch lateralisation that might indicate that both assemblages were manufactured by the same socio-cultural grouping, as opposed to that of the Lower Phase. Nonetheless, there are also shifts in technology in the Upper Phase, including the more thorough use of available raw materials and subtle changes in microlithic shapes.

Based on the number of sites broadly contemporary with the Upper Phase, it appears possible that there was a regional increase in populations at this time (Linstädter/Eiwanger/Mikdad/Weniger 2012). Regrettably, however, only a few of these lithic assemblages have been described in any detail. Amongst the sites that offer comparison are the *escargotière* layers at Ifri el-Baroud, which have yielded nine radiocarbon determinations in stratigraphic order ranging from 12,932 ± 78 BP (15,738-15,204 cal BP) to 11,508 ± 60 BP (13,469-13,230 cal BP) (Nami 2007). Of the microlithic elements from the *escargotère* in *sondage II*, the clear majority are convex-backed bladelets *sensu lato* and pointed straight-backed bladelets *sensu lato*, and there are also a comparable number of geometric segments, as observed in the Upper Phase at Taforalt. A similarity in microlithic forms is also observed at Ifri n'Ammar (Moser 2003), with a proliferation of convex-backed bladelets *sensu lato*, but largely to the exclusion of all other microlithic forms from *enlèvement* 18 onwards. The latter can be dated at the earliest from about (UtC-6177) 12,480 ± 80 BP (15,072-14,235 cal BP), near the beginning of the Taforalt Upper Phase, and is marked by the development of a large ashy midden. A notable increase is also recorded in the occurrence of geometric types (mainly segments) from *enlèvement* 11 onwards, which has been dated to (Erl-4399) 11,009 ± 144 BP (13,134-12,690 cal BP). Another site, Ghar Cahal, located in the Tingitane peninsula of northwest Morocco, has also yielded a stratified sequence of radiocarbon determinations for the later Iberomaurusian: (OxA-11323) 11,125 ± 65 (13,102-12,810 cal BP), (OxA-11322) 11,180 ± 65 BP (13,165-12,840 cal BP) and (OxA-11321) 9,470 ± 44 BP (10,799-10,578 cal BP) (Bouzouggar et al. 2008). Preliminary investigation of the lithic material shows similarities in knapping strategies, including the use of coarser-grained rocks for the manufacture of relatively expedient tools, as well as similar tool types to those found at Taforalt in the Upper Phase (Hogue pers. obs).

Grotte des Contrebandiers, situated on the Atlantic Coast of Morocco, has yielded three radiocarbon determinations of (Gif-2579) 14,460 ± 200 BP (18,095-17,071 cal BP), (Gif-2577) 12,500 ± 170 BP (15,261-14,089 cal BP) and (Gif-2580) 12,320 ± 600 BP (16,331-13,086 cal BP), although these 1980s dates are generally considered to be ambiguous (Roche 1976; Olszewski/Schurmans/Schmidt 2011). Nonetheless, there are some similarities with the lithic technology of the Upper Phase at Taforalt, with evidence for cores-on-flakes, as well as *pièces esquillées*, both probably intended at Taforalt to maximise the use of small-sized fine-grained raw materials. Differences in typology somewhat limit comparisons, although non-geometric forms are described as including pointed (*Aïn Kéda* points and points/spikes), curved-backed, and blunt-ended forms. The prevalence of *Aïn Kéda* points is potentially interesting, as this form is only found in any frequency at the (surviving) top of the Upper Phase at Taforalt. This microlithic form is known from the eponymous site of Aïn Kéda (western Algeria), which has tentatively been assigned to the Iberomaurusian *sensu lato* (Tixier 1963, 102). However, it should be noted that *Aïn Kéda* points have also been identified in Holocene assemblages, such as those observed at Mechta el-Arbi (Pond/Collie/Romer/Cole 1928), the Aïoun Berriche localities (Pond/Chapuis/Romer/Baker 1938) and Dakhlat es-Saâdane (Tixier 1955). Thus, the presence of this form might give some indication the assemblages belong to the end of the Pleistocene with similarities to the early Holocene industries.

The rockshelter site of Afalou Bou Rhummel, located at the edge of the *Golfe de Béjaïa* (eastern Algeria), shows broad similarities in the stratigraphic sequence to that of Taforalt, with a lower series of reddish clays (*couches XII-XI*) overlaid by an upper series of less compact sediments with a strong anthropogenic input that has been subdivided between relatively thin archaeological horizons (*couches X-V*) and overlying lighter-coloured more friable lenticular sediments with numerous cobbles, molluscs remains and bone fragments (*couches IV-I*) (Hachi 2003; 1996; Hachi et al. 2002). Unfortunately, only the finds from the *couches V-I* have been described in any detail. A wide range of ages have been given for *couche III* (11,450 ± 230 BP, Ly-3327, 13,753-12,824 cal BP; 11,560 ± 90 BP, unknown lab no. (Hachi 2003), 13,570-13,216 cal BP; 11,900 ± 140 BP, unknown lab no. (Hachi 2003), 14,080-13,456 cal BP) and *couche IV* (13,120 ± 370

BP, Alger-0008, 16,849-14,409 cal BP; 12,400 ± 230 BP, Ly-3288, 15,268-13788 cal BP; 12,020 ± 170 BP, Gif-6532, 14,477-13,461 cal BP). Each of the radiocarbon determinations has large error margins and must be treated with caution, but they give a general indication of an overlap in age with the Upper Phase at Taforalt. Based on the typological data at Afalou Bou Rhummel, the microlithic toolkit in each of the described *couches* is dominated by convex-backed bladelets *sensu lato* and by pointed straight-backed bladelets *sensu lato*. A notable feature of the assemblage is the increase in numbers of geometric segments towards the top of the sequence. However, there are also sizeable amounts of geometric triangles (types 89-93) in *couche IV*, which are practically absent in broadly contemporary deposits of the Upper Phase at Taforalt. Hachi (2003, 230) has also noted the increasing prevalence of coarse-grained local materials towards the top of the sequence at Afalou Bou Rhummel, which suggests at least superficial similarities with use of raw materials observed at Taforalt.

Earlier and more recent analyses of the lithic assemblages from Columnata (Brahimi 1972; Sari 2012; 2014), also suggest broad similarities in the lithic assemblages to those from the Upper Phase at Taforalt. The Columnata assemblage has been recorded as being dominated by convex-backed bladelets *sensu lato* and straight-backed bladelets *sensu lato*, but there are also particularly high numbers of geometric segments. A relatively high proportion of microburin discards has also been recorded and it is thought that the microburin technique was predominantly used to manufacture convex-backed bladelets *sensu lato* and segments. Sari (2012; 2014) has observed that there is a good availability of raw material in the vicinity, suitable for producing bladelet blanks, and it is plausible that the hypothesised recycling of microburin products was not necessary at this site. Irrespective of this detail, most microliths are retouched along the left edge at Columnata, which is consistent with the pattern observed in the Upper Phase at Taforalt. A single radiocarbon determination on freshwater mollusc shells (*Unio*) of (Alg-97) 10,800 ± 425 BP (13,495-11,394 cal BP at 95.0 % probability) has provided a broad age for the assemblage, suggesting a dating towards the end of the Pleistocene (Brahimi 1970; Rahmouni / Roussillot / Armanet 1972).

A small assemblage has also been described from El Onçor (Bou Saâda, Algeria) (Heddouche 1977), which has been dated by a single radiocarbon determination on ostrich eggshell to (Gif-4433) 10,040 ± 190 BP (12,390-11,161 cal BP). The microlithic toolkit consists almost entirely of convex-backed bladelets *sensu lato* and straight-backed bladelets *sensu lato*, showing an affinity in the frequency of these types with the Upper Phase at Taforalt. The use of the microburin technique is also attested.

Many sites lacking radiocarbon dates have been subject to more detailed lithic studies and might also be related on techno-typological grounds to the Upper Phase at Taforalt, including the sites of Bou Aïchem (Goetz 1967), El Hamel (Tixier 1954), Oued Yquem (Collina-Girard 1988), Rhirane (Wengler / Wengler 1980) and Velozzo (Treinen 1975). Gragueb (1983) has also described a sub-group of the "Southern Tunisian bladelet industries", including Menchia, Aïn el Atrous, Mareth, Aïn Zigzou and Buttes d'Guettar, as being characterised by high frequencies of backed bladelets (70-90 %), that tend to be pointed straight-backed bladelets *sensu lato* and convex-backed bladelets *sensu lato*, with backing most often on the left margin (55-70 %) and formed by crossed retouch (c. 55 % of cases). This sounds strikingly like the description of the Upper Phase at Taforalt, although these industries have been considered distinct from the Iberomaurusian (Gobert 1962; Castany / Gobert 1954). Lubell et al. (1984) have previously highlighted that several regionally discrete entities follow the Iberomaurusian (e. g. Keremian, Columnatian, varieties of the Capsian) and have reasonably made the argument for increased regionalisation towards the end of the late Pleistocene. Certainly, subtle differences in the occurrence of particular microlith types (e. g. *Aïn Kéda* points, segments, triangles) might indicate some diachronic and / or regional variation amongst later contemporary assemblages.

13. ORGANIC ARTEFACTS

A. DESMOND

13.1 BONE INDUSTRY

The following will form a preliminary account of bone tools recovered from Iberomaurusian archaeological levels at Taforalt Cave, Morocco. Materials studied include bone tools excavated from 2003 to 2016 (n = 40), as well as a number of tools from excavations undertaken in the 1950s (n = 160). These tools will be analysed as a unitary group, as all were recovered from Grey Series units and all but two are associated with Iberomaurusian burial areas.

There exists a further published record indicating that 543 additional tools were recovered during excavations during the 1950s (Roche 1963). In addition to the 200 tools currently under study, this brings the total number of bone tools known to have been excavated from the site to 743. While only a subset of these tools remains available for study, the size of this subset alone represents the largest Palaeolithic North African bone tool industry recovered to date and indicates a numerous, widespread and well developed bone tool industry within the Iberomaurusian.

The study of these tools is the focus of an ongoing research project, aimed at examining the bone tools from a *chaîne opératoire* perspective. This analytical method seeks to understand tools from initial selection and creation, through to use and function, and finally to their eventual deposition and recovery as archaeological artefacts. As a part of this larger study, a number of methods will be used together to investigate different stages along this operational chain. The first stage of the *chaîne opératoire* will continue to be assessed through the use of ZooMS (zooarchaeology by mass spectrometry), in order to identify patterning in the taxa selected for tool construction (Desmond et al. 2018). How the tools may have functioned will be assessed through a comparative examination of tool microtopography. These can then be compared to use-traces found on ethnographic tools of known function, from geographically and technologically commensurate cultures (e. g. prehistoric groups from thermo-Mediterranean biozones, semi-sedentistic groups, groups which exploit similar food resources, etc.).

The current study describes an intermediate stage in the *chaîne opératoire* and details the development of a typological framework used to analyse the tools' individual and collective attributes. In deploying such a typology, it will become possible to assess repeatedly occurring size, shape and, in some cases, wear patterns, to examine the relationship of individual tools to the assemblage overall, and to determine whether the Iberomaurusians were engaged in the repeated production of specific industrial types. When features such as overall shape and wear patterning are combined with an examination of construction patterning (e. g. taxa selected for raw material) and use-wear correspondences among types, repetition in tools with like overall features can indicate the repeated construction of tools for particular purposes through time.

As such, the typological assessment of the tools described here represents a single methodological avenue among many, situated within a diachronic, life-history approach to the study of these tools. These descriptions do not represent the catalogue as an end-goal; rather, the following typology serves merely as a descriptive record, itself a platform for continued assessment of use-trace correspondences among like tools. These categorisations will form the basis for a synthetic research program which can demonstrate most likely specific uses for individual tools and tool-types, based on ethnographic analogy, and with the potential for an experimental programme. Following this, we wish to understand how these tools functioned as constituent components within a larger cultural complex, by attempting to situate tools within the larger themes of subsistence, craftsmanship, industry, practice, ideology and meaning. For example, if a number of tools are consistent with perishable-crafting activities, we might ask what this can tell us about the relationship between increasing sedentism and the emergent creation of perishable food collection, transportation, processing and storage technologies.

Reports from the Abbé Roche excavations undertaken at Taforalt during the 1950s indicate that 543 bone tools were recovered, the present location of which remains unknown (Roche 1963). Based on reconstructions of Roche's *Niveaux* system (in particular, its interpolation with the initial stratigraphic units of A, B and C; see **Chapter 2**), 206 tools (37.9 %) were recovered from interior parts of the cave, 139 (25.6 %), from the central parts and 198 (36.5 %) from the more exterior parts. Though the subset of 200 tools currently available for study were recovered primarily from burial areas, it should be noted that over 60 % of the Roche reported collection (present whereeabouts unknown) were present in the centre of the cave and near its entrance, positions to be expected from 'everyday' manufacture and use activities.

Additionally, those bone tools classed by Roche as 'points' in one form or another (e. g. *poinçons*, *alènes*, etc.) show an even greater bias towards the 'light zone' of the cave, where daylight would have made crafting and other activities practicable. Pointed tools occur in the highest frequency near the exterior of the cave (n = 108, or 47.3 %), followed by the middle of the cave (n = 64, or 27.9 %), with fewest found in the cave's interior (n = 57, or 24.9 %) (see **Chapter 2** on the spatial distribution of Roche's *Niveaux*).

Through an examination of such 'zones' of recovery, it may be possible to deduce where activities necessitating bone tools were likely to have taken place. For example, Roche recovered a total of 66 pointed bone tools from C_{av}/*Niveau C en avant*, a small area abutting the northern cave wall near the cave entrance (see **fig. 2.5c**). While the fact that these tools cluster near the cave wall may indicate a passive accumulation, the much higher frequency in occurrence here suggests that the manufacture and/or use of these tools was happening nearby, within probably the best-lit area of the cave. The presence of bone tools in great numbers outside burial areas necessarily informs the understanding of bone tools recovered within burial areas, and will be discussed further at the appropriate juncture.

Of the 200 tools currently available for study, 40 were excavated since 2003, during the current research programme. All but 2 of these (95 %) were excavated from Sector 10 (see **Chapter 15**). Two tools were also recovered from Sector 8, during the excavation of a molluscan column. In November 2016, a collection of previously unpublished tools (n = 161) was located in the Rabat Archaeological Museum, material which had been recovered during excavations at Taforalt in the 1950s. These are distinct from the collection of 543 tools reported in Roche (1963) and, like the post-2003 tools, were excavated primarily from burial areas (specifically *Nécropole I* and *Nécropole II*).

These tools were contained in 16 different boxes and, in some cases, provenience data were written on either the boxes or the tools themselves. Four of these boxes retain a written date of "1952" (boxes 4, 6, 12 and 14). Many annotations found on the outside of these boxes remain obscure, and may refer to a variety of stratigraphic references (see **Chapter 2**). Following annotations where "Sep" stands for *Sépulture*, seemingly indicating either single burial groups or wider zones within particular coarse stratigraphic units of the GS in the cemetery areas, and "N" for *Nécropole*, indicating a cemetery area, 13 of the 16 boxes containing bone tools indicate that they were recovered from such areas (boxes 7 and 8 were determined not to contain bone tools). In his writings, Roche defined two different cemetery areas; namely, N1 (or NI) in the main alcove and N2 (or NII) further west (deeper into the cave) (see **Chapter 15**). Of the 16 boxes, seven are associated with *Nécropole I* (boxes 1, 2, 3, 9, 10, 14 and 15a) and two are associated with *Nécropole II* (boxes 4 and 11). Additionally, five different boxes relate to specific burial groups, boxes 5, 9, 12 and 12a, are all associated with "Sep A" (the uppermost stratigraphic division). In total, these boxes attesting a direct relationship to burial areas account for 97 of the 161 total tools; however, this may be an underestimation, as the remaining 64 tools came from boxes which had either indeterminate or no provenience data.

Because the majority of the tool subset available for study was recovered from burial areas, it is tempting to ascribe these tools a ritual or symbolic function, and/or to presume their deliberate placement as grave goods. Distinctively modern ontological categories of 'symbolic' vs. 'utilitarian' notwithstanding, it is, at present, difficult to untangle whether those tools found in burial areas do consist of deliberately placed tools, whether they are accidental inclusions present in the burial matrix, or a combination of both. Among the 'missing' collection of 543 tools, the higher frequency in tools reported near the front of the cave in non-burial areas is suggestive. As sequential, intercutting burial episodes have been attested in Sector 10 (Humphrey et al. 2012), there is an indication that elements from previous burials were treated with care, and sometimes included in subsequent burials, placed to the side, etc. This suggests that burials were (at least initially) localised to a special, rear area of the cave, and due to the spatially delimited nature of the burial area, sometimes earlier burials were disturbed in the process of later ones. One obvious solution to this would have been to 'import' matrix from other areas of the cave; this could serve as a suspension medium for any new bodies being interred, and minimise the chances of disturbing earlier burials. That some Grey Series sediment was brought to Sector 10 for this explicit purpose is indicated by a number of other lines of evidence. For example, in the GS, Sector 10 contains no structures associated with habitation areas (hearths, etc.), yet the matrix does contain artefacts associated with living areas, workshop areas, processing areas, etc., in the form of burnt and unburnt animal bones, lithic debitage, charcoal, etc. It is extremely unlikely that these activities were taking place *in situ* in Sector 10; at the very rear of the cave, Sector 10 is the least-lit area of the cave and all such activities would have had to have taken place atop the burials. It is far more likely that some of the Sector 10 Grey Series sediment was brought in from other areas of the cave, in order to facilitate new burial episodes and minimise the disturbance of previous ones. As such, any small habitation or industrial related inclusions in the Sector 10 Grey Series must be considered 'imported'; this, of course, should include the possibility that some of the smaller bone tools came to be deposited in the same fashion. Nevertheless, preliminary ZooMS analyses have suggested the inclusion of some of these tools with specific burial episodes; for example, the placement of equid remains on the axial skeleton of Individual 1 (Desmond et al. 2018).

Furthermore, an initial analysis of the Sector 10 bone tools' spatial distribution appears to show that these do not form what we would expect from a passive accumulation, as evident, for example in "C_{av}/*Niveau C en avant*"; they do not cluster around the cave wall, but rather generally spread across the burial area. Again, this could indicate either their deliberate inclusion as grave goods, or their unintended presence in imported Grey Series matrix. What is not indicated by this pattern is that Sector 10 served as a bone tool workshop area. Research into the distribution of tools within burials in *Nécropoles I* and *II* is ongoing; until such a point, however, specific determinations about the inclusion of smaller tools as deliberate or accidental should be suspended. Further ZooMS research is currently underway, and this may shed light on a deliberate inclusion of tools created from particular taxa.

Methods and Terminology

In Palaeolithic North Africa, as elsewhere, bone tools have generally not served as diagnostic elements of technocomplexes; lithic technology has usually served to define cultural entities. Though bone tools are omnipresent in the world archaeological record, non-systematic descriptions and presuppositional, functionality-based characterisations of bone tools (e.g. 'needles' or 'arrowheads' to describe gracile pointed tools) have served to obscure their true functions, and have hindered comparability between collections, both on an inter-site and inter-industry basis. For this reason, this study uses a morphological, feature-based typology without resort to subjective categories (e.g. 'awls' or 'pins'). While a morphologically descriptive typology must be developed in order to assess tools' quantitative and qualitative attributes, this is undertaken only as a preparatory stage in order to facilitate a more broad *chaîne opératoire* understanding of tools, based on specific correspondences in construction and use-wear, rather than on general correspondences in overall size and shape.

The first step in developing a descriptive typology is to examine the tools physically, to create descriptive categories, and to use these to guide the collection of comparable quantitative and qualitative data. At present, few typological studies have been undertaken on North African bone tool technologies. One notable exception is the work of Camps-Fabrer, whose 1966 study analysed tools from a number of North African Palaeolithic sites, including Bou Zabaouine, Columnata, Afalou Bou Rhummel, Tamar Hat and a few tools from Taforalt, among others (Camps-Fabrer 1966). As had Roche (1963) originally, Camps-Fabrer assigned tools to different categories based on an assessment of functionality due to gross form, largely following the French prehistoric bone tool tradition (with categories including *tranchets*, *lissoirs*, *poinçons*, *alènes*, etc.) (Camps-Fabrer 1966, 51). Camps-Fabrer's work therefore provides a ready comparative study for interrogating typological correspondences, particularly between the European Aurignacian and Magdalenian and the North African Palaeolithic. Though some authors posit cultural and/or technological connections between the European and North African Palaeolithic, as yet no evidence has been found linking contemporary North African and French/European Palaeolithic technocomplexes (*contra* Ferembach 1962; Pallary 1909; etc.). For these reasons, we have chosen to develop an independent typological schema, rather than use Camps-Fabrer's (or Roche's) extant categorisations, which are themselves embedded in the study of the European Upper Palaeolithic.

In creating an analytical approach to tools from Taforalt, we have also chosen to eschew whole-tool typological descriptions, as most extant bone tool typologies use functional descriptors (e.g. awl, pin, polisher, etc.) as category names. These can serve to presuppose (and potentially obscure) individual tool functionality from a use-wear perspective, as tools are *de facto* presumed to have been used as members of their eponymous classes. Ethnographic and archaeological collections worldwide prove that a similarity in gross morphology often belies any similarity in use. Long thin pointed tools, classed together as 'needles', are shown to have specific applications, ranging from roof-thatching tools, to tools for threading fish, to spindles (Soffer 2004, 408). While initial typological categories must rely, to a certain extent, on overall shape and tool morphology, these typological categorisations will here serve only as a basis for assessments of tool functionality driven by use-wear criteria. It is our hope that the future application of associative statistics and/or cluster analyses to these quantitative and qualitative characteristics (such as degree of completeness, tip type, profile type, base type, size class, etc.) will eventually provide a firmer basis for apprehending correspondences and differences in use-wear patterning, and therefore functionality. This approach will also allow tools to be grouped inclusively, rather than solely by assigning each tool to one of a number of mutually exclusive type categories. This is important, as a single tool may display characteristics of more than one functional class (e.g. being both spatulate and pointed, incised and fragmentary, etc.). We use Douglas Campana's 1989 study of Natufian and Zagros Proto-Neolithic bone tools and Mark Newcomer's 1974 study of Natufian bone tools as the basis for much of the following typology. These studies have been chosen because they investigate transitional Levantine Epipalaeolithic bone tool technologies in many ways similar to the Iberomaurusian, and both studies include robust experimental components. The typological methods (and therefore results) employed here will also then be comparable with those describing many

Breakages	Category
Broken tip	Base fragment
Broken base	Point/ovoid/spatulate etc. fragment
Broken base and tip	Shaft fragment
Broken irregular/indeterminate	Broken end
With refitting breaks or without visible breakages	Relatively complete
No breakages	Complete

Tab. 13.1.1 Breakage categories.

pre-Neolithic Levantine bone tools. In the descriptions, rather than 'distal', 'medial' and 'proximal', we use the terms 'tip', 'shaft' and 'base' to refer to the ends and body of the tool (following Newcomer 1974, 141). The term 'tip' refers to the working end of the tool, the term 'base' refers to the held, hafted or otherwise articulated non-main working end, and 'shaft' refers to what otherwise might be considered the medial portion of the tool (between the base and tip).

Typological Categories

Degree of Completeness

In considering the tools, the degree of completeness of each tool is first assessed into a binary, as being either complete or broken. Next, examination is made of where the tool shows breakage(s): e.g. to the tip, base, etc. (**tab. 13.1.1**).

By using these categorisations, relevant data can still be extracted even from incomplete tools. For example, when calculating the average tip-diameter of pointed tools, complete, relatively complete, and point fragments shall all be considered. When determining the types and degrees of smoothing evident on bases, complete, relatively complete, and base fragments will all be considered. This allows for a more inclusive appraisal of individual features, without having to discount all but complete tools.

As many tools have elements which may not have been modified even at the time of their use (e.g. tools with a broken or anatomical base), these are categorised as 'relatively complete'. This category includes tools which do not display clear recent or taphonomic alteration (e.g. different colours, sharp angles, etc., at breaks), and may have functioned as tools in their current form. This also includes tools with indeterminate levels of completeness, such as weathered tools, and tools with re-fitting breaks which can be examined as though they were whole.

Points which show breaks only at the very point tip are also considered relatively complete, as their morphology, formation strategies, use-traces, etc., can all be examined given the extant tool, and size-categorisations will not be greatly affected. In these cases, however, tip-diameter cannot be assessed.

Size Measurements

Next, all tools are measured and their maximum length, maximum width and tip diameter (for points) are recorded. These measurements are taken on all complete and relatively complete tools, and these data are plotted in order to determine size-clustering of the tools and tool types. Measurements were taken using digital callipers at the longest/widest point for each tool. For points and point fragments, tip-diameter

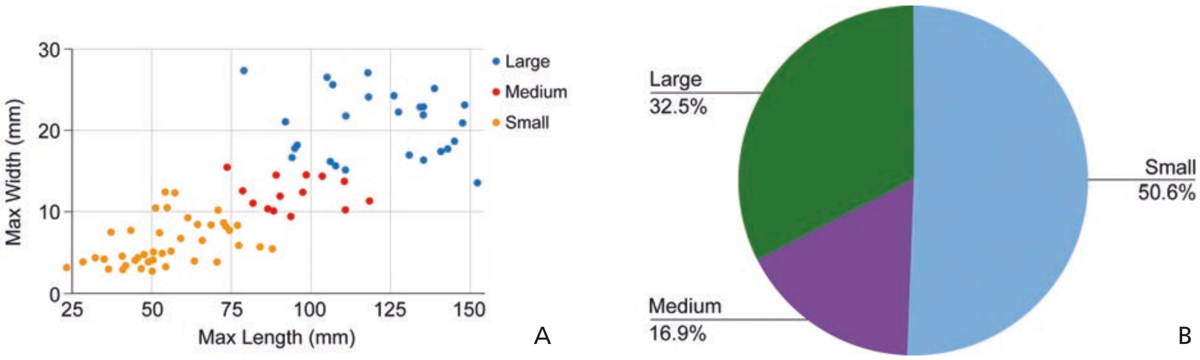


Fig. 13.1.1 **A** Complete tool size distribution plot; **B** Complete tool size-value determinations. – (After Desmond 2017).

measurements were taken in accordance with Campana's 1989 study of Natufian tools, in order that these data should be comparable between the two studies. Because of the nature of varied point-tip symmetries, shapes, etc., the tools were measured using digital callipers as close to the point-tip as possible, along the widest possible platform.

After determining the most prominent typological features among the tools, tool size can be plotted to uncover correspondences and patterning within and between different types. Here I use two different analyses: a basic length/width size plot (fig. 13.1.1A), and a surface-area proxy (here called 'size-value') (fig. 13.1.1B). Though all tools were measured, only complete or relatively complete tools are plotted for size (to the exclusion of all fragments) based on their maximum length and maximum width (fig. 13.1.1A). For figure 13.1.1A, size category determinations were constructed using the following criteria: small tools are considered as such if their length times width is 70 % or less of the average length times width, medium tools have size-values within 71 % to 129 % of this average, and large tools have size-values of 130 % or more of this average. As is evident from this chart, there exists quite a wide spread of tool-size, but most tools fall into the small size category. This is interesting, as, although larger tools are represented, their presence is not enough to pull the average size toward 'medium'. While this length times width value is a useful metric for constructing tool size categories, it does not give any idea as to the tools' surface area. For this reason, a size proxy for the surface area of each tool has also been created, using the square-root of maximum length times maximum width for each (fig. 13.1.1B) (following Hodgkins et al. 2016). While this size-value does not provide a mathematically exact representation of a tool's total surface area, it has the advantage of assigning each tool a single, individual size-value. This value can then be plotted and compared to the size-values of other tools and tool-types. At Taforalt, the average size-value for all 83 complete and relatively complete tools of all types is 30.99 mm. Here, surface area size-value determinations were constructed using the same criteria as size categories: small tools are considered as such if they have size-values of 70 % or less of the average (50.6 % of total); medium tools have size-values within 71 % to 129 % of the average (16.9 % of total), and large tools have size-values of 130 % or more of the average (32.5 % of total) (fig. 13.1.1B). Both of these analyses provide useful benchmarks in understanding the size and surface area of complete tools. When considering use-wear and functionality at a later stage, it is important to understand where an individual tool falls within a comparative size spectrum specific to that assemblage being examined. Understanding both tool size and rough surface area are crucial when attempting to understand correspondences between overall shape, formation strategy, and use-wear.

As pointed tools are the most numerous type at Taforalt, these were naturally included in the first size-distribution assessment. However, because of the great number of pointed tools (67.9 % of the total as-

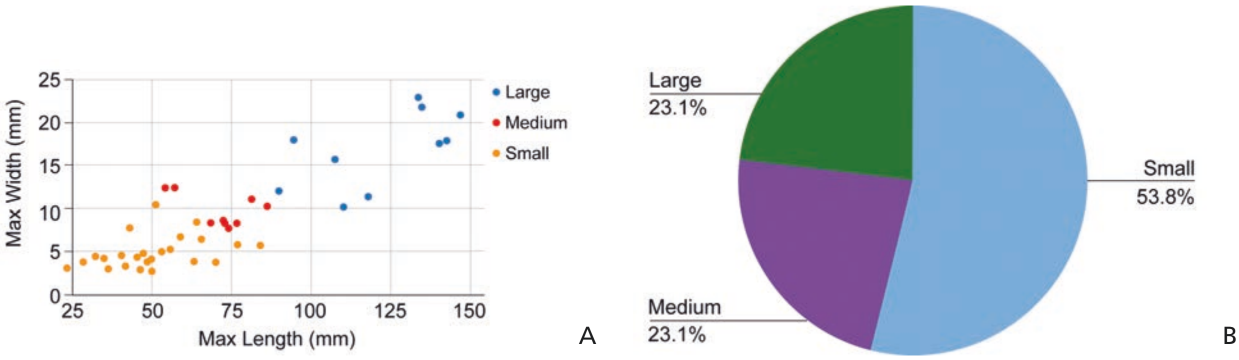


Fig. 13.1.2 **A** Complete point size distribution plot; **B** Complete point size-value determinations. – (After Desmond 2017).

semblage; see **fig. 13.1.7**), we have also established internally relative size groupings for pointed tools, to the exclusion of all non-pointed forms. As with the first size class assessment, only complete and relatively complete pointed tools have been considered. As **figure 13.1.2** illustrates, most points again cluster within the smallest size class and size-value, even when larger tool-types (e.g. spatulate pointed and metapodial pointed tools) have been included.

As in **figure 13.1.1**, these size category determinations were constructed using the following criteria: small tools are considered as such if they have size-values of 70 % or less of the average, medium tools have size-values within 71 % to 129 % of the average, and large tools have size-values of 130 % or more of the average (**fig. 13.1.2A**).

To determine an average surface area (or size-value) categorisation internal to pointed tools, size-value categories were again created using the square-root of maximum length times maximum width for each (**fig. 13.1.2B**). Small points are those tools with size-values of 70 % or less of the average (53.8 % of total pointed tools), medium points have size-values within 71 % to 129 % of the average (23.1 % of total pointed tools), and large points have size-values of 130 % or more of the average (also 23.1 % of total pointed tools). Here, it is interesting to note that, while small pointed tools are the dominant component of the assemblage, medium and large pointed tools both represent 23.1 % of total pointed tools (in contrast to large tools representing 32.5 % of the total overall assemblage; see **fig. 13.1.1B**). Future comparative use-wear studies must be based on comparison with ethnographic tools of a similarly small size. While not enough to determine specific tool uses, it is clear from size class data alone that the spectrum of possible functional categories for the smallest Taforalt points can be constrained.

Following points, the next most common tool characteristic is spatulate tools. All complete and relatively complete tools which can be classed as 'spatulate' (inclusive of spatulate ovoid, spatulate point, etc.) have been considered. This analysis was based on a total of 15 complete or relatively complete spatulate tools (15 % of total complete or relatively complete tools). Represented here are the proportions of small, medium, and large tools within the general length times width size categories (rather than surface area approximations/size-values) (**fig. 13.1.3**). Following points and spatulate tools, the next most numerous tool-categories contained less than ten elements, shown in **table 13.1.2**.

Shaft Types

All tools and tool fragments are then assigned a shaft type, consisting of one of the types shown in **table 13.1.2** and **figure 13.1.3**.

Metapodial tools (n=7)	• **7 large tools, 100 %**
Double-ended tools (n=6)	• 6 small tools, 100 %
Ovoid tools (n=5)	• 1 small tool, 20 % 4 large tools, 80 %
flat bevels (n=5) *see **fig. 13.1.8n**	• 4 small tools, 80 % 1 large tool, 20 %

Tab. 13.1.2 Size categories for other tool types.

Parallel (fig. 13.1.4a)	**Curved (fig. 13.1.4h)**
Parallel converging (**fig. 13.1.4b**)	Angled (**fig. 13.1.4i**)
Convex (**fig. 13.1.4c**)	Asymmetric angled (**fig. 13.1.4j**)
Asymmetric Convex (**fig. 13.1.4d**)	Asymmetric peak (**fig. 13.1.4k**)
Convex tapering (**fig. 13.1.4e**)	Steep mid-shaft angle (**fig. 13.1.4l**)
Concave (**fig. 13.1.4f**)	Asymmetric steep mid-shaft angle (**fig. 13.1.4m**)
Asymmetric concave (**fig. 13.1.4g**)	Irregular (**fig. 13.1.4n**)

Tab. 13.1.3 Shaft type.

Parallel n=8, 7.8 %	**Curved n=8. 7.8 %**
Parallel converging n=34, 33 %	Angled n=1, 1.0 %
Convex n=7, 6.8 %	Asymmetric angled n=11, 10.7 %
Asymmetric Convex n=6, 5.8 %	Asymmetric peak n=2, 1.9 %
Convex tapering n=6, 5.8 %	Steep mid-shaft angle n=1, 1.0 %
Concave n=2, 1.9 %	Asymmetric steep mid-shaft angle n=6, 5.8 %
Asymmetric concave: n=3, 2.9 %	Irregular n=3, 2.9 %

Tab. 13.1.4 Shaft type percentages.

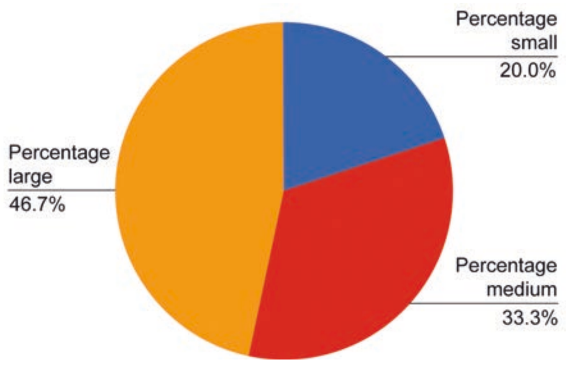


Fig. 13.1.3 Size categories for spatulate tools.

Here tools with a 'faintly x' profile have been grouped in with the general profile; for example, tools with a 'faintly concave' profile will be grouped with tools with a 'concave profile'. Though these types function as discrete categories, it is important to remember that similar or identical uses may produce different shaft types, and/or different uses may produce similar shaft types, in part based on the original morphology of the bone used and the degree of use. For example, concave (**fig. 13.1.4f**), asymmetric steep mid-shaft angle (**fig. 13.1.4m**) and asymmetric concave (**fig. 13.1.4g**) could be formed by similar kinds of use-wear, or may represent different use-wear stages for the same tool type. Since the true shape of a shaft type may not be evident in broken tools, only complete or relatively complete tools were assessed for diagnostic shaft-type (**tab. 13.1.4**).

Shaft types in themselves can reveal some information as to the nature of a tool's function. For example, tools with a marked shaft asymmetry can provide clues as to the direction-of-movement of the tool, if, for example, one side or edge is worn down more than another (assuming an initial symmetry in shaping). This can be borne out by an investigation of polish along the affected areas (with higher polish indicating more extensive use/handling), and/or the presence of lithic striations or undulations (discussed below). Considering the overall shape of a tool shaft is a crucial step in finding best-fit matches among ethnographic tool

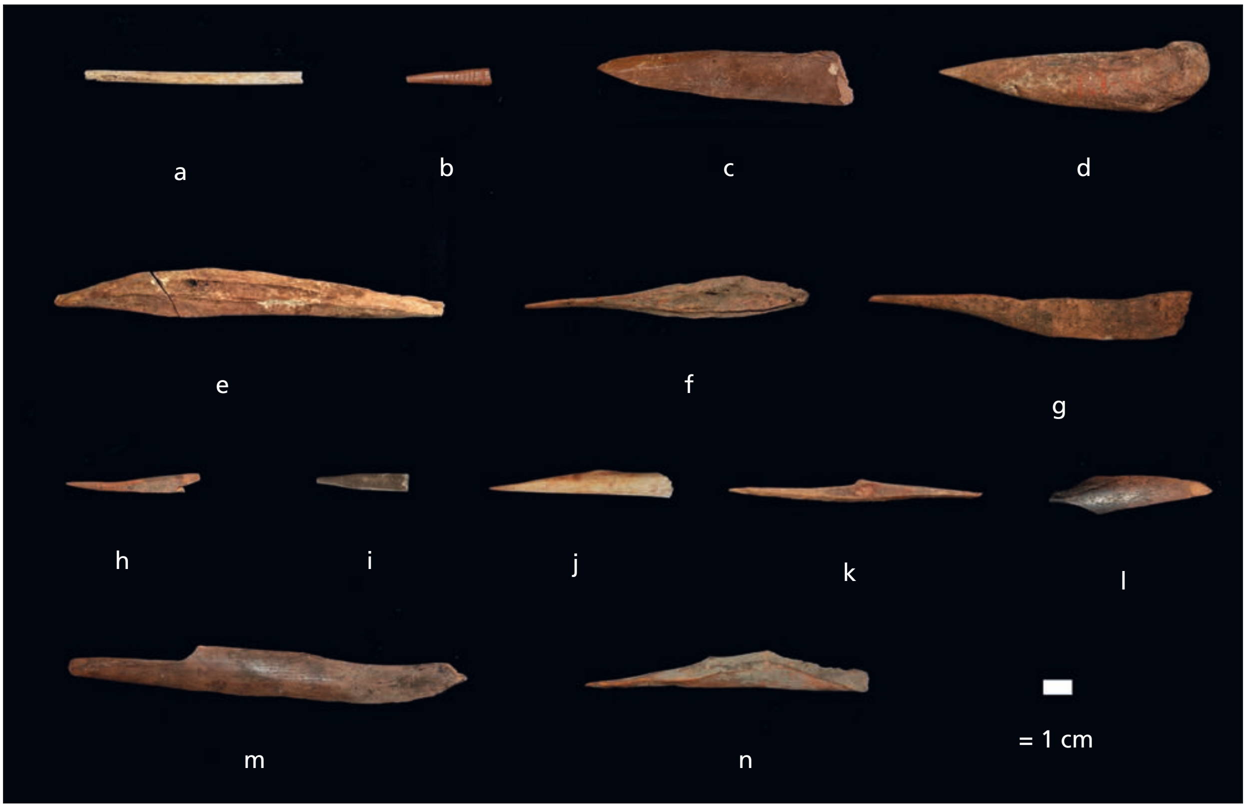


Fig. 13.1.4 Shaft type. – (After Desmond 2017).

Straight/non-undulating (fig. 13.1.5a)	Undulating (one side) (fig. 13.1.5c)
Faintly undulating (**fig. 13.1.5b**)	Undulating (**fig. 13.1.5d-e**)

Tab. 13.1.5 Shaft profile.

Fig. 13.1.5 Shaft profile. – (After Desmond 2017).

collections, as the location and degree of wear (e.g. polish to the tip end only or along the whole tool) affect the entire shaft profile, and can demonstrate concentrated and/or diffuse use foci along the tool's shaft.

Shaft Profile

Following shaft type, all tools are assessed for their shaft profile, and grouped into one of the categories shown in **table 13.1.5** and **figure 13.1.5**.

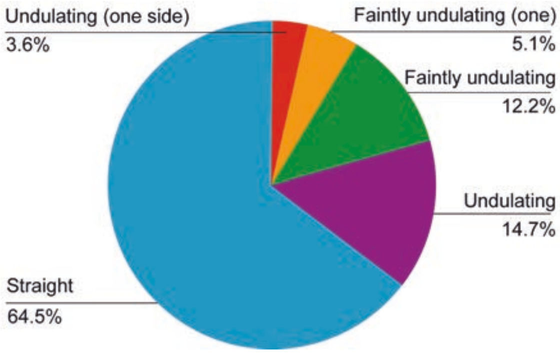


Fig. 13.1.6 Shaft profile percentages for all types, complete and fragmentary.

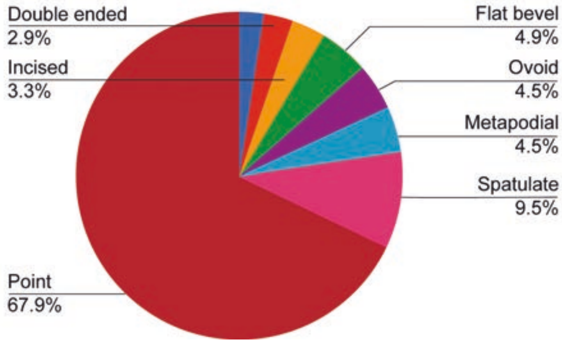


Fig. 13.1.7 Inclusive types.

The profile of the tool shaft (straight/undulating) may also offer clues as to the tool's degree, stage and manner of use. Undulating profiles occur when a tool's natural morphology or breakages have been smoothed over, rounded and/or obliterated, indicating lithic shaping or long-term repeated use. Manner-of-use categories in tools with undulating profiles can also be inferred, because, in order to gain this profile, they must be continuously abraded against a material softer than bone (e.g. repeatedly passed through a softer yielding material), held in the hand, etc. Undulating profiles can also be a product of lithic (re-)sharpening (Newcomer 1974; Campana 1989). In cases where the tool was deliberately shaped or reshaped, longitudinal lithic striations will be visible; if lithic striations are obliterated/not present, the tool can be inferred to have long-term repeated articulations with a material softer than bone (Campana 1989). At Taforalt, 35.3 % of tools exhibit some degree of undulation, ranging from faint to strong undulation (**fig. 13.1.6**).

While the lack of an undulating profile does not preclude re-sharpening and re-use of tools, the presence of undulations is an excellent indicator that a tool has been smoothed through repeated use, lithic re-sharpening or a combination of both. For example, a bone tool which was shaped from a splinter with irregular edges will, through repeated contact with material softer than bone, display smoothing and rounding of these irregular edges consistent with an undulating profile. Undulation then is a useful criterion in determining the stage of a particular tool's use, as it implies long-term and repeated articulations with a material softer than bone (e.g. hand-held uses) and/or, in the case of lithic re-sharpening, the deliberate curation of tools. There is an observable difference between initial shaping and resharpening of used bone tools: for example, the presence of polish and/or use wear obliterating and/or overlying lithic scraping striations (e.g. striations seeming to 'fade' into polish) indicate that the tool has been used since it was initially shaped.

When imparted as a result of longitudinal lithic scraping, undulating profiles can appear in the form of chattermarks. These are visually distinctive and, according to Newcomer (1974, 149):

> [...] chattermarks seem to be caused by the stone tool bouncing over uneven parts of the bone surface and thus failing to maintain contact with the bone throughout its sweep. An analogous situation occurs on unmetalled roads, which inevitably develop ruts, and corrugations perpendicular to these ruts through the failure of passing vehicles wheels to maintain constant contact with the road's surface.

Discrete and Inclusive Types

Once measurements, degree of completeness, shaft type and shaft profile have been assessed, the gross form of the tool will be typed as a member of one of the discrete categories listed below. These categories, however, do not preclude inclusive analyses of individual features, wherein all tools exhibiting a certain charac-

Point	Point: n = 64, 32 % Point fragment: n = 37, 18.5 %
Incised	Incised: n = 2 Incised point: n = 2, 1 % Incised hollow: n = 4, 2 % Incised irregular: n = 1, 0.5 % Incised shaft fragment: n = 1, 0.5 %
Flat bevel (those tools with a flattened platform at tip)	Flat bevel: n = 5, 2.5 % Flat bevel fragment: n = 4, 2 %
Ovoid	Ovoid: n = 5, 2.5 %
Metapodial	Metapodial point: 4, 2 % Metapodial flat bevel: n = 1, 0.5 % Metapodial fragment: n = 6, 3 %
Spatulate	Spatulate: n = 3, 1.5 % Spatulate point: n = 7, 3.5 % Spatulate flat bevel: n = 1,0.5 % Spatulate point fragment: n = 3, 1.5 % Spatulate ovoid: n = 5, 2.5 % Spatulate ovoid fragment: n = 1, 0.5 % Spatulate shaft fragment: n = 3, 1.5 %
Double ended	Double ended: two points: n = 2, 1 % Double ended: one point one flat bevel: n = 1, 0.5 %
Irregular	Irregular: n = 2, 1 % Irregular point: n = 1, 0.5 % Irregular fragment: n = 1, 0.5 % Irregular: tooth: n = 1, 0.5 %
Indeterminate	Point or double ended: n = 2, 1 % Point/double ended fragment: n = 2, 1 % Base/shaft fragment: n = 1, 0.5 % Flat bevel/shaft fragment: n = 1,0.5 %
Shaft fragment	Shaft fragment: n = 18, 9 %
Base fragment	Base fragment: n = 11, 5.5 %

Tab. 13.1.6 Percentages of discrete types.

teristic (e.g. 'pointed tools') are considered together (e.g. spatulate pointed, point fragment, irregular point, etc.). Though there exists a wider spread of potential categories (e.g. ovoid fragment), only those categories represented within the Taforalt data-set are included. Here tools are assigned to either the 'parent' category (e.g. 'spatulate') or to a relevant descriptive sub-category (e.g. 'spatulate flat bevel') (**tab. 13.1.6**).

From these data, it is clear that most of the discrete types only contain a few elements, with points, point fragments, shaft fragments and base fragments accounting for nearly 65 % of total tools. While types containing only one element may have the potential to be diagnostic (for example, were we to find a harpoon, this would be fairly clear), those represented here are not, and as such the study of categories with few elements (one or two) will be left until later.

Within this discrete categorisation, we separate tools which possess more than one diagnostic feature (e.g. spatulate points), and group them in a qualitative way as members of the category which describes their most 'prominent' feature (e.g. metapodial flat bevels are classed as metapodial tools, rather than as flat bevels). This necessarily prevents tools being considered as members of more than one category. For this reason, an inclusive attribute typology has also been created, wherein a single tool may be counted in multiple attribute categories at once. For example, in this inclusive attribute typology, a spatulate point would be

Category	Subtypes
Symmetrical	Symmetrical pointed (**fig. 13.1.8a**) Symmetrical rounded (**fig. 13.1.8b**) Symmetrical gouged (**fig. 13.1.8c**) Symmetrical rounded gouged (**fig. 13.1.8d**) Symmetrical irregular (**fig. 13.1.8e**)
Acute	Acute pointed (**fig. 13.1.8f**) Acute rounded (**fig. 13.1.8g**) Acute rounded gouged (**fig. 13.1.8h**) Acute irregular (**fig. 13.1.8i**)
Obtuse	Obtuse pointed (**fig. 13.1.8j**) Obtuse asymmetric (**fig. 13.1.8k**) Obtuse rounded (**fig. 13.1.8l**) Obtuse gouged (**fig. 13.1.8m**)
Flat bevel	Snapped (**fig. 13.1.8n**)
Spatulate	Convex spatulate (**fig. 13.1.8o**)

Tab. 13.1.7 Point types.

Triangular n = 12 (**fig. 13.1.10a**)	Minimally modified n = 43 (**fig. 13.1.10f**)
Angular n = 10 (**fig. 13.1.10b**)	Intact anatomical n = 14 (**fig. 13.1.10g**)
Ovoid n = 12 (**fig. 13.1.10c. d**)	Flattened n = 6 (**fig. 13.1.10h**)
Irregular n = 8 (**fig. 13.1.10e**)	

Tab. 13.1.8 Base type counts.

grouped with both 'spatulate' and 'point'. Though some tools will be counted more than once, this allows for more robust comparisons to be made among tools with like features (**fig. 13.1.7**).

This kind of analysis allows trends across otherwise discrete types to become much more clear. From most to least common, the most prominent features of tools from Taforalt are: pointed, spatulate, metapodial, ovoid, flat bevel, incised, double-ended, and irregular.

Point Type

Points, flat bevels (tools with a flattened platform at the point tip; see **fig. 13.1.7n**), and spatulate points (and fragments thereof) are then further classed by point type, based on their point-tip profile. This category considers only the very tip of the point, as the tool itself may have concave, convex or irregular sides, faces or edges (accounted for in the shaft profile). Though other point-type combinations are possible, only those categories represented within the Taforalt data-set are listed in **table 13.1.7** and **figure 13.1.8**.

As with shaft type, these categories may represent different stages of use within the same manner of use, or differences may be due to repurposing, sharpening, etc. There may be correspondences across types as well; for example, 'acute pointed' (**fig. 13.1.8f**) and 'obtuse pointed' (**fig. 13.1.8j**) may have effectively served the same purpose, and similarly 'symmetrical rounded' (**fig. 13.1.8b**) and 'acute rounded' (**fig. 13.1.8g**).

The notion that tools served a singular purpose within their life must also be avoided; along with re-purposing, it is possible that an individual tool could have served many different functions, both synchronically

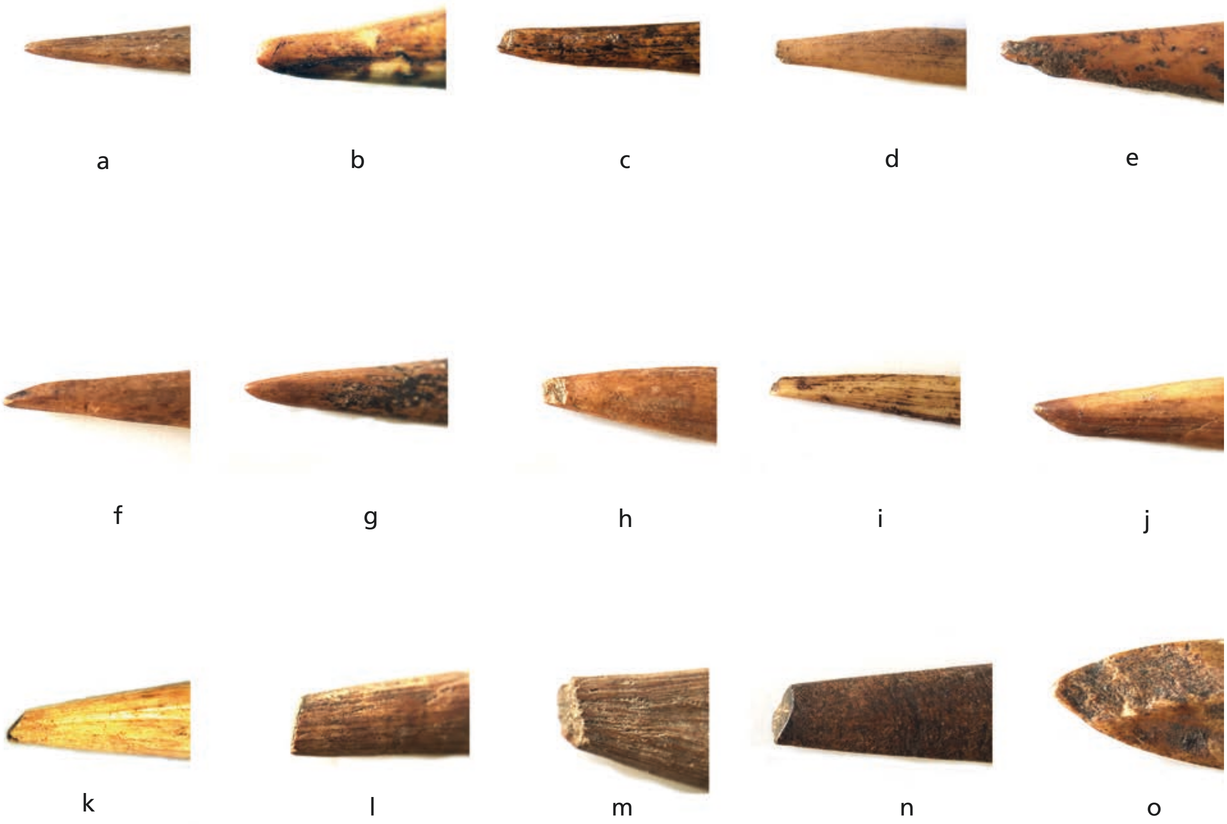


Fig. 13.1.8 Point types. – (After Desmond 2017).

(e.g. using a thin tool as a convenient toothpick) and diachronically (a tool used for one purpose becomes better suited for another purpose as it is used). However, using these data to track correspondences between tip-type and other tool features may allow for an understanding of congruences between different forms, morphologies and kinds of use wear, and, as such, is considered a useful typological metric. Since in most cases the working-end (or tip) of the tool manifests the bulk of the information relating to use, these categories have been expanded to include more types rather than less, in order to get a higher resolution picture of correspondences between tip-type and other tool features. The results of this analysis are as follows (**tab. 13.1.8**, with cross-references to the photographs in **fig. 13.1.8**).

For pointed tools, the most common tip-type is 'symmetrical pointed', normally considered a true point. Not all symmetrically pointed tips however are perfectly sharp; the tip-diameter and roundedness of the point tip should be viewed on a continuum and as potentially representative of different stages of use (e.g. Campana 1989, 69).

Though different tip-types could represent tools of a similar utility in different stages of use, tip-type is still a useful descriptive category, in that it can be combined with other evidence of long-term, repeated use (e.g. an undulating shaft profile, a high degree of polish, a very smoothed base, etc.) to provide evidence for tool creation, curation and use patterns. Diagnostic tip-wear patterns, such as the 'rounded gouge' considered later, may also be indicative of specific functions and we can search for similar distinctive trace markers among ethnographic tools.

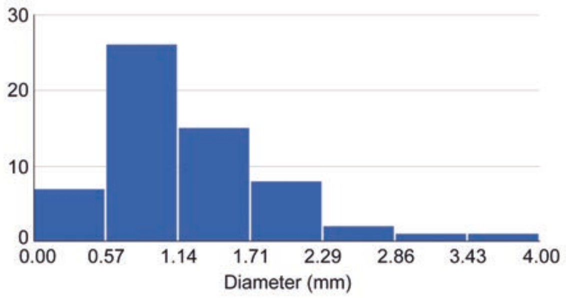


Fig. 13.1.9 Point tip diameter counts.

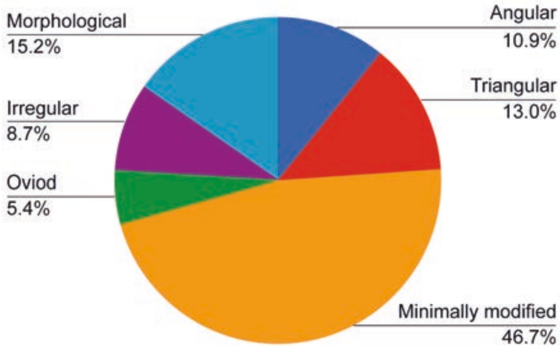


Fig. 13.1.11 Base type percentages.

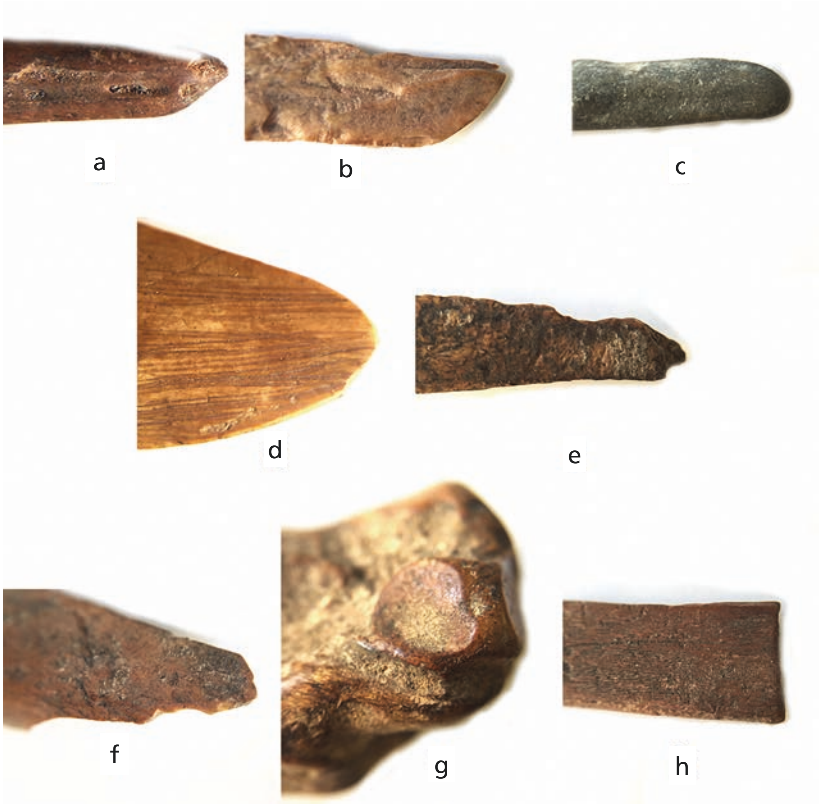


Fig. 13.1.10 Base types. – (After Desmond 2017).

Tip Diameter

Another useful tool for understanding potential uses of pointed implements is to measure the tip diameter. Experimental studies have shown that among pointed bone tools, different tip diameters are suited to different practices; for example, point-diameters above 2 mm are not effective in the penetration of leather (Campana 1989, 57). Tip diameters were measured on a sample of 60 implements with intact points; the average tip diameter is 1.26 mm, with the distribution of tip diameters as shown in **figure 13.1.9**.

As this chart shows, the most common tip-diameter range is between 0.5 mm and 2 mm, which account for just over 88 % of all tools measured. These data underline the trend in small features, size-classes, etc., among points, indicating that these gracile bone points generally had very small tips as well. Clues as to function are further indicated through use-wear present on the tools' tips, discussed at a later stage, which suggests that these were not sharpened to a fine point and then abandoned before use. In order to address the potential for equifinality, however, the only way to investigate particular functionalities is through an examination of use-wear. Though a small point tip size is suggestive, it is the presence of wear to the tip which will suggest specific functions, whether in crafting, weaving, hideworking, projectile use, or otherwise. Tip-diameter data taken together with forthcoming microscopy and micro-topographic analyses may help to uncover specific size-class, point type, point-diameter and use-wear patterning, revealing the presence of repeated industrial types with similar use-wear through time.

Base Type

Next, complete tools, relatively complete tools anf base fragments are categorized by base-type. Along with a tool's working end/point, shaft, and shaft profile, this allows for the presumed 'base', or non-main working end of the tool, to be analysed. This category describes the shape of the base when (if applicable) the tool is lying on its widest side (**tab. 13.1.8** and **fig. 13.1.10**). This represents solely a categorisation based on overall shape, and yielded the results shown in **table 13.1.8** and **figure 13.1.11**.
That the most numerous category among base types is 'minimally modified' is perhaps no surprise; it is this feature, in large part, that allows us to identify the (opposed) working end of the tool. However, correspondences between base type and point type, or base type and shaft type, may be revealed under a more thorough examination of use-wear. For example, tools with an unmodified base and an irregular shaft are less likely to show use-wear on the base end, indicating that the working portion of the tool was highly concentrated at the tip, or in some cases extending no more than halfway down the shaft. Tools which were only used at the tip eliminate a number of potential uses, and, when combined with an examination of use-wear patterning, may suggest specific uses.

Base Smoothing

After the shape of the base has been assessed, we then categorise tools by the degree of smoothing or polish present on the base. Smoothing at the base is a meaningful feature of tools, as it may indicate the stage of use (e.g. from faintly smoothed/less used to very smoothed/highly used). Smoothing and/or polish specifically were not assessed for the tips of the tools; as the tips are the 'working end' of the tool, it is to be expected that they will exhibit use wear here. Smoothing/polish on the base, however, may provide clues as to how the tool was engaged during use, with significant smoothing indicating repeated abrasive contact with a material softer than bone, and can be a good indication of hand-held uses (Campana 1989, 68). We have chosen to examine for 'smoothing' rather than 'polish', as tools which exhibit very smoothed bases may not exhibit polish due to the nature of the bone (e.g. cancellous or spongy), weathering, differential cleaning techniques or the base being obscured by matrix/concretions. In order to assess this, tools have been classed into three categories based on base-smoothing (**fig. 13.1.12**).

- Faintly smoothed (**fig. 13.1.12b**)
- Moderately smoothed (**fig. 13.1.12c**)
- Well smoothed (**fig. 13.1.12d**)

Tools with a well-smoothed base may in some cases have been double-ended tools, although, unless an equal amount of diagnostic use-wear is present at the base of the tool, it will not be typed as such. As a

Fig. 13.1.12 Base smoothing. – (After Desmond 2017).

result, the number of double-ended tools may be an underestimation. Degrees of smoothing may also indicate different stages and/or degrees of use, and as such, tools with different degrees of smoothing on the base should not necessarily be considered to have been used in different ways. For example, tools with well-smoothed and faintly-smoothed bases may have been used the same way, and exemplify different stages of wear imparted by the same function, rather than different uses.

In order for tools to have been classed as possessing 'faintly smoothed' bases, these tools must display more roundedness and/or polish on the base than do tools examined as unmodified taphonomic control samples (e. g. **fig. 13.1.12a**). Photos of these control samples show the degree of rounding that one might expect to occur on unmodified animal bone excavated from the same or neighbouring archaeological contexts. Since some unmodified faunal controls show incipient rounding (assumed to be post-depositional), a slightly more advanced (yet still 'faint') degree of rounding has been taken as the threshold for recognition as an artefactual effect here. The degree of smoothing on base types is shown in **figure 13.1.12**.

As this chart shows, the degree of smoothing when all tool bases are considered together is almost equally distributed between the three categories. We can further examine degrees of base smoothing by tool-type, to see if this internal ratio holds true among different tool-classes, particularly points (**fig. 13.1.13B**). Among points, a different patterning of abrasion to the tools' bases emerges. Here, faint smoothing is present on 39.4 % of tool bases, moderate smoothing on 18.2 %, and well smoothed bases are evident on 42.4 %. Clearly there is a visibly higher percentage of well-smoothed and faintly smoothed bases among pointed types, and this may be an indication of different curation of pointed tools (e. g. used for longer durations) and/or an emphasis on hand-held uses among tools with these attributes.

The presence of different degrees of base smoothing demonstrates that the tools at Taforalt likely represent different 'life' stages of tools with similar uses. Among tools with hand-held uses, faint smoothing at the base of the tool can be an indication of earlier stage uses, where the abrasive, repeated contact of the hand in using the tool has only begun to wear-down the tool's base. This logically exists on a continuum with later-stage tools, which would themselves display heavily smoothed bases; these tools may also display other signs of heavy use and/or curation in the form of an undulating profile, high all-over tool polish, a rounded or re-sharpened tip, etc. While this analytical stage merely represents an assessment of particular attributes extant among Iberomaurusian bone tools from Taforalt, it is still possible to detect a number of use-stages among tools which likely served similar functions. The next research stage will be to identify ethnographic tools with like morphologies, which may have had analogous functions. The specific use-wear imparted as micro-typography through performing specific tasks (e. g. in piercing hides, crafting basketry, etc.) can then be identified, and an assessment of similar functionality can be further constrained through the comparison of archaeological and ethnographic tools with similar overall morphological attributes. Even in this initial comparison of size-class, shape, tip-type, base-type, base smoothing and undulating profiles, there are clear indications of long-term, repeated technological traditions present in the bone tool assemblage.

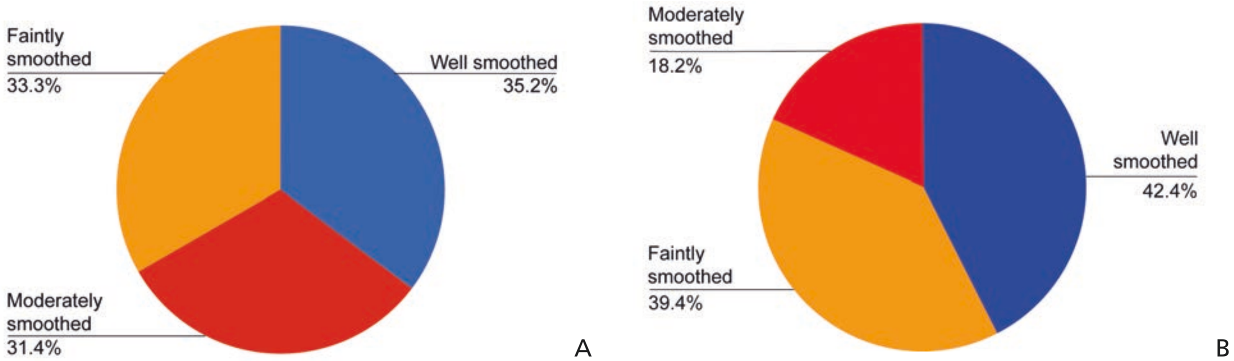
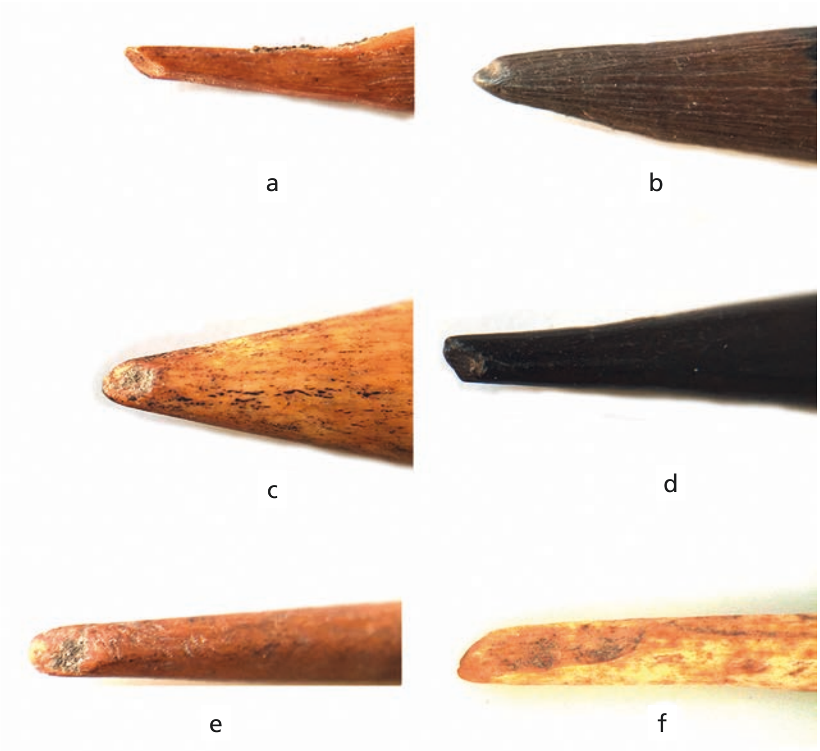


Fig. 13.1.13 Base smoothing percentages: **A** all types; **B** points.

Fig. 13.1.14 Rounded gouges.



Emergent Typological Categories

One of the benefits of using an assessment of individual tool attributes rather than an eponymous functional-based typology (with categories such as 'pins', '*lissoirs*', etc.) is that unique features of the collection can be described as they emerge. In this way, features which would not be accounted for under prefabricated typological schema can be considered, classed, and used to direct later stage use-wear investigations. At Taforalt, a number of pointed tools retain distinctive use-wear to the point-tip in the form of a rounded gouge or divot (**fig. 13.1.14**). This repeatedly occurring use-wear element is evident as a smoothed-over hollow, appearing at one side of a point-tip. While it remains possible that these represent slightly broken points which have subsequently been worn (because the overall point was still functional), or a concavity attributable to the interplay between stresses and bone structure, they may also represent a specific, repeated manner/gesture of use associated with a particular function.

Fig. 13.1.15 Incisions and transverse use-wear: **d. g-k** incisions; **a-c. e-f** transverse use-traces.

Rounded gouges appear on 13 complete, relatively complete or point fragment tools. While the origin of this hollow is as yet obscure, this pattern may be identified on ethnographic tools of a known function, and determined to be likely a product of broken tip wear, natural mechanical stressors, or a specific and repeated bone tool functionality in place at Taforalt during the Iberomaurusian.

Furthermore, a number of tools at Taforalt have distinctive macroscopic transverse striations, either in the form of use-wear visible to the naked eye (**fig. 13.1.15a-c. e-f**) or intentional decorative/functional notching (**fig. 13.1.15d. g-k**) to the tools' shafts. In these cases, transverse use-wear occurs in the form of scratches, incisions, scoring, etc., perpendicular to the tool's main axis. Transverse use-wear is particularly useful, as it can indicate a working direction-of-movement inconsistent with longitudinal uses (e.g. a piercing-motion), and can serve as evidence for more complex articulations with other materials (e.g. crafting). In some cases, such macroscopically visible transverse wear may represent a later use-stage, where a tool has been abraded long enough to produce deep, visible striations. It is important therefore also to look for smaller, micro-topographical transverse scratches, which may be indicative of an earlier use-stage. Incised tools also provide important data relating to use and/or function. In future use-wear analyses, an attempt will be made to distinguish decorative incisions from notching related to functional uses (e.g. hafting), based on high magnification microscopy, comparative assessment with ethnographic bone tools and, potentially, an experimental programme.

Preliminary naked-eye and low magnification microscopic assessments revealed this kind of use-wear on a total of 27 tools from the categories shown in **figure 13.1.15**.

It is interesting to note that transverse use-wear appears on almost every tool type evident at Taforalt, from points to ovoid tools to spatulate tools. This is crucial in the understanding of each of these types' uses, as use-wear may only be evident on tools at a later 'life' stage (e.g. more heavily used), may be obliterated by the nature of the worked surface (e.g. polish may obscure fainter use-trace evidence) or in curation of the tools (e.g. lithic resharpening). The specific location, angle, and degree (e.g. diffuse, clustered) and nature of this use-wear also provide a much stronger platform for comparison with ethnographic tools.

Discussion and Conclusions

As a typological description of the Iberomaurusian bone tools from Taforalt cave, this study aims merely to provide a preliminary description of the 200 tools currently available for analysis. This was done in order to develop a record of the patterning of specific tool attributes and features, so that these can inform future taxa selection and use-wear investigations. These data can provide a basis for assessing typological use-wear patterning, which will then be compared with ethnographic wooden and bone tools (after Soffer 2004). As such, the goal in collecting and extracting patterning from these data is not merely to type the tools but also to allow for coherent comparisons of inter- and intra-assemblage use-wear patterns (such as whether transverse use-wear occurs only on tools of a certain size class, whether tools from geographically proximate sites show the same repeated types, etc.). While individual data-sets (like size-class) cannot enumerate specific functions, they do eliminate certain functional possibilities, and constrain comparative analyses to ethnographic tools exhibiting like features. Patterning in size-class does reveal a concerted technological strategy at Taforalt; the repeated construction and use of implements with a specific shape and size suggests a well developed bone tool industry, rather than an opportunistic and haphazard use of bones as tools. It also suggests use-based, repeated articulations through time and space; whatever process(es) imbued tools with the specific macro-wear patterning seen here, it can be said that these processes are industrial, repeated undertakings rather than one-time extemporaneous occurrences. This is bolstered by data gleaned from ZooMS testing, which suggests that specific and less-common taxa are repeatedly selected for the construction of particular tool types (Desmond et al. 2018).

Points are the most numerous type evident within the Taforalt tools. A basic trend in size-patterning shows us that points are overwhelmingly 'small' when compared to other elements of the bone tool assemblage (**fig. 13.1.2**); however, size and shape are not enough to suggest functionality among these tools. Based on size and shape alone, the point assemblage from Taforalt matches the dimensions of South African bone arrowheads, as well as bone awls from Prehistoric Missouri (Bradfield/Lombard 2011, 69; Chomko 1975, 34). For this reason, it is necessary to look for indications of use on the tool itself. The presence of polish on the base (indicative of long-term repeated handling and/or use; see Campana 1989, 131), tip-ends displaying rounding, and the absence of diagnostic impact fracturing (e.g. Letourneux/Pétillon 2008; Bradfield/Lombard 2012; etc.) suggest that this was likely not a projectile-focused industry. Future micro-topographic analyses will further bolster the understanding of these types by examining minute use-wear traces, and either refute or substantiate particular functional uses (e.g. as projectile-points), based on comparisons with ethnographic collections exhibiting like features (e.g. tools with similar size-ratios, profiles, bases and tips, tip points, polish, etc.).

Points and point fragments also, therefore, comprise the most common type represented in exclusive categorisations, wherein each tool is counted as a member of a single class. Points and point fragments account for 101 out of 200 total elements, or 50.5 % of the total assemblage. The next most common types are shaft and base fragments, which account for 29 out of 200 total elements, or 14.5 % of the total assemblage. However, because base and shaft fragments lack a diagnostic tip end, points could in fact represent up to 65 % of the total assemblage (if all base/shaft fragments were originally pointed tools).

Moreover, other tools with a pointed tip (such as metapodial and spatulate pointed tools) were not classed as 'points' within the exclusive type categorisations, indicating a further potential for underrepresentation. The third most numerous tool category (spatulate points) accounts for only 7 elements out of 200 (or 3.5 % of the total assemblage). The fourth most common exclusive type (metapodial fragments) accounts for 6 elements, comprising 3 % of the total assemblage. Each of the remaining exclusive type categories have less than 5 elements each, and individually represent less than 3 % of the total assemblage. Exclusive tool categories are useful in determining the overall industrial focus of a given assemblage; at Taforalt, this clearly seems to have been the production of pointed tools. However, classifying the tools within an inclusive typology is also useful. Within an inclusive typology, a single tool may be counted multiple times; however, this analysis effectively circumvents the over- or underrepresentation of specific tool features that arise as a result of assigning individual tools to exclusive categories. Here again, tools with a pointed element dominate the assemblage, representing 67.9 % of inclusive tool types. The next most commonly recognised feature is tools which are spatulate, representing 9.5 % of inclusive tool types. Even within an inclusive appraisal of features, all other types each represent less than 5 % of the total assemblage. This underlines the results from exclusive typologies; namely, that pointed tools overwhelmingly dominate the Taforalt assemblage.

In addition to individual features (e. g. pointedness, shaft shape, etc.) represented on a given tool, size plays an important role in constraining the potential uses of the bone tools considered here. In an assessment of all complete or relatively complete tools of all types, the average length is 83.4 mm, and the average width of a tool is 11.9 mm. These provide an average 'size-value' of 31.5 mm. This average size-value can be used to plot the relationship of an individual tool or group of tools to the assemblage overall. For example, it is clear that pointed tools have smaller overall size-values than the average of all types; pointed tools have a smaller average length (71.6 mm) and an average width (8.65 mm).

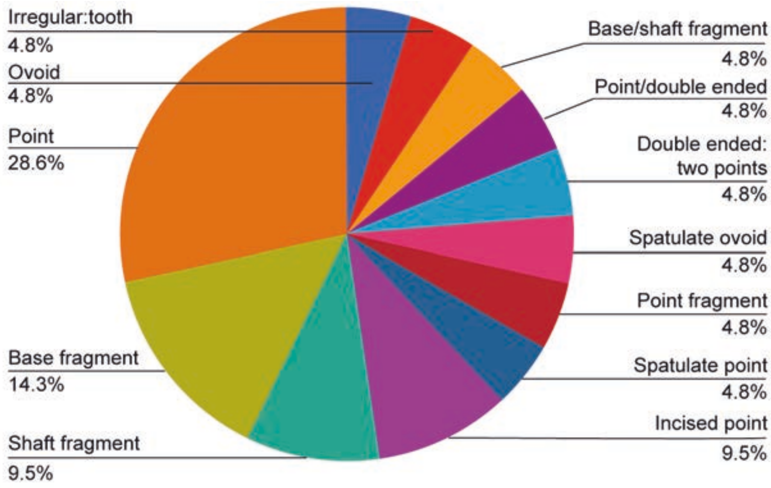
Furthermore, this categorisation includes the potentially larger pointed metapodial tools and pointed spatulate tools, indicating an industrial emphasis on the creation of small, gracile pointed tools.

It is therefore prudent to examine what exactly constitutes a 'point'. The most obvious way to assess this is by looking at the point-tip itself, and attempting to characterise differences which appear here (**fig. 13.1.8**). Among pointed tools, the most common point types are as follows:

- Symmetrical pointed: 28 %
- Symmetrical rounded: 19.5 %
- Gouged: 11.9 %
- Acute rounded: 11.9 %
- Snapped (flat bevel): 10.2 %
- Acute pointed: 5.1 %

Other point types do exist, but each accounts for less than 5 % of the total. As discussed previously, diverse point types may be the result of similar to identical uses, merely representing different stages of use or idiosyncratic use (e. g. individual handedness, technique, etc.). For this reason, it is also informative to collapse these refined categories into broader ones. One example of this is points which display a degree of smoothing / roundedness; this in turn indicates repeated abrasive articulation with materials softer than bone. Such point types include symmetrical rounded, acute rounded, obtuse rounded, snapped, and convex spatulate points, which together account for 46 % of pointed tools. As smoothing and roundedness only develop at a sufficiently advanced stage of use, some of the remaining tools may have been used for similar or identical functions but were simply lost / deposited at an earlier stage of use. Furthermore, tools may have been resharpened to re-establish an effective point; this would have obliterated any rounding or polish which had previously accrued through use.

Fig. 13.1.16 Transverse use-wear by type.



The diameter of individual point-tips can be useful in exploring what functions these tools could have effectively served. For example, point tips with diameters greater than 2 mm have been experimentally shown to be ineffective in the penetration of leather (Campana 1989, 57). At Taforalt, tools with tip diameters between 0 and 2 mm account for 88.3 % of pointed tools, tools with tip diameters greater than 2 mm account for 11.7 %, and the average tip diameter of pointed tools overall is 1.26 mm. So far, we see that most tools are small, pointed, and have point-tip diameters of around 1.26 mm. These data suggest that a likely utilisation in refined mechanical tasks which would necessitate such gracile tools, and eliminate other functional purposes, such as functions involving torsion or forceful impacts (e.g. as tools used as chisels, prises, etc.), which would certainly have left an archaeological signature in the form of repeatedly broken point-tips without smoothing or rounding.

Another consideration which can provide clues as to tool function is the presence of features on the tools' bases. When all tools which have intact bases are considered, the degree of smoothing evident on each falls into three roughly equal categories. Tools with faint base smoothing account for 33.3 % of this subset, moderate base smoothing 31.4 % and well smoothed bases 35.2 %. Clearly, tools with moderately and well smoothed bases comprise the majority of the assemblage, and it would be reasonable to infer that these differential degrees of smoothing may be linked with different stages of use. Tools with well smoothed bases are commensurate with hand-held uses, where they articulate with the user's hand and become smoothed-over through time. However, alternative causes for this must also be explored. Hafted tools, for example, generally do not display significant smoothing of bases, but it will be important to examine the kinds of wear produced by different hafting techniques in a comparative assessment.

Interestingly, when only points (as the dominant component of the assemblage) are considered, a different pattern of base smoothing emerges. Among pointed tools with intact bases, faint smoothing accounts for 39.4 %, moderate smoothing 18.2 % and well smoothed bases 42.4 %. Among pointed tools, there is thus a higher percentage of well-smoothed and faintly smoothed bases, differing from the more regular continuum seen when considering all tools with intact bases. This may be an indication of different use-stage or curation patterns evident among pointed tools, and may further indicate their use in effecting tasks in which they were held in the hand.

Considering a tool's shaft can likewise provide insight into tool construction and use patterning. For example, tools with a marked asymmetry to their shaft may indicate functional gestures necessitating preferential use or abrasion to one 'side' of the tool. Tools which retain anatomical shafts or have ancient breaks (present during use) indicate that in these cases, the shaft was not heavily shaped or worked. As such, the method of use in these cases did not put the tool's shaft into repeated contact with abrasive material. This knowledge can be used to constrain further the potential functions. Among all complete and relatively complete bone tools at Taforalt, the most common shaft types are:

- Parallel converging: 28.4 %
- Asymmetric angled: 12.3 %
- Parallel: 7.4 %
- Asymmetric convex: 7.4 %
- Asymmetric steep mid-shaft angle: 7.4 %
- Convex tapering: 6.2 %
- Irregular: 6.2 %
- Convex: 6.2 %

All other shaft types present within the assemblage each represent less than 5 % of the total. Through assessing the shape of tools' shafts, patterns indicating or precluding specific functions already begin to emerge. For example, tools with asymmetrical shafts would normally preclude an effective use as projectile tips (Henshilwood et al. 2001; Bradfield 2016). We see that symmetrical shaft types account for 46.9 % of the assemblage and asymmetrical shaft types account for 53 %. While a tool's having a straight shaft is not enough to suggest projectile use (based on this feature alone), having an asymmetrical shaft usually makes use as a projectile implausible. As over half of the total tools within the Taforalt assemblage could not have been effectively used as projectiles (based on shaft asymmetry), this, along with other data (such as smoothing present on bases, roundedness and polish to point tips, etc.), suggests that production of bone points as projectiles at Taforalt was not the primary industrial objective. The 46.9 % of tools with symmetrical shafts should be assessed for other features which may give clues as to their function, projectile or otherwise.

In addition to the overall shape of a tool's shaft (described in 'shaft type'), tools' shafts may also display different degrees of undulation. Undulation occurs when the topographic irregularities present on a tool's shaft (e.g. breaks, original bone morphology, etc.) have been smoothed over. This can occur as a result of repeated abrasion during use or through intentional lithic scraping, and gives the tool a 'wavy' profile. Here, 64.1 % of tools have a straight (or non-undulating) profile, and 35.3 % of tools exhibit some degree of undulation. Like shaft-type, if shaft undulation is asymmetrically distributed, this may give clues as to the working portion of the tool (e.g. with one side or edge more smoothed over). Undulation may also provide evidence for a given tool's stage and manner of use; for example, heavily undulating tools which do not retain clear lithic striations indicate that this is the result of an advanced degree of use-wear, during which the tool was repeatedly abraded against another material, resulting in smoothing to elevated shaft surfaces.

Repeating suites of features present within the assemblage suggests the repeated production of specific industrial types (presumably with related industrial functions). This hypothesis has been bolstered by ZooMS analyses, showing that gazelle and hartebeest were being preferentially selected for the construction of long, thin, gracile points (Desmond et al. 2018). Examinations of bone tools in the ethnographic present have shown that particular taxa were selected for tool construction based on favourable histological properties (Dominy et al. 2018), and Palaeolithic peoples would have been familiar with the mechanical properties of different animals' bones (Bradfield 2018; Newcomer 1974). Bone tools considered here come from all levels of the cemetery including those dating from shortly after the onset of Grey Series sedimentation to potentially later levels (such as the "Sep A" stratigraphic level in *Nécropole 1*).

At this analytical stage, it is necessary to situate the emergent bone tool trends and features discussed above within their larger cultural and archaeological contexts. Bone tools do not constitute a natural ontological

Fig. 13.1.17 Modern Esparto crafting in Tafoughalt. – (Photo courtesy of Jacob Morales).

category as 'artefacts', but are rather constituent components of a wider cultural and technological complex, based on materials engaged in human practice through time. As such, results gained from complementary lines of archaeological inquiry can serve to illuminate bone tool patterning in suggestive ways. At Taforalt, the Grey Series levels in which these bone tools were found show an intensification in three main food resources; *Quercus* sp. (acorns) and *Pinus pinaster* (pine nuts), and five dominant species of edible mollusc (Taylor et al. 2011). As evidenced in both the skeletons (in the form of dental caries; see Humphrey et al. 2014) and in macro-botanical analyses, this intensification in acorns, pine nuts, and edible molluscs as food resources would have necessitated advanced collection, transport, processing, cooking, and/or storage techniques and technologies. The ubiquitous presence of *Stipa tenacissima* (Esparto grass) rhizomes throughout the Grey Series deposits suggests that the Iberomaurusians were using this as a material for the production of vegetal crafts. It is clear that the grasses were carried to the site whole with roots intact: Esparto rhizomes (root portions) were discarded and burned, and the stalks were likely used as a crafting material (e.g., for baskets, cordage, netting matting, etc.) (Humphrey et al. 2014). Esparto crafting persists into the ethnographic present, particularly in Morocco and southern Spain; in the region surrounding Taforalt, modern artisans still practice Esparto weaving with use of a long, thin, pointed tool (**fig. 13.1.17**). Grey Series faunal remains are dominated by *Ammotragus lervia* (Barbary sheep) (Desmond et al. 2018; **Chapter 9.1**); animal skins, fur/wool, etc. could also have served as raw material for the construction of food collecting, processing, and storage technologies, as well as other uses (such as clothing, bedding, etc.). Though hides, baskets, and other perishable crafted forms are not prone to archaeological survival, the technology used to produce such forms may still be in evidence; namely, in the bone tools used to produce these items. The above feature-based analyses of the Taforalt tools indicate that 53 % have markedly asymmetrical shafts, making their use as projectiles implausible (Henshilwood et al. 2001; Bradfield 2016). While pointed forms overwhelmingly dominate the Taforalt assemblage, most pointed forms also show base-wear commensurate with hand-held uses (Campana 1989). Among those pointed forms with anthropogenic smoothing on the base (i.e. greater smoothing/rounding than that which would be expected to occur postdepositionally), 39.4 % exhibited faint smoothing, 18.2 % moderate smoothing, and 42.4 %

had well-smoothed bases, indicative of tools at different stages of use and/or curation. Further, 46 % of pointed tools displayed visible rounding and polish at the point-tip; this may be an underrepresentation, as such wear-patterning only develops at a significantly advanced stage of use, and may be obliterated by subsequent re-sharpening. Within the Taforalt assemblage, 88.3 % of pointed tools had tip diameters between 0 and 2 mm, and experimental studies have shown that bone point-tips over 2 mm in diameter are ineffective in penetrating leather (Campana 1989, 57). Furthermore, no tools display diagnostic impact fracturing, here taken to be spin-off fractures of greater than 6 mm (Bradfield/Brand 2013). While none of these features are individually conclusive, they are collectively suggestive. In order to substantiate archaeological indications of craft activities (implied both by bone tool features and corresponding lines of archaeological evidence), it is necessary to examine the tools for use-traces which are diagnostic of craft activities. Through an examination of use-traces, bone tools used in craft activities can offer insights into constructed technological forms used in food collection, preparation, and storage (e. g. the use of baskets or hides), clothing, bedding, and other seemingly 'invisible' life-ways. Use-trace analyses performed on bone tools from other Palaeolithic contexts have shown that it is possible to diagnose and distinguish industrial activities such as leather/hide working (Akhmetgaleeva 2017; Buc 2011; Campana 1989; etc.), textile weaving (Campana 1989; Soffer 2004) and vegetal crafting (Buc 2011; Campana 1989; Stone 2015; etc.), based on an examination of microtopography. Taken together, these disparate lines of evidence may form robust inductive proxies for the use of perishable materials, and exponentially enhance our understanding of how the Iberomaurusian transition towards sedentism was facilitated technologically.

It is crucial to deploy such a framework at an early analytical stage, in order to avoid the pitfalls of 'received wisdom' in bone tool categorisations. Studies based on use-wear and experimentation have revealed a world-wide bias in the Palaeolithic bone tool interpretive record, wherein many bone tools are presuppositionally (mis-)characterised as weapons. An in-depth analysis of morphology and use-traces among Natufian and Zagros bone tool assemblages has shown that from a total of 312 Natufian bone objects, only 17 had use-wear consistent with hunting/projectile weaponry (Campana 1989). Use-trace analyses instead indicate that craft-related activities (such as net-making, basketry, hide-working, weaving, and other textile arts) account for the majority of the assemblage, formerly assumed to be weapons-dominated (Campana 1989). This is not an isolated case; rather, mischaracterisations of bone tools seem to occur widely and consistently. Bone tools from a number of Upper Palaeolithic European sites (from France, Germany, Czechoslovakia and Russia) were shown to retain clear weaving use-wear. These, however, were catalogued primarily as weapons, tools for animal-processing, or as enigmatic objects (Soffer 2004). Original categorisations of these tools include spear-tips, *pointes de sagaie*, *lissoirs* and *polissoirs*, *bâtons de commandement*, *lochstabe*, *baguettes demi-rondes*, spatules, etc. (Soffer 2004). Studies of Magdalenian bone tools showed that these too displayed hitherto unrecognised use-traces commensurate with perishable crafting (Stone 2011; 2015). In southern Africa, a study of putative MSA and LSA 'arrowheads' revealed similar inconsistencies (Bradfield 2016). Many tools initially classed as weapons were shown to retain use-traces consistent with hide-working and woodworking (Bradfield 2016).

Taken together, these studies indicate that simplistic and/or presuppositional appraisals of bone tools' function are both insufficient and inaccurate. World-wide, bone tool assemblages have been shown to contain a great internal functional diversity, and historical frameworks for categorising bone tools have effectively obscured this variety in use. Such potential under-recognition probably extends beyond miscategorisation, as many tools used in the creation of textiles will display wear only on the tool's shaft (e. g. battens), and it is disconcerting to consider the number of weaving/crafting tools which might not have been identified as tools at all, due to their lack of diagnostic 'ends' (e. g. Soffer 2004). This is likely due, in part, to preservational vagaries inherent at sites dating to the Palaeolithic. For example, if the organic products of craft activities have not survived burial for tens of thousands of years, these products (and the technological know-how used to make them) are unlikely to be accounted for in the development of bone tool typo-functional frameworks. Insights into this 'missing' technocomplex can be glimpsed through a comparative assessment with recent prehistoric sites with favourable preservation. In many dry cave sites, fibre artefacts outnumber stone artefacts by a factor of 20, and in waterlogged sites, wood and fibre artefacts often account for more than 95 % of recovered materials (Taylor 1966; Croes 1997, as referenced in Soffer et al. 2000). While organic and crafted products in the Palaeolithic may have been less elaborate and/or less numerous than more modern examples, even conservative estimations of their archaeological underrepresentation are high. One suggestion places the Old World archaeological recovery-rate at a mere 15 % of the cultural materials actually in-use, and many believe even this to be a modest estimation of cultural-product loss (Clarke 1968; Soffer et al. 2000).

These considerations underline the need for a robust *chaîne opératoire* approach to bone tools. The formulation of an in-depth descriptive catalogue serves here not as an end-goal of the study but, rather, as a platform from which to approach different stages in the bone tool *chaîne opératoire*. The use of an individual feature-based typology allows emergent features of the collection to direct archaeological investigations; in other words, the tools 'describe' themselves. In a feature-based schema, typological categories (shape, size-class, etc.) emerge from a consideration of the tools at hand. This method does not rely on the *ex post facto* application of pre-conceived typological tool categories (e.g. '*lissoirs*', 'awls', etc.). When the results of each feature assessment are considered together, patterns in construction and use clearly begin to emerge. Perhaps most importantly, this typology provides a firm and scientific basis for selecting like comparative material from ethnographic and experimental tool collections. Ethnographic tools with similar typological features to those recovered from Taforalt can be assessed for use-traces, and these traces can be compared to the traces evident on the bone tools from Taforalt. When there exists a good match between overall feature patterning and microwear patterning, it will become possible to create best-fit use scenarios for the Taforalt tools, and to build an evidence-based understanding of how these tools may have actually been used. Following the forthcoming comparative microscopy and micro-topographic analyses, and when paired with ZooMS analyses, it will become possible to determine robust best-fit scenarios for both individual tool and tool-class functionalities based on biological taxa (the source bones) and ethnographic use-wear congruences (e.g. Soffer 2004; Stone 2011; Desmond et al. 2018). After bringing together data regarding the taxa from which the tool was created, ethnographically and/or experimentally consistent use-wear patterning, it will be possible to tailor experimental studies in order to substantiate specific tool-uses and life-history narratives. The applications of this method are potentially quite profound, as understanding bone tool functionality in early sedentistic LSA contexts (like those evident at Taforalt) is a vital step in understanding how cultural transitions (and concomitant new lifeways) were orchestrated technologically, without having to rely solely on the lithic record.

Once the life history of a tool has been tightly defined, it will become possible to subject tools to more qualitative analyses, aimed at understanding the associated meanings and larger cultural contexts within which tools were used. For example, do certain types of bone tool (or bone tool taxa) occur repeatedly within burial contexts (see Desmond et al. 2018)? Are tools notched for functional purposes (e.g. to aid in hafting) or as exemplars of aids to memory and/or notation (e.g. tally sticks)? Do pigment-bearing tools indicate a superficial post-depositional transfer, or is pigment found within use-traces, indicating use-based contact with pigmented materials? Are bone tools or bone tool types associated with other artefacts (e.g. lithic cores, ochre, etc.) in a statistically meaningful way? It is our hope that the application of diverse and multi-scalar methods to bone tools will elicit a coherent scientific narrative, encompassing and bridging this critical cultural and technological phase.

A. FREYNE

13.2 SHELL ORNAMENTS

The recent excavations of the Late Stone Age (LSA) levels from Sector 8 and Sector 10 have produced several marine and freshwater shells, some of which show evidence of human modification, that have been interpreted as ornaments or special items.

Methods

All of the shells were collected in the course of excavation and sieving and identified using field identification guides.

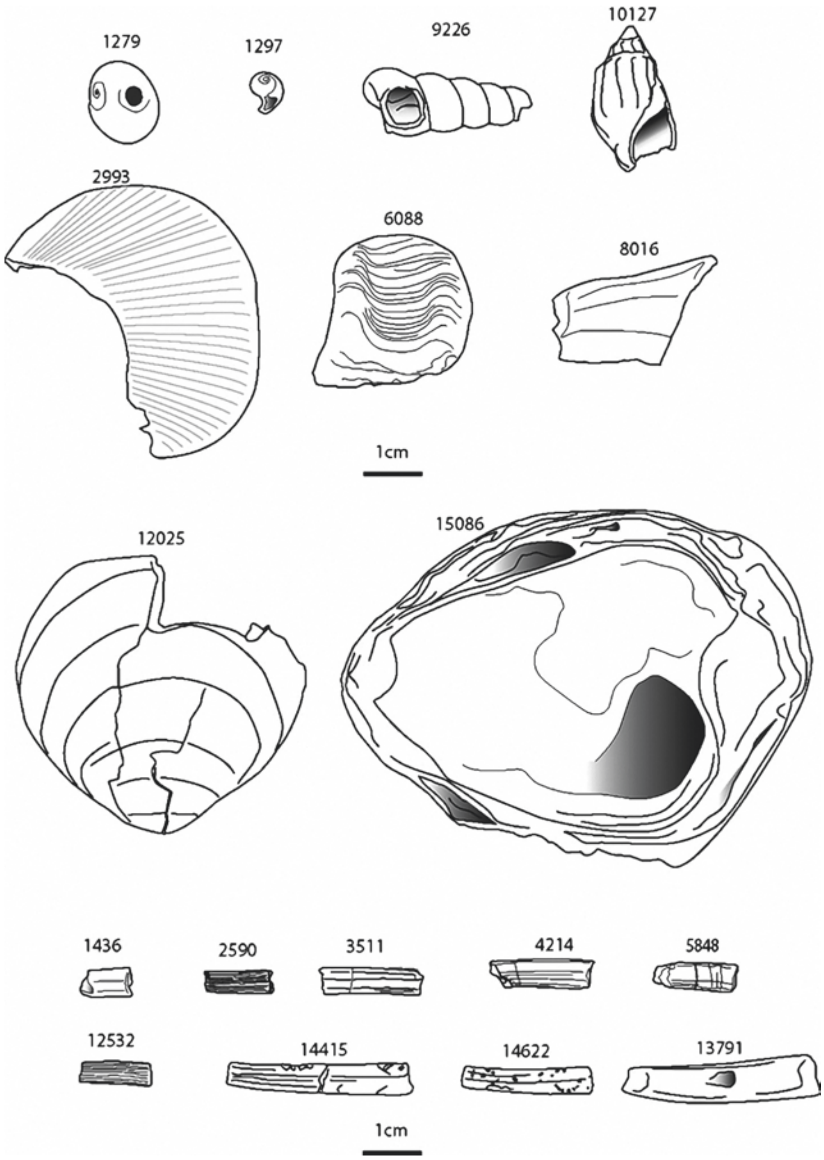
Sector 8

The Sector 8 shells were excavated from two vertical sections, around 20 cm wide and about 3 m apart, running to a depth of about 4-5 m, excavated from 2003-2010 (Barton et al. 2013; Taylor et al. 2011; **Chapter 8**).

Find no.	Year	Sector	Unit	Identification			Length mm	Width mm	Perforation Y/N	Ochre Y/N
Gastropods				Family	Genus	Species				
<1279>	2004	8	Y2	Littorinidae	*Littorina*	*obtusata*	13	10	Y	N?
<1297>	2004	8	Y2	Littorinidae?			6	4	Y?	N
<9226>	2010	8	L16	Turritella			27	11	Y	N
<10127>	2010	10	S10 GS	Nassariidae			20	12	N	N
Bivalves										
<2993>	2005	10	S10 GS	Unknown			41	46	N	Y?
<6088>	2008	10	S10 GS	Cuspidariiae	*Cuspidaria*		26	24	N	Y
<8016>	2009	8	L5	Unknown			28	15	N	N
<12025>	2013	10	S10 GS	Glycymerididae	*Glycymeris*	*nummaria*	46	46	Y	N
<15086>	2016	10	S10 BL	Ostreidae	*Ostrea*	*edulis?*	81	59	N	Y
Scaphopods										
<1436>	2004	8	L10	Dentaliidae	*Dentalium*		8	5	N/A	N
<2590>	2005	10	S10 GS	Dentaliidae	*Dentalium*		11	4	N/A	Y
<3511>	2005	10	S10 GS	Dentaliidae	*Dentalium*		17	5	N/A	Y
<4214>	2006	10	S10 GS	Dentaliidae	*Dentalium*		17	5	N/A	Y
<5848>	2008	10	S10 GS	Dentaliidae	*Dentalium*		14	5	N/A	Y?
<12532>	2015	10	S10 GS	Dentaliidae	*Dentalium*		12	4	N/A	Y
<13791>	2015	10	S10 GS	Dentaliidae	*Dentalium*		32	7	N/A	N
<14415>	2016	10	S10 GS	Dentaliidae	*Dentalium*		30	5	N/A	N
<14622>	2016	10	S10 GS	Dentaliidae	*Dentalium*		21	5	N/A	N

Tab. 13.2.1 Sector 8 and Sector 10 shell ornaments, with year, stratigraphy, identification, dimensions and modifications.

Fig. 13.2.1 Drawing of Sector 8 and Sector 10 shell ornaments (recent excavations).



Sector 10

One shell from Sector 10 comes from the 'Brown Layer' (BL, equivalent to Roche *Niveau IX*) and the rest are all from the overlying ashy facies of the Grey Series (GS).

The shells are grouped below by sector and then by taxon, with a summary of the information in a table (**tab. 13.2.1**). Family, genus and species are identified where possible, using identification guides which are referenced in the shell description. All shells are drawn in **figure 13.2.1** (with photographic illustrations in **fig. 13.2.2**).

Fig. 13.2.2 Photographs of Sector 8 and Sector 10 shell ornaments (recent excavations): **a** *Littorina obtusata* showing round perforation; **b** *Littorina* sp.(?) with notch; **c** *Turritella* sp. with perforation; **d** *Melanopsis* sp.; **e** Bivalve, species unknown; **f** *Cuspidaria* sp.; **g** *Glycymeris nummaria* with perforation at the umbo. Worn smooth by use or by wave action; **h** Bivalve, species unknown; **i** *Ostrea edulis*; **j** *Dentalium* sp.; **k** *Dentalium* sp.; **l** *Dentalium* sp.; **m** *Dentalium* sp.; **n** *Dentalium* sp.; **o** *Dentalium* sp.; **p** *Dentalium* sp.; **q** *Dentalium* sp.; **r** *Dentalium* sp. – Scale 2 cm; details scale 1 cm.

Results

Sector 8 Gastropods

<1279> *Littorina obtusata,* flat periwinkle – Unit Y2

This is a marine gastropod which lives in the littoral or sublittoral zone and is found in many regions, including the western Mediterranean (Robin 2008, 117; de Kluijver/Ingalsuo/de Bruyne 2016).

This specimen is a small (13 mm × 10 mm), globular beige-coloured shell, which bears a 3 mm wide perforation on the body whorl, opposite to the aperture. This appears to have been randomly placed, as it is not located conveniently in relation to the aperture for stringing, and is very round with a bevelled edge on the outer surface. The shape and location distinguish this perforation as having most likely been made by a predator rather than by a human (Stiner 1999, 740-741). Although the shell was not manufactured into a bead, it may have been used as one, and may indeed have been collected due to its potential to be strung using this perforation.

This, and potentially <1297> (see below), are the only *L. obtusata* found at Taforalt during the current round of excavations since 2004; Roche does not report any from his excavations.

<1297> *Littorina* sp? Juvenile – Unit Y2

This shell has been tentatively identified as a juvenile *Littorina sp.* (de Kluijver/Ingalsuo/de Bruyne 2016), as it looks very similar to <1279> in colour and shape, but is far smaller, measuring only 6 mm × 4 mm. This specimen is also a beige-coloured globular sea snail. It is broken next to the aperture, and this may have been due to the presence of a perforation used to string it, as the edges of the break look smoothed. However, its very small size calls into question how practical it would have been to string.

<9226> *Turritella* sp. (de Kluijver/Ingalsuo/de Bruyne 2016) – Unit L16

This shell is that of a turriculate, elongated sea snail. It measures 27 mm × 11 mm. It is beige in colour and very lustrous. Five whorls are preserved but the end is broken, perhaps purposely, and the shell probably had at least one more. There is a large, irregularly shaped perforation (6.5 mm wide) opposite the aperture on the largest whorl. This may have been intentionally made in order to string the shell as a bead. The second perforation at the narrow end is not where human-made perforations would be expected if the purpose is to create a bead, but this does have smooth, worn edges. This could have been the result of taphonomic processes before collection, i. e. sand abrasion.

Roche found several examples of perforated *Turritella* shells during his campaigns at Taforalt (Roche 1963).

Sector 8 Bivalves

<8016> Bivalve, species unknown – Unit L5

Dark grey-brown in colour, this is a fragment of fossilised shell. It is quite large, measuring 28 mm × 15 mm, yet is also quite flat, which may indicate that the complete shell may have been considerably larger. The more convex surface is shiny and well preserved, showing growth lines, and scratches and pit marks from use. The concave surface is more damaged, having exfoliated in places, though growth lines are still visible in patches.

Sector 8 Scaphopods

<1436> *Dentalium* sp. (Jones/Baxter 1987) – Unit L10
This is a small fragment of a Scaphopod, or tusk shell, measuring 8 mm × 5 mm. This is off-white in colour and has an angled, tubular form, giving it a polygonal outline in section. The outer surface is quite polished, either by wave action or by use wear.

Sector 10 Gastropods

<10127> *Melanopsis* sp. (Welter Schultes 2012b)
This is a freshwater gastropod native to North Africa (and other parts of the Mediterranean) and has a ribbed, ovate shell, which is dark grey-brown colour, and measures 20 mm × 12 mm. There are 4 whorls, and it is damaged along the lower border of the aperture. The surface is worn and shiny, particularly the lower half of the body whorl. This appears to have been a fossil shell when collected.
The specimen was recovered from around the burial area of Individual 13.

Sector 10 Bivalves

<2993> Bivalve, unknown genus and species
This shell is broken and the umbo is not preserved. The surviving piece measures 41 mm × 46 mm. It is somewhat similar in size and shape to <12025>, which has been identified as *Glycymeris nummaria* (see below). <2993> has a chalky textured surface, with a mottled yellow colour with some pink straining. The shell bears frequent very faint white radiating striae, and the concentric lines are hard to discern. The staining is most likely from ochre, either from use with the pigment or from incidental contact from the surrounding sediments.

<6088> *Cuspidaria* sp.
This is a bivalve found in many areas including the Mediterranean, usually in deeper water (Allen/Morgan 1981).
This is a broken fragment of what would have been a much larger shell, and measures 26 mm × 24 mm, and is 8.5 mm thick. The preserved fragment is from the beaked portion of the shell, and is roughly thumb-shaped. This shell is highly calcified, thick with many layers. The internal, concave surface is somewhat stained brownish-red, possibly by the surrounding sediment or by contact with ochre.
This is the only example from this family of mollusc at the site.

<12025> *Glycymeris nummaria* (de Kluijver/Ingalsuo/de Bruyne 2016)
This bivalve is off-white, with faintly visible brown concentric rings. It measures 46 mm × 46 mm. There is an oval-shaped perforation at the umbo, with smooth, worn edges, suggesting it was strung as a pendant. This kind of pendant, made using a clam valve, is seen relatively frequently at Grotte des Pigeons. Overall Roche reported 83 complete or fragmented examples of this species, the Bittersweet clam, which he called *Pectunculus violacescens* (Roche 1963).

This shell was found associated with the burial of Individual 14, and was probably used as a pendant. The polished edges of the valve and of the perforation suggest that the shell was worn for some time before it was included in the grave of this individual.

<15086> *Ostrea edulis* (de Kluijver / Ingalsuo / de Bruyne 2016)
This is the only oyster shell recovered during the recent excavations at Taforalt, and was found towards the rear of the cave under the typical ashy facies of the Grey Series in the basal 'Brown Layer'. At 81 mm × 59 mm and 38.5 mm thick, it is the largest marine shell we have collected. The shell is white, and highly calcified, with many layers. It is in a rather brittle state, with layers separating and exfoliating easily. There is a flat impression on one side of the shell where it was adhered to another shell or to the substrate. It is ochre-stained all over, with more dense patches inside the valve, which suggests it may have been used as a container or palette for the pigment.
Roche reported just one example of an oyster, found in *Niveau VI* in the exterior part of the cave (Roche 1963).

Sector 10 Scaphopods

<2590> *Dentalium* sp. (Jones / Baxter 1987)
This fragment, broken at both ends, is an off-white coloured shell, 11 mm long and 4 mm at the wider end. It bears marked longitudinal ridges, which in some *Dentalium* species are more marked on the apical end of juvenile animals (Jones / Baxter 1987, 100). There is clear ochre staining in the furrows, giving the surface a striped appearance. The shell appears worn, and this polish must have taken place after the application of ochre as the colour is worn off the peaks of the ridges.

<3511> *Dentalium* sp. (Jones / Baxter 1987)
This is also off-white coloured, and broken at both ends. It measures 17 mm long and 5 mm at the wide end. Clear longitudinal ridges are present, though not as closely spaced as those of <2590>, suggesting that this too may be the shell of a juvenile animal. The surface is worn, and there are faint traces of ochre.
This was collected from the surface of the Grey Series deposit in Sector 10, found amongst a scatter of bones of a human infant (Individual 12). Given the level of disturbance in this area, the apparent association between this shell and the infant burial is not certain.

<4214> *Dentalium* sp. (Jones / Baxter 1987)
This off-white shell is broken at both ends, and measures 17 mm × 5 mm. It bears faint longitudinal ridges, and is worn to a high shine, with faint ochre staining visible.

<5848> *Dentalium* sp. (Jones / Baxter 1987)
An off-white coloured shell, broken at both ends. It measures 14 mm × 5 mm. This specimen is poorly preserved, and has a chalky texture. The surface is pitted and exfoliating at the narrow end of the shell. The surfaces at the wider, better preserved, end of the shell are a somewhat pink / orange colour which may be due to ochre staining.

<12532> *Dentalium* sp. (Jones/Baxter 1987)
This small shell is off-white in colour, and shows marked longitudinal ridges. It measures 12 mm × 4 mm and is worn and polished in patches towards the foot end, and is substantially ochre stained. The ochre has worn off the tops of the ridges and remained in the furrows giving it a striped appearance seen frequently in the *Dentalia* at Grotte des Pigeons. It is not clear whether this appearance was achieved by the purposeful application of pigment, or whether it was stained from contact with the substrate and eroded from the ridges over time in the ground.

<13791> *Dentalium* sp. (Jones/Baxter 1987)
This is one of the largest *Dentalia* in the assemblage, measuring 32 mm × 7 mm. It is stained a light brown by surrounding sediment, a creamy colour underneath. The surface of this shell is quite smooth and worn, showing some pitting and also scratches, potentially from use.

<14415> *Dentalium* sp. (Jones/Baxter 1987)
Off-white coloured shell, measuring 30 mm × 5 mm. Longitudinal ridges are clearly visible towards the apical/narrow end of the shell, and these become less marked as the shell widens, which suggests this was the shell of a juvenile. This shell is quite pitted and etched around its circumference, most likely caused by the marine environment, pre-collection. No ochre staining was observed. This specimen was recovered in 2016 close to two elements from the arm of Individual 6 and is thought therefore to be linked to this burial.

<14622> *Dentalium* sp. (Jones/Baxter 1987)
This is an off-white coloured shell, measuring 21 mm × 5 mm, with a slightly polygonal outline in cross-section. The surface is substantially worn and pitted. No ochre staining was observed.

Discussion

The overall number of shell ornaments recovered from the LSA layers in Sector 8 and Sector 10 in recent excavations is relatively low: 18 shells in total, from at least 7 different species. These are all from marine environments (see **tab. 13.2.1**), apart from one *Melanopsis* sp., a freshwater gastropod. Roche also encountered marine shell at Grotte des Pigeons, reporting 384 examples (Roche 1963), as well as additional freshwater/brackish specimens (including *Melanopsis* from all parts of the cave). Considering these marine specimens from the earlier campaign, especially the apparently two most well-represented taxa (*Dentalium*, representing over 75 % of the total count, and *Glycymeris* "*Pectunculus*"), and using Roche's original stratigraphic units in the Grey Series (cf. **Chapter 2**), there would seem to have been a strong presence towards the front of the cave, showing a consistent increase in numbers through time, although there was another marked peak in *Dentalium* towards the back (perhaps adjacent to the burial areas). Overall, the relatively low number of marine shells at the site suggests that they were special items, rather than a routine source of food, in contrast to the land molluscs, shells of which are abundant (see **Chapter 8**) throughout the Grey Series. This is supported by the fact that many of the marine shells bear modifications such as perforations, potential string wear and pigment staining.
All the marine shells found at Grotte des Pigeons could have come from the nearest coastal areas. Many marine shell taxa from the western Mediterranean are quite generalised in their preferred environments (Claassen1998, 212), and therefore do not offer precise information on their source.

Change in species representation of, and in modifications to, shell ornaments from Sector 8 and Sector 10 through time cannot be reconstructed from the assemblage due to the small sample. The spatial distribution of species however may be informative: Scaphopods are the most frequent taxon (all identified as *Dentalium* sp. at Grotte des Pigeons), and appear througout Sector 10, but only 1 was found amongst the 5 shells from Sector 8 described here (although two extra fragments of *Dentalium*, one from the GS (MMC81, mid-height stony GS) and one from the YS (MMC118, lower Y2), were recoved amongst the shell material reported in Chapter 8). Out of 9 *Dentalia* in total, 8 came from Sector 10 in close proximity to burials. *Dentalia* made up approximately 78 % of Roche's marine shell finds (approximately, as some went uncounted), with most of those found in the interior of the cave. They may have had a role in the funerary behaviour of the caves' inhabitants, and as a result become concentrated close to the burials at the deepest recess of the cave, becoming less frequent towards cave entrance and exterior (Roche 1963).
Out of the 9 gastropod and bivalve specimens recovered, 4 were probably or definitely perforated. This was most likely done by marine predators, though it is possible some were purposely perforated by humans in order to string them as pendants or otherwise make them suitable for ornamentation. Predator and human-made perforations on gastropods may be differentiated from one another by the shape of the hole, and its position on the shell. Predatory snails tend to make very round, bevelled holes in the shells of their prey, which are placed anywhere on the shell. Human-made perforations are often irregularly shaped and generally positioned close to the aperture for ease of stringing (Stiner 1999, 740-741). Shells perforated by predators may still have been favoured for collection when encountered, as ready-made beads, which appears to have been the case with <1279>, *Littorina obtusata*. Further study of the perforations using a microscope would be useful so wear patterns can be more closely studied. The one freshwater species, *Melanopsis* (<12027>) did not appear to have been perforated, though it was broken along the outer border of the aperture which may have been as a result of intentional human action. Scaphopods (tusk shells), the most represented genus type, are made suitable for stringing easily by their tubular morphology. They can simply be snapped at one or both ends to make a bead (Stiner 1999, 741).
Marine and freshwater shells found at Grotte des Pigeon were clearly valued as unusual or special items when encountered, either to be collected during expeditions the coast, or traded between groups. This collection or trade in shells does not appear to have been undertaken intensively as a large part of the economy of the cave's inhabitants, though these items were likely prized as for either personal or group collections and incorporated into body or clothing decoration, potentially used as vessels for pigments, and incorporated into burials as adornments worn by the deceased, or perhaps as grave goods in their own right. Research into the sources of raw materials for lithic production at Taforalt indicates that most could have come from the local area, not more than about 25 km away (see Chapter 12), and this is consistent with the idea that the inhabitants may have been quite sedentary and did not undertake long distance expeditions frequently. Iberomaurusian sites from across North Africa show similar evidence of shell bead use and manufacture, generally using *Dentalia, Glycymeris* and *Turitella* (Camps 1974, 99; Campmas/Chakroun/Merzoug 2016, 96). The shell ornament evidence from the recent excavations at Taforalt is consistent with that reported by Roche for Grotte des Pigeons, who also saw mainly perforated clams and *Dentalia*, occasionally *Turritella*, with other species represented more rarely (Roche 1963). It is worth mentioning that the use of shell ornaments has a deep history at the site, from which 82,000 year old *Nassarius gibbosulus* beads have been found, amongst the earliest shell beads known anywhere in the world (Bouzouggar et al. 2007).

Fig. 14.1.1 Formed clay: **a** <TAF10-7517b>; **b** <c> from the same piece of clay. – (Photos J. Morales). – Scale 1 cm.

14. INORGANIC MATERIAL

R. N. E. BARTON · S. N. COLLCUTT

14.1 LARGER CLAY OBJECTS

Tiny clay fragments, sometimes burnt, have been noted throughout the Grey Series (see **Chapters 2** and **3**). In 2010, excavations in Sector 8 revealed a small selection of larger objects that appear to be of baked clay. The five or six objects were recorded in Units L17 and L20 and were conspicuous by their bright orange colour and because they seem to have been deliberately shaped out of soft clay and then heated (**figs 14.1.1-14.1.3**).

Of particular interest are <TAF10-7517b> and <c>, which belong to the same piece of clay with a modern break (**fig. 14.1.1**). The object is approximately 40 mm in length and is 10-12 mm in diameter. It appears to have been shaped by moulding in the fingers and by partial rolling into a cylindrical form, therefore fitting the definition of a deliberately fashioned artefact. However, it is unclear whether the heating was accidental or done intentionally to produce a fired earthenware object.

Looking closely at the surface of these pieces, in particular of <TAF10-7517b> (**fig. 14.1.1a**) and of <TAF10-9380> (**fig. 14.1.2b**), there are linear impressions that seem to have been caused by plant material; fine cordage might also be possible, although there are no impressions of a twist or plaiting. The impressions are simple (implying long, narrow tissues, lacking leaves, secondary branches and nodes) and are largely oriented parallel with the clay surface, suggesting a single taxon (or at least similar taxa, such as sedges), deliberately

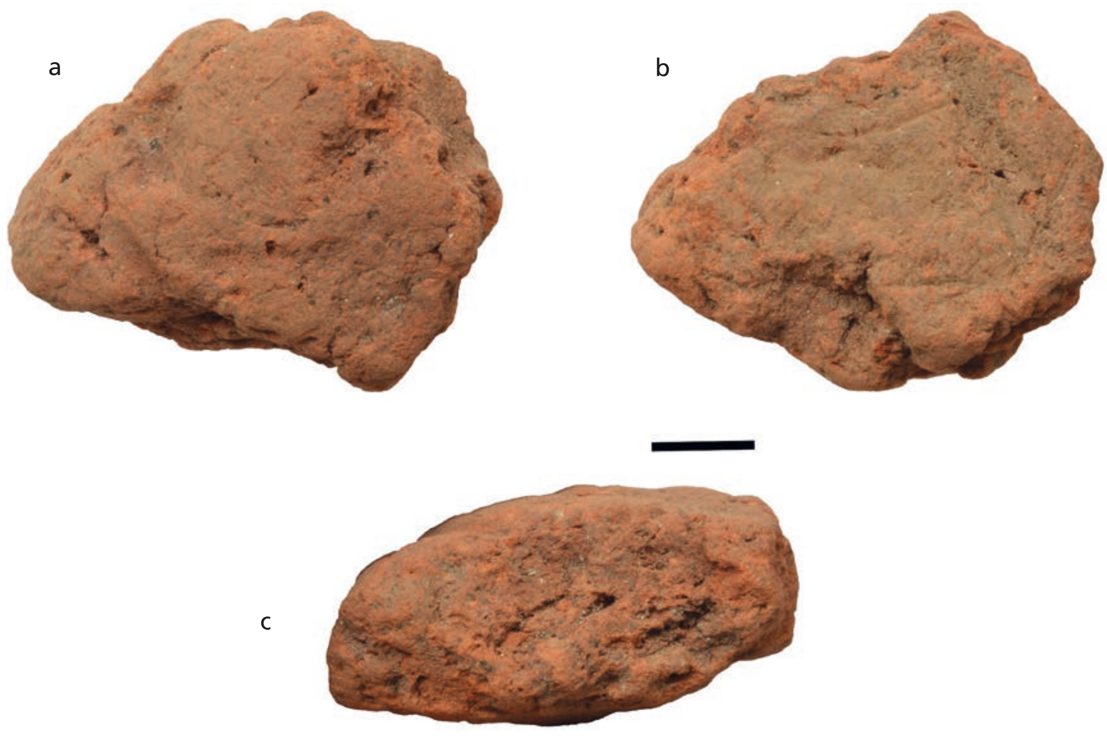


Fig. 14.1.2 <TAF10-9380> Baked clay irregular fragment. – (Photos J. Morales). – Scale 1 cm.

<Site ID>	Square	Unit	Description
TAF10-9380a	A24	L17	Irregular fragment
TAF10-9380b	A24	L17	Irregular fragment
TAF10-9380c	A24	L17	Irregular fragment
TAF10-9383	A24	L17	Irregular fragment
TAF10-9517b	A24	L20	Cylindrical piece
TAF10-9517c	A24	L20	Fragment of same cylindrical piece

Tab. 14.1.1 Larger baked clay fragments from Sector 8.

Fig. 14.1.3 <TAF10-9383> Baked clay irregular fragment. – (Photos J. Morales). – Scale 1 cm.

placed (Jacob Morales and Miguel del Pino Curbelo, pers. comm.). There also appear to be fine holes (of comparable dimensions) actually within the clay, which may owe their similarly face-parallel orientation to compression of the matrix. Whether the objective might have been to add plant material to clay to lend strength or to add clay to plant material to help with water-proofing, or both, is not immediately obvious from these specimens.

Further tests would be required to see if these objects were exposed to temperatures significantly higher than those of a small fire (400°-600°C). On present evidence, therefore, it is uncertain whether these objects can be described as ceramic in the strict sense, i.e. "clay that has been fashioned into a desired shape & dried to reduce its water content before being fired or baked to fix its form" (Darvill 2002, 337-338). It is worth noting that none of the objects at Taforalt was found in direct association with a hearth.

Other objects of fired clay have been noted in Iberomaurusian contexts from sites in North Africa. These include modelled ceramic zoomorphic figurines from the site of Afalou Bou Rhummel in Algeria (Hachi 2003). The anthropomorphic and animal figures from this site were made out of different types of clays and then intentionally baked at temperatures of 500-800°C (Hachi et al. 2002). Similar figurative art has been recognised at Tamar Hat, Algeria (Saxon et al. 1974), while small balls of modelled clay have been found in Iberomaurusian contexts at Ifri n'Ammar, Morocco (Moser 2003), which lies on the northwest side of the Moulouya Valley, not far from Taforalt. Returning to Afalou Bou Rhummel, Hachi (2006) has also reported: "*des fragments et des morceaux d'argile mouillée, modelée et portant, généralement sur une seule face, des traces de moules externes de tiges ou de feuilles végétales*" [fragments and pieces of clay, wetted and formed, and carrying, generally only on one surface, traces of the imprints of vegetable stems or leaves], objects apparently similar to the Taforalt examples. On balance, therefore, it seems highly plausible that knowledge of embryonic ceramic technology was well established in the Iberomaurusian.

14.2 GRINDSTONES AND PESTLES

A number of objects that can be described as grindstones and pestles have been recorded in our excavations. Characteristically, the grindstones comprise large, flat water-worn cobbles and vary in shape from elliptical to sub-triangular forms (cf. de Beaune 1993). The objects range in dimension from complete examples of up to 35 cm in diameter (**fig. 14.2.1** <5861>) to broken fragments of less than 10 cm in size, though these are less common. A usual characteristic feature is the presence of a shallow dish-shaped concavity on one of the flatter surfaces which can be associated with traces of crushed red ochre pigment (**fig. 14.2.2** unprovenanced). The pestles are sometimes no more than small hand-size rocks with smooth, flat surfaces and covered in red pigment.

The petrology of the stones is yet to be formally identified but they are believed to be mainly sedimentary rocks (including limestones) similar to those found today in river or plateau gravels near the cave. In terms of original function it appears that, amongst other things, they were used for grinding pigment into powder, although the surfaces also reveal heavy use wear and deep pitting and grooves that might suggest

Fig. 14.2.1 <TAF08-5861> A large triangular-shaped stone slab, slightly rounded (water-worn?) cobble with patches of pigment. – (Photo I. Cartwright). – Scale bar 5 cm.

Fig. 14.2.2 <TAF uncatalogued> Found *ex situ* inside the cave. – (Photo I. Cartwright). – Scale bar 5 cm.

Fig. 14.2.4 <TAF10-13632> [S10] Pestle associated with Individual 14. – (Photo I. Cartwright). – Scale bar 10 mm.

earlier stages of preparation including crushing and pounding, as well as grinding of mineral pigments. A preliminary study of <TAF10-11456> (**fig. 14.2.3**) by A. Henry (pers. comm.) has revealed no traces of plant residues such as phytoliths that might indicate the grinding of grass seeds. However, since no systematic wear studies or residue analyses have yet been undertaken on the rest of the collection, it cannot be ruled out that they were also used for processing soft plant material or for pulverising acorns and other nuts. One potential candidate of this kind (<TAF16-13999>, **tab. 14.2.1**) has a smooth main surface covered in small pecks and scratches but with no ochre residues.

The four typical grindstones recorded in our excavations all come from Sector 10, in positions that suggest they were deliberately placed either close to or within burials (see **Chapter 15**). For example, <TAF10-11456> (**fig. 14.2.3**) was found in an undisturbed grave pit directly alongside the right leg of Individual 14; it is believed that it was either intentionally placed there or possibly slipped from higher up on the body as it decomposed *in situ*. On the opposite side of the same skeleton near the elbow was located an ochre-stained pestle <TAF10-13632> (**fig. 14.2.4**) that was probably paired with this tool. Another instance of a funerary association is a grindstone (**fig. 14.2.5** <6084>) deliberately placed on top of the remains of an infant (Individual 8). The grindstone lay with its dished surface facing down on the body. It has been hypothesised that ochre may have transferred from Individual 8 to the grindstone given the absence of staining in the depressed central area of the stone. An ochre-stained grindstone of similar size was also placed above Individual 9 (**fig. 14.2.6** <8057>).

One significant early discovery of a grinding artefact was made by Ruhlmann in August 1947 in the stony unit between his upper and middle archaeological layers, towards the inner end of his northern trench (i.e. just alongside what would later turn out to be the main burial area in the cave). This is a large grindstone, 23 × 17 × 3 cm, exhibiting a central concave depression on one side and copiously stained in red ochre. On the same face, it shows engraved

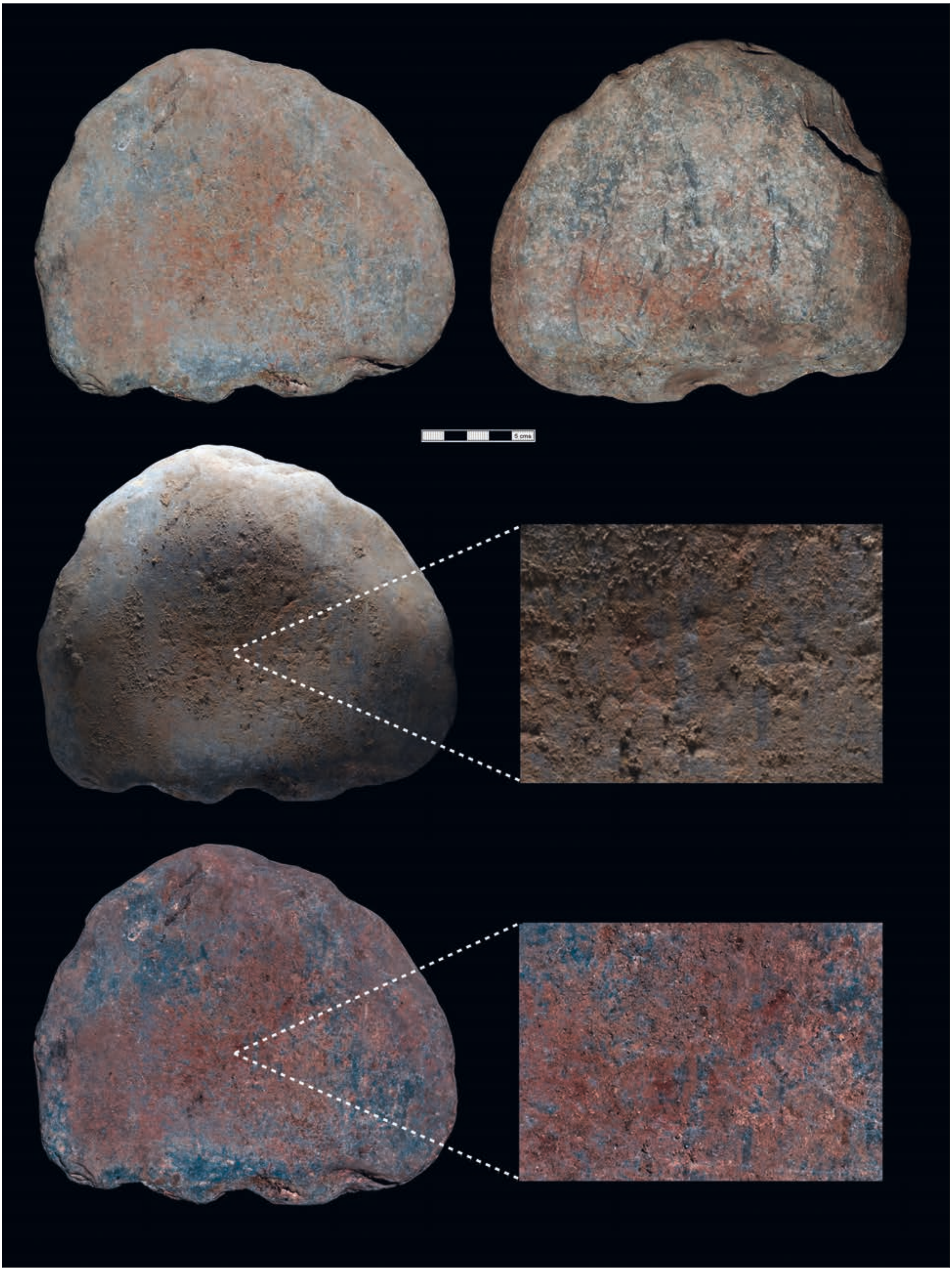


Fig. 14.2.3 <TAF10-11456> [S10] A large disc-like cobble with three deeply flaked notches along one edge; found with a pestle in the same grave fill as Individual 14 (see also **fig. 6.7**). – (Photos I. Cartwright). – Scale bar 5 cm.

Fig. 14.2.5 <TAF08-6084> [S10] A large sub-triangular stone with a sub-circular stain of red pigment; it lay atop Individual 8. – (Photos I. Cartwright). – Scale bar 5 cm.

lines; Ruhlmann sketched the piece in his notebook but gave no interpretation, whilst Roche (1963, 89) interpreted the engraving as the stylised back-curving horns of two opposed Barbary sheep (**fig. 14.2.7**). This piece is in the *Musée archéologique* in Rabat and has not yet been fully re-studied.

Also in the Museum are examples of pestles, mortars and grindstones from the Roche excavations (Roche 1963). He referred to them under a variety of terms, including "*broyeurs*", "*molettes*" and "*molettes de champ*", and occasionally "*meules*". Comparing Roche's text and illustrations, these three categories can

<TAF find>	Sector/unit	Find	Description
TAF08-5861	*Ex situ*, inside cave	Grindstone [Possible equivalent of Roche *meule*]	A large triangular-shaped stone slab, slightly rounded (waterworn?) cobble. The object has two flattened sides and measures 34 × 30 cm in maximum dimension. It is covered in small patches of red pigment, especially developed on one of its flat surfaces. Pitting and short parallel grooves (use wear?) are also visible on the stone. The find came from the surface and is suspected of being a discard from the Roche excavations.
Uncatalogued	*Ex situ*, inside cave	Grindstone [Possible equivalent of Roche *meule*]	A broken fragment of a thin water-worn cobble that measures 21 × 17 × 3. It is much thinner than any other comparable artefact and shows a series of wide grooves on both of its surfaces that might be structural to the rock rather than artificial. Both surfaces are pitted and show copious traces of red pigment.
TAF10-11456	S10	Grindstone [Possible equivalent of Roche *meule*]	A large disc-like cobble with three deeply flaked notches along one edge. It measures approximately 21 × 19 × 7 cm in maximum dimension. The distinctive notches appear to have been flaked and are heavily worn (rounded) possibly through use. The two faces of the stone comprise one slightly dished (concave) surface and one almost flat surface. Both surfaces are scored and pitted and show visible patches of red pigment. The find occurs with a pestle in the same grave fill as Individual 14.
TAF10-13632	S10	Pestle [Potential equivalent of Roche *molette*?]	Associated with Individual 14. A short cylindrical cobble, with flat surfaces at either end. It is about 4.5 cm thick and 8.5 cm in length and fits comfortably into an adult's hand. One of the flat surfaces is stained a reddish purple. Many multi-directional striations are also clearly visible on this surface, most likely due to abrasion against another stone surface and an intermediary substance. For these reasons we have provisionally interpreted this as a hand stone or pestle which was used for grinding ochre against a grinding stone to prepare pigment.
TAF08-6084	S10	Grindstone [Possible equivalent of Roche *meule*]	A large sub-triangular stone with two major surfaces, one of which is slightly dished (concave) in appearance. It has maximum dimensions of 30 × 27 × 16 cm. There are signs of pitting or pecking on the dished surface, near the centre in the deepest part of the concavity and these are surrounded by a sub-circular stain of red pigment. There is no staining in the depressed central portion of the stone. The pitting does not appear to be part of the natural surface of the rock and seems to have been the result of pounding and grinding, despite the absence of pigment traces within the depressed central area. The stone lay atop Individual 8.
TAF09-8057	S10	Grindstone [Possible equivalent of Roche *meule*]	A large elliptical cobble slab measuring 28 × 18 × 14 cm. It has one fairly rounded side and the lower side, which covered baby Individual 9, was flattish and very slightly dished. Unlike the other mortars in this category it shows signs of pecking along its perimeter and traces of red pigment also extend onto its edges.
TAF10-10030	S8-L24	Pestle? [Possible equivalent of Roche *pierre ocrée*]	A sub-rectangular partially flaked cobble made of limestone with maximum dimensions of 6 × 6 cm. Traces of red pigment occur on part of its flaked edge that appear to extend onto the natural surface. It may plausibly have served as a pestle. The find comes from L24 relatively low in the Grey Series
TAF15-12628	S10	Pestle [Potential equivalent of Roche *molette*?]	A broken pestle measuring 4 cm × 6 cm. It has a rounded outline with several flat surfaces, one of which is stained a reddish purple colour, presumably as a result of the tool being used to prepare pigment. The stained surface also bears several multi-directional striations/scratches.

Tab. 14.2.1 Grindstones and pestles from Sector 10 and elsewhere in the cave (recent excavations).

<TAF find>	Sector/unit	Find	Description
TAF16-14418	S10	Pestle? [Potential equivalent of Roche *molette* or *broyeur*?]	8 × 7 × 6 cm, c. 500 g weight (estimated); limestone block, good size to hold in the hand; rough surfaces on most faces but with patches of red ochre; one surface is very smooth (pecks and scratches), with ochre in the peck marks and strong ochre stains around (beyond) the peripheries of the worn surface; possible pestle but note that the supposed grinding surface is quite flat (not rounded at edges), suggesting that motion was gentle, not 'pushed-rolled' [SNC].
TAF16-13999	S10	Grindstone? [Potential equivalent of Roche *broyeur*?]	Approximately 13 cm long, 10 cm wide, 2-2.5 cm thick; 'plaquette' of dense dolomitic limestone; break surfaces all around and on the 'back'; 'top' surface has a peripheral mechanical scar with red ochre but the main surface is smooth (covered in small pecks and scratches) and no ochre at all; a possible grindstone for soft (plant?) material [SNC].

Tab. 14.2.1 (continued)

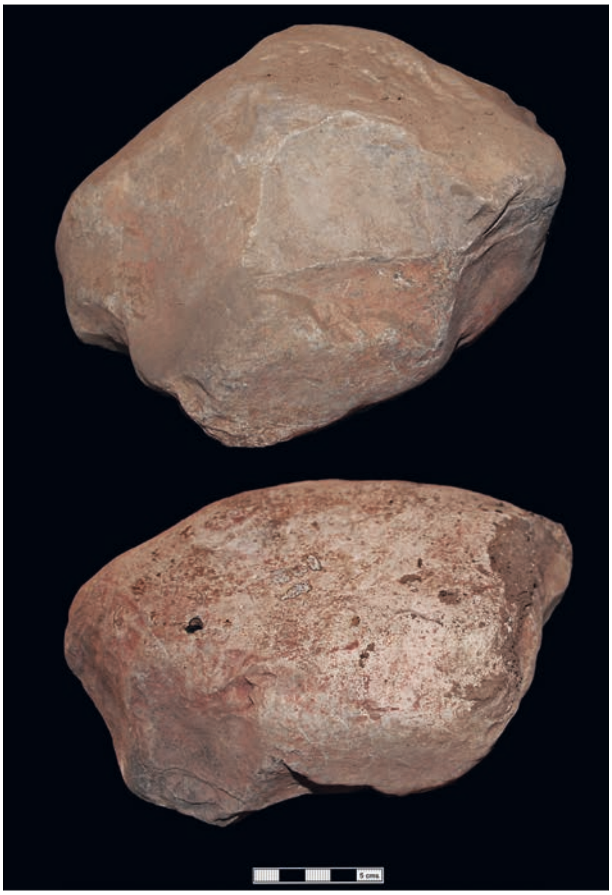


Fig. 14.2.6 <TAF09-8057> [S10] A large elliptical grindstone cobble showing signs of pecking along its perimeter and traces of red pigment also extend onto its edges; the object was found above Individual 9. – (Photo I. Cartwright). – Scale bar 5 cm.

Fig. 14.2.7 Grinding stone with stylised zoomorphic engraving (excavated by Ruhlmann 1947). – (Photo J. Hogue). – Scale bar 5 cm.

be described as follows. A "*meule*" (of which Roche recorded only 2) is a larger (>20 cm) grindstone, sometimes with a marked central concavity; one can think of these as the passive lower stone in a grinding process. A "*broyeur*" (of which Roche recorded 47) carries wear facets on one or both major opposed surfaces of a flattened rock/pebble, interpreted as a hand-held upper stone. A "*molette*" (of which Roche recorded 25) carries smaller wear facets (sometimes converging from two main surfaces to form an angle/ridge at an

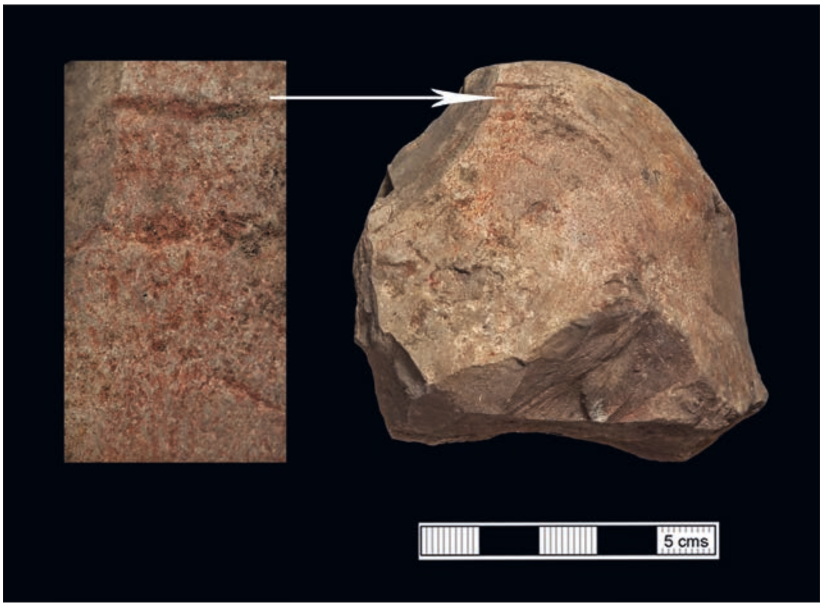


Fig. 14.2.8 <TAF10-10030> [S8] A sub-rectangular, partially flaked cobble made of limestone with traces of red pigment on part of its flaked edge that appear to extend on to the natural surface; the find comes from L24 well above the base of the Grey Series. – (Photo I. Cartwright). – Scale bar 5 cm.

Fig. 14.2.9 <TAF16-14418> [S10] Possible pestle with ochre in the peck marks and strong ochre stains around (beyond) the peripheries of the worn surface. – (Photo I. Cartwright). – Scale bar 5 cm.

edge) at one or more ends and / or along all peripheries of a rock / pebble, also interpreted as a hand-held upper stone. Many of Roche's "*broyeurs*" and "*molette*" also carry zones of pecking or battering, sometimes overlaying wear-facets, sometimes on a separate part of the same stone.

Using the broad stratigraphic and cave geographic divisions recognised in **Chapter 2** from Roche's published and unpublished commentaries, certain interesting patterns emerge. First, the unpublished Rabat archive contains records of a small number of ochred stones from the two main burial areas (*Nécropoles I & II*) but there is only one explicit reference to a pair of grinding tools, "*meule et molette*", from *Nécropole II*, an area immediately adjacent to our Sector 10. Indeed, looking at the lower level of the Grey Series right through the cave to the entrance, Roche recovered relatively few grinding tools of any kind (10 in all, some 14 % of his total). Although a rigorous calculation of comparability (involving volume excavated, adjusted for sedimentation rate) has not yet been attempted, it seems likely that some of the apparent numerical trends are real. With over 55 % of the total, the upper level of the Grey Series seems to have the most grinding tools

(especially since the real volume excavated was probably lower than for deeper levels), perhaps a few more towards the front than further back. The middle level of the Grey Series has more tools in the middle of the cave, although fewer overall (31 %) than the upper level. The *molette* type is definitely concentrated further forward (over 75 % of these tools are from the outer part of the cave); these pieces are not usually ochred. The *broyeur* type is quite common in all geographic areas, counts rising somewhat towards the back; there is a tendency, increasing inwards (from about one sixth near the front to a half at the back), for these pieces to be ochred. There are too few large *meules* to see any patterns. These figures would support the propositions, (a) that the use of grinding tools increased through time, (b) that the *molette* type (with localised end-and-edge facets, usually lacking ochre) was preferentially located towards the cave exterior, and (c) that intensity of ochre association with grinding tools increased towards the cave interior.
No detailed study has yet been made of the distribution in Sector 10 of pestles (figs 14.2.8 <10030> and 14.2.9 <14418>) but it is interesting that only one was found in direct association with a burial, while others were scattered in the surrounding deposits implying that they were either discarded there or were part of the re-used sediments brought in as a matrix for the burials (see Chapter 2). With respect to the grindstones, does the spatial link with individual burials in Sector 10 suggest that these were special items of equipment (and prized personal possessions) that were sometimes incorporated into the graves for symbolic purposes? Or could their presence be related to more practical purposes such as the preparation of ochre beside the graves as part of a funerary ritual, as has been suggested in other burial settings by Dubreuil/Savage (2014, 143)?

S. N. COLLCUTT

14.3 OCHRE, MINERALS AND OTHER CURIOSITIES

By the end of 1947, Ruhlmann had already noted a number of implements carrying red ochre from his northern trench. Roche (1963) reported a wide variety of mineral components from the different zones of the 1950s excavations, including: red ochre source ores (haematite, 'oligist' or specular iron ore, etc.) and yellow ochre source ores (limonite), together with pigmentation (usually red) on bones, bone tools, shells, stones, sediment, etc.; anthracite; galena; mica; pyrites and gypsum crystals; crystalline quartz; a fossil ammonite fragment; and often brightly-coloured river pebbles (e. g. in chalcedony). Because the categories of personal ornaments, on the one hand, and curiosities or 'baubles', on the other, are not always clear cut, especially given the potential of any of these objects to carry pigmentation, one may also mention pierced shells (discussed in Chapter 13.2 of the present text) and four stone pendants, three pierced and one circumferentially grooved. Similarly, the issue of preparation of pigments in powder form has been mentioned in Chapter 14.2 on grinding implements.
Probably the most striking occurrences of ochre were noted in passing by Roche (1963, 151): "[…] *Certains niveaux des nécropoles ont les terres absolument imbibées d'ocre. Certains objets de parure, certains outils ont été enduits d'ocre.* […]" [At certain levels in the burial areas, the ground have been absolutely drenched in ochre. Certain decorative objects and tools have been daubed in ochre.]. The occurrence of ochre, especially of the red varieties, in the burial areas has been discussed in detail in relation to both the 1950s finds and those from the present campaign (Mariotti et al. 2009; Belcastro/Condemi/Mariotti 2010; Aoudia-Chouakri 2013; Humphrey et al. 2012; Mariotti/Condemi/Belcastro 2014; see Chapter 15). The extent to which ochre was deliberately applied to full burials and associated objects (some of which may already have

Fig. 14.3.1 <TAF16-S10-14460> Large block of Fe-dominant ore. – Scale 10 cm.

Fig. 14.3.2 <TAF16-S10-14838> Fe-dominant vein ore. – Scale 5 cm.

been ochred), was applied to regrouped remains, came into contact with matrix objects inadvertently during a burial event or transferred (especially from, or in the presence of, decaying organic matter) after deposition may now be difficult to ascertain, although a better understanding will become available once the photographic archive and the as yet unpublished excavation notes (Jodin 1954/1955) have been fully analysed. However, Roche recorded exotic mineral components from most of his excavation units, right through the cave. His short commentaries on these materials, although not quantified, seem to imply a slight increase in curiosities and 'baubles', and possibly even colourants, upward through time in his excavations of the Grey Series. Colourants (especially iron-ores) are perhaps more commonly reported in the middle to back of the cave (thus, closer to the burial areas), although they are not absent from the front; in the lowest levels of the outer cave, there are no colourants in the main entrance area but there is a concentration in the outer zone near the north wall (Roche's *Niveau C*). Ochred objects were also found in the uppermost Yellow Series (Roche's *Niveau X*), already with a concentration of colourants towards the back of the cave.

Fig. 14.3.3 <TAF16-S10-15161> Glittering Pb-dominant ore, with plausibly worked groove. – Scale 3 cm.

In respect of colourants, Roche noted that many of the fragments of mineral ore (especially the ochres) showed various types of wear facets, striation and general polish, implying that they were either used directly upon the substrate to be coloured or that small quantities of powder were needed on occasion and were scraped off an ore fragment with a tool of some type.

During the present campaign, various mineral components, plausibly collected and imported by humans, have been encountered, some at least in all the sectors in which we have excavated. These materials have not yet been analysed. However, a few examples (all excavated from Sector 10 in 2016), with field notes, will suffice here to illustrate the potential for future work. Object <14460> (**fig. 14.3.1**) is a large block of dominantly Fe-ore, 12 cm long; vuggy; silver grey metallic, red and yellow ochres, a little green Cu at one end (right of photo); high density suggests Pb content; dark red-brown streak. Object <14838> (**fig. 14.3.2**) is an angular fragment of vein (ore) mineral; Fe dominant and present even as red sub-veins; red streak even from 'grey' matrix; vugs in places; small patches of dark grey/green/blue possibly Cu; some light coloured 'silvery' metallic cubic crystals possibly Pb; 29.93 g, displaces 7.8-7.2 g of water, thus estimated bulk specific gravity of c. 3.8-4.2 g/cm³ (consistent with many impure iron ores). Object <15161> (**fig. 14.3.3**) is a high sheen, 'silvery' metallic ore; only very light 'grey' streak but the 'glitter' detaches easily on the skin, soft; 15.13 g, displaces 2.8-2.2 g of water, thus estimated bulk specific gravity of c. 5.4-6.9 g/cm³ (a very high value indicating Pb is likely to be dominant, although typical cubic galena crystals were not observed, suggesting a possible argentiferous ore with tiny crystals of Ag interrupting the Pb lattice to give this overall glittering habit). On the flat side, there is at least one long groove that appears man-made (there is no explanation in the geological structure of the specimen as seen beyond the 'ends' of the grooving); this piece would seem to be an excellent pigment source.

Recent studies of material, a little older and a little younger than the LSA (e.g. Rifkin 2012 for the MSA; di Lernia et al. 2016 for early Holocene material), have shown that a combination of advanced physico-chemical analyses and experimental replication can provide considerable information on mineral use in the Stone Age. It is hoped that such work will be carried out on the Taforalt collections in due course. Certainly, mineral 'manuports' of various types, and especially ochres, are quite common in the North African LSA (e. g. Grotte des Contrebandiers and Ifri n'Ammar in Morocco, or Tamar Hat in Algeria), and not only in cave/shelter sites but also in the open-air (cf. the shaped ochre discussed by Sari 2009). Indeed, red ochre seems already to have been applied (whether deliberately or via stringing material) to MSA shell beads at Taforalt, whilst Blombos Cave (South Africa) has, at a similarly early date, not only ochred shells but also faceted ochre fragments. Less well known and understood perhaps is the use of galena, although this mineral was amongst the first to be reported from LSA/Iberomaurusian sites (cf. La Mouillah and Abri Alain (Algeria); Pallary 1934). The question as to the purpose, or purposes, of these mineral components often remains contentious and it cannot yet be said that the range or diversification/intensification of uses has been fully explored, either chronologically or geographically. Many of the 'baubles' probably served no purpose beyond the apparently deep-rooted human interest in the unusual and the curious, although it is not impossible that this was taken a further step, perhaps as memory tokens or charms or other markers of individual identity. Traditional archaeological interpretations of colourants (cf. Camps-Fabrer 1960; Camps 1974) have included body-painting and funerary rituals. More 'practical' uses for ochres have also been suggested. Inclusion with resins seems to improve the performance of mastics (cf. Wadley 2005; Lombard 2007) but there are many other, more easily assembled or gathered materials that do equally well. Similarly, ochre can be used in hide preparation, although it is more obviously involved in desiccation and subsequent preservation (as an anti-microbial) than as an actual leather tanning agent. It has even been suggested that red ochre powder would have served as a human sun-screen (Rifkin et al. 2015) and an insect-repellent (Rifkin 2015). Rifkin (2011; 2012) has drawn attention to the most practically useful dichotomy in the archaeological context concerning minerals, namely that it is extremely laborious to prepare large quantities of mineral powder using pestle and mortar (and yet this was demonstrably done in many cases, including at Taforalt), whilst it is relatively easy (even allowing for the effort needed for any required adjustment of colour through prior heat treatment) to transport and use small mineral fragments (thus creating wear-facets and striations from either scraping or direct application), especially given the wide range of both organic and rock surfaces that would have been available upon which to 'draw'. Whilst each ore source will behave differently, Rifkin was grinding good quality haematite that, as an average in 22 replications, gave reasonably fine powder at the rate of only 37.3 g (10-15 cm^3) per hour. This ergonomic dichotomy should perhaps guide future investigation of likely uses at LSA sites such as Taforalt.

L. T. HUMPHREY · A. FREYNE · P. J. BERRIDGE · P. BERRIDGE

15. HUMAN BURIAL EVIDENCE

15.1 BACKGROUND

A large assemblage of Iberomaurusian (Later Stone Age) skeletons was recovered from Grotte des Pigeons during excavations directed by the Abbé Jean Roche between 1951 and 1955. Preliminary details of the archaeological context of fragmentary remains found in 1951 and a series of burials excavated between 1952 and 1955 were published by Roche (1953a; 1953b; 1959; 1963) and a more detailed account of the human osteology was published by Denise Ferembach in 1962.

In 1951, Roche reopened Ruhlmann's trench "S2" (north trench), which ran for about 16 m east to west, turning northwest and running for another 4 m under a large block of debris from the cave roof. During cleaning of the trench, a small fragment of cranial vault was recovered from level "D" in Square M21. The fragment was considered to date from the later part of the Aterian (Roche 1953a; 1953b) but, since the trench had been left untouched for several years, it is possible that it had fallen from a higher stratigraphic position due to erosion of the sides of the trench. During the same season, human bones from at least two individuals were recovered from level "A" (Roche 1953a). These comprised a cranium of a male aged about 15 years who had undergone dental evulsion, a robust humerus that could have belonged to the same individual, and a fragment from the anterior part of the cranium of a child aged about 7 years (Roche 1953b).

In the spring of 1952, two partial skeletons were exposed in Square L18 due to erosion of the "*coupe Nord*" of trench S2, and assigned to level "B" (Roche 1953b; 1963). The lowermost skeleton lay beneath a stone slab measuring 20 cm thick and 70 cm long. A layer of horn cores of Barbary sheep (*Ammotragus lervia*, referred to by Roche as *mouflon*) was located between the stone and the skeleton. As the burial was at risk of collapsing into the adjacent trench, the skeleton was removed by the R. P. Bienvenu Blondeau, who was then priest at Tafoughalt. The second skeleton was located slightly above the first, lying on its side with the legs tightly flexed (Roche 1953a; 1963). This skeleton was observed *in situ* by participants of the 2nd Pan-African Congress on Prehistory during an excursion to the site (Cole / Clark / Davis 1952). Balout (1954) reported that the lowermost skeleton was found at a depth of 4 m but the source and reliability of this information are unclear.

At the end of 1952, excavations were extended into the alcove located to the north of Ruhlmann's north trench (fig. 15.1). Approximately 70 cm of unusually stony sediment were removed to the base of layer "A", revealing, in layer "B" below, a dozen more or less complete skeletons (Roche 1953a; 1953b). In one publication, Roche describes the skeletons as placed one on top of another with no apparent order (Roche 1953b). In a second paper published in the same year, he reports that the majority of the skeletons were lying on their backs with the head to the west and the face turned towards the rising sun (Roche 1953a). One burial containing remains of several young children was described consistently in both papers (Roche 1953a; 1953b). The bodies were placed in the centre of a trapezoidal pit and aligned on an east west axis with the heads to the west. The pit was delimited by stone blocks. The stone block on the north side of the grave was from the roof of the cave, whereas the stones on the east and west sides were Liassic limestone from an external source and must have been deliberately transported to the cave. Crania from three Barbary sheep were placed directly above the bodies, with the horns pointing outwards, and were held in place by a

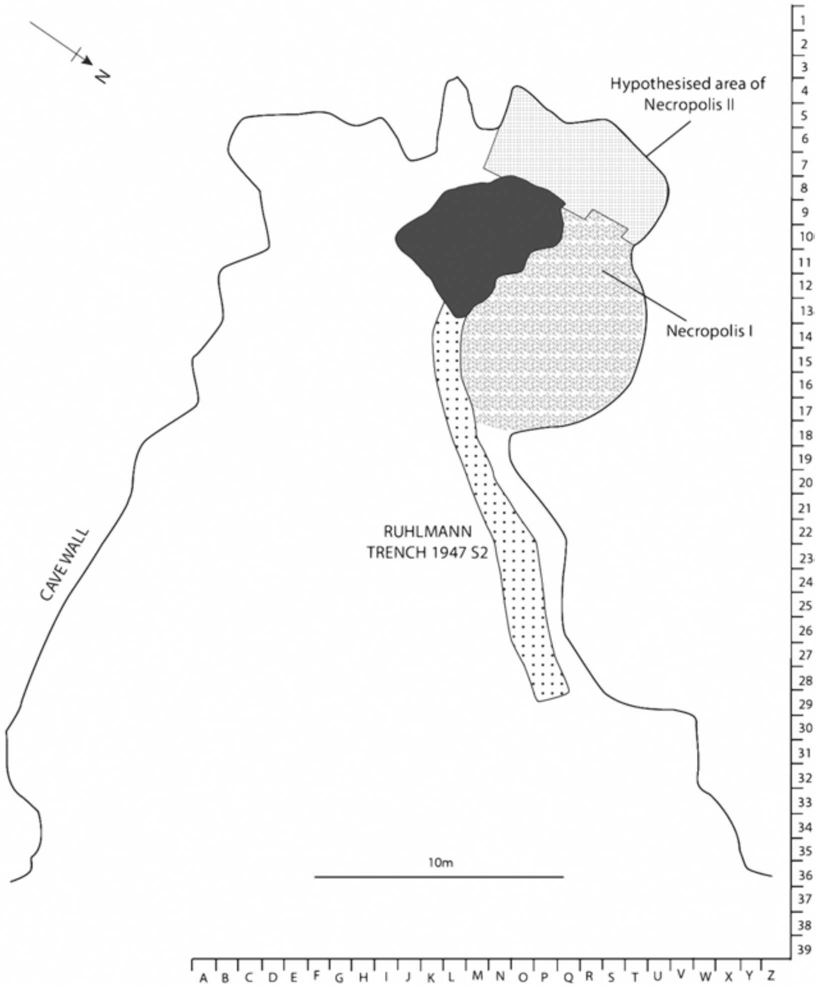


Fig. 15.1 Map of Grotte des Pigeons showing Ruhlmann's (north) trench S2 and the Iberomaurusian Necropolis I & Necropolis II excavated by J. Roche. Ruhlmann's trench undercut a large block of debris at the western end (shaded black).

centrally positioned stone. Another infant was buried flexed on its left side with the face turned towards the stone block on the north side of the burial pit. The grave was filled with fine black sediment and contained no lithic artefacts or charcoal (Roche 1953b). Roche reports that all of human bones recovered in 1952 were sent to Professor Vallois in Paris.

No burials were excavated in 1953 (Roche 1963). At the end of the 1953 season, a pile of scree situated between L13 and N17, blocking access to the west part of the cave, was carefully removed. Excavation of the burial area was resumed in 1954 with the assistance of A. Jodin. An area located between Ruhlmann's S2 (north) trench and the wall of an alcove on the northern side the cave was excavated to a depth of 1.5 m. The long east-west axis of the excavated area ran between Squares L18 and O/P11 and the shorter north-south axis ran between Squares L14 and R14. Excavation of this area, designated Necropolis I, continued in 1955, and extended deeper into the alcove and down to the level of the underlying yellow (dominantly mineral) deposit. The total excavated area covered an approximately ellipse-shaped area of 10 × 7 m with the longest east-west axis running between Squares M18 and S10 and the shorter north-south axis running between Squares S16 and M13 (Roche 1963).

Towards the end of the 1955 season, excavations were extended into a second burial area, designated Necropolis II, in the extreme west of the cave. This area is described as an approximately rectangular-shaped recess measuring 9 × 3 m (Roche 1959). Roche did not specify the exact location of Necropolis II but the dimensions suggest that it must have occupied most of the previously unexcavated northwest part of the cave. The presumed location is shown in **figure 15.1**. Excavation of Necropolis II was halted abruptly and

Fig. 15.2 **A** Photograph showing the northwestern alcove taken by Serge Kostomaroff (photographer for the *Service des Antiquités du Maroc*) and labelled "1962" (slides held in the George Souville Archive at *la Maison Méditerranéenne des Sciences de l'Homme, Centre Camille Jullian (UMR7299-CNRS) à Aix-en-Provence, Université d'Aix-Marseille*). – **B** Sector 10 as it appeared in 2004 (photo by Ian Cartwright).

never completed (Roche 1963). A photograph from the George Souville Archive shows the northwest recess of the cave in 1962 (**fig. 15.2**).

Additional information about the archaeological context of the burials from Necropolis I and Necropolis II can be inferred from the descriptions of the osteological series made at the time of the excavation or shortly thereafter (Balout 1954; Ferembach 1962) or through re-analysis the skeletal collection (Mariotti et al. 2009; Belcastro/Condemi/Mariotti 2010). Balout (1954) published a brief summary of skeletal elements recovered between 1951 and 1953, including a preliminary inventory prepared by Vallois. The inventory lists the contents of six burials, each containing bones assigned to several individuals. These burials were reported to have been excavated from level B in 1952-53. Since no human remains were recovered in 1953, the inventory presumably refers to the skeletons excavated in 1952 (Roche 1953a; 1953b; 1963).

The first comprehensive description of the human remains excavated between 1951 and 1955 was published by Denise Ferembach in 1962. Ferembach listed the partial skeletons and isolated bones found in 28 separate *sépultures,* or graves, and calculated a minimum number of individuals for each of these assemblages. She also recognised 13 juveniles from *sépulture* E, one child from *sépulture* 52C, five children from levels A, B and C and two further children based on cranial fragments found at the surface of level A. This method yielded a cumulative total of 183 to 186 individuals, including 80 adults, 6 adolescents, 53 to 55 children and 44 to 45 infants (Ferembach 1962). The inventory presented by Ferembach (1962) differs in so many details from the previous inventory (Balout 1954) that it is not possible to confirm the same numbering of burials. One point of consensus is that Balout's burials 4a and 4b correspond to Ferembach's burials IV and IVa and are consistent with Roche's description of a trapezoid burial pit containing the bodies of several small children and an infant (Mariotti et al. 2009). In most cases, the specific skeletons referred to in the preliminary reports of the burial context published by Roche cannot be individually identified among the osteological assemblage now held at the Institut de Paléontologie Humaine (IPH) in Paris (Mariotti et al. 2009).

Ferembach did not attempt to match human bones found in different levels or *sépultures,* thus assuming that each of these burial deposits represented a separate and closed entity. More recent analyses of the osteological assemblage has revealed that bones that belong to the same skeleton are sometimes marked with different numbers implying that they were found in different *sépultures* (Mariotti et al. 2009; and LH personal observation). Mariotti and colleagues re-evaluated adult and adolescent skeletons from the osteological assemblage at the IPH to determine a minimum number of individuals in this age group, disregarding the separation by *sépulture*. Their estimate of the minimum number of adults and adolescents is only 35-40 for the entire assemblage (Mariotti et al. 2009), which is less than half (41-47 %) of the original estimate for this age group (Ferembach 1962). The extent to which the number of juveniles in the assemblage may also have been overestimated has not yet been determined. Assuming that the extent of overestimation by Ferembach was similar across in all age groups, the actual numbers of children and infants in the original assemblage may be as low as 22-29 and 18-21 respectively.

15.2 NEW EXCAVATIONS: SECTOR 10

Necropolis I and Necropolis II may have formed part of a contiguous burial area in the northwest part of the cave, or may have been separated by the pile of rocks from the roof fall that lay directly on top of the Aterian levels. All of the burials were removed from Necropolis I but the burial area in the extreme west of the cave, designated Necropolis II, was only partially excavated when Roche closed his excavations in 1955 (Roche 1959). Preliminary surveys of archaeological deposits at Grotte des Pigeons in 2003 and 2004 revealed human and animal bones and bone fragments eroding out of deposits in an alcove of restricted height in the northwest corner of the cave. The presence of a partially articulated human foot indicated that there were relatively undisturbed burials within this deposit (Humphrey et al. 2012).

Excavation of part of the surviving burial deposits was undertaken to: (a) investigate the spatial and chronological extent of the mortuary deposits at Grotte des Pigeons and their relationship to archaeological deposits elsewhere in the cave; (b) investigate the processes underlying the accumulation of the mortuary deposits; (c) document funerary treatment at an individual level and determine whether there was patterning in relation to age and sex; (d) provide an additional perspective on the diversity of funerary behaviour of Late Pleistocene and early Holocene populations of the Maghreb.

The uppermost archaeological deposits in the rear alcove of Grotte des Pigeons comprise a large accumulation of human and non-human bones, burnt land snails, lithic artefacts and lithic debris within fine powdery ashy grey sediment. In 2004 and 2005 bone fragments judged to be eroding out of the surface and no longer *in situ* were collected over an area covering approximately four square metres (fig. 15.3). This area was designated Sector 10. Excavations in Sector 10 took place over eight seasons between 2005 and 2016 and are ongoing. The deposits judged to be least stable, situated at the front of Sector 10, were excavated during the first two seasons and excavations were then extended towards the rear wall of the cave.

A unique find number and three-dimensional coordinates were allocated to each diagnostic or recognisable fragment of human and non-human bone, horn core and ostrich eggshell, and to isolated teeth, lithic artefacts, bone pins, marine shells and other objects of interest. Drawings were made and photographs taken at each stage of the excavation.

Complete and fragmentary human bones and teeth were allocated to an individual skeleton on the basis of spatial consistency and anatomical associations within the deposit. Partially articulated skeletons and recognisably associated groups of skeletal elements from the same skeleton were given an "Individual" number, and the burial is referred to by the same number. Isolated bones and bone fragments were assigned to an Individual, where possible, by reconstructing broken bones, matching bones from the left and right side and ensuring consistency in skeletal size and developmental stage. Age and sex were determined using standard dental and osteological methods (see Chapter 16 and Humphrey et al. in press for further details). Genetic sex was determined for seven individuals including all six infants and one adult (van de Loosdrecht et al. 2018). At the end of each season all archaeological material was removed to *L'Institut National des Sciences de l'Archéologie et du Patrimoine* (INSAP) in Rabat for curation and further study.

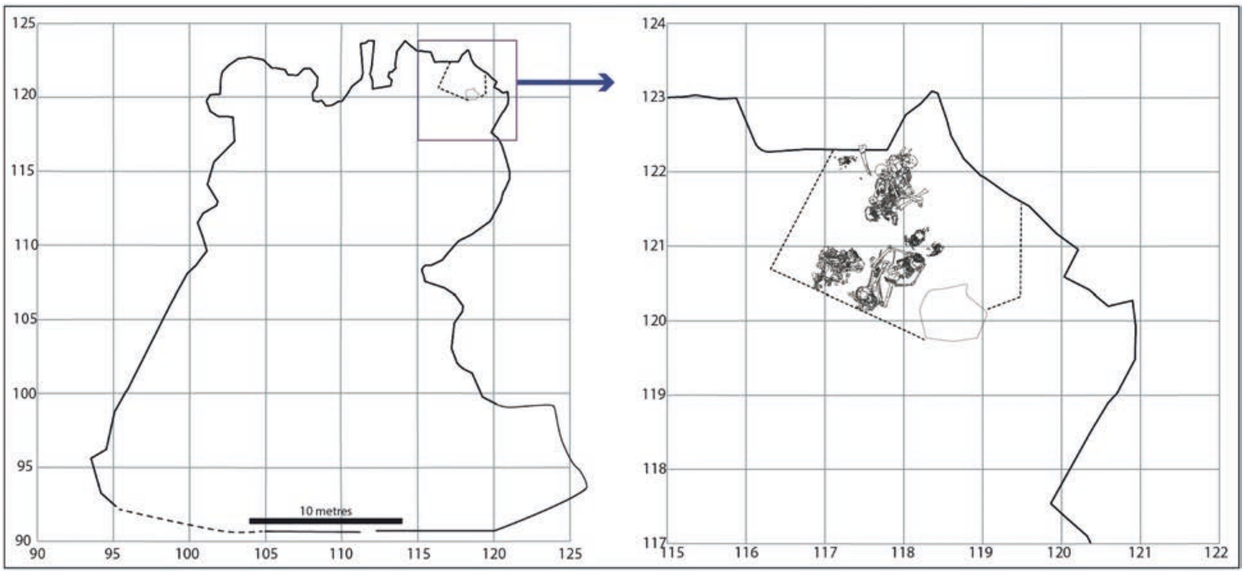


Fig. 15.3 Map of Grotte des Pigeons showing location of Sector 10 in the cave, excavated area (demarcated by dotted lines, cave wall and large *in situ* rock) and location of human burials excavated since 2005; the cave outline is based on X-Y coordinate data and is shown here with the digital (total station) grid used during the current excavation, with units in metres from site datum (see **fig. 15.1** for broad comparison with Roche's grid).

15.3 BURIAL DESCRIPTION

The excavations in Sector 10 revealed relatively complete skeletons from three adults and four infants, and incomplete but articulated skeletons of three further adults and an infant. The deposit also incorporated another reasonably complete but disturbed infant skeleton and a broken adult cranium and associated mandible. The position of each body at the time of burial was reconstructed from the undisturbed parts of the skeletons. Many of the bones recovered from Sector 10 were not in anatomical articulation but could be allocated to one of the numbered Individuals. These included bones that had become relocated within the burial during decomposition due to empty space within the burial or loosely packed sediment. Other bones had been moved from their original position by taphonomic factors including pressure from above, erosion (short-distance displacement at an open surface) or burrowing. Many of the burials had been truncated by subsequent burial activity, resulting in deliberate or accidental relocation of bones from the disturbed burial. Where possible, these different causes of movement were identified.

Individuals 1, 2 and 4 were found in a stack one above the other. Parts of all three skeletons were visible on the sloped surface of Sector 10 or found very close to the surface, and for this reason the numbering of the skeletons is inconsistent with the order in which they were buried. The uppermost skeleton was Individual 2 and the lowest Individual 4, with Individual 1 located between these two burials (**fig. 15.4**).

Individual 1

Individual 1 was a young adult with an estimated age-at-death of 20 years (**fig. 15.5**). The skeleton was originally inferred to be female based on cranial features but was revealed by aDNA to be male (van de Loosdrecht et al. 2018). The body had been carefully placed in a slightly reclined, seated position with both legs flexed (**fig. 15.6**). It was orientated on an east-west axis and faced approximately east towards the en-

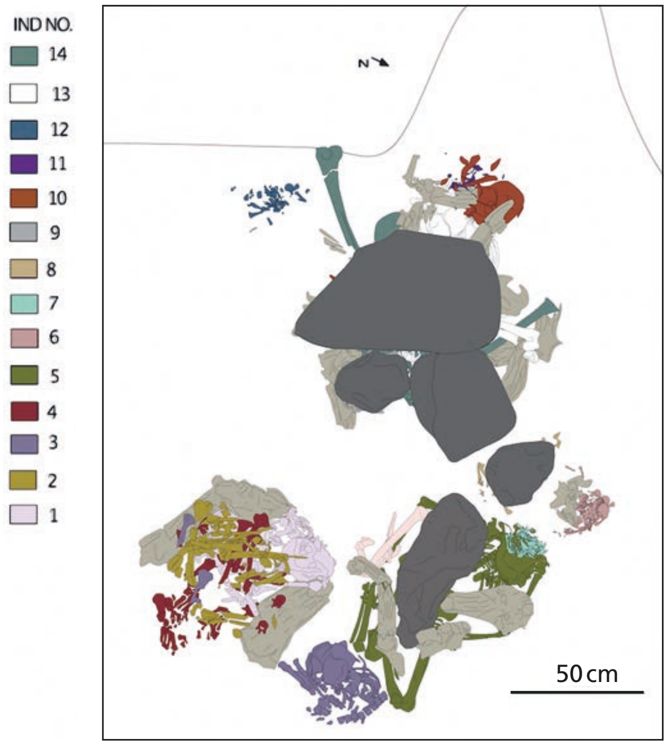


Fig. 15.4a Composite drawing of Sector 10 burials showing Individuals 1-14 and including cover stones and horn cores.

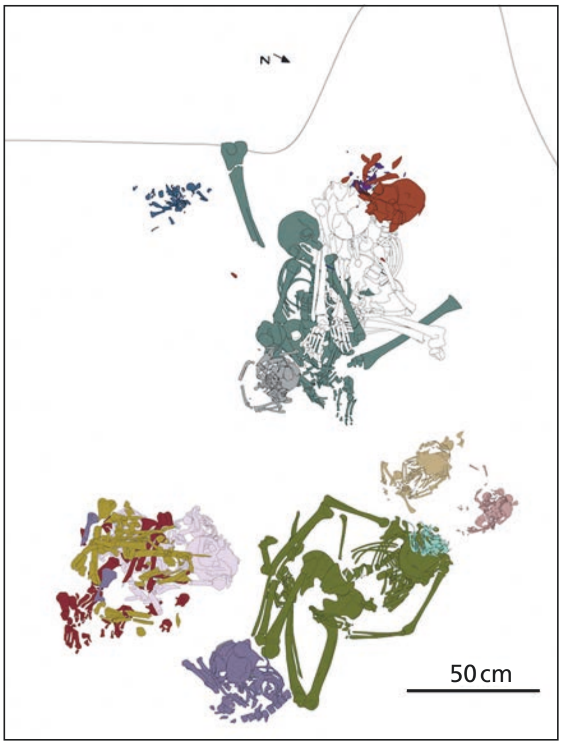


Fig. 15.4b Composite drawing of Sector 10 burials showing Individuals 1-14 but with cover stones and horn cores removed.

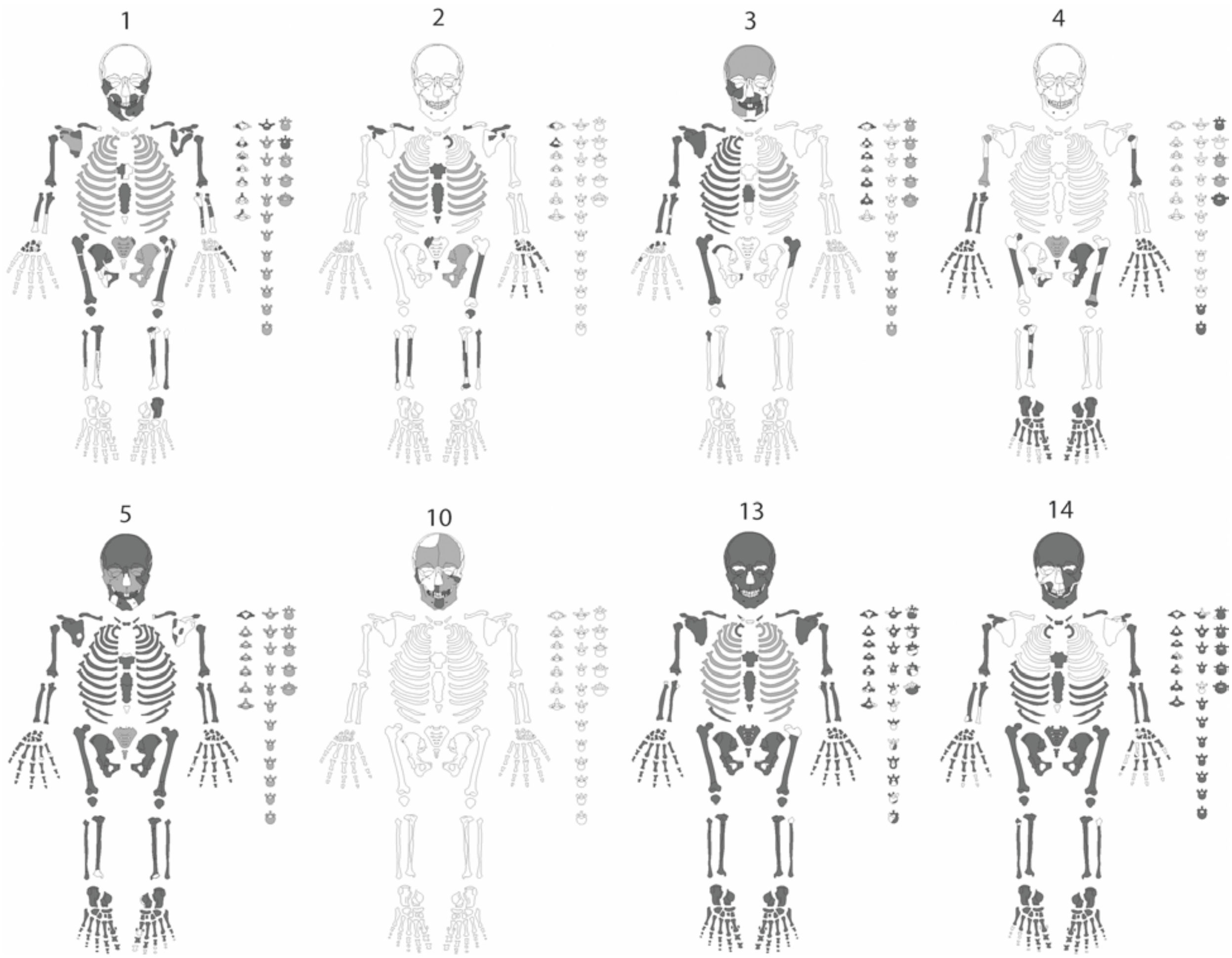


Fig. 15.5 Charts representing recovered skeletal elements of adult burials from Grotte des Pigeons, showing Individuals 1-5, 10, 13 and 14; lighter grey areas represent badly fragmented bone, dark grey represents better preservation.

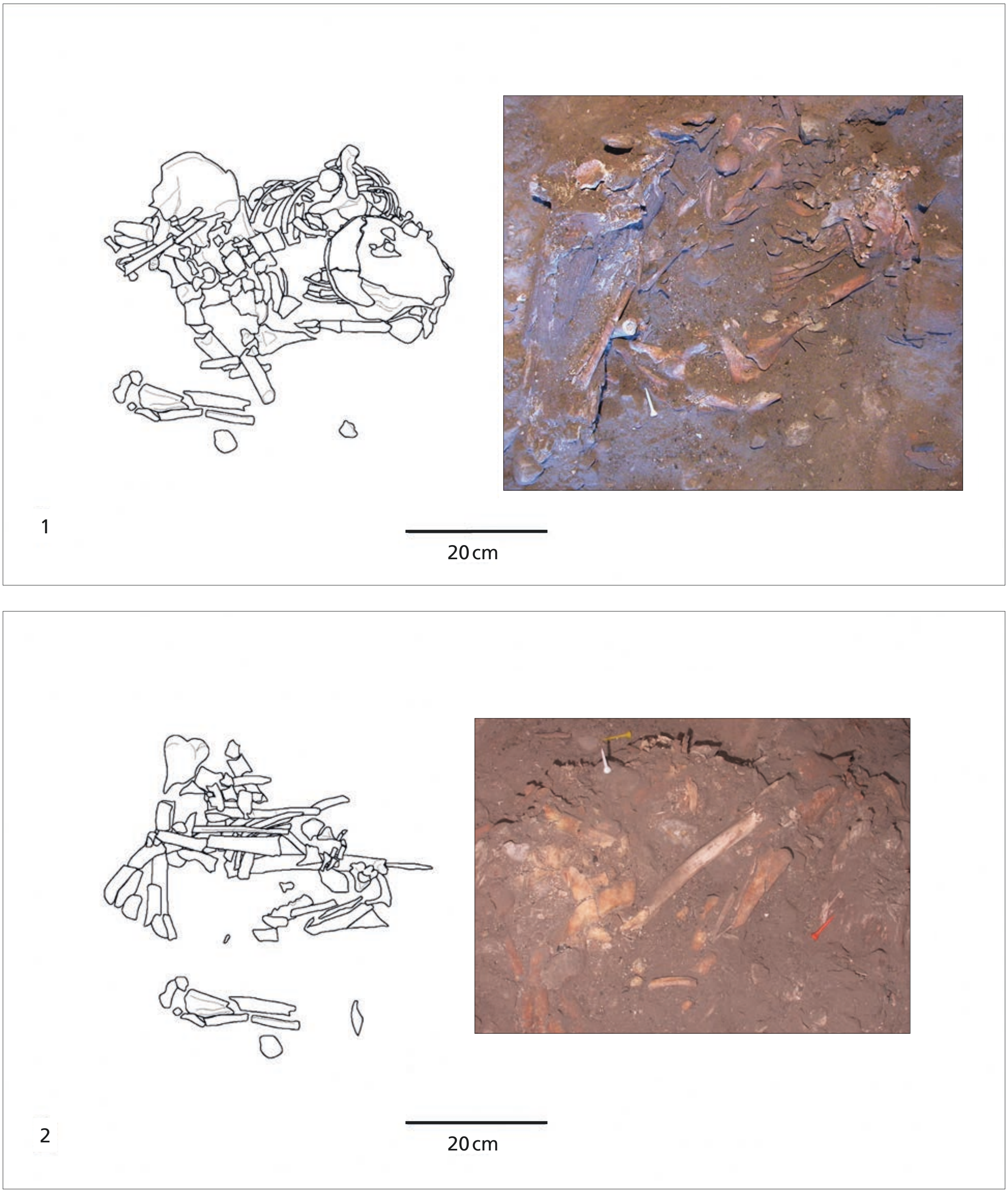


Fig. 15.6 Adult Individuals 1 & 2: drawings showing all skeletal elements assigned to each individual, along with photographs taken during excavation.

trance of the cave. Most parts of the skeleton were present with the exception of some of the small bones of the hands and feet. Many of the bones were in a fragmentary state, particularly the cranium, mandible, pelvis and ribs. Despite the poor condition of the skeleton, some of the bones were found fully articulated indicating a largely undisturbed primary deposition. These instances included the articulations of the bones of the left shoulder and right elbow and the left *os coxa* and left femoral head. The vertebrae and ribs were found in anatomical position, in some instances still articulated.

The cranium and several cervical vertebrae had fallen forwards, forming an acute angle with the rest of the vertebral column, but the atlas and occipital bone remained articulated. The mandible was laterally compressed against an adjacent horn core and broken along the symphysis but the temporo-mandibular articulation was partially maintained. The surviving articulations indicate that the collapse of the head probably occurred when the body was not completely decomposed (Haglund 1991). The head may have shifted into this position during the burial of the overlying skeleton or may have simply collapsed forwards under its own weight. The collapse of the cranium forwards onto the mandible and underlying sternum and rib cage, the flattening of the rib cage and the collapse of the pelvic girdle suggests either the body was deposited in an empty or semi-empty space or that the fine silty characteristics of the surrounding sediment allowed a gradual displacement of the bones during and subsequent to decomposition of the body.

The left and right horn cores from a single large bovine had been placed on either side of the body of Individual 1. Both horn cores are preserved to a length of approximately 400 mm with the upper parts missing (cf. Chapter 9). The horn core located at the southern side of the burial on the right side of the body had a portion of the frontal bone attached, which was located towards the front of the burial. The horn core located on the left side of the body was in a reverse orientation, with the occiput pointing towards the recess of the cave. The long axis of this horn core followed the same orientation as the body and its position in the grave marked the northern limit of the burial. The southern horn core was almost parallel to the northern but converged by about 10° towards the centre of the grave at its tip. Both horn cores had been compacted and flattened. This may have been caused by human or animal activity above the burial or due to the weight of the overlying burial. It is also possible that the burial was originally marked or closed by a large rock, and that this had been removed during previous excavations.

The relationship between the horn cores and the skeleton demonstrates that they were added to the grave subsequent to the deposition of the body. The northern horn core was placed above the left shoulder (scapula, clavicle and humerus) and may have caused a slight rotation in the torso of Individual 1 toward its left side, which would account for the collapse of the head towards the left side of the body. The southern horn was positioned above the right ilium and alongside the right humerus. The right ulna, radius and several hand bones were found lying against and on top of the southern horn core, and their positions indicate that the right arm was extended with the hand placed facing palm down on the horn. As the horns were placed in the grave after the body, it is unlikely that this position could be obtained without the intervention of somebody who lifted the hand into this position. The left arm was positioned between the legs in an extended position. The hand was resting palm upwards and may have been touching the left foot. The legs were tightly flexed at the hips and knees with the ankles close to the pelvis at the centre of the burial. The presence of both patellae and part of the knee articulations on each horn core indicates that the legs were parted at the knees, with the knees resting against the horn cores. The articulation of the left *os coxa* with the femur was maintained, with the distal portion of the femur resting against the horn and the broken diaphysis lying flat at the bottom of the grave. The right femur was partially buried by the southern horn core but fragments of the right tibia and fibula and the right patella were found on the horn core. It is possible that the loss of the knee articulation was caused by movement of the southern horn core toward the centre of the burial area after partial decomposition of the body.

In addition to the two large bovine horns, several other faunal remains were found within the sediment surrounding Individual 1. One hemi-mandible of a Barbary sheep was found directly below the pelvis. A horse incisor lay directly across the sternum and a broken bone point (artefact) was found nearby in the thoracic region. Other fragmented pieces of horn and animal bone were found close to the body but it is uncertain whether there was a deliberate association between these objects and the body. A smooth-textured blue/grey stone measuring approximately 15 × 12 cm was situated immediately above the cranium, and a small fragment of this stone had dislodged and become wedged into the parietal bone.

Individual 2

Individual 2 was directly below the surface of the surviving deposit, partially overlying and in close proximity to the underlying skeleton of Individual 1. The two bodies were separated by several small irregular stones but the significance of the latter, if any, is unclear. The stones may have been placed immediately prior to the deposition of Individual 2 with the intention of separating the two bodies, or deposited earlier to close the burial of Individual 1. Alternatively the stones may have accumulated unintentionally as a result of human activity or natural causes during the interval between the two burials; stones of these dimensions are frequent throughout the Grey Series deposit.

Individual 2 was a mature and probably older adult (**fig. 15.5**). The skeleton of Individual 2 was incomplete and poorly preserved, and sex was not determined. Individual 2 was larger-bodied than Individuals 1, 4, 5 and 13, and smaller-bodied than Individuals 3 and 14. Enough of the post-cranial skeleton was present to indicate that Individual 2 had been placed on its left side with both legs flexed and folded against the chest (**fig. 15.6**). The distal end of the left femur rested against the cranium of Individual 1. Two carpal bones from the left hand were found lying on the proximal part of the left femur, suggesting that the left hand was placed between the thighs. The pelvis was located to the south and the head to the north with the vertebral column forming an arc stretching north from the sacrum towards the missing cranium.

Several features of Individual 2 suggest a primary deposition. The vertebral column was in anatomical position but the individual vertebrae were not strictly articulated with each other. The left *os coxa* and femur were articulated and the proximity of the left femur and tibia indicates that they were in anatomical association, although no articulation was observed. Several bones from the neck, chest and shoulder girdle, including the axis, manubrium, sternum, clavicles and a first rib, had collapsed downwards during decomposition. These bones were relocated between the vertebral column and the left leg and no longer articulated, suggesting decomposition in an empty or semi-empty space. Some skeletal elements had eroded further down slope, including a fragment of the atlas and cranial bones that might be associated with Individual 2. The distribution of bones downslope is indicative of post-depositional disturbance or erosion of the surface deposits.

Individual 3

Individual 3 was a middle-aged adult male and was one of the largest adults buried in Sector 10 (**fig. 15.5**). Individual 3 was found in a single burial to the north of the burials of Individuals 1, 2 and 4. The position of the vertebrae, ribs and right *os coxa* suggests that Individual 3 was placed in a semi-upright or reclining position facing approximately southeast towards the southern corner of the cave entrance (**fig. 15.7**). The right forearm was folded onto the lap. A flat stone found above the right *os coxa* and below the right ulna and radius, must have been present prior to the decomposition of the body and may have been deliberately placed.

The right and left lower limb and foot bones, sacrum and left *os coxa*, most of the left side of the upper body, the right humerus, clavicle, scapula and hand were not recovered *in situ* due to the post-depositional

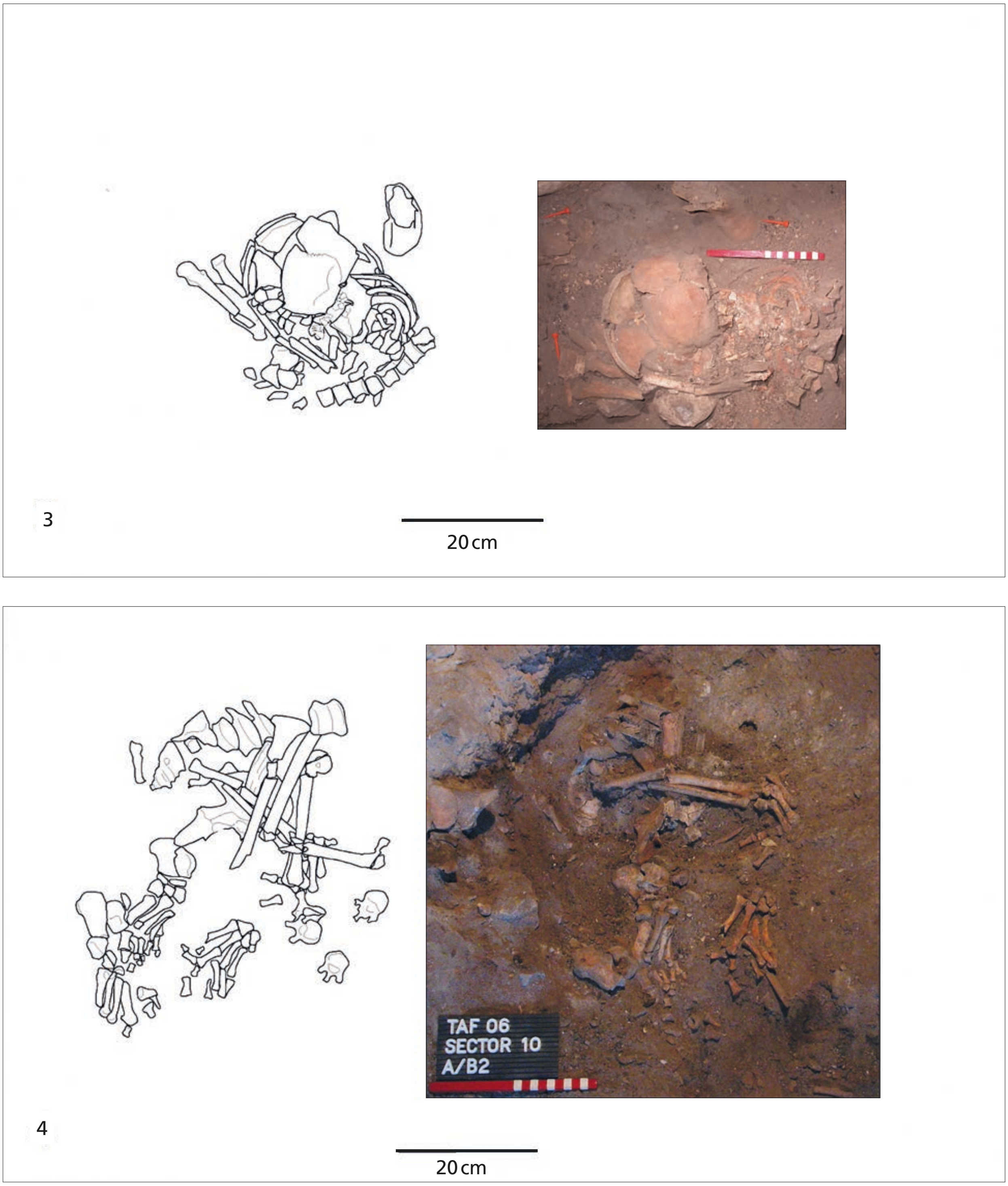


Fig. 15.7 Adult Individuals 3 & 4: drawings showing all skeletal elements assigned to each individual, along with photographs taken during excavation.

disturbance of the grave. The anatomical articulation of many of the skeletal elements indicates a primary deposition. For example, the temporo-mandibular articulation was maintained, the right radius and ulna were in anatomical position with respect to each other, and most of the vertebrae were articulated. Most of the right ribs were found in anatomical position and were still articulated with the corresponding vertebrae, although overall the thoracic cage was flattened. The cranium and mandible and three of the cervical vertebrae appear to have collapsed forward against the chest, with these vertebrae forming an acute angle with the rest of the vertebral column. The collapse of the cranium and attached vertebrae forward and the flattening of the ribcage suggest burial and partial decomposition in empty or partially filled space (Duday 2006).

The burial of Individual 3 had been deliberately or inadvertently disturbed by subsequent burial activity in the surrounding deposit. The western edge of the burial was truncated by the subsequent burial of Individual 5, displacing the right femur, right shoulder girdle and the upper thoracic and lower cervical vertebrae of Individual 3. These vertebrae would have formed an acute angle at the edge of the grave following the forward collapse of the cranium and mandible. The right hand and the left side of the body of Individual 3 would have been located beyond the eastern limit of the remaining burial deposit. It is not known whether this part of the skeleton was truncated by another burial but it is more likely that these bones were removed during earlier excavations or lost to erosion.

The southern part of the burial of Individual 3 was probably disturbed during the burial of Individual 1 as several displaced skeletal elements from Individual 3 had been incorporated into the deposits surrounding Individual 1. These included broken parts of a left proximal femur, and a fragment of proximal fibula found close to the northern horn core and the distal portion of right tibia situated close to the southern horn core and above bones assigned to Individual 1 and Individual 4. The massive size of these skeletal elements is consistent with their belonging to Individual 3, and they were assigned on that basis. Displaced bones from the right shoulder girdle (humerus, clavicle and scapula) and the right lower limb (femur) of Individual 3 were found within the burial pit of Individual 5. The location of these bones suggested that they were disarticulated and added to the burial pit after placement of the body of Individual 5. They may have been knowingly recovered and deliberately placed within the burial pit as part of a funerary rite or put there for practical reasons.

Individual 4

Individual 4 was an older adult male and was one of the smallest adults from Sector 10 (**fig. 15.5**). The articulated partial skeleton of Individual 4 was located directly below Individual 1. The right radius and ulna, three lumbar vertebrae, left *os coxa* and sacrum were found in anatomical position and partially articulated (**fig. 15.7**). Both hands and feet were found in almost complete anatomical articulation. All of hand bones apart from one distal phalanx were recovered. The partial right foot that was found eroding out of the sloped surface of the surviving grey deposit in 2004 was assigned to Individual 4 based on its position and orientation within the deposit, recovery of *in situ* bones from the same foot, and matching with corresponding elements from the left foot.

The burial of Individual 4 was truncated through the lower part of the vertebral column during the burial of the overlying Individual 1. The parts of the skeleton of Individual 4 that were uppermost in the burial, including the cranium and mandible, femora, tibiae, fibulae and most of the bones of the upper body, were removed from their primary depositional context during this process. Some of these skeletal elements were found incorporated into other burials, either deliberately or inadvertently, and others were found distributed within the sediment between burials. Fragments of a right ilium that could be matched with the *in situ* left ilium for Individual 4 were identified among the intrusive disarticulated bone fragments surrounding Individual 1. Other displaced skeletal elements were assigned to Individual 4 on the basis of degenerative changes to the bone and size compatibility. The left and right humeri of Individual 4 lay across the lower body of Individual 1. The right femur, right tibia and right fibula lay alongside the right arm of Individual 1

and against the southern horn core. The left femur was found against the same horn core but slightly separate from the bones of the right lower limb. The extent to which the incorporation of these bones into the burial of Individual 1 was deliberate is uncertain. The bones had either been placed within the space between the chest and lower limbs of Individual 1 and the two horn cores or they had been placed directly above the body of Individual 1 and fallen into this position during decomposition. One thoracic and two cervical vertebrae assigned to Individual 4 lay directly below the northern horn core indicating that the vertebral column of Individual 4 had decomposed at the time of disturbance. Many of the displaced skeletal elements from Individual 4 were less well-preserved than those found in their primary depositional context. Several bones were not identified including the cranium, mandible, sternum, scapulae, clavicles, left fibula and tibia and the right ulna and radius. The sediment surrounding Individual 1 contained several unassigned long bone mid-shaft fragments and some of these are likely to have belonged to Individual 4. Some parts of Individual 4 may have been lost to erosion or removed during the excavation of Necropolis II in 1955.
Most of the hand and foot bones belonging to Individual 4 were in anatomical articulation suggesting that the body decomposed in a filled space (Duday 2006). The position and orientation of the bones, including the almost vertical position of the lowest three lumbar vertebrae, indicates a seated position with both lower limbs tightly flexed and the feet folded together in front of the pelvis. The right forearm was resting across the lap with the hand to the left of the body, facing palm down and with the fingers folded around the thumb. The left arm was extended with the open hand facing palm down next to the feet. The orientation of the sacrum and *os coxae* suggests that the body was aligned on an east-west axis and that Individual 4 was facing east towards the entrance of the cave. The flexed upright position of the body is consistent with the size of the burial pit. There were no human bones or teeth from any other individual in the undisturbed part of the burial. Some animal bones were found in the pit but it is not known whether these were deliberately placed alongside the body or inadvertently incorporated into the fill of the burial.

Individual 5

Individual 5 was a young adult or late adolescent female with an estimated age-at-death of 16-18 years (**fig. 15.5**). Individual 5 was buried in a semi-reclined position. The skeleton was almost complete and most bones were articulated (**fig. 15.8**). The position of the atlas implied that the neck was held upright, but the rest of the vertebral column was less vertically orientated. It is possible that the head and neck were deliberately tilted into a more vertical position to face forwards or fit the constraints of the burial pit. The head had shifted slightly forward and to the right. The maxilla was fragmented and pushed into the eye orbit implying that pressure was applied from above. The pressure was sufficient to cause breakage of the facial bones but did not smash the cranial vault.
The pelvis was fully articulated at the base of the grave. The lower limbs were flexed and leaned towards the left of the body with the right leg overlying the left leg and the left and right knees close together. Both lower limbs were fully articulated at the pelvis, knee and ankle. The feet were close together, and drawn up towards the pelvis and located slightly to the right side of the body. The undisturbed anatomical articulations of the pelvis and lower limbs imply decomposition in a filled space. The left upper limb was fully articulated. The proximal end of the left humerus was directly adjacent to the left side of the cranial vault, and the upper arm lay alongside the left side of the upper body. The left forearm was flexed inwards at the elbow towards the body. The left hand was tightly folded and tucked between the upper left femur and the front of the pelvis. The right upper limb was disarticulated at the wrist, elbow and shoulder. The proximal end of the right humerus was found close to the scapula, but out of articulation. The right humerus was pointing

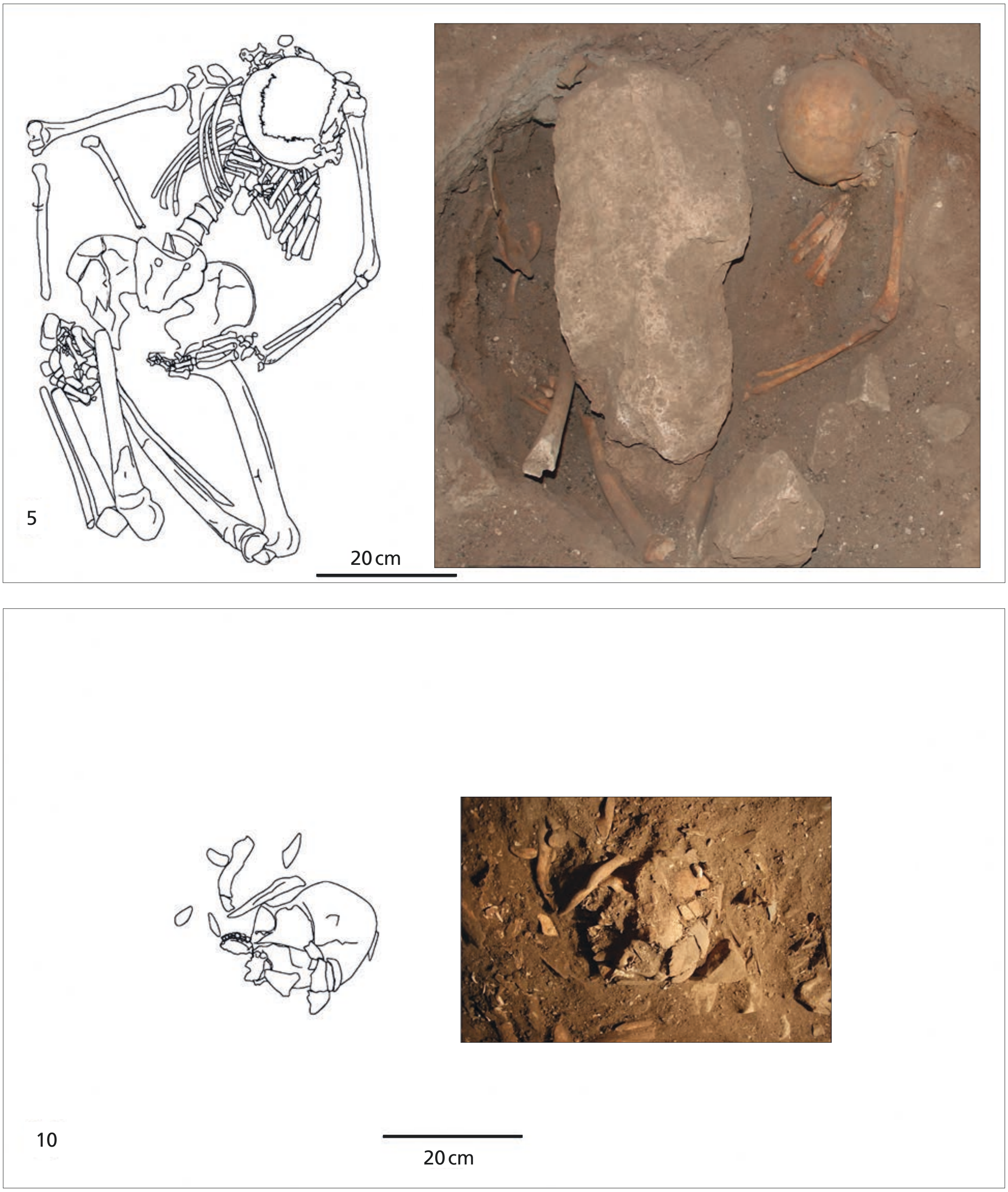


Fig. 15.8 Adult Individuals 5 & 10: drawings showing all skeletal elements assigned to each individual, along with photographs taken during excavation.

distal end upwards propped against the steep edge of the grave cut. The lower arm bones had fallen out of articulation and may have been shifted due to movement of the overlying rock. The right hand was clasped and resting on the sternum, hyoid body and upper left ribcage.

The southern edge of the burial was defined by a deep vertical cut into denser underlying sediment. It was not possible to define a clear cut on the north side of the burial. The position of skeleton and surrounding

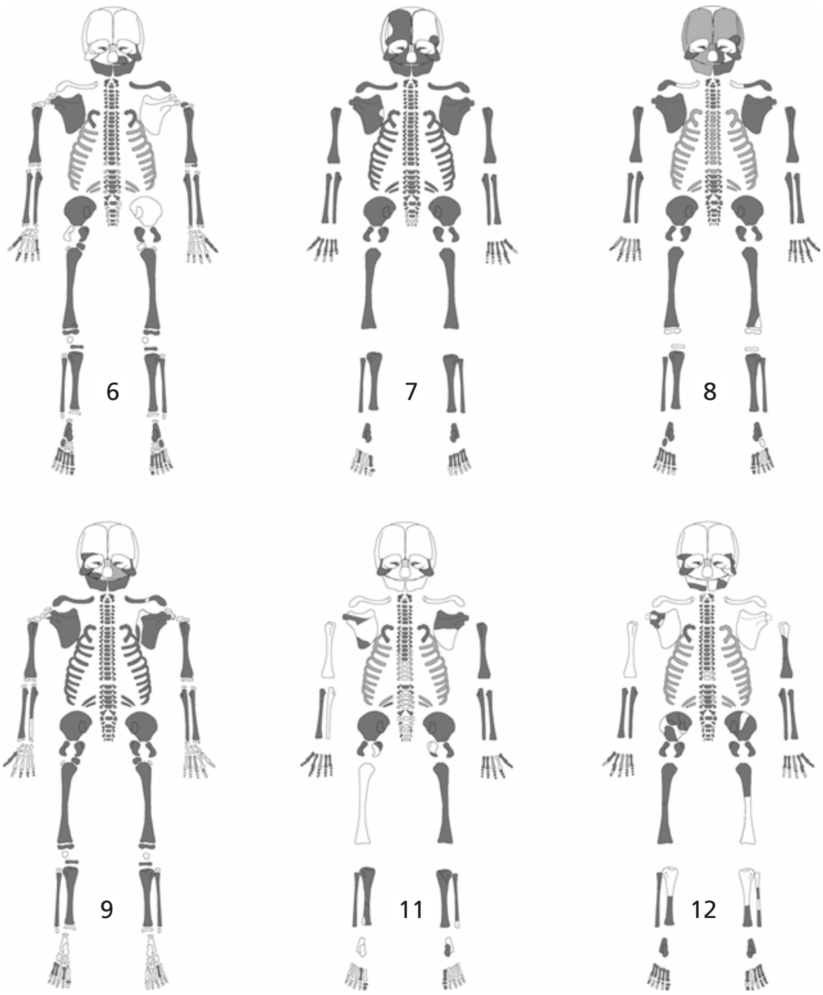


Fig. 15.9 Charts representing recovered skeletal elements of infant burials from Grotte des Pigeons, showing Individuals 6-9, 11 and 12; lighter grey areas represent badly fragmented bone, dark grey represents better preservation.

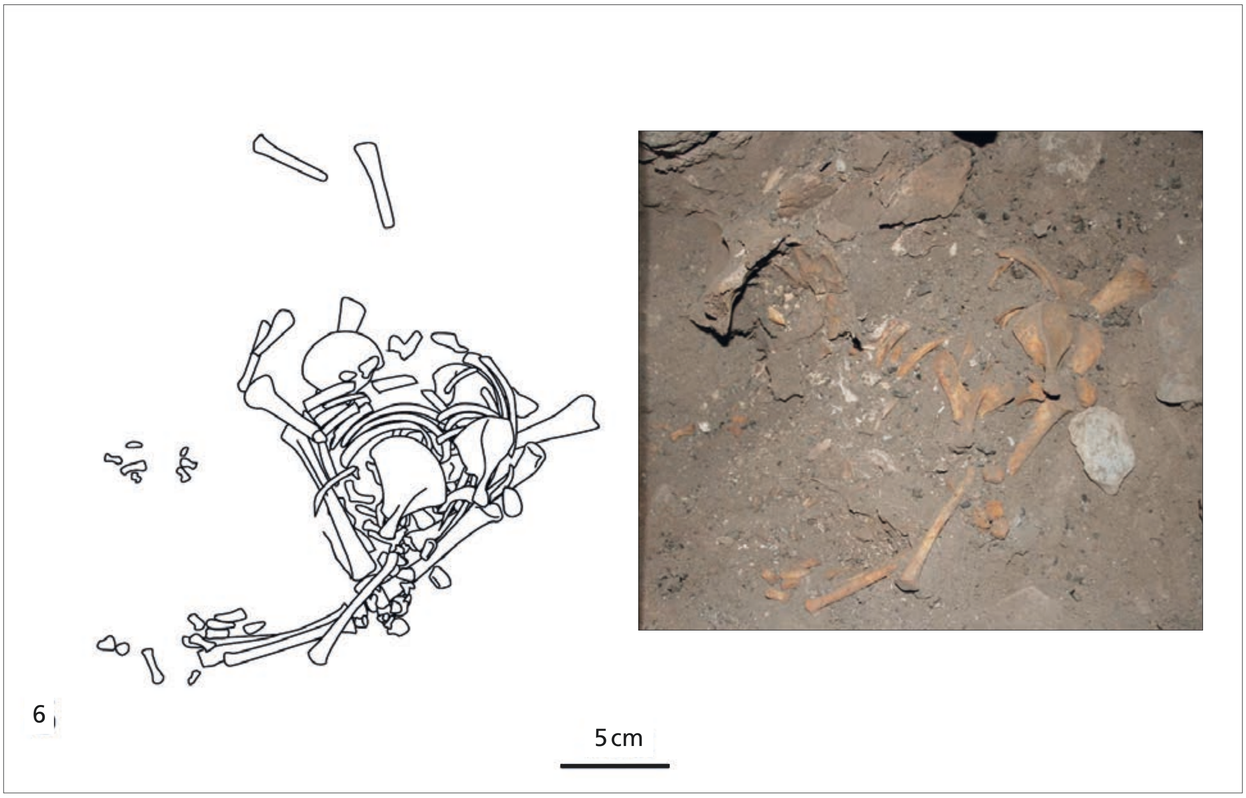
horn cores suggests a gentle slope, assuming these objects rested at the edges of the pit. This may mean that a steep vertical cut was made on the southern side to accommodate the height of the flexed lower limbs and the sediment was then scooped outwards towards the north creating a sloped edge to the pit. A large irregularly shaped rock measuring approximately 53 × 24 cm had been placed directly above the pelvis and right part of the thorax. The rock was tilted downwards towards the front of the cave and may have shifted down in a southeast direction due to pressure from above or the presence of empty space or loosely packed sediment on the right side of the body. Several Barbary sheep horn cores had been placed between the central stone and the edges of the burial. A large horn core with part of the cranium attached had been placed above the left elbow with the broken tip pointing towards and overlying the central stone. A modified cranium with both horn cores attached and broken at the tips, was located above the left forearm and left upper leg, and slightly overlying the central stone. Another partial cranium with horn cores was situated close to the flexed knees with one of the horn cores orientated vertically adjacent to the right knee and the other in a more horizontal position alongside the central stone. The horn core situated to the south of the central stone appears to have been shifted and broken by the stone as it settled. The displaced bones from Individual 3 were found between the rock and the southern edge of the burial, above the feet of Individual 5 and below the horn core. It is not clear whether these intrusive bones were added to the burial before or after the placement of the central stone.

Individual 6

Individual 6 was a male infant with an estimated age-at-death of 6-12 months, and delayed skeletal growth relative to the state of dental development (fig. 15.9). Individual 6 was positioned flexed forwards at the pelvis with the head overlying the upper body and upper right leg. The position of the cranial bones and mandible indicated that that the infant lay with the face downwards (fig. 15.10). Both scapulae lay flat with the dorsal side upwards indicating that the upper body was in an almost horizontal position during decomposition. The pelvis was closest to the rear of the cave (west), with the head orientated towards the front of the cave (east). The left leg was tightly flexed at the knee with the foot resting directly in front of the pelvis. The right leg extended forward from the pelvis and was flexed outwards at the knee with the lower leg and foot orientated away from the body. The left arm was extended forwards from the shoulder and towards the right side of the body with the upper left arm overlying the lower left leg and the left forearm overlying the lower right leg. The right arm lay alongside the body and was disarticulated at the elbow with the forearm and hand no longer in anatomical association. The right ulna and radius were broken, and the distal parts were found close together and slightly removed from the rest of the body, suggesting that this part of the burial had been disturbed. The overall position of the body may imply a hasty and slightly careless burial but it is also possible that the original intention was to place the infant body in a seated position facing east towards the cave entrance and that the body was floppy and slumped forward during burial or shortly thereafter. Fragments of cranium and horn core from at least one juvenile Barbary sheep were found along the right side of the body, and overlying the right forearm and right ilium. A relatively large end-scraper made on chert lay close to the left upper arm. These items are considered to have been deliberately included within the burial. A marine shell (*Dentalium*) was located close to the displaced right forearm bones and may also have been deliberately placed within the burial.

Individual 7

Individual 7 was a male pre-term infant who died perinatally (fig. 15.9). Individual 7 was buried in a seated position facing west towards the back of the cave (fig. 15.10). The body had slumped slightly forwards and to the right. A small rock located on the right side of the body may have propped it up and prevented further slumping. The left leg was tightly flexed at the knee with the foot tucked beneath the pelvis. The right leg was flexed at the knee with the lower leg orientated towards the centre of the burial and the right foot in front of the pelvis. The right side of the ribcage overlay the right lower leg. The head was positioned above the upper body, right arm and leg and the adjacent rock. The left upper arm overlay the ribcage but the left elbow was no longer articulated indicating that the arm had either been disturbed, or had shifted under the influence of gravity during decomposition. The right forearm rested on the right upper leg. The right scapula and humerus had fallen out of anatomical association, with the humerus found above the scapula, suggesting that decomposition had occurred in a somewhat empty space. There were no objects clearly associated with this burial and no traces of red ochre on the bones. A hartebeest deciduous tooth (upper dp3 of *Alcelaphus buselaphus buselaphus*) was found close to the left forearm bones and a deciduous incisor of a medium sized animal was found among the cranial bones but, as isolated animal teeth occur throughout Sector 10, it cannot be assumed that these objects were deliberately placed adjacent to the infant body during burial.



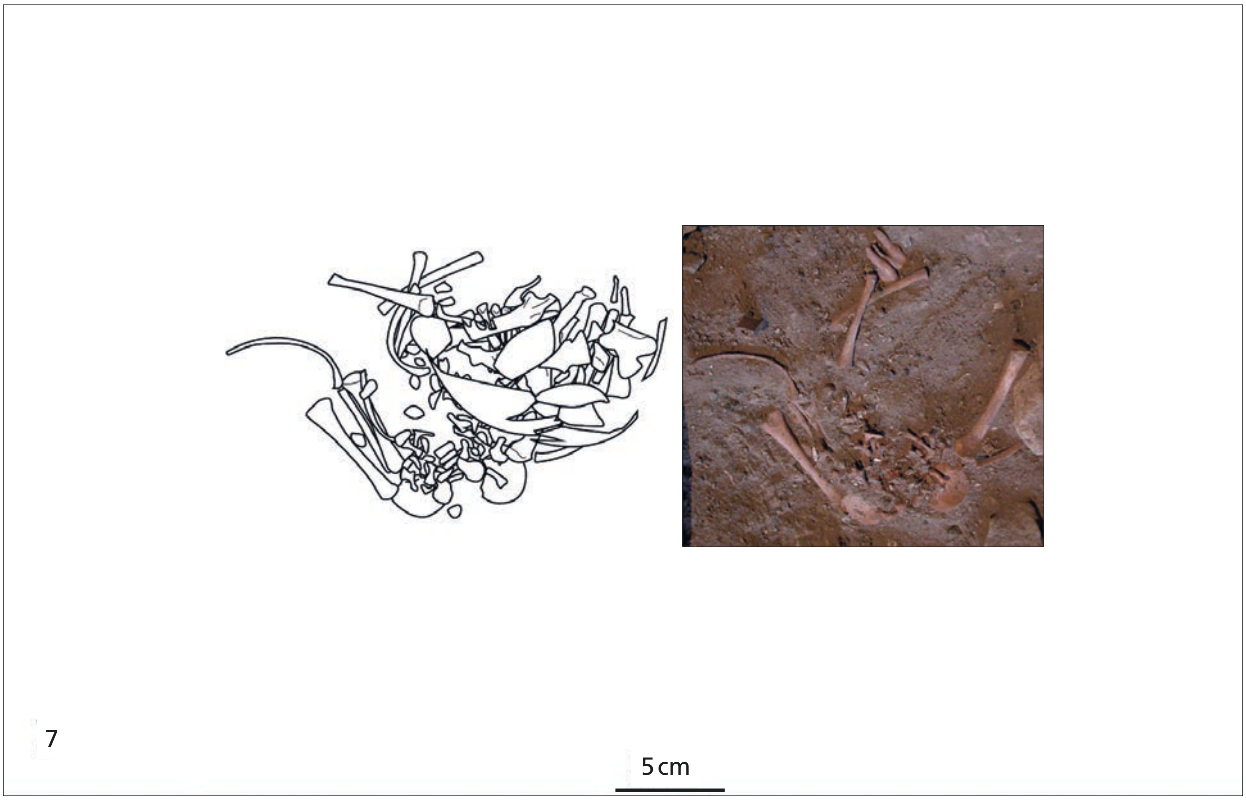


Fig. 15.10 Infant Individuals 6 & 7: drawings showing all skeletal elements assigned to each individual, along with photographs taken during excavation.

Individual 8

Individual 8 was a male infant with an estimated age-at-death of 2-3 months (**fig. 15.9**). Most of the skeleton of Individual 8 was located beneath a blue / grey-coloured stone measuring 30 × 23 cm that had been placed above the baby at the time of burial. The baby was buried lying on its back, orientated northwest to southeast with the head furthest from the cave exit (**fig. 15.11**). The overlying stone had settled onto the burial during decomposition, crushing the more fragile underlying bones. Most of the ribs, cranial vault and part of the facial skeleton had been reduced to a mass of bone fragments. Both lower limbs were flexed at the hip and knee, with the knees extending beyond the edges of the cover stone. The feet met at the front of the stone with the right foot pointing directly upwards. The right arm was flexed at the elbow with the right forearm folded over body and the hand resting palm downward on the left ilium. The left arm lay alongside the body with the hand slightly disturbed and resting palm upwards. The surface of the overlying stone that rested directly on top of the baby's body was stained with a well-defined circular outline of red ochre. The red ochre did not extend into the concave central area of this surface. The shape of the stone is consistent with a grindstone but the absence of ochre staining in the concave central area suggests that the stone had not recently been used to prepare ochre. Instead the pattern of ochre distribution on the inferior surface of the stone suggests that the more prominent areas of the stone may have rested on an ochre layer that covered the baby's body or any (hypothetical) covering of the body and that the ochre was transferred in this way. Traces of ochre were also found on other surfaces of the stone. The concentration of charcoal within the grave appeared to be even higher than the frequent background levels for Sector 10. During excavation, three lithic artefacts were recorded adjacent to the left shoulder and upper arm, but these are knapping debris and as such unlikely to be funerary objects. There were no animal bones or horn cores clearly associated with this burial.

Individual 9

Individual 9 was a female infant with an estimated age-at-death of 5-6 months (**fig. 15.9**). Individual 9 was placed in a seated position facing southeast away from the cave wall (**fig. 15.11**). The back rested against and was supported by a large irregularly shaped rock associated with an earlier adult burial. The cranium and mandible directly overlay the post-cranial skeleton, and the body remained in an almost upright position, tilted slightly forwards and to the right. Both lower limbs were flexed, with the knees parted and the feet folded together in front of the overlying stone. The right upper limb had been disturbed but some of the hand bones were found adjacent to the right temporal, suggesting that the head may have been cradled in the right hand. The left upper limb extended in front of the body, and was flexed at the elbow with both the upper and forearm overlying the left upper leg. A blue- / grey-coloured stone measuring approximately 24 × 18 cm was placed directly above the body of Individual 9. The left elbow projected beyond the limits of the overlying stone. The cranial bones were only slightly damaged as a result of settling of the overlying blue / grey cover stone, implying that the stone had not moved downwards into an empty space. Most parts of the skeleton were found in their original anatomical position and the pelvic bones maintained a bowl shape instead of lying flat at the base of the grave as was the case for the other infant burials. This implies that the body must have been closely surrounded by sediment or tightly wrapped during decomposition. The distinctive stone placed directly above Individual 9 was stained with red ochre and was similar in size and shape to the stone overlying Individual 8.

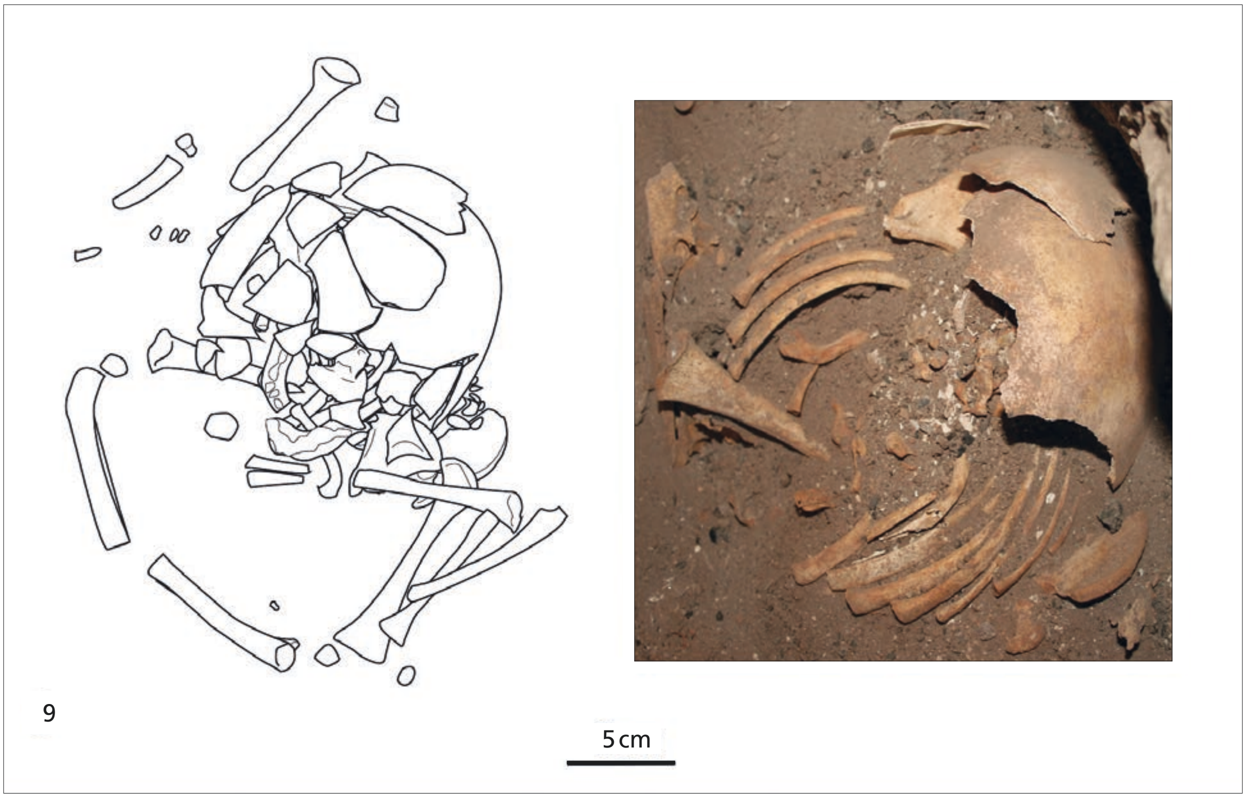


Fig. 15.11 Infant Individuals 8 & 9: drawings showing all skeletal elements assigned to each individual, along with photographs taken during excavation.

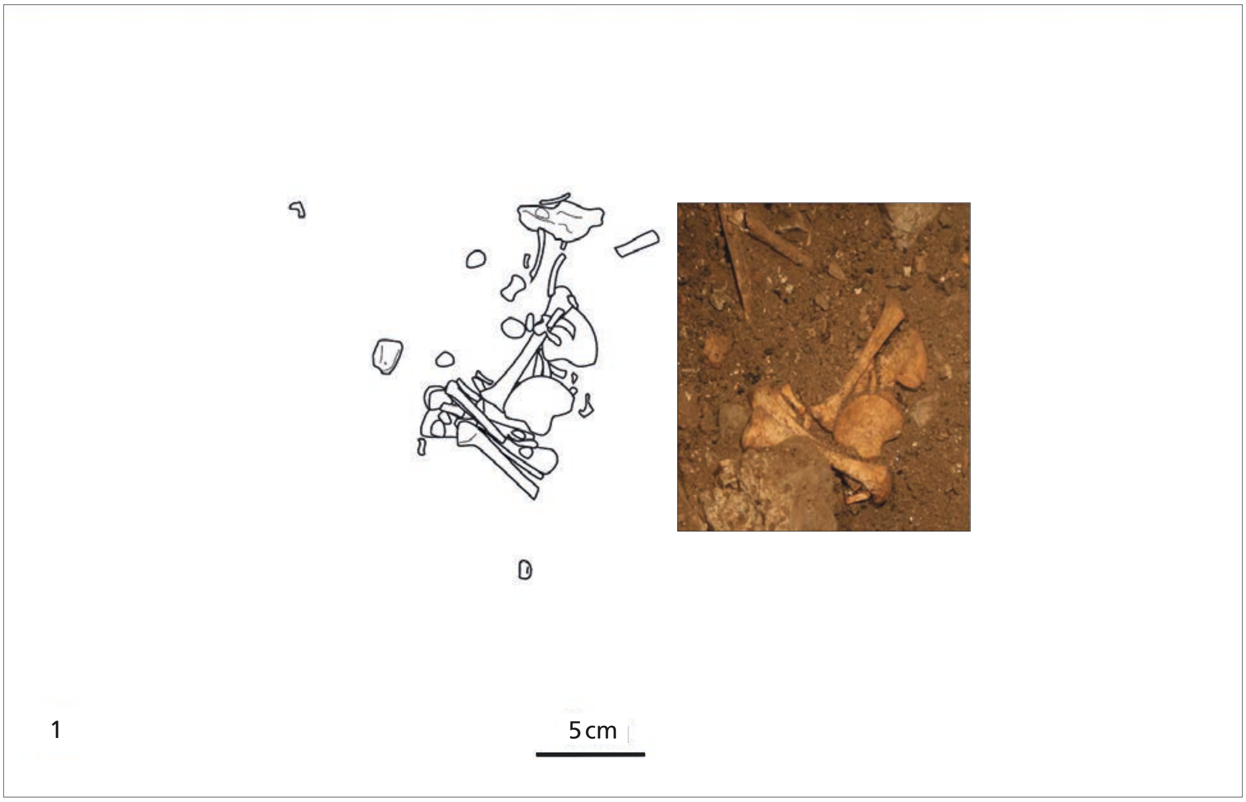


Fig. 15.12 Infant Individuals 11 & 12: drawings showing all skeletal elements assigned to each individual, along with photographs taken during excavation.

Individual 10

Individual 10 was a middle-aged adult male (**fig. 15.5**). The skull of Individual 10 was found just below the surface of the Sector 10 deposit and close to the back of the cave (**fig. 15.8**). The cranium was badly damaged with some recent breaks, and appeared to have been broken *in situ,* possibly as a result of pressure on the shallow overlying deposit. The left maxilla and fragments from the right were found with the palate facing upwards, together with part of the cranial base, implying that the cranium was lying with the cranial base upwards when it was broken. The mandible was found adjacent to the cranium and in three parts, with the base of the mandibular body facing upwards. The mandible may originally have been deposited still articulated with the cranium and subsequently become dislodged and displaced to one side. Two heavily worn right maxillary molars found close to the skull of Individual 10 could be matched to this individual. The alveolae for the upper central incisors of Individual 10 were well-preserved and showed no evidence for *ante mortem* remodelling. The two central incisors were subsequently found separately in lower deposits, confirming that Individual 10, uniquely amongst the adults excavated from Sector 10, had not undergone evulsion of the upper central incisors prior to death. No other bones belonging to Individual 10 have been identified and Individual 10 is considered to represent an intrusive element rather than an *in situ* burial.

Individual 11

Individual 11 was a male full-term infant who died perinatally (**fig. 15.9**). Bones from Individual 11 were found disarticulated and within a restricted area overlying the burial of Individual 13 (**fig. 15.12**). The disarticulated state of most of the skeleton suggests that the body had been disturbed at a late stage of or subsequent to decomposition. Some bones from Individual 11 had accumulated against a small stone which overlay the cranium of Individual 13. The position of some of the bones relative to others was consistent with their anatomical relationship, suggesting that some parts of the skeleton had not shifted far from their original location. The right ilium was found close to the right pubis and rested flat with the auricular surface upwards. The left ilium lay with the lateral side upwards close to the left pubis and proximal left femur. The left tibia and fibula were orientated with the proximal end upwards and propped against the stone, suggesting that the left lower limb was originally flexed with the knee pointing upwards, but the femur had dropped into a horizontal position. The baby appears to have been buried lying on the right side with the upper body orientated towards the rear cave wall. Both upper limbs were disturbed and most of the right upper limb was missing. The left humerus overlay the pelvis and left lower limb and may have shifted into this position during disturbance or slippage of the skeleton. The left ulna and part of the right radius were among the stack of bone parts that had accumulated against the stone that overlay the cranium of Individual 13. The left radius was found closer to the cave opening, but may have been moved inadvertently into this position when the large stone slab found above Individual 13 was removed during the current phase of excavations. The original position of the head of Individual 11 could not be determined. The crushed skull of Individual 10 was found immediately above Individual 11 and it is possible that placement or subsequent breakage of this skull may have caused parts of the skeleton of Individual 11 to shift both downwards and eastwards towards the cave entrance. It is not possible to discern whether any funerary objects were deliberately placed in the burial of Individual 11 due to its disturbed state and placement directly above an existing burial.

Individual 12

Individual 12 was a male full-term infant who died perinatally (**fig. 15.9**). Fragmentary parts of Individual 12 were identified among the accumulation of small bones, shells and stones on the flat surface of the unexcavated deposit close to the cave wall during the 2005 season. There was no discernible anatomical cohesion in the positioning of the bone fragments but they were distributed within a restricted area. The human bone fragments appeared to have weathered out from the underlying sediment, over an unknown period of time. In a subsequent field season, part of the skeleton of Individual 12 was excavated from the immediate sub-surface sediment in the same location (**fig. 15.12**). Both sides of the pelvis were found in approximate anatomical position, although the left ischium was slightly removed from the ilium and pubis. The right radius and ulna were found in correct anatomical association resting almost above the right ilium. The position of the pelvis indicated that Individual 12 was buried with the back towards the closest cave wall (the south side of the deepest alcove) and facing north towards the cave wall on the far side of the alcove. The infant appears to have been placed in a reclining position with the left arm resting across the lap, the right arm alongside the body and the legs flexed and parted at the knee. A horse tooth (permanent upper incisor) was tucked against and under the left elbow. A blue/grey-coloured rock was located close to the left side of the body and a lithic artefact made from a red-coloured raw material was within the sediment close to the burial but these may not have been deliberate associations. A marine shell (*Dentalium*) was collected from the surface deposits directly above the burial. Faint traces of red ochre were present on some cranial fragments but did not appear to have been applied directly to the bone.

Individual 13

Individual 13 was an adult male with an age-at-death of 18-20 years (**fig. 15.5**). The position of the pelvis and lower vertebrae and vertical orientation of the right shoulder blade indicate that Individual 13 was buried in a seated position (**fig. 15.13**). Both lower limbs were tightly flexed. The right foot was placed in front of the pelvis and pointed forwards. The left foot was angled at 90° towards the heel of the right foot and was partly underneath the right wrist. The right shoulder and elbow were in articulation and the right arm extended forwards and downwards. The right elbow rested just above the most lateral part of the right iliac crest and the right hand rested alongside and medial to the right foot. The right hand rested palm downwards and the fingers were slightly cupped. The left elbow was articulated and flexed towards the body at an angle of about 45°. The left hand lay alongside the left foot and directly below the right forearm. The bones of the hands and feet maintained their burial position in near-perfect articulation. They lay alongside and over one another undisturbed, apart from some phalanges which may have shifted in the loose powdery sediment during excavation.

The cranium, mandible, upper part of the vertebral column, sternum and the left shoulder girdle and ribcage had been relocated to a lesser or greater extent from their original position. Several groups of vertebrae had shifted in articulated blocks, suggesting that the vertebral column had not completely decomposed when this disturbance took place. Some of the bones from the upper central and left part of the body had fallen slightly out of anatomical position including the left scapula and clavicle, proximal half of the left humerus, left ribs, sternum and manubrium. The mandible had fallen to the base of the grave. These movements indicate the presence of empty space in the burial during decomposition. The burial of Individual 11 and placement of Individual 10 directly above Individual 13 may have caused some disturbance. There was clearly some empty space within the sediment surrounding Individual 13 subsequent to these events, as this

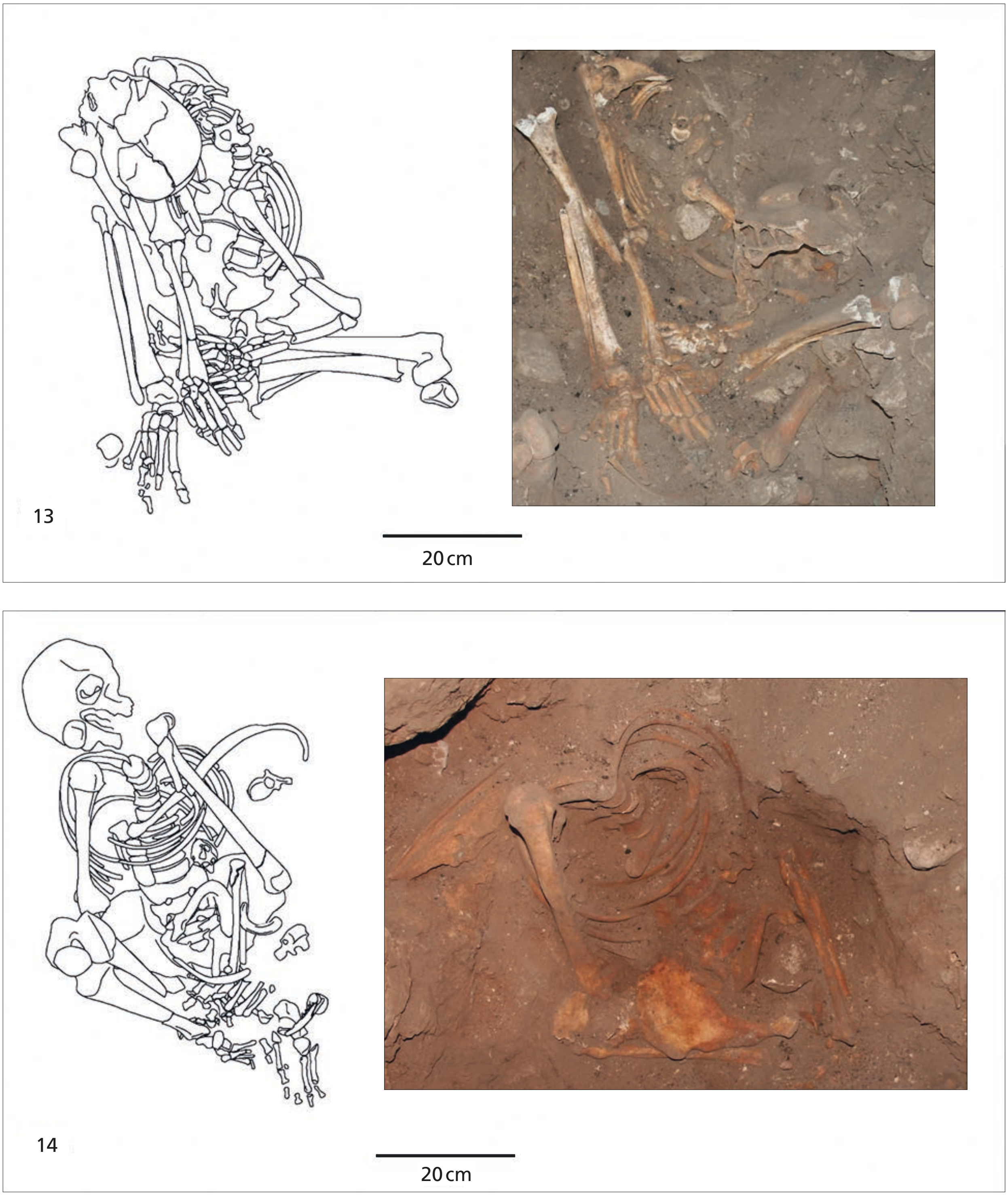


Fig. 15.13 Adult Individuals 13 & 14: drawings showing all skeletal elements assigned to each individual, along with photographs taken during excavation.

allowed two teeth from Individual 10 and some of the bones from Individual 11 to fall or trickle downwards into the burial of Individual 13. The left radius of Individual 13 shows gnaw marks, suggesting that the burial deposits were disturbed by burrowing or that there were empty spaces that allowed a small gnawing animal to enter the burial.

A large stone slab measuring approximately 81 × 45 cm directly overlay the burial of Individual 13. A large part of this rock was visible at the surface of the grey ashy deposits. The skeleton of Individual 13 was overlain by a jumbled assemblage of partial crania and horn cores from at least seven Barbary sheep. Many of these were in poor condition due to pressure from the overlying stone slab. The cranium of Individual 14 was situated below the uppermost layer of horn cores alongside the cranium of Individual 13. A long curved section from close to the tip of a horn core from a large bovine was found alongside the crania of Individuals 13 and 14 in a horizontal position. A second piece of bovine horn core measuring approximately 40 cm pointed downwards towards the base of the grave alongside the large irregularly shaped rock next to the feet of Individual 13. A large piece of bovine cranium was found at the base of the burial on the left side of body. Two bone points and a freshwater snail shell (*Melanopsis* sp.) were found within the sediment surrounding the skeleton, but it is not certain that these were deliberately incorporated into the burial. Some of the objects found close to the skeleton of Individual 13 may have been relocated from the underlying burial of Individual 14.

Individual 14

Individual 14 was an adult male with an age-at-death of 18-20 years, and was one of the largest adults from Sector 10, comparable in size to Individual 3 (**fig. 15.5**). Individual 14 was buried in a seated position, facing away from the back cave wall (**fig. 15.13**). The burial of Individual 14 was disturbed by the subsequent burial of Individual 13 situated almost directly above. As a result, the skeleton of Individual 14 was truncated at the level of the intersection of the 8th and 9th thoracic vertebrae. The lower vertebral column, ribs and pelvis, together with bones from the right arm and leg, the left forearm and left foot were found in approximate anatomical association. Several disarticulated bones belonging to Individual 14 were identified as intrusive elements in the overlying burial. Displaced parts of Individual 14 include the cranium, left femur, tibia and fibula, left humerus, parts of both scapulae and several ribs and vertebrae. None of the displaced bones from Individual 14 were articulated suggesting that the body was already fully or almost fully decomposed at the time of disturbance.

The right lower limb was flexed with the right foot resting flat in front of the pelvis at the base of the grave. The right upper limb was articulated at the elbow with the upper arm resting alongside the rib cage. The right forearm was positioned beneath the right side of the pelvis with the right hand in front of the pelvis. The left hand was above the right hand, and was in a fist shaped position with the outstretched thumb overlying the flexed fingers. The left foot lay at the base of the grave and was slightly tilted laterally with the first digit uppermost. The position of the left foot relative to the pelvis suggests that the left lower limb, which was not found *in situ*, was also buried flexed at the knee and angled upwards from the ankle.

The mandible and several bones from the upper thoracic region of Individual 14 were found below the level at which the burial was truncated but out of anatomical association. The mandible rested above the sacrum with the teeth facing downwards. The atlas, axis and third cervical vertebra were found in articulation on the left side of the body, with the superior side of the atlas facing down. These three bones must have dropped into this position while still connected by soft tissues. The left clavicle, left first rib, sternum and hyoid rested against the lower vertebral column. The displaced bones suggest that the body was buried in an empty or semi-empty space, allowing bones to fall into a lower position in the grave as they became disconnected during the process of decomposition of supporting soft tissues. The left ulna and radius were found adjacent to one another but were not in anatomical association. The proximal left radius had shifted sideways and was found resting above the left side of the pelvis and slightly overlying the mandible. It may

have shifted into this position during decomposition or when the left humerus was removed from its original position, as this would have disturbed the articulation of the elbow.
The lower outline of the grave cut of Individual 14 could be defined in its entirety. The grave was cut through a more compact brown-coloured sediment ('Brown Layer') that underlay the ashy grey sediment and into the underlying orangey-coloured sediment. There was a sticky deposit adhering to the proximal end of the right femur which matched the underlying sediment, suggesting that the part of the body that was lowest in the grave was pushed downwards into the sediment underlying the grave cut. The body of Individual 14 was tightly flexed but did not extend to the edges of the burial pit. This suggests that the corpse may originally have been bound or wrapped to hold the legs, arms and thorax close together, and then placed in an upright position, supported on one side by the cave wall. Alternatively the space between the lower legs and the front of the grave may have been filled by other objects that subsequently decomposed.
Several unusual animal bones were found in close proximity to the undisturbed part of the skeleton of Individual 14. These included half of the lower jaw of a fox, which was found directly above the left ankle, part of a canid jaw located close to the pelvis, a large piece of Barbary sheep jaw located directly above the right elbow, and part of a large animal cranium found adjacent to the right shoulder. Bird bones from several species were also found within the burial and surrounding sediment. A large ochre-stained discus-shaped stone rested alongside the right leg. The ochre staining is most pronounced on the concave side, suggesting that the stone may have been used as a mortar. An ochre stained pestle/grindstone was found at the base of the burial pit on the far side of the skeleton, and is probably associated with the mortar. An unusual deep-red-coloured stone was found adjacent to the left foot and below the fox jaw and a well-made backed blade was found close to the feet. One half of a bivalve marine mollusc shell identified as a species of bittersweet clam (*Glycymeris nummaria*) was found in an alcove in the cave wall alongside the right upper arm. A stack of three Barbary sheep horn cores was located on the left side of the body and a single large horn core was found adjacent to the right knee. A large irregularly shaped rock, measuring 53 × 24 cm, was situated above one edge of the burial of Individual 14, although it is not certain that this formed part of the burial as the large rocks situated above other burials, for example the burial of Individual 5, were typically placed more centrally. It is possible that the rock was moved during the burial of Individual 13. Part of this rock was visible at the surface of the grey ashy deposits, but the rock became wider towards its base.

15.4 UNASSIGNED BONES

Fragments of cranium and mandible consistent with two middle-to-old aged adults were found in deposits close to Individual 1. These may be associated with Individual 2 and/or Individual 4. They included left and right maxillary fragments from separate individuals, each showing evulsion of an upper central incisor. The right fragment included four anterior teeth which survived only as polished dentine stumps due to heavy wear. This was found lying on the left tibia of Individual 2, suggesting that it may have eroded downslope from Individual 2 together with other cranial parts. The alveolar region of the first upper central incisor had fully remodelled. The left maxillary fragment was found below the disturbed long bones of Individual 4, but above the *in situ* bones of Individual 1, close to the right femur. The location suggests that it potentially belonged to Individual 4 and had been disturbed and redeposited during the burial of Individual 1. Only the two premolars remained in the maxilla and these were heavily worn. The alveolar region of the first upper central incisors had fully remodelled and the bone surrounding the lateral incisor and first permanent molar was actively remodelling indicating *ante mortem* tooth loss. The canine appears to have been lost *post mortem* since there was no evidence of remodelling of the socket and surrounding bone.

A broken but complete mandible was recovered between Individual 3 and the northern horn core from the burial of Individual 1. The anterior teeth exhibited compensation, consistent with evulsion of the upper central incisors (Marchand 1936; Humphrey/Bocaege 2008). The degree of wear on the anterior teeth was less than that of the teeth from the isolated right maxillary fragment, but the relatively slight amount of wear on the mandibular incisors could reflect the absence of upper central incisors to occlude against. There was substantial dentine exposure on the third molars but a thin rim of enamel was retained on all sides. First and second molars, both second premolars and the left first premolar had been lost *ante mortem.* The remaining premolar was worn to a dentine stump. Neither of the two isolated partial maxillae could be unambiguously associated with this mandible, but in the case of the left maxillary fragment this was due to the absence of occluding teeth. Given the completeness of this mandible and its location, it was more likely to have belonged to Individual 4 (and been associated with the left maxilla) than to Individual 2.

A piece of the right side of a second mandible including part of the body and ramus, collected from the sediment surface in 2004, may be associated with one of the heavily worn maxillae. All three permanent molars had been lost *ante mortem* with the surrounding bone completely remodelled. The bone surrounding the missing anterior teeth showed evidence of active remodelling associated with *ante mortem* tooth loss. The gonial region of this mandible showed less expression than that of the mandible from below the horn core, suggesting a more gracile individual. This mandible and the right maxilla may be associated with Individual 2.

Several other cranial pieces were found close to the surface of deposits downslope from Individual 2. They included an almost complete occipital bone with a small fragment of parietal attached, fragments from each side of a frontal bone including the superior orbital margins, a fragment of the temporal bone and part of a zygomatic arch. The cranial sutures of the occipital showed minimal closure on the ectocranial surface but were at an advanced state of closure on the endocranial side.

An isolated partial mandible of a juvenile containing several developing tooth germs was found at the surface of deposits in 2004. The mandible does not belong to any individual subsequently excavated. The state of dental development and fusion of the mandibular symphysis indicate an age-at-death of about 1 year.

Two isolated bone fragments were found close to the burials of Individuals 13 and 14. A fragment of *os coxa*, which included the pubic symphysis, belonged to an older adult. It may have been displaced from an earlier burial than any of those excavated. Part of a foot bone of a small and lightly built adult was found close the back wall of the cave, and potentially belonged to the same adult as the *os coxa*. The foot bone exhibits gnaw marks, and may have been gnawed *in situ* or transported to this location by a bone-collecting animal.

15.5 BURIAL SEQUENCE

The horizontal distribution of the burials within the excavated part of Sector 10 is shown in **figure 15.4**. The bulk of Sector 10 deposits comprise fine ashy sediment and it was not possible to identify clear burial limits within that interval. The edges of a burial could sometimes be identified where it had been cut into the firmer underlying sediment. The edges of the grave pits could also be inferred from the position of the skeletons and associated horn cores and objects within the grave. All of the burials identified in Sector 10 are considered to be primary inhumations of intact bodies, as there is no evidence to suggest that any of the individuals were incomplete or disarticulated at the time of deposition. As the area was extensively used

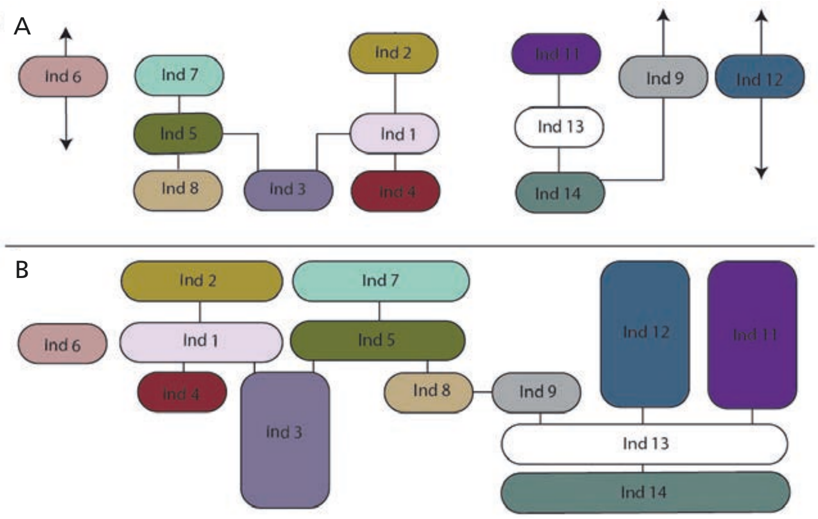


Fig. 15.14 **A** Graphic showing the sequence of Sector 10 burials based on their stratigraphic relationships; **B** The sequence of Sector 10 burials refined by the inclusion of radiocarbon dates and aDNA data.

and reused, many of the burials had been truncated or disturbed by subsequent funerary activity. During this process, bones from the disturbed graves were deliberately or inadvertently removed from their primary burial context and reincorporated into subsequent burials or the surrounding deposit. As a result many of the graves incorporate skeletal elements from an earlier period and may also incorporate other objects previously associated with earlier burials (Humphrey et al. 2012). It is uncertain whether the cranium and mandible of Individual 10 were deliberately buried or inadvertently relocated to the position in which they were found.

The sequence of burial events could be partly resolved based on their spatial relationships and the distribution of disturbed and undisturbed bones, and is shown here as a stratigraphic matrix (fig. 15.14A). The burials comprise two main groups. The first group was situated closer to the cave entrance and comprises Individuals 1-5 and Individuals 7 and 8. Individual 6 lay alongside the first group but its chronological relationship to those burials could not be established. The burials of Individuals 1, 2, 3 and 4 extended slightly beyond the limits of the remaining deposit, and some bones from these skeletons had either been lost to erosion or removed during previous excavations. The second group was situated close to the rear cave wall and comprises Individuals 9, 11, 12, 13 and 14 and the intrusive skull of Individual 10.

Individual 4 was interred in an upright seated position in a small individual grave. The lower edges of the grave for Individual 4 could be clearly identified as it was cut into the underlying sediment. The uppermost edges could not be detected. The surviving contours of the burial pit for Individual 4 indicate that a steep vertical cut was made on the south and west sides of the burial pit to a depth that would accommodate the height of the flexed legs and the height of the upper body in an almost upright seated position. A larger burial pit was prepared for Individual 1 directly above Individual 4. The skeleton of Individual 4 was severely truncated during this process and the uppermost parts of the skeleton were deliberately or inadvertently displaced from their primary depositional location. The larger bones belonging to Individual 4 must have been noticed and consciously set aside. Individual 1 was placed in the burial pit in a seated position facing east towards the entrance of the cave. Some of the larger bones from Individual 4 appear to have been gathered up and deliberately placed within the burial of or directly above Individual 1. The other displaced skeletal elements from Individual 4 must have been inadvertently scattered, pushed aside or perhaps deliberately removed from this burial area. The burial of Individual 1 was not truncated by any subsequent burial, but it may have been disturbed during the deposition of Individual 2. The burial pit for Individual 1 must have extended beyond the boundaries of the underlying burial pit for Individual 4 in order to accommodate the slightly reclined body and the two massive horn cores placed on either side of the body, but no clear cuts were identified. Finally, Individual 2 was placed in a highly flexed position on the left side directly above the skeleton (or body) of Individual 1. The horizontal distribution of the skeleton of Individual 2 was contained entirely within the boundaries of the horizontal distribution of Individual 1 and no trace of a burial cut was detected.

Individual 3 was buried in a separate grave adjacent to Individual 4. There was not an obvious intersection between the burial pits for Individuals 3 and 4, so the sequence of these two burials is uncertain. The original outline of the burial pit for Individual 3 could not be determined due to erosion and truncation of the edges of the burial. Most long bones and hand and foot bones from Individual 3 were missing due either to erosion of the deposits or truncation by previous archaeological interventions. The skeleton of Individual 3 had also been truncated during construction of the adjacent burials. Several large and robust skeletal elements found among the surplus bones surrounding Individual 1 are likely to belong to Individual 3, but it is not clear whether they were redeposited directly from their primary burial location or whether they had already been disturbed. There is no indication that these elements were deliberately or consciously incorporated into the burial of Individual 1.

Individual 5 was buried in a wide shallow grave in a slightly reclining position. The burial pit of Individual 5 cut through the western part of the burial of Individual 3. During this process bones from the right shoulder girdle of Individual 3 were displaced and subsequently reincorporated into the burial pit of Individual 5. Individual 8 was situated adjacent and to the southwest of Individual 5. The left tibia and fibula and some foot bones from Individual 8 were found at the edges and base of the burial pit for Individual 5, with the tibia directly below the lumber region of the spine of Individual 5. This indicates that the burial pit for Individual 5 was dug immediately alongside the stone overlying Individual 8 causing the bones of the lower left leg to be relocated into the new burial.

Individual 7 was located directly above the skull of Individual 5. The skeleton of Individual 7 was found in almost perfect anatomical articulation, suggesting that the underlying body had decomposed and settled into its final position prior to the burial of Individual 7 or that Individual 5 was buried in a filled space so that the body did not settle during decomposition. The burials of Individuals 3 and 8 must have predated those of Individuals 5 and 7. Both of these must have been at least partly decomposed when their burials were disturbed because the re-deposited bones from these burials were not found in anatomical association. Individual 6 was situated close to Individuals 7 and 8 but the burial did not truncate or directly overly any other burial and had not been disturbed by any subsequent burial activity.

Individuals 9 to 14 were farther back in the cave recess and are within or at the periphery of a complex sequence of intercutting burials that includes two partially articulated adult burials (Individual 13 overlying and truncating Individual 14), two infant burials (Individuals 11 and 12) and an isolated skull (Individual 10). The location of these burials within the cave suggests that they are earlier than the burials of Individuals 1-8. The timing of burials within each of the two groups of burials relative to those in the other group is unclear, but the similarity and spatial proximity between burials of Individuals 8 and 9 (referred to on site as the "blue stone babies") suggests that these two burials may have occurred within a short space of time.

The earliest burial in the sequence was Individual 14. Individual 14 was buried in a seated position in a well-defined circular pit that cut though the 'Brown Layer' underlying the grey ashy deposit and into the underlying orange-coloured sediment. The right shoulder of Individual 14 was situated close to the back wall of the cave. A large irregularly shaped rock overlay one edge of the burial of Individual 14 but it is not clear whether this formed part of the burial of Individual 14. The burial of Individual 14 was truncated from above by the burial of Individual 13, and parts of the skeleton were disturbed and displaced. The burial of Individual 13 is situated entirely within the grey ashy sediment and the edges of the grave cut could not be

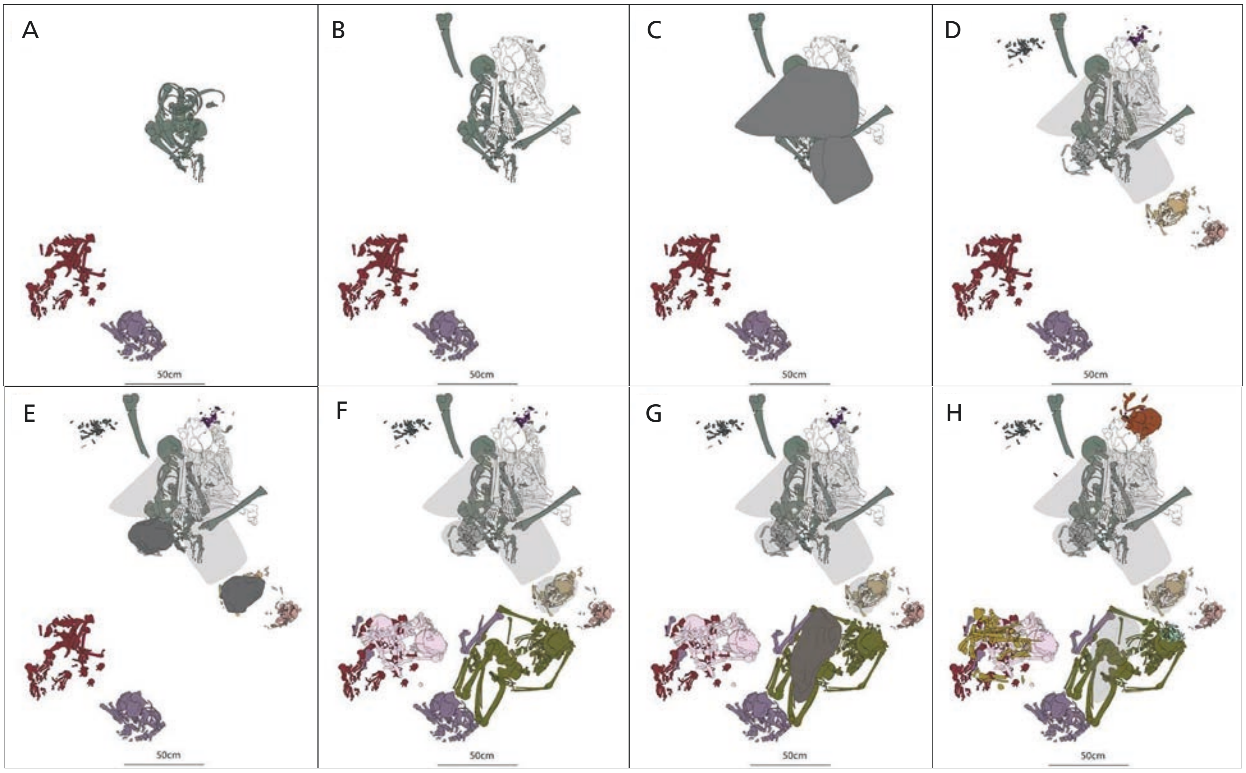


Fig. 15.15 A-H Plan drawing of burials in Sector 10, reconstructing successive stages of deposition of the bodies and overlying stones, inferred from stratigraphic, dating and aDNA information; depositions are shown to occur concurrently where the actual sequence has not been determined; the stones are shown in dark grey at first appearance and faded out in subsequent frames.

defined. Individual 13 was also placed in a seated position. Some of the bones from Individual 14 were incorporated into the burial of Individual 13. The cranium of Individual 14 was located close to the top of the burial at the same level as and alongside the cranium of Individual 13 and its placement may have been deliberate. A layer of horn cores and a large shallow stone slab was situated above the burial of Individual 13 and the displaced cranium of Individual 14.

Individual 11 was located within the upper part of the grave fill surrounding Individual 13 and directly below the broken skull of Individual 10. The flat slab overlying the burial of Individual 13 did not extend over Individuals 11 and 10. Individual 11 may have been buried subsequent to Individual 13 or at the same time. The skeleton of Individual 11 was disturbed after decomposition of the body, possibly at the time that the skull of Individual 10 was incorporated into the top part of the grave. It is unclear whether the skull of Individual 10 was deliberately placed at the top of this grave as part of a funerary ritual and subsequently crushed *in situ* or was accidently shifted into this position and crushed as a result of human activity unrelated to burial rituals. Although Individual 10 was positioned above Individuals 11, 13 and 14, it is not possible to determine whether Individual 10 belongs to a later period than all of the underlying burials or whether the skull had been relocated from an earlier burial. A sample of cranial bone was submitted for radiocarbon dating but did not yield sufficient collagen.

Individual 12 was found at or just below the surface of surviving deposits to the south of Individuals 14, 13, 11 and 10. Parts of Individual 12 were located very close to the disarticulated left femur of Individual 14, and it is likely that Individual 12 was buried after the femur of Individual 14 was relocated to this position. Despite its close spatial proximity, none of the bones from Individual 12 has been displaced into the sediment surrounding Individuals 14, 13, 11 and 10, suggesting that the burial of Individual 12 was more recent.

Individual 9 was positioned directly above the articulated feet and lower right leg of Individual 14 but separated by a considerable depth of sediment. The burial of Individual 9 caused damage to a vertically projecting horn core that was associated with the underlying Individual 14. The ochre-stained stone placed above Individual 9 was located within the angle formed by the two rocks situated above the burial of Individual 13. The large rock that was situated partly above Individual 14 must already have been present since the skeleton of Individual 9 was almost in contact with one side of the rock suggesting that the infant's body rested against it. It is possible that both rocks were already present and visible and that the burial pit for Individual 9 was deliberately situated in a niche between them. Alternatively, the second more superficial stone slab may have been added subsequently (**fig. 15.15**).

Two other types of information can be used to constrain the sequence of burials in Sector 10. Direct dates on human bone representing six individuals were obtained by AMS using ultrafiltration (Humphrey et al. 2014; Humphrey et al. in press; **Chapter 4**). The most recent dated burial is that of Individual 6, which was more or less contemporaneous with that of Individual 5. The burials of Individuals 9 and 4 are slightly earlier, and the earliest reliably dated burial is that of Individual 14. The dates for these five burials are consistent with the stratigraphic matrix and allow Individual 6 to be better anchored within this sequence. The two dates for Individual 7 are earlier than those of Individual 5 which directly underlies Individual 7. This reversal is highly improbable as both skeletons were articulated and the burials were undisturbed, and it is more likely the dates for one of the burials are less accurate (although the uncalibrated dates all still overlap at 2σ). The dates for Individual 7 are also inconclusive with respect to the other dated burials and have a higher standard error than the other Sector 10 dates.

Analysis of DNA from seven of the Sector 10 burials revealed that two of the infants (Individual 8 and Individual 9) are likely to be brother and sister (van de Loosdrecht et al. 2018). Comparison of pairwise nucleotide mismatch rates between library pairs revealed a particularly low rate for Individual 8 and Individual 9 indicating that they are first degree relatives. The two infants also had identical mitogenome sequences indicating that they could be maternally related. Individual 8 and Individual 9 were buried in a similar manner and at a comparable depth and were separated by only 65 cm measured horizontally from centre of the overlying stones. Individual 8 is a male who died aged ~2-3 months and Individual 9 is a female who died aged ~5-6 months. The two burials could have taken place within an interval of 3 months if the siblings were dizygotic twins and one died a few months after the other. At the other extreme, the time difference between the burials could have been ~30 years if the mother gave birth to the infants at ~15 years and ~45 years, but the interval is more likely to be less than this (Humphrey et al. in press). Assuming that the burials of Individuals 8 and 9 were more or less contemporaneous (within the resolution of available information on the burial sequence), the stratigraphic matrix can be realigned, providing a basis for anchoring the timing of the two main groups of Sector 10 burials with respect to one another (**fig. 15.14B**).

15.6 DISCUSSION

A primary aim of the new excavations was to investigate the spatial and chronological extent of the mortuary deposits and their relationship to archaeological deposits elsewhere in the cave. Roche's publications provide a clear description of the size and location of Necropolis I and a much vaguer indication of the size and location of Necropolis II (Roche 1959; 1963). On the basis of these descriptions, it is likely that Sector 10 is within the part of the cave previously designated Necropolis II (**fig. 15.1**). Necropolis I and Necropolis II may have formed part of a contiguous burial area in the north and west part of the cave, or may have been fully or partially separated by rock debris. Roche noted that it was not possible to connect the stratigraphy of the burial areas to the rest of the cave due to the intervening blocks of stone and the earlier Ruhlmann trench (Roche 1959; see **fig. 15.1**).

The burials from Sector 10 were located in the deepest recess of the cave in an area of restricted height. At the moment, this part of the cave receives a significant amount of natural light during the morning and a limited amount of light during the afternoon. When still present, the rock debris removed by Roche's team from 1954 onwards would have reduced the amount of natural light reaching the northwest of the cave. One possible route of access to the hypothesised area of Necropolis II would have been to the north of the rock debris, but this route would have been blocked following the use of this area for burials (Necropolis I). At present the most plausible hypothesis is that some or all of the burials in Necropolis II, including Sector 10, are earlier than those in Necropolis I.

At first sight, an early radiocarbon assay of 14,639-13,257 cal BP (L399E, 11,900 ± 240 BP), obtained by Roche on a large bulk charcoal sample from a level above the burials and close to the roof of the cave in the northern recess, specifically from Squares Q 12 to 13 and R 12 to 13, at a depth of 0.5-1.0 m from the then surviving top of the Grey Series (Roche 1959; 1976), seems consistent with a younger date for Necropolis I. However, the reliability of this assay is dubious (cf. **Chapter 2**), such that it is to be hoped that further material from the collections can be dated in the future to test this hypothesis.

Radiocarbon dates on human bone from Sector 10 span a period of only a very few centuries, between 15,086-14,189 and 14,431-13,993 cal BP (95.4 % range; cf. **tab. 4.5**). Used in combination, the direct dates and the stratigraphic matrix of the hypothesised burial sequence imply that the burial of Individual 14, which is the deepest burial situated next to the cave wall, is the earliest of the newly excavated burials. The burials excavated from Sector 10, and particularly those at the base of the sequence, are likely to be among the earliest burials at Grotte des Pigeons. There may be earlier as yet unexcavated burials at the site, for example to the north of Sector 10 where the cave roof is even lower. Cross-matching between the dates on human bone from Sector 10 and the dating evidence from the S8 sequence (**Chapter 4**), it seems that the burials took place perhaps a few centuries after the start of the GS accumulation, though exactly how long afterwards is still a matter of conjecture. It appears likely that the burials belong to the equivalent of the later Middle Phase of the archaeological sequence in Sector 8 but it is also plausible that there is some overlap with the earliest part of the Upper Phase, coinciding with the stony S8-G96 that began to accumulate at roughly 14,500 cal BP.

One issue that is not fully resolved is the original depth of the grey ashy deposits in the north and northwest alcoves of the cave and the impact of previous excavations. Roche (1963) illustrates a progressive outward shift in the outline of the north and northwest alcoves of the cave during successive excavation seasons between 1952 and 1955. The apparent enlargement of the cave probably reflects a gradual lowering of sediments, such that the intersection between the sediment and the cave wall shifted outwards. This would suggest that the original sediment level may have reached the ceiling in both north and northwest alcoves of the cave and that a substantial quantity of sediment was removed from both alcoves. Roche recorded that the sediments in the northern alcove of the cave, where Necropolis I is located, reached almost to the ceiling of the cave (Roche 1963). The entire thickness of grey sediment was removed from this alcove between 1952 and 1955. Roche did not directly comment on the original height of the deposits in the northwest alcove of the cave, where Necropolis II is located. This part of the cave was partially separated from the rest of the cave by a pile of rocky debris that included several large rocks, including a least one that had fallen from the cave roof prior to the formation of the Grey Series deposits, which would have affected light levels, access and formation of archaeological deposits. Roche's plan of the cave from 1972 (Roche 1973-1975) suggests that a narrow trench had been dug towards the back of the cave but that the sediment on either side was left untouched during this later phase of excavations.

The height and appearance of deposits in the northwest corner of the cave in the 1962 photograph (**fig. 15.2**) are more or less as they appeared in 2003. One difference is the presence of a large irregularly shaped rock located at the front of the remaining grey deposits and close to the location of Sector 10. This rock may have been part of the debris from the cave roof or may have been related to funerary activity. Specifically, the location of the rock suggests that it might have overlain the burial of Individual 3, which would account for the poor condition of that skeleton. The front of the remaining grey ashy deposits in the extreme northwest corner was sloped and eroding, causing an accumulation of heavier elements including stones and bone fragments at the base. Parts of Individuals 1 and 4 were visible on the sloped surface. The surface of deposits behind the eroding slope was flat, and covered in a thin layer made up of fragments of broken bone, other small objects and stones, vast quantities of broken snail shell and cobwebs, including bones from Individual 12. The flattening extends into the deepest part of the northwest recess of the main cave chamber where the surface is less than 50 cm below the cave roof and may have been created during previous excavations. The surface accumulation is consistent with deflation of the light ashy deposit, leaving behind a layer of heavier objects from within the sediment, and may have been caused by natural processes. There was no evidence of recent disturbance and it is unclear over what period this deflation surface would have accumulated.

The skeletons excavated from Sector 10 occupied a relatively narrow range of depths (**fig. 15.16**), spanning ~1.5 m below the site datum for the top of the shallowest burial (Individual 12) to ~2.4 m below the site datum for the base of the deepest burial (Individual 5). Several of the burials were lying immediately below the surface of the surviving deposits in Sector 10. There was no indication that any of the burials excavated from Sector 10 had been truncated from above by previous archaeological excavations. As a result it seems unlikely that any burials had been removed from immediately above the intact burials in Sector 10 during the 1955 excavation of Necropolis II. This suggests that sediment directly above Sector 10 was devoid of burials or that the burials were at a higher level and did not cut into the unexcavated sediment.

All of the human bones in Sector 10 were surrounded by grey ashy sediment. The shallower burials were contained entirely within the grey ashy sediment and the deeper burials cut through into the underling layers. These deeper burials may have been filled with mixed sediment, but this was indistinguishable from the grey ashy sediment during excavation. This implies that a reasonable depth of grey ashy deposits must have formed prior to the onset of burial activity. The grey ashy sediment in Sector 10 is similar in many respects to the typical Grey Series deposits from elsewhere in the cave (Barton et al. 2013) but lacks any recognisable stratigraphic horizons. This sediment may have formed *in situ* at the back of the chamber due to activities similar to those closer to the cave entrance or it may have been transported from elsewhere in the cave either as a means of disposal or to provide a medium for the burials.

The second purpose of the excavations in Sector 10 was to investigate the processes underlying the accumulation of the mortuary deposits at Grotte des Pigeons. Roche's published accounts of the archaeological context of the skeletons excavated from Necropolis I and Necropolis II provide some useful information but lack details of specific burials and an interpretation of the underlying funerary behaviour (Roche 1953a; 1953b; 1959; 1963). Early research on the osteological assemblage was primarily concerned with the demographic profile of the assemblage and the skeletal biology of those represented (Ferembach 1962).

More recent research on the human osteological assemblage from Grotte des Pigeons has yielded further insights into the funerary behaviour associated with burials in Necropolis I and Necropolis II (Mariotti et al. 2009; Belcastro/Condemi/Mariotti 2010). Mariotti and colleagues (2009) documented evidence of deliberate *post mortem* manipulation of human bones in the form of cut marks and percussion damage. Human bones that had been intentionally stained with ochre were found in 13 of the 28 *sépultures* or graves from Roche's excavations (Mariotti et al. 2009). The location and extent of ochre staining of skeletal elements

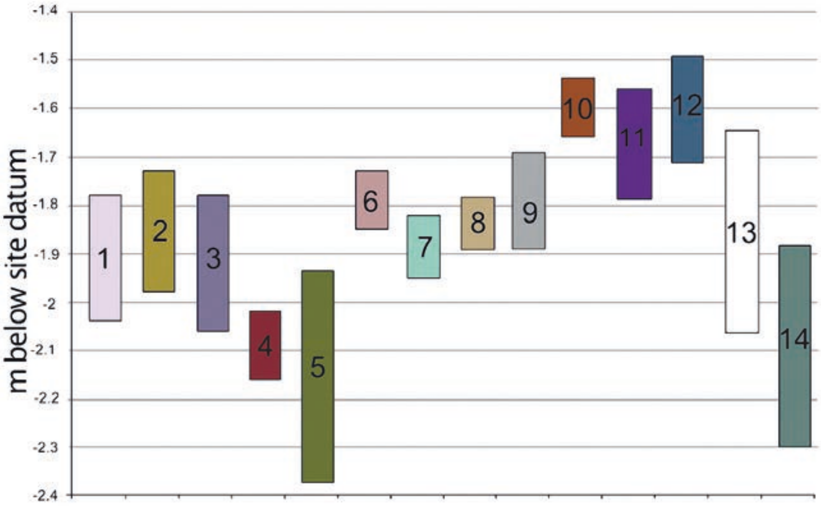


Fig. 15.16 Approximate depths of burials relative to one another based on the height distribution of undisturbed bones within each burial.

from both adults and children implies that disarticulated and sometimes fragmentary human bones were handled after decomposition (Mariotti et al. 2009; Belcastro/Condemi/Mariotti 2010). Ochre staining occurs on bone surfaces that would not have been accessible prior to decomposition or removal of soft tissues and fragmentation of the bones, including endocranial surfaces, orbits, sutures, broken surfaces, and within the empty sockets of teeth that had been separated from the jaw after death. On bones where both cut marks and ochre staining were present, the ochre occurs within the cut marks and therefore must have been applied subsequently. The human bones from Grave XII, which contained two juveniles and three adult males, showed particularly pronounced evidence for intentional modification including extensive cut marks consistent with dismemberment and defleshing and dying with ochre (Belcastro/Condemi/Mariotti 2010).

The extent to which the structuring of the burial deposit excavated during the 1950s reflected a set of deliberate and presumably meaningful interventions is difficult to ascertain. The presence of bones or teeth from the same skeleton in more than one of the numbered graves ("*sépultures*") clearly invalidates the original assumption (Ferembach 1962) that the osteological assemblage could be interpreted as a set of discrete burials (Mariotti et al. 2009) but this situation could arise through intentional or unintentional actions. In cases where there is no evidence for intentional manipulation of skeletal remains, the redistribution of bones from a single skeleton into multiple graves may simply have been an unintended consequence of successive episodes of burial activity in the same location. Contrastingly, the evidence for manipulation of human bone following decomposition is unequivocal for some of the elements recovered during the Roche excavation. Mariotti and colleagues concluded that these bones were deliberately retrieved from burials with the intention of handling and modifying them for ritual purposes. An alternative explanation is that some of the bones were recovered unintentionally following unforeseen disturbance of previous burials. Some skeletal elements that show evidence of *post mortem* manipulation were subsequently reincorporated into the burial deposits. This may have involved a deliberate decision to place those elements within another burial or other significant location (Mariotti et al. 2009) or the bones may simply have been abandoned or discarded and inadvertently incorporated into other burials.

The new excavations at Grotte des Pigeons provided an opportunity to record Iberomaurusian mortuary activity using modern excavation techniques. Excavations in Sector 10 revealed a succession of single burials placed in very close spatial proximity. All of the burials involved the primary deposition of complete bodies, with the possible exception of the skull of Individual 10. In numerous cases existing burials were disturbed or truncated by subsequent burial activity that encroached into the same space. During this process, some skeletal parts from disturbed burials were incorporated into the fill of subsequent burials or into the surrounding deposit. Small or unrecognised bones and bone fragments from disturbed burials are likely to have been relocated unintentionally. Larger and more obvious skeletal elements such as the long bones could not have been so easily overlooked. Some of these bones seem to have been purposefully gathered up following disturbance and were either set aside or deliberately incorporated into other burials. It is also possible that some of the disturbed bones were deliberately removed from the burial deposits for utilitarian purposes, such as use as a tool, or for inclusion in a more complex set of funerary rituals, but the new excavations did not reveal any evidence of this behaviour.

The newly excavated adult burials from Sector 10 lack several aspects of the funerary traditions inferred from the assemblage excavated earlier. There was no indication that any of the Sector 10 burials had been deliberately reopened to retrieve human bones. Furthermore, there was no evidence for the manipulation of human bones following decomposition. The evidence recorded in Sector 10 for movement of bones between burials is entirely consistent with a practical interpretation. Several of the newly excavated skeletons were incomplete but, in each case, missing parts could be accounted for either by truncation of the burials during subsequent burial activity or by erosion of the surface of the burial deposit. The photograph showing the back of the cave following the completion of the excavations directed by Roche (**fig. 15.2**) reveals that, outwards, the uppermost grey ashy deposits had been removed more or less to the edge of the surviving deposit. The burials of Individuals 1-4 situated at the front of Sector 10 may have been truncated during the Roche excavation and would have been vulnerable to erosion due to the powdery nature of the deposits.

A third aim of the excavations was to document funerary treatment of individuals and determine whether there was patterning in relation to age, sex or other factors. Several features were common between all or most of the burials in Sector 10. All of the burials in Sector 10 were primary single inhumations. Many of the bodies were placed in a seated or semi-reclined position, with the pelvis, feet and often the hands at the base of the grave and the head and knees uppermost. The adults were placed so that they were facing approximately towards the cave entrance. The location of *in situ* bones suggested that most bodies were buried in pits with at least one side dug to sufficient depth to accommodate the height of the vertically flexed legs. In the three cases where all or part of the grave cut could be determined, the outline of the graves at the base appeared to be more or less circular. The hands and feet often remained in anatomical articulation suggesting that the lower part of the graves were filled. Many of the crania, mandibles, bones from the upper part of the vertebral column and thoracic region and occasionally the upper limbs, had shifted out of anatomical association and fallen downwards onto the chest or to the base of the grave. This suggested that there may have been empty space at the top of the burials or that empty space occurred during the process of decomposition. There was no evidence for direct application of red ochre to human bones, and no evidence for deliberate dismemberment, defleshing or other intentional modification of bones.

The newly excavated burials are those of infants and adults, including four young adults who had not yet reached skeletal maturity. The absence of juveniles may imply that few individuals died at this stage of life or that they were buried elsewhere. Three of the adult burials (Individuals 3, 4 and 14) had clearly been truncated from above or from the side by subsequent burials. All three of these individuals were male but the number of adult burials from Sector 10 is too small to determine whether this is significant or relevant. The disarticulated state of the bones relocated from the three disturbed burials indicate that the bodies had already decomposed when the burials were disturbed, and suggest that the existence and identity of the underlying burials would not have been known to those responsible for the disturbance. Burials 1 and 5 had not been truncated by subsequent burials, and both had another individual buried directly above and in close proximity to their heads. A pre-term infant, Individual 7, was buried almost directly above the head of Individual 5 (**fig. 15.4b**) but it is not possible to determine at present whether these burials were penecontemporaneous or whether the two individuals were related to one another. An older adult, Individual 2, was buried directly above Individual 1 with its knee almost abutting the cranium of the underlying burial. Uniquely among the Sector 10 adults, Individual 2 was buried on its side in a position that would have required less vertical space than the other seated or reclined burials. This may indicate that the depth of sediment available in the preferred location was only sufficient to accommodate the body in a horizontal position. Neither skeleton has been dated, but their proximity and the lack of truncation of the lower burial suggest that the deposition of Individual 2 occurred not long after that of Individual 1. This may imply a memory of the underlying burial and a deliberate decision to bury the two individuals with a close spatial association. There is no reason to infer or exclude a familial relationship between these two adults.

All of the undisturbed adult burials were associated with multiple horn cores, regardless of the sex of the deceased. The most richly endowed burial in Sector 10 was that of Individual 14, a large bodied young adult male. Objects unambiguously associated with the burial include several horn cores of Barbary sheep, jaws from a fox and another canid, bird bones, a seashell, an ochre stained pestle and mortar, a distinctive red coloured stone and a side scraper. As the burial of Individual 14 was truncated it is possible that other items that were originally associated with the burial had been displaced into adjacent burials or into the surrounding sediment. The three undisturbed adult burials revealed evidence for an elaborate funerary tradition, but the burials did not contain valued utensils such as those found with Individual 14. Two horn cores from a large bovine were incorporated into the burial of Individual 1, and had been deliberately placed on either side of the body. Other items situated close to the body and considered to represent deliberately placed funerary items included a horse incisor found above the sternum, one half of a Barbary sheep mandible placed below the pelvis at the base of the grave, and a smooth blue / grey-coloured stone that partially overlay the cranium. Individuals 5 and 13 were both associated with numerous horn cores and each burial was marked or closed with a large and irregularly shaped rock. The burials of Individuals 2, 3 and 4 had been disturbed or truncated and there was no unequivocal evidence for the presence of horn cores or other burial items, or a cover or marker stone.

The infants were buried in single graves and are situated in close proximity to adult burials as well as those of other infants. The sequence of burials reveals that infants were buried in this part of the cave both subsequently and prior to adult burials (**fig. 15.14**). This demonstrates that, despite the high representation of infant burials, Sector 10 was not used selectively for the burial of stillborns and babies. The baby burials were typically located closer to the surface of the surviving deposit than adult burials which may imply that they were deliberately buried in shallower graves than most of the older individuals. The dimensions of each burial pit were probably determined according to the size of the deceased individual, such that the depth of the grave reflected the amount of space required to accommodate the body (Tocheri / Dupras / Sheldrick / Molto 2005). Some of the baby burials may have occurred when the burial deposit was considered too tightly packed to accommodate more seated adult burials but still acceptable for the smaller infant bodies. However, one infant burial (Individual 8) had been truncated by a larger and deeper subsequent burial (Individual 5).

The infants showed a greater diversity in the positioning of the body than the adults. This might reflect the more compact shape of the infant body and greater difficulty in maintaining the head in an upright position, but could indicate that less care was taken in some cases. As with older individuals, the bodies were placed with the lower limbs flexed at the hip and knee and one or both feet tucked beneath or in front of the pelvis. The position of the upper body varied from almost supine to almost vertical, and in some cases directly overlying the lower body. Several of the bodies appear to have slumped forwards or towards one side and these might have been placed initially in a seated position. In contrast to the adult burials, there was no consistency in the orientation of the bodies within the cave, with some infants buried facing or with the head leaning forwards towards the cave wall and others with the head or face orientated towards the cave entrance. The slight rearrangement of skeletal elements within most of the burials suggests that some of the bodies were surrounded by pockets of empty space during decomposition, which may imply that the bodies were loosely wrapped or covered by an organic material.

The infant burials in Sector 10 were associated with a variety of funerary objects, and some items may have been overlooked as the nature of the burial deposits means that it is difficult to demonstrate an unambiguous association. Two of the infants were found directly below ochre stained stones (Individuals 8 and 9). The distinct blue/grey colouration and ochre-staining of these stones may have had a symbolic meaning or reflected the social status of the deceased or their immediate family. Alternatively these may simply have been a convenient way to close or mark a burial. The stones are locally sourced from outside the cave, with similar rock occurring in the wadi bed below the cave. Notably, these two infants are those who were identified as probable siblings based on genomic analysis (van de Loosdrecht et al. 2018) suggesting that kinship contributed to the patterning of funerary behaviour in Sector 10 (Humphrey et al. in press). A smaller rock of the same blue/grey colour was situated close to another infant, Individual 12. This was similar to the piece of stone found next to the head of Individual 1. Interestingly, both Individual 1 and Individual 12 were also found in association with horse incisors. This may be coincidental or may reflect a tradition specific to one family group, but this cannot be demonstrated at present as it was not possible to extract reliable genetic information from Individual 1. Only one of the newly excavated infant burials was associated with a piece of cranium and horn core from a Barbary sheep (Individual 6) although these are commonly found in association with the adult burials. Two of the infants were associated with small marine shells (Individuals 6 and 12), which occur relatively rarely in Grey Series deposits across the site. An end-scraper was found lying flat alongside the left arm of Individual 6 and was notably larger than most other end-scrapers (**Chapter 12**) suggesting a particular value or significance. Two of the infants lacked any clear association with burial items and showed no evidence for the use of ochre during burial (Individuals 7 and 11). The burial of Individual 11 had been disturbed and the body may originally have been buried alongside other items.

The fourth aim of the research was to provide an additional perspective on the diversity of funerary behaviour of Late Pleistocene and early Holocene populations of the Maghreb. Human remains have been reported from a variety of Iberomaurusian contexts, including both burials and disarticulated skeletal elements. An isolated, nearly complete cranium and associated mandible were recovered from the upper stratum at Taza Cave I, situated close to the Eastern Algerian coast (Meier/Sahnouni/Medig/Derradji 2003). The skull was found close to the base of a horizon dated between 23,717-16,390 cal BP and 16,915-16,475 cal BP (16,100 ± 1,400 BP and 13,800 ± 30 BP in Meier/Sahnouni/Medig/Derradji 2003) and, if it is reliably associated with this horizon, it may be the earliest known Iberomaurusian skull. Isolated human bones from at least four individuals were found in a disturbed horizon at Kehf el Hammar in the western Rif. The bones have not been dated but the right maxilla of a young adult showed evulsion of the upper central incisor, which is consistent with an Iberomaurusian cultural affiliation (Barton et al. 2005; Humphrey/Bocaege 2008).

Elsewhere a range of funerary contexts have been described demonstrating that funerary traditions varied within and between Iberomaurusian sites. Excavations at Afalou Bou Rhummel in Algeria between 1927 and 1929 revealed partial remains of approximately 48 individuals in level I, at a depth of 3.25 m and covering an area of approximately 3 × 4 m (Arambourg/Boule/Vallois/Verneau 1934). Only six of the skeletons were reported to have been found in anatomical association, and some of those skeletons were incomplete suggesting disturbance or truncation by subsequent depositions or other agents. No burial items were recorded in association with this assemblage but a lump of crushed iron oxide was found on top of the cranium of an adult male located in level III, together with a piece of polished bone (Arambourg/Boule/Vallois/Verneau 1934). Arambourg proposed three possible explanations for the main osteological assemblage. The first suggestion, that bodies may have been lowered or dropped onto the cave floor through an opening in the roof of the cave, appears unlikely because the closely articulated position of some of the bodies suggests that they were covered by sediment prior to decomposition. Secondly, Arambourg suggested that some of the bodies were secondarily deposited in the cave following partial or complete decomposition elsewhere, which could account for the uneven representation of different skeletal elements and under representation of post-cranial bones. Arambourg also speculated that the assemblage could have accumulated following a massacre by another group (Arambourg/Boule/Vallois/Verneau 1934), but this would not account for variation in the degree of anatomical articulation of the skeletons or uneven representation of skeletal elements. A possible alternative to the explanations suggested by Arambourg is that the deposit accumulated through a succession of closely spaced burials similar to that observed at Sector 10, with earlier depositions truncated or pushed aside to make space for later burials.

More recent excavations at Afalou Bou Rhummel revealed a further assemblage of partially articulated human bones in a low alcove on the southern wall of the rock shelter (Hachi 1996). Eight crania, including some in anatomical connection with their vertebral columns, were located towards the back of the alcove. Anatomical connections were also maintained between some of the vertebrae and ribs, indicating that complete bodies must have been deliberately placed within the alcove and not lowered from above or secondarily deposited. Some of the lower limb bones were located above the articulated thoracic skeletons suggesting a highly flexed burial position. The bones closest to the front of the alcove were disordered and lacking anatomical associations. This distribution of skeletal elements may have resulted from the gradual introduction of new bodies with each successive burial contributing to the breakage and displacement of the more exposed bones from previous burials (Hachi 1996). The most recently excavated burials from Afalou Bou Rhummel were from layer V of the deposits. The dates available for layer IV are 16,894-14,409 cal BP (Alger 0008, 13,120 ± 370 BP), 15,300-13,770 cal BP (Ly 3228, 12,400 ± 240 BP) and 14,477-13,461 cal BP (Gif 6532, 12,020 ± 170 BP), and it is likely the layer V burials are of a similar age or slightly older. The skeletons excavated between 1927 and 1929 have not been directly dated and it is not clear how these relate chronologically or stratigraphically to those from more recent excavations at the site.

Excavations at Columnata in Algeria carried out between 1938 and 1959 revealed a series of burials from the Iberomaurusian, Columnatian (transitional Epipalaeolithic) and Neolithic, incorporating partial skeletons and isolated skeletal elements from 48 adults and 68 sub-adults, including infants (Maître 1965; Chamla 1970). Nine of the burials, representing 13 individuals, were considered to be Iberomaurusian. These burials have not been dated and one individual, an adolescent from burial 1, had undergone evulsion of all 8 incisors. This pattern of tooth evulsion is not otherwise documented among Iberomaurusian human remains and is more typically associated with later periods (Humphrey/Bocaege 2008). Several of the burials contained bones or partial skeletons from more than one individual, implying multiple burials or reuse of the same space for successive burials and redistribution of disturbed bones.

Iberomaurusian burials have been reported at two open-air sites in Algeria. At Kef-oum-Touiza, a young adult male was buried in a highly flexed position with the knees on the chest (Balout/Briggs 1949). At Rachgoun, four adults were found in primary single burials. Two of the adults appear to have been buried on their side, one with traces of ochre on the uppermost femur. A third adult was in a highly flexed position with the knees on the chest and another was lying on the back, with the lower limbs flexed and at least one knee pointing upwards (Camps 1966). The burials at Rachgoun and Kef-oum-Touiza have not been dated.

Five burials, including four of infants and an adult male, were recovered from Iberomaurusian levels at Ifri n'Ammar in Eastern Morocco (Mikdad/Moser/Ben-N'cer 2002). Three of the infants were buried with the head orientated to the north, suggesting deliberate placement of the body. The fourth infant appeared to have been dismembered before burial. Each of the burials was marked by a block of stone placed directly above the body but separated by a few centimetres of sediment (Mikdad/Moser/Ben-N'cer 2002). The adult was buried in an upright seated position with the lower limbs flexed and parted at the knees and the feet close to the pelvis (Eiwanger 2006). The cranium was found lying on its side immediately above the pelvis and right forearm, and may have collapsed into this position during decomposition, suggesting that there was empty space within the burial. The four infant burials were dated between 14,935 and 12,690 cal BP (Moser 2003) and are broadly contemporaneous with the human burials from Sector 10 at Taforalt.

At the nearby site of Ifri n'Baroud (Ifri el-Baroud), a single adult female was buried in a reclining seated position with both lower limbs flexed in front of the body (Ben-N'cer 2004). The close anatomical articulation of the bones suggests that the body was deposited in a gradually filling space ("*espace à colmatage progressif*") (Ben-N'cer 2004). The burial at Ifri n'Baroud was from a trench which has yielded radiocarbon dates on charcoal of between 14,315-13,830 cal BP (12,198 ± 65 BP) and 11,223-10,785 cal BP (9,677 ± 60 BP) (Ben-N'cer 2004; Görsdorf/Eiwanger 1998) and is probably slightly younger than the newly excavated Taforalt burials. The similarity in the positioning of the body within the grave observed for burials at Ifri n'Baroud and Ifri n'Ammar and six of the adults from Sector 10 at Taforalt suggests that this burial position was not unusual in the Eastern Rif and Beni Snassen during the Iberomaurusian. The absence of seated burials at other Iberomaurusian sites suggests that the tradition may have been geographically restricted. The burials at Ifri n'Baroud and Ifri n'Ammar were not associated with any deliberately placed funerary objects (Ben-N'cer 2004).

Further afield, a single burial of a young adult male was found at Hattab II Cave in northwestern Morocco. The body was placed in a flexed position on its left side (Barton et al. 2008). The burial incorporated several items considered to be funerary objects including a gazelle horn, a bladelet core, a marine shell, two bone points and a large animal vertebra found close to the skeleton. The male burial at Hattab II was dated indirectly at 8,900 ± 1100 years BP from a thermoluminescence age determination on a burnt lithic artefact. It is more recent than the Eastern Rif and Beni Snassen Iberomaurusian burials, geographically more distant, and exhibits a different funerary tradition. Other isolated human bones and teeth from Hattab II have not been dated, and may indicate the presence of other burials at this site.

At least three sites on the Atlantic coast have yielded Iberomaurusian human burials. At Dar es-Soltan I, an adult male cranium and partial skeleton together with cranial fragments and teeth from a juvenile aged 10-12 years were found in level C, indicating the possible burial of at least two individuals (Vallois in Ruhlmann 1951). Excavations at the neighbouring site of Dar-es-Soltane (Dar es-Soltan) II yielded evidence for the burial of a young adult female, found in *couche 3* in 1971. The body was placed in a highly flexed position on its left side, with the left side of the face resting on the right hand (Debénath 1972; 2000). The left arm was extended beneath the body with the hand lying adjacent to the left foot. No funerary objects were found in direct association with the burial but a large stone with a concave surface showing traces of red ochre was found close to the head, and the body was placed on a slab of rock and covered with smaller stones. Parts of a second poorly preserved skeleton, including a large robust mandible, were found nearby and may have been pushed aside to make space for the subsequent burial (Debénath 2000). *Couche 3* has been dated to 13.4 ± 0.7 ka (OSL4-X2402) (Schwenninger et al. 2010).

Excavations at El Harhoura 2 in 1996 revealed a well-preserved skeleton of a young adult male (H3) in *couche 2* (Oujaa/Lacombe 2012). The body was buried on an east-west orientation with the head towards the west. The upper part of the body was situated in a crevice between rocks. The body rested on the right side with the head tilted to the side. The legs were flexed backwards from the knees at an angle of 60° and rested on a rock at a slightly higher level than the rest of the body. The skeleton remained in anatomical articulation indicating decomposition in a filled space. The young man had undergone evulsion of the upper right central incisor but not the upper left central incisor, which was broken at the base of the crown with the root still *in situ* (Oujaa / Lacombe 2012).

Funerary activity was highly variable during the Iberomaurusian. The burials reveal a variety of body positions including seated, extended, flexed or contracted. Six of the adults from Sector 10 at Taforalt were buried in a seated or slightly reclining position and this tradition is shared by broadly contemporaneous burials from the same region of Morocco. Roche's accounts of the burials from Necropolis I and Necropolis II indicate a diversity of burial positions and the possibility of multiple burials (Roche 1953a; 1953b; 1963). There is also no consistency concerning the deliberate inclusion of funerary artefacts, the presence of ochre, or the closure or marking of burials with a stone or other marker. The scarcity of funerary items at other sites contrasts markedly with the newly excavated burials from Sector 10. All of the undisturbed burials from Sector 10, apart from that of a pre-term infant (Individual 7), incorporate funerary items, although the nature of the objects varies between individuals. Two of the most recurrent and enduring features among the burials from Sector 10 and those described by Roche are the inclusion of horn cores above the bodies or at the edges of the burial pits and the presence of overlying stones or stone slabs, which could be interpreted as grave markers.

At most Iberomaurusian sites, the position and representation of skeletal elements indicate that bodies were intact before burial and that any disarticulation and fragmentation was caused by disturbance during subsequent funerary or other activities. One of the infants from Ifri n'Ammar may have been dismembered prior to burial (Mikdad / Moser / Ben-N'cer 2002). There is no documented evidence for deliberate manipulation of skeletal elements following decomposition or removal of soft tissues at any of the Iberomaurusian sites, apart from Grotte des Pigeons. The extent of manipulation of human bones from the latest part of the Iberomaurusian sequence at Grotte des Pigeons is comparable to the more recent Capsian period, during which *post mortem* manipulation of skeletal elements for ritual or practical purposes is well documented. The partial cranium (*crâne-trophée*) from the Capsian site of Faïd Souar in Algeria is an unequivocal case of recovery and deliberate modification of skeletal elements for ritual purposes (Vallois 1971). The perforated human frontal bone from Mechta el Arbi, another Capsian *escargotière* in Algeria, also exhibits intentional modification and is thought to have been suspended (Debruge 1927; Vallois 1971). Elsewhere, the underlying motive for manipulation of body parts may have been more pragmatic. Some of the skeletons recovered from Site 12, a Capsian *escargotière* in Algeria, were incomplete and partially disarticulated and detailed analysis of marks on the bones revealed evidence for decapitation and dismemberment of cadavers prior to burial (Haverkort / Lubell 1999). These actions may have been carried out to facilitate transportation of the cadavers, particularly the bodies of those who died far away. This implies that Site 12 had become a recognised burial locality and that considerable importance was attached to placement of the deceased in this location. Three of the skeletons from Site 12 were missing either the cranium and mandible or major long bones and it is possible that those parts of the skeleton were deliberately retained for another purpose (Haverkort / Lubell 1999).

15.7 CLOSING COMMENTS

The recently excavated Sector 10 and the burial deposits excavated by Roche in the 1950s (**fig. 15.1**) form part of a spatially demarcated collective burial area, with numerous closely spaced and inter-cutting burials. The earliest burials occur within a few hundred years of the onset of more intense phases of human activity marked elsewhere in the cave by a major sedimentary transition. One of the questions that arises is whether the burial deposits in Grotte des Pigeons qualify as a cemetery or a place of multiple burials. Several parameters contribute to the differentiation between places of multiple burials and cemeteries (Pettitt 2010). Places of multiple burials involve sequential burial of a small number of individuals (typically 6-12) over a short period of time. Cemeteries usually contain a greater number of burials (typically >20) and tend to be better organised and more enduring. Places of multiple burials typically lack a clear spatial demarcation between the living and the dead, with burials often surrounded by evidence of daily activity reflecting their placement within an occupational setting whereas cemeteries are areas set aside for burials and associated funerary behaviour and are usually located away from living areas. Even the most conservative estimate of the number of burials at Grotte des Pigeons is likely to exceed 100 individuals. The duration of use of Sector 10 has been shown by direct dating to cover at least 200 years and burials in Necropolis I may have continued for most of the period of formation of Grey Series deposits at Grotte des Pigeons.

The degree of spatial organisation and the extent to which the activities associated with the living and dead were separated are debatable. The burials at Grotte des Pigeons occur in a restricted area at the back of the cave and no human bones were recovered from midden deposits closer to the entrance. The high concentration of burials and disarticulated human bones in the north and northwest alcoves of the cave and absence of human bones in Grey Series deposits elsewhere suggests that these places were recognised repositories for human bones during the latter part of the Iberomaurusian and that other parts of the cave were not considered suitable for either casual or purposeful deposition of human bones. It is likely that this demarcation of areas of the living and of the deceased was deliberate and that the more secluded part of the cave was set aside for funerary activity.

However, it is not certain that all non-mortuary activity was excluded from these parts of the cave. The accumulation of occupational debris in the grey ashy deposits at the back of the cave may have occurred prior to or concurrently with burial activity or the use of the back of the cave may have alternated between phases of mortuary and occupational activities. One possibility is a that the grey ashy sediment at the back of the cave formed *in situ* as a midden during normal occupational over a period of up to 400 years and that this part of the cave was subsequently designated for burials. It is also possible that the grey ashy sediment was dumped in the back of the cave from occupational areas elsewhere in the cave over an unknown period of time prior to the period in which this area was used for burials. Alternatively grey ashy sediment may have been transported to the back of the cave from occupational areas elsewhere in the cave with the deliberate intention of providing a medium for burials. This process may have occurred only once at the onset of burial activity or on multiple occasions as required. One of the animal bones from Sector 10 is slightly earlier than any of the human bones for which dates are available, suggesting that at least some of the occupational debris predates the burials.

The burials uncovered from Sector 10 were primary inhumations of complete bodies. The distribution of articulated and disarticulated bones indicates intensive use and reuse of the area, with earlier burials disturbed or truncated by subsequent burials. The movement of skeletal elements can be accounted for by the unintentional disturbance of previous burials during subsequent funerary preparations. There was no evidence for intentional movement or modification of the corpse subsequent to the onset of significant decomposition among the Sector 10 burials. This contrasts with the burials excavated during the 1950s, where there is evidence for modification of bones following decomposition or removal of soft tissues and secondary deposition of manipulated bones. Burials situated towards the front of the cave and those higher within the deposits are likely to be progressively younger, which would mean that the burials in Sector 10, located in the deepest recess of the cave, are among the earliest so far recorded at Grotte des Pigeons. The differences between the funerary behaviour recorded in Sector 10 and that inferred for the burials excavated by Roche (Mariotti et al. 2009; Belcastro/Condemi/Mariotti 2010) is consistent with a change and specifically a diversification in the treatment of bodies and skeletal parts over time.

The more extensive and complex set of mortuary behaviours documented for burials in Necropolis I would have required a greater investment of time and resources. The simplest explanation for this change would be an increased sense of the importance and desirability of assembling and commemorating the dead at a single location. During the earliest phase of mortuary activity only burials of complete bodies are represented. This suggests that the people buried in Sector 10 were buried before the onset of significant decomposition and probably died within the immediate vicinity of the site. During this period, members of the community who died when they were engaged in activities further from the site may have been buried or abandoned close to their place of death. Over time, Grotte des Pigeons may have become a recognised repository for the dead, including those who died elsewhere. The bodies of individuals who died at locations far away from the cave may have been buried at those primary locations and then wholly or partly recovered following decomposition of soft tissues and returned to the cave for secondary burial. Alternatively they may have been dismembered or defleshed at a distant location to facilitate transportation of the all or part of the cadaver to the cave for burial. The specific motivation for these actions is likely to remain obscure, and may have changed over time. The developments in mortuary activity documented at Grotte des Pigeons are likely to have mirrored other changes in the use and perception of space and resources during the Iberomaurusian.

I. DE GROOTE · L. T. HUMPHREY

16. THE HUMAN SKELETAL REMAINS: A PHYSICAL ANTHROPOLOGICAL ASSESSMENT

16.1 INTRODUCTION

The skeletal and dental remains of 14 individuals, including both primary and secondary burials, were recovered during the recent excavations in Sector 10 (**Chapter 15**). The present chapter will describe the analyses of the newly excavated skeletal and dental material and compare the adult individuals to the previously excavated sample (Ferembach 1962; Roche 1963).

16.2 STATURE ESTIMATION

Only three of the newly excavated skeletons retained long bones complete enough to permit measurements for stature estimation. Stature estimation regression formulae are affected by population affinity and it is therefore important to use a regression formula with a close biological affinity to the sample in question. In order to determine which of the stature estimation regressions would be the most suitable for this population from Northwest Africa, it was necessary to look for the populations for which regressions exist which had the most similar intra-limb index to the individuals in Northwest Africa (Ruff/Walker 1993; Zakrzewski 2003; Raxter et al. 2008) (**tab. 16.1**). The tibia-femur index and radius-humerus index of the Northwest Africans is most similar to those of the ancient Egyptians in Raxter et al. (2008); therefore, these regression equations for the different long bones were used to estimate stature. The combination of femur and tibia was used wherever possible, as they show the smallest estimation error, although the equations for the individual bones as well as radius and humerus were used where no femur or tibia was preserved.

Stature was estimated for Individual 5 (150 cm; range estimates: 147-157 cm), Individual 3 (177 cm; range estimates: 171-178 cm) and Individual 14 (156 cm; range estimates: 154-159 cm). Average stature for all the previously excavated Taforalt adults was estimated using measurements taken by IDG and using the Raxter et al. formula and was estimated at 166.6 cm (s. d. = 5.9 cm, n = 41). Males were on average 171.1 cm (s. d. = 3.8 cm, n = 13) and females 162.2 cm (s. d. = 6.9 cm, n = 10). There was a sample of 18 undetermined sex and for these stature was estimated at 165.9 cm (s. d. = 4.6 cm, n = 18). These means calculated using the Raxter et al. regressions are lower than those reported by Ferembach (1962) using a different regression formula. Nevertheless, the three newly excavated individuals for which stature could be assessed were well within the range of variation of the previously excavated Taforalt sample.

Comparisons were made with data from LSA/Upper Palaeolithic samples from Jebel Sahaba (Sudan) (male mean = 176.9 cm, female mean = 167.5 cm) (Anderson 1968), Grimaldi caves (Monaco) (male mean = 179.5 cm, female mean = 158.0 cm) and Moravian sites (male mean = 175.9 cm, female mean = 159.7 cm), and a collection of Late Upper Palaeolithic samples from Southern Europe (male mean = 165.3 cm, female mean = 152.4 cm) and Central Europe (male mean = 166.1 cm, female mean = 154.6 cm) (Formicola/Gi-

		Intra-limb Index	
Sample	Study	Tibia Max/Femur Max	Radius/Humerus
Egypt	Raxter et al. 2008	83.0-84.8	77.5-78.8
Modern Africans	Ruff/Walker 1993	82.8-85.8	76.4-78.7
Modern Europeans	Ruff/Walker 1993	78.4-83.1	72.9-74
Egypt	Zakrzewski 2003	83.8	78.3
This study		**83.48**	**78.04**

Tab. 16.1 Intra-limb bone length indices in present and previous studies.

annecchini 1999). Results demonstrate that the Taforalt individuals (total sample n = 45) were of comparable stature to other LSA/Upper Palaeolithic populations and that tall stature was the norm in this area in the Iberomaurusian. In other contemporaneous areas, for example in the Middle East and Europe, a reduction in stature was noted. Comparison with a small sample of early Holocene Capsian (n = 10) and Neolithic (n = 8) individuals, shows that it was not until the early Holocene that stature in the Maghreb reduced: average stature for the Capsian and Neolithic sample was 160.6 cm (s. d. = 5.9 cm, n = 10) and 156.9 cm (s. d. = 4.6 cm, n = 8) respectively.

16.3 MOBILITY

Interpretation of measures of skeletal strength and robusticity allow for the assessment of mobility from the skeleton (Bridges/Martin/Solano 2000; Ruff 2000; Stock/Pfeiffer 2004). Several studies have highlighted the correlation between measures of cross-sectional strength and mobility patterns (Stock/Pfeiffer 2004; Stock 2006; Stock et al. 2011). Cross-sectional strength of the femur in particular is indicative of mobility (Trinkaus/Ruff 1999; Stock 2002). Here, shaft dimensions at 50 % of femoral length were used to calculate strength (DPROD) and shape (Ix/Iy). External dimensions (DPROD/L = "anteroposterior diameter at 50 % shaft length" × "mediolateral diameter at 50 % shaft length" / "femur length") suggest that males are more robust than females (males mean: 1.87 ± 0.21, females: 1.66 ± 1.9, t(14)2.109, p < 0.06) (**fig. 16.1a**). Measures of cross-sectional strength are however highly dependent upon the accurate standardisation to body size (Ruff 2000) and should be standardised to: (100 / [body mass × bone length]) resulting in the measure DPROD/LxBM = ([anteroposterior diameter at 50 % shaft length × mediolateral diameter at 50 % shaft length] × 100) / [body mass × femoral length]) (Stock/Shaw 2007). Results are quite different in this case (using measurements of length in millimetres and of weight in kilograms) and show the effect of body size correction on the male individuals (**fig. 16.1b**) who now appear less strong than the females but this difference is not statistically significant (males mean: 2.52 ± 0.21, females: 2.66 ± 0.27, t(13)-1.133, p = 0.278). In most contemporary cases, males are stronger than females (e. g. Stock/Pfeiffer 2004; Stock 2006; Stock et al. 2011).
The ratio of I_x (widest shaft diameter at 50 % shaft length) and I_y (diameter orthogonal to I_x) is used to compare bending strength in the long bones. Particularly in the femur, a more circular cross-section has been associated with a more sedentary lifestyle, whereas high shape ratios tend to be associated with high mobility (Carlson/Marchi 2014). The mean shape index of the individuals from Taforalt is indicative of high mobility levels but there are individuals with more circular shafts in the sample. The Taforalt sample (mean total sample: $I_x/I_y = 1.11$, s. d. = 0.11; males $I_x/I_y = 1.13$, s. d. = 0.11; females $I_x/I_y = 1.13$, s. d. = 0.11; undetermined sex $I_x/I_y = 1.09$, s. d. = 0.09) shows slightly lower shape ratios than a sample of Late Upper Palaeolithic individuals from Europe (mean $I_x/I_y = 1.32$, s. d. = 0.21) and a Neolithic sample from Italy (mean $I_x/I_y = 1.34$,

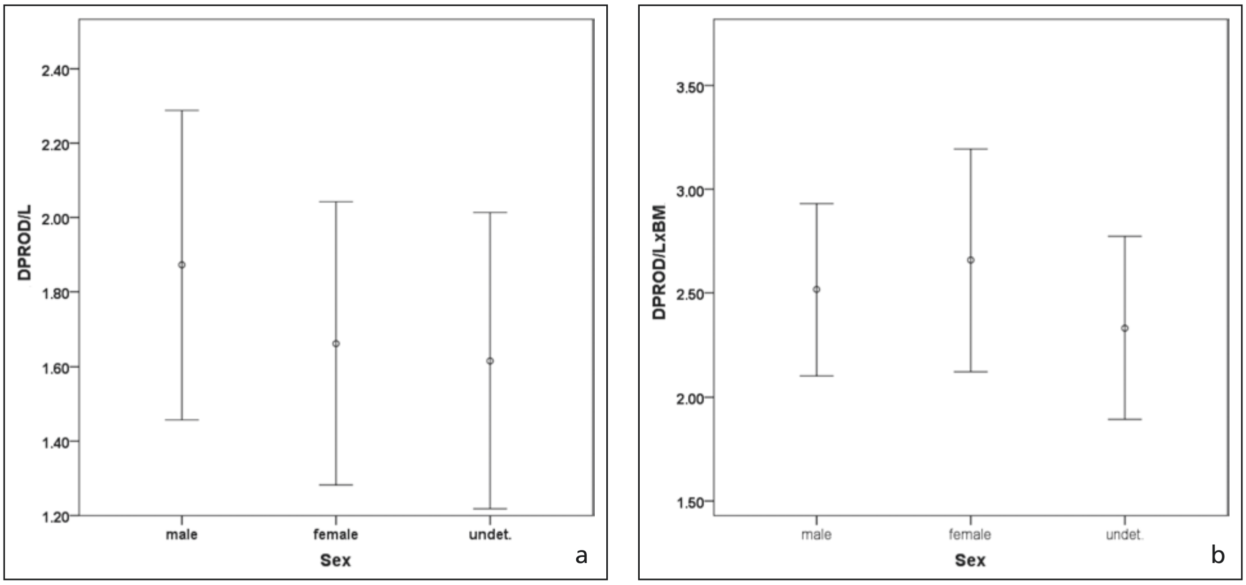


Fig. 16.1 Femoral robusticity (means ± 2σ): **a** corrected for bone length only; **b** corrected for bone length and body mass; see text for full formulae.

s. d. = 0.20) (Carlson / Marchi 2014) but slightly higher ratios than in an Iron Age series (mean $I_x/I_y = 1.03$, s. d. = 0.14) (Carlson / Marchi 2014). In conclusion, cross-sectional measures of femoral robusticity and shape are suggestive of moderate levels of terrestrial mobility in the individuals at Taforalt.

16.4 DENTAL ANTHROPOLOGY

Teeth are sensitive to fluctuations in diet, pathogenic load, physiological stress, oral hygiene, food preparation, non-dietary use of the teeth, and fluoride intake (Larsen 1999). Diseases and abnormalities of teeth are therefore indicative of individuals' interaction with their environment. In the case of Taforalt, teeth are also indicative of cultural behaviour. The following conditions were recorded in all teeth: attrition, caries presence, and tooth loss (including evulsion). In addition, the mandibles and maxillae were observed for evidence of abscesses and alveolar resorption. Of the recently excavated adult sample, Individuals 1, 3, 5, 10, 13 and 14 retained sufficient teeth for study. The extant teeth and supporting structures provide evidence for overall poor oral health for the sample and the widespread practice of evulsion of the upper central incisors.

Attrition

Attrition was recorded using the Smith system (1984) for incisors, canines and premolars, and the Scott system (1979) for occlusal wear in molars. Angle of the attrition facet was not considered in this study.
Left and right are not considered independently. Upper and lower dentitions have been noted to vary (Hillson 2001) and, therefore, upper and lower attrition rates are considered separately. Mean attrition of each observed tooth was calculated for six adult individuals in the newly excavated sample. Mean attrition rate for each tooth type is also reported for the subsamples of young adults, middle adults and old adults of the total Taforalt (Roche excavation) sample for which attrition could be recorded. The sample was divided into three

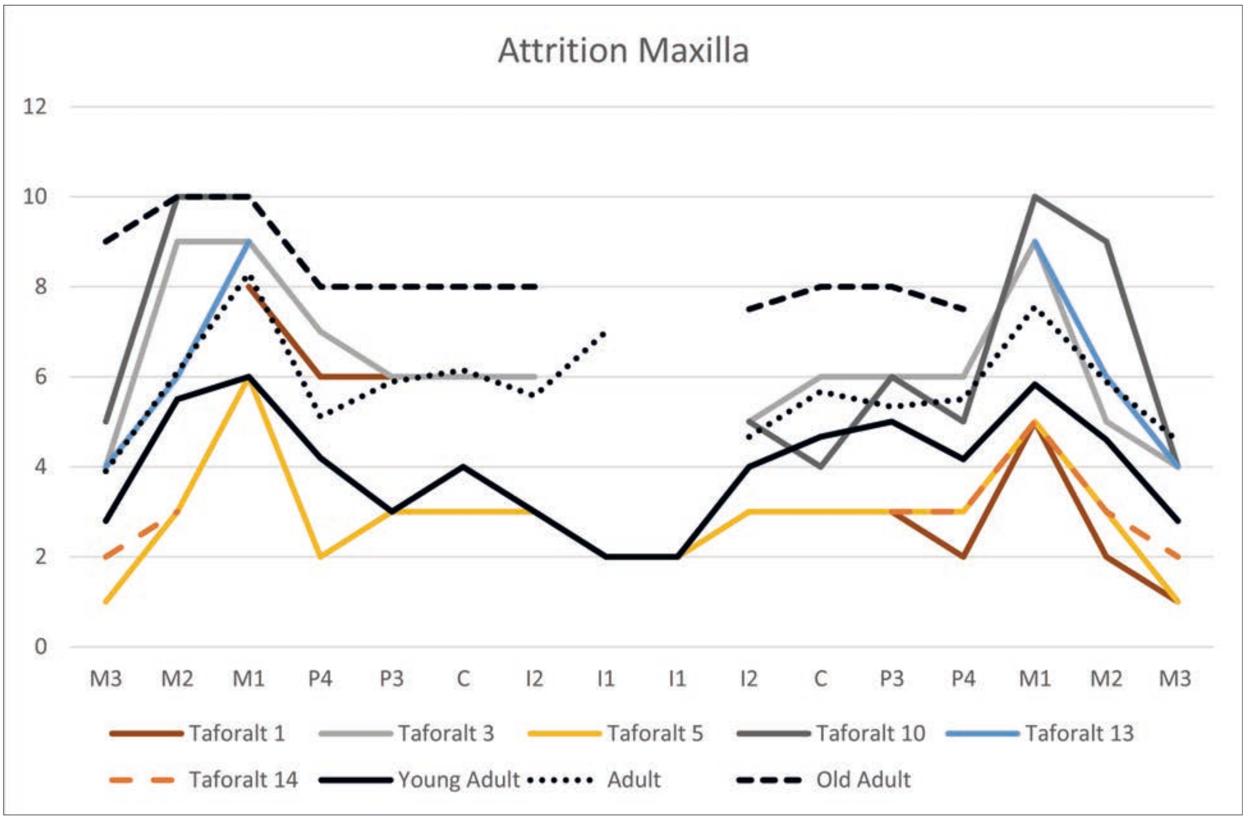
broad age categories because attrition is age progressive, which can also be observed in **figure 16.2**. Where possible, age estimation was carried out using pubic symphysis morphology (Todd 1920; Brooks/Suchey 1990), auricular surface morphology (Lovejoy et al. 1985), ectocranial suture closure (Meindl/Lovejoy 1985), and sternal rib end changes (İşcan et al. 1984). Based on these observations, the sample was divided into three age categories – young adult, middle adult, old adult – and an undetermined category.
Individual 5 of the new sample has the lowest attrition rates. Individuals 1 and 14 exhibit slightly more advanced dental wear than Individual 5 and are both considered to be young adults. Individual 13 has more advanced dental wear than Individual 14 but exhibits a similar stage of skeletal development and is considered to be a young adult. Individuals 3 and 10 are middle adults.

Evulsion

The practice of tooth evulsion is characteristic across the Maghreb from the Iberomaurusian through to the Neolithic (Briggs 1955; Humphrey/Bocaege 2008). Evulsion is the voluntary removal of teeth during the life of the individual and can be distinguished from tooth loss caused by disease or accidental loss based on the recurrence of particular patterns within a population (Briggs 1955; Mariotti et al. 2002; Bonfiglioli et al. 2004; Balzeau/Badawi-Fayad 2005; Humphrey/Bocaege 2008). Evulsion of the upper incisors is often accompanied by compensation of the mandibular anterior teeth, which emerge into the space provided by the lack of the upper incisors forming a characteristic arch (Marchand 1936; Ferembach 1962). A recent study by the authors (De Groote/Humphrey 2016) considered the prevalence and pattern of evulsion in the Maghreb region and showed that there was an almost universal pattern for both central upper incisors to be removed in the Iberomaurusian. By the early Holocene there is a tendency for all four central incisors to be removed. This pattern becomes more varied and evulsion becomes less prevalent in males during the Capsian. With the onset of the Neolithic in the region, the prevalence of evulsion is dramatically reduced and eventually disappears (Humphrey/Bocaege 2008). Although evulsion effects the biomechanics of the oral apparatus (Balzeau/Badawi-Fayad 2005) and the occlusion of the other teeth (Marchand 1936), it is not believed to be linked directly to oral pathology.
Only three of the Sector 10 individuals could be included in the evulsion analyses due to poor preservation of the maxillary region in other crania. Both Individuals 5 and 3 had experienced evulsion but no teeth were removed from Individual 10. Individual 5 had undergone removal of both upper central incisors. Individual 3 had undergone evulsion of the upper left central incisor but the right side of the maxilla was too poorly preserved to determine whether any teeth had been removed. Individual 13 had extensive damage to the anterior upper alveolar region but its morphology suggests that it experienced evulsion of the central incisors. For the whole Taforalt assemblage it was possible to observe evulsion in 34 individuals. Of these, 76.9 % of males (10/13), all females (10/10) and all unsexed individuals had evulsion. For those individuals for which it could be assessed, the most prevalent pattern was the removal of both left and right central incisors (n = 14/20). Only one individual from Taforalt (Taforalt VIII-2) presented evulsion of the lower central incisors in addition to the upper incisors.

Oral Pathologies

Caries is caused by intra-oral microbial activity associated with the consumption of processed carbohydrate-rich plant foods (Hillson 2008). Caries were recorded using Hillson's (2001) categories. Discoloration of the



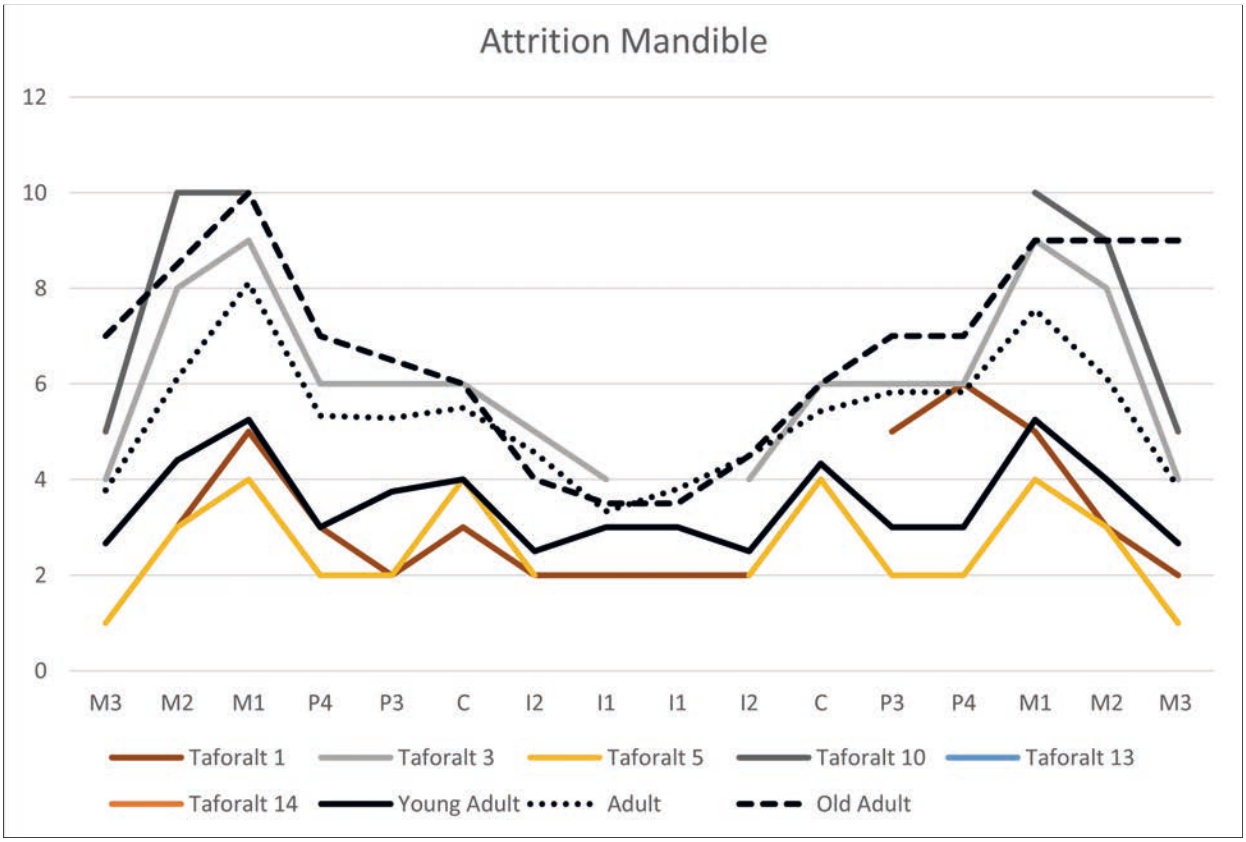


Fig. 16.2 Attrition rates for the newly excavated skeletons compared to those for the overall sample of young adults, middle adults and old adults; maxilla (above), mandible (below).

	Age									
Pathology #	Young Adult		Middle Adult		Old Adult		UD		Total	
	N	%	N	%	N	%	N	%	N	%
Observed teeth	132	100.0	228	100.0	55	100.0	257	100.0	672	100.0
Carious teeth	44	33.3	125	54.8	29	52.7	146	56.8	344	51.2
Abscess*	2	1.2	9	3.1	17	19.8	23	5.7	51	5.4
Alveolar resorption	75	56.8	155	68.0	28	50.9	138	53.7	396	58.9
Gross caries	0	0.0	9	7.2	8	27.6	11	7.5	28	8.1

Tab. 16.2 Numbers of observed teeth affected by caries, abscesses, and alveolar resorption.
Caries types as % of carious teeth.
* Abscess as % of observed sockets (including those with *ante mortem* tooth loss).

enamel was recorded and could be an early sign of caries formation (Hillson 2001) but, for these analyses, a carious lesion was only considered present when there was clear penetration in the enamel (score 3 or above). The number of lesions and locations was scored for each observed tooth. Only one surface (occlusal, mesial, distal, lingual or buccal) of the tooth had to be affected for caries to be considered present on the tooth site. Gross caries was determined present when a lesion affected more than one surface and the origin of the caries could no longer be determined (score 7 or 8). Caries rates are expressed here as the proportion of observed teeth. The reported caries rates are likely to be slightly inflated compared to other populations who do not practice evulsion because caries rarely affects the incisors.

Periodontal disease is identified by alveolar resorption in skeletal material. It is assessed by measuring the distance between the alveolar margin and the cemento-enamel junction. If this distance is larger than 2 mm periodontal disease is assumed present (Hillson 1996). The distinction between abscesses, granulomas and cysts is difficult to make in an archaeological assemblage without x-ray observations (Hillson 1996; Nelson 2015). Thus, all periapical cavities are grouped here under the term abscess. Abscesses were recorded by direct naked-eye observation only and defined as present when there was a clear cavity in the alveolar bone and reported as the proportion of observable sockets.

Individual 1 had 24 observable sockets and no evidence of ante- or post-mortem tooth loss. Twelve of the 24 observed teeth were affected by caries (50 %) and four had alveolar resorption. This individual had no abscesses.

Individual 3 preserved 30 observable sockets with one socket affected by ante-mortem tooth loss due to evulsion. This resulted in 29 observable teeth. Caries affected 21 of these teeth (72 %) and nine had alveolar resorption over 2 mm. No abscess was recorded.

Individual 5 preserved 32 observable sockets of which two were affected by ante-mortem tooth loss due to evulsion. Seventeen of the teeth had at least one carious lesion (57 %) and nine teeth had alveolar resorption. There were no abscesses recorded.

Individual 10 retained 31 observable sites but only 19 preserved teeth because 12 teeth were lost post-mortem. Seventeen of the 19 teeth had signs of caries (89 %) and 11 sites had alveolar resorption over 2 mm (58 %). Two abscesses were visible.

Individual 13 retained seven observable teeth. Six of these teeth were affected by caries (85 %) and periodontal disease. The individual had no abscesses.

Individual 14 retained seven observable teeth of which three were affected by caries (42 %). There was no abscess recorded but three of the teeth showed alveolar resorption over 2 mm.

Caries rates for all age groups were high in the entire Taforalt sample, with 33 % of observed teeth for young adults, 55 % for middle adults and 53 % for old adults affected by caries (**tab. 16.2**). These results suggest that high caries frequencies may have been characteristic of the time-period represented by these samples. Caries rates in our excavated sample were higher than the average for the site as a whole and for their age category. This observation will require further analyses when excavations continue to discern if this pattern is due to sampling bias or a true pattern.

16.5 DISCUSSION AND CONCLUSION

The skeletal and dental properties of the individuals from Sector 10 show good correspondence with the individuals excavated by Roche (Ferembach 1962). The presence of evulsion of the upper central incisors in most adults from the S10 sample reflects a pattern of dental modification that is characteristic of the Ibero-maurusian and occurs at other sites, such as Afalou in Algeria (De Groote / Humphrey 2016).

The overall results for Taforalt show high oral pathologies in the individuals from Taforalt exceeding those observed in many food producing populations. Charred macro-botanical remains from Taforalt (**Chapter 6**) suggest that the consumption of carbohydrate-rich wild plant foods, such as acorn and pine seeds, was a likely contributor to the poor oral health observed in these populations (Humphrey et al. 2014), and high attrition rates possibly due to the use of grindstones may have further contributed to the elevated caries rates. The frequent consumption of fermentable carbohydrates would have resulted in an oral environment well-suited to cariogenic bacteria. The increased reliance on carbohydrates with the onset of food production and their cariogenicity is well documented from both archaeological and historical samples. These results imply an early origin of virulent cariogenic microbiota, predating the onset of food production in Northwest Africa.

Post-cranial and archaeological evidence support moderate to high levels of terrestrial mobility for this sample, consistent with other populations exploiting wild food resources. The data presented here reveal that both a cariogenic diet and virulent caries causing oral microbiota predated the onset of the Neolithic in North West Africa but that the pathways to sedentism in this region may have differed from those observed elsewhere.

J. A. LEE-THORP · A. VAUGHAN · P. DITCHFIELD · L. T. HUMPHREY

17. ISOTOPE ECOLOGY OF THE SECTOR 10 BURIALS

17.1 INTRODUCTION

The Taforalt human burials excavated from Sector 10 consist of a relatively large number of tightly packed and intercutting adults and infants, as described in **Chapters 15** and **16**. According to the radiocarbon dating programme (**Chapter 4**), inhumation took place over a relatively short period of time, coincident with the rapid climate warming c. 15,000-14,000 cal BP, following the Last Glacial Maximum. Coupled with an apparently sudden appearance of intense occupation, several observations emerge from the physical anthropology. One is the poor oral health, and second is the relatively large number of infants in addition to adults. Together, they may suggest a rapidly expanding population and appearance of a large, perhaps semi-sedentary, community contributing to exchange of oral pathogens, as well as to the involvement of a cariogenic diet (**Chapter 16**), possibly abundant sweet acorns (**Chapter 6**) having been identified as a possible dietary staple. Further, since Taforalt is within striking distance of the coast (40 km from the present coastline), if the inhabitants were transhumant, marine foods may have featured in the diet without showing up in the deposits.

The impetus for an isotopic study therefore arose from questions about the diets of the hunter-gatherers in this North African Mediterranean biome during the rapid warming period following the LGM. The number of individuals in Taforalt Sector 10 is unusual amongst Late Pleistocene/early Holocene forager sites, where burials are rare and usually isolated. So far, isotope studies to assess the nature of forager diets in the western Mediterranean coastal fringes have been limited to just a few individuals in younger sites (Mannino et al. 2011; 2012; Salazar-Garcia et al. 2014), where the results were inconclusive on the matter of marine inputs. This contrasts with observations from other Mediterranean-type coastal biomes, such as southern African coastal foragers who clearly consumed significant but variable amounts of marine foods, thereby allowing inferences to made about territorial group boundaries (Sealy 2006). A further aim of the present study was to assess the isotopic composition of infants compared to adults, as, elsewhere, their trophic distinctions have been used to identify breastfeeding and weaning processes (Fuller/Fuller/Harris/Hedges 2006; Nitsch/Humphrey/Hedges 2011; Prowse et al. 2008; Schurr 1998). This approach is rarely feasible amongst foragers due to low numbers of comparable individuals (but see Clayton/Sealy/Pfeiffer 2006; Eerkens/Berget/Bartelink 2011). Adult and infant human bone collagen carbon and nitrogen isotope compositions, compared against those of a range of coeval fauna, were used to address these questions.

17.2 STABLE ISOTOPES IN HUMAN ECOLOGY

The principles of applying carbon ($^{13}C/^{12}C$) and nitrogen ($^{15}N/^{14}N$) isotopes to clarify dietary ecology and environments are well-rehearsed. For carbon, the primary distinctions reside in plants at the base of all foodwebs, which are predicated partly on the sources of carbon (whether atmospheric CO_2 or carbon dissolved in seawater), and partly according to photosynthetic pathway of terrestrial plants. Plants reliant on the ancient C_3 RuBisCo-mediated pathway are strongly depleted in the heavier isotope ^{13}C, compared to tropical grasses and sedges following the C_4 pathway, with global average values of c. $\delta^{13}C$ [66] = -26 ‰ and -12 ‰ respectively (O'Leary 1981). The C_3 pathway is sensitive to climate influences, especially low relative humidity (Farquhar/Ehleringer/Hubick 1989), so that C_3 vegetation typical along the coastal fringes of North Africa, with warm dry summers, tends to be more positive, thus shifting the entire foodweb. Vegetation in the desert zones to the south almost certainly included C_4 grasses and sedges, especially during the Late Pleistocene/early Holocene 'greening' episode driven by increased monsoonal precipitation. Finally, marine trophic systems are distinctly ^{13}C-enriched compared to typical terrestrial systems dominated by C_3 vegetation, starting with the different source of carbon for primary producers.

The primary application of $\delta^{15}N$ in diet studies relies on the stepwise trophic level isotope effects observed in ecosystems (Minigawa/Wada 1984) that occur during *in vivo* protein metabolism (O'Connell 2017). The marine baseline for primary producers is higher in $\delta^{15}N$, compared to those in terrestrial systems, and, coupled with longer marine trophic chains, the net result is that strongly marine diets are ^{15}N-enriched compared to terrestrial diets (Schoeninger/DeNiro 1984). There is some complexity in the general picture. First, local environmental conditions control soil nitrogen balance and $\delta^{15}N$ and thus that of plants and animals (Robinson 2001). The $\delta^{15}N$ values in arid-climate foodwebs tend to be higher (Handley et al. 1999), although highly variable (Craine et al. 2009), and digestive physiologies for different mammalian taxa may introduce further distinctions (Ambrose 1991). The stepwise trophic enrichment is often reported as c. 3-4 ‰ between prey-predator pairs but the range can be greater and is influenced by physiology. In humans, the offset with dietary protein is higher (c. 5 ‰) (O'Connell et al. 2012). Infants entirely dependent on breastmilk form a special case as they obtain all nutrition from their mothers and consistently show offsets of 1.5-2 ‰ (Fuller/Fuller/Harris/Hedges 2006), an observation that has been used to address duration of breastfeeding and infant nutrition in the past (Schurr 1998). Studies initially measured bone collagen $\delta^{15}N$ in skeletons aged by standard physical anthropology methods (e.g. Clayton/Sealy/Pfeiffer 2006; Prowse et al. 2008; Nitsch/Humphrey/Hedges 2011) but more recently researchers have measured dentine increments that reflect early life history in surviving adults (e.g. Eerkens/Berget/Bartelink 2011; Sandberg/Sponheimer/Lee-Thorp/van Gerven 2014).

Finally, a trophic effect is also observed in $\delta^{13}C$, roughly $^{1}/_{3}$ the magnitude compared to $\delta^{15}N$, and the combined directional effect in an ecosystem is useful in separating sources and effects.

17.3 MATERIALS AND METHODS

Adult and infant human bone collagen $\delta^{13}C$ and $\delta^{15}N$ composition was compared against the values obtained for coeval fauna in the site, either from the immediate burial environment or from Sector 8. This approach is required to provide both an isotopic baseline for the Taforalt environment at the time and to assess likely dietary sources for humans. We included bone samples of identified fauna from Sector 8 in addition to those associated with the burial zone to increase the numbers of specimens and taxa (**Chapter 9**). Of the 23 faunal samples, 10 are from Sector 10. The Barbary sheep (*Ammotragus*) is best represented. For the humans, adults are in the minority (n = 4), and infants (n = 7) of which 3 are perinates, in the majority.

Collagen preparation followed standard procedures for acid demineralisation and preservation assessment used in the Oxford Radiocarbon Accelerator Unit (e.g. Brock/Higham/Ditchfield/Bronk Ramsey 2010).

66 Stable isotope ratios are by convention expressed as per mil in the δ notation relative to an international standard, as $\delta^{13}C$ ‰ or $\delta^{15}N$ ‰ = $(R_{unknown}-1)/R_{std} \times 1000$, where the standards are PDB and AIR respectively.

Most of the samples reported here were associated with radiocarbon dates (**Chapter 4**) allowing the associated carbon and nitrogen isotope determinations on the ORAU's SerCon CF-IRMS system to be used, as well as independent determinations in the SERCON 20/22 CF-IRMS system in the Stable Isotope Laboratory. In both cases an internal alanine standard was used and, in the latter case, samples were measured in duplicate or triplicate and the results averaged. Where measured by both methods, the results were comparable within standard error (± 0.2 for both isotopes). Collagen preservation was assessed by C/N ratios, which are required to fall between 3.0 and 3.5 for well-preserved collagen (Brock/Higham/Ditchfield/Bronk Ramsey 2010).

17.4 RESULTS AND DISCUSSION

The $\delta^{13}C$ and $\delta^{15}N$ results for both faunal samples from Sectors 10 and 8 and the human samples from Sector 10 are reported in **table 17.1**, along with their C/N ratios, and, in the case of humans, their developmental age. Faunal and human samples that yielded poorly preserved collagen are not shown. From the bivariate plot of the isotope data (**fig. 17.1**), it can be seen that faunal $\delta^{13}C$ and $\delta^{15}N$ values are lower than those of the humans, as well as more variable.

The faunal data-set has a mean $\delta^{13}C$ of -21.11 ± 0.73‰, showing that local vegetation was entirely C_3. An outlier Barbary sheep sample with suspiciously low $\delta^{13}C$ and $\delta^{15}N$ values (compared to the rest), but acceptable C/N, was retained in the calculations. Combined with a $\delta^{15}N$ mean of +6.42 ± 1.72‰, these data suggest there is little evidence for strong regional aridity of the sort one might expect in a modern hot/dry Mediterranean climate. However, a smaller number of equids, gazelle and Barbary sheep show higher $\delta^{13}C$ and $\delta^{15}N$ values (**fig. 17.1**). Given the several taxa in this group, we can discard distinct digestive physiologies as a cause, and so the data suggest either that these specimens came from different, drier ecozones (possibly further afield) or that they reflect short-term climate shifts within the timespan of the accumulation of deposits. This was, after all, a period of rapid climate change. We do not have enough data for each of the herbivore taxa to deduce whether there is any significant distinction in herbivore faunal values between Sectors 10 and 8. The bustard as the single omnivore has higher $\delta^{13}C$ and $\delta^{15}N$ values of -20.5‰ and +9.5‰ respectively; the specimen was in firm association with the burials (and thus of the same period), so these values are consistent with an omnivore in the same environment as the bulk of the fauna and humans.

The overall means and standard deviations for humans ($\delta^{13}C$ = -18.91 ± 0.19‰; $\delta^{15}N$ = +11.25 ± 0.97‰) stand in contrast to the faunal data in two respects. First, they are less variable than the fauna, as can be observed from **figure 17.1** and from the standard deviations. The difference in variability is marked for $\delta^{13}C$ and less so for $\delta^{15}N$, since the human $\delta^{13}C$ data are very tightly clustered while the latter are more variable (see below). Nevertheless, the observation holds overall. This pattern is commonly observed in many studies, especially from the Neolithic onwards where there are sufficient numbers of fauna and humans to assess distinctions in variability. We cannot be certain but here it *may* reflect a common, standard dietary regime amongst the Taforalt individuals, an observation consistent with remains of food waste in the site. Next, the overall human-fauna trophic offset in $\delta^{15}N$ is +4.8‰, or +4.2‰ if we include only adults, and in $\delta^{13}C$ +1.2‰. This is consistent with observations for a larger trophic offset amongst humans set out by O'Connell et al. (2012). Thus, the values for both $\delta^{13}C$ and $\delta^{15}N$ are entirely consistent with the terrestrial faunal data, given expected isotopic offsets between the trophic levels. Therefore, we conclude that there is little evidence for involvement of marine foods. Further, even if sweet acorns were an important energy source, the cave's inhabitants clearly had access to reasonable amounts of animal proteins.

Fauna				
Taxon	Sector	d13C ‰	d15N ‰	C/N
Ammotragus	8	-20.3	4.8	3.5
Ammotragus	8	-19.5	5.7	3.3
Ammotragus	8	-20.6	6.3	3.4
Ammotragus	8	-20.1	4.3	3.4
Ammotragus	8	-20.8	5.8	3.3
Ammotragus	8	-19.7	8.5	3.3
Ammotragus	8	-22.4	3.4	3.3
Ammotragus	8	-19.2	8.4	3.3
Ammotragus	8	-20.5	5.4	3.3
Ammotragus	8	-20.2	3.2	3.2
Ammotragus	8	-18.9	6.6	3.3
Ammotragus	8	-20.2	4.8	3.3
Ammotragus	8	-19.9	6.3	3.3
Ammotragus	10	-19.6	6.7	3.4
Ammotragus	10	-21.2	6.5	3.4
Ammotragus	10	-20.2	5.7	3.4
Bos	10	-19.6	6.6	3.5
Equus	10	-20.2	8.1	3.2
Equus	10	-20.2	9.5	3.5
Equus	10	-19.9	6.6	3.5
Gazella	10	-19.6	6.8	3.4
Gazella	10	-19.4	8.1	3.3
Otis tarda	10	-20.5	9.5	3.3
Humans				
Individual	Age	d13C ‰	d15N ‰	C/N
4?	Adult	-18.8	11.4	3.3
5	17-25 years	-19.0	9.7	3.2
6	8-10 months	-19.0	12.0	3.3
7	perinatal	-19.2	10.1	3.4
8	2-3 months	-19.0	11.3	3.2
9	5-6 months	-18.9	12.1	3.2
11	perinatal	-18.9	12.0	3.4
12	perinatal	-18.6	10.9	3.5
13	17-25 years	-18.9	10.4	3.4
14	17-25 years	-18.6	10.9	3.3
Surface infant, Individual '20'	8-10 months	-19.1	12.9	3.2

Tab. 17.1 List of the faunal and human samples whose bone collagen isotopic composition is reported in this study, along with C/N ratios. Sectors are reported for the fauna but, since all humans were from Sector 10, their estimated developmental ages are shown in Column 2 instead.

If we then examine isotope distinctions according to developmental age (**fig. 17.1** and **tab. 17.1**), it is readily apparent that there are no differences in $\delta^{13}C$ but that there are distinctions in $\delta^{15}N$. The latter make little sense unless one separates perinates from infants. Three of the four infants have higher $\delta^{15}N$ than the adults (by 1.5‰), while two of the three perinates are consistent with adult values. This is entirely consistent with expectations and the model of Nitsch/Humphrey/Hedges (2011), since perinates should reflect the maternal values. Breastfeeding infants (dependent solely on breast milk) should reflect maternal values plus a small 'trophic' offset. Even the youngest infant (2-3 months) already has higher values ($\delta^{15}N = +11.3$‰) than the adults (mean $\delta^{15}N$ +10.62 ± 0.72‰). It is interesting that the offset in breastfeeding infants has

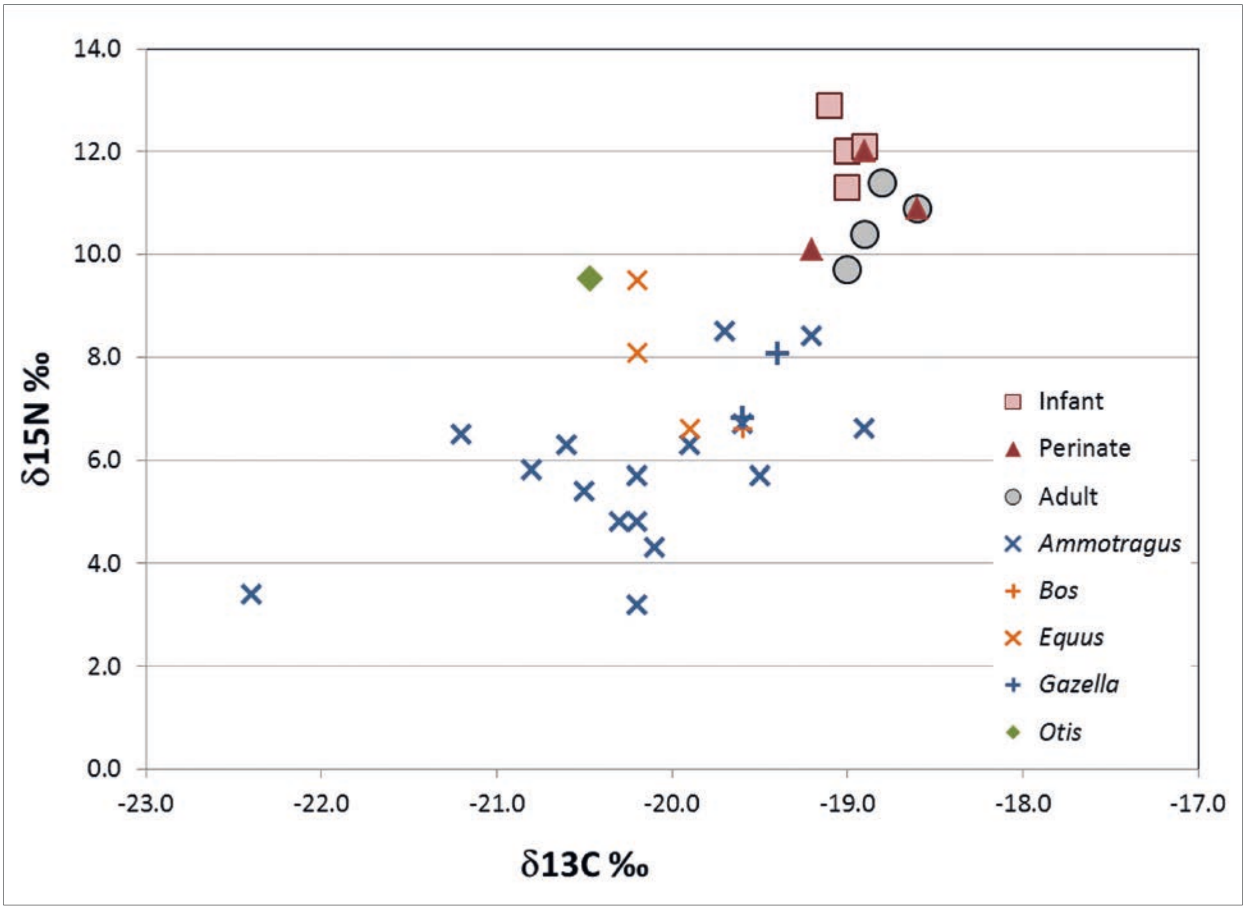


Fig. 17.1 Bivariate plot of the $\delta^{13}C$ and $\delta^{15}N$ data reported in **tab. 17.1**.

never been found to be of the same magnitude trophic increase as shown in ecological studies or the calculations of O'Connell et al. (2012). The metabolic explanation outlined by O'Connell (2017) may suggest an explanation, if human breastmilk requires less metabolic 'rearrangement' of nitrogen than that required for other proteins found in meat, nuts and vegetables. Bone turnover rates and intake of non-milk foods especially after 5-6 months may also be relevant factors.

17.5 SUMMARY

We can conclude that the environment during the cave's occupation was largely mesic, based on the faunal isotope data although there are some hints of arid episodes and/or distinct exploited ecozones. The individuals buried in Sector 10 showed trophic offsets in both $\delta^{13}C$ and $\delta^{15}N$ consistent with diets that included reasonable amounts of animal protein but not marine foods. Thus there is no clear dietary evidence for significant transhumance between the site and the coast. The humans are remarkably invariant in $\delta^{13}C$, suggesting highly uniform sources of dietary carbon, while $\delta^{15}N$ variability amongst infants is consistent with current models that place perinates at the maternal level, followed by a rapid trophic shift related to nursing.

Acknowledgements

We are grateful to Dr Elaine Turner for identification of the mammal fauna used in this study, and Dr Jo Cooper for identification of the bustard bones.

THE EDITORS AND TEAM

18. SYNTHESIS AND INTERPRETATION

18.1 INTRODUCTION: THE THEORETICAL BACKGROUND

In this final chapter we consider some of the broader issues and interpretations that have arisen from the detailed studies presented in earlier chapters. One of the key issues to be addressed concerns how theoretical ideas and generalisations can be interpreted in the light of empirically derived data which, by definition, are neither perfect nor complete. In the following we consider the basic theoretical underpinning that has helped drive some of the questions raised by the 'Cemeteries and Sedentism' project and discuss how these fit (and, interestingly, do not fit) with preconceived ideas concerning the behaviour of later hunter-gatherers. We begin with some brief notes on the theoretical background which has influenced the thinking of archaeologists working on the 'Epipalaeolithic' and related cultures in the Mediterranean.

Intensification

We have found the use of the term 'intensification' in the literature to be somewhat ambiguous and we have therefore tried to use this term sparingly, save where a restricted meaning was absolutely clear. In the context of subsistence pattern modelling, 'intensification' usually has connotations which may lead to circular or otherwise prejudicial arguments. For example, Binford (1999, 6) equated "pressures to intensify the subsistence base" with "the need to extract more and more resources from smaller and smaller segments of the landscapes". Thus, the hunter-gatherer group is 'constrained' (in the example given, constrained in territory, due to population pressure) and is 'forced' to respond by means of 'intensification', which must, at some point if not immediately, become less 'efficient' (producing a lower return for the same effort) than if the 'constraint' were not in operation. All this may be entirely reasonable given the specific context, or historical trajectory, of 'constraint' envisaged by Binford (and others). However, one may ask whether the observable results of 'intensification' could arise from different causes (not necessarily involving undesirable 'constraints'), indeed, whether 'intensification' might, under some circumstances, be an efficient response. In our discussion below, we will attempt not to prejudge the cause of anything which might look like 'intensification', pending some plausibly independent evidence of a driver (cf. Morgan 2015).

Broad Spectrum Revolution (BSR)

The concept of a broad spectrum revolution was first proposed by Flannery (1969) to explain dietary changes that were the precursors of plant and animal domestication and foreshadowed the emergence of agriculture. He suggested that, in the Near East, a number of previously ignored taxa (invertebrates, fish, water fowl and plant resources) were added to the diet which enabled hunter-gatherers to improve the carrying capacity of the environment and allowed a burgeoning population to overflow into more marginal resource zones (Zeder 2012).

Since then, much has been written about the Broad Spectrum Revolution (BSR) which, it has been suggested, should be decoupled from the Neolithic, as similar responses may have taken place many times earlier in the past (see Stiner/Munro/Surovell 2000 and comments, one by Flannery). In the recent literature, BSR has been much discussed in relation to pre-agricultural hunter-gatherer populations of the Epipalaeolithic (Stiner/Munro/Surovell 2000; Bar-Oz/Dayan 2002; Stutz/Munro/Bar-Oz 2009; Yeshurun/Bar-Oz/Weinstein-Evron 2014). In the Near East, key dietary changes have been described in the Natufian (from c. 15,000 cal BP), when pressure on the main ungulate resource (mountain gazelle) led to an enforced shift in exploitation patterns, as well as to the hunting of less cost-effective but hunting-resilient (fast turn-over and recovery rates) animals such as lagomorphs, smaller birds and other lower ranked resources (Yeshurun/Bar-Oz/Weinstein-Evron 2014). Developments in parallel in some areas of the Near East would seem to have included an increase in plant exploitation with extensive use of wild plants, long before their domestication in the Neolithic (Maher/Richter/Stock 2012; Asouti/Fuller 2012; Snir et al. 2015). Another point that emerges from these and other studies in the eastern Mediterranean is the proposed strong link that existed between subsistence intensification (usually of the 'constrained' type mentioned in our comments above) and signs of increasing sedentism. From analysis of Natufian sites, greater permanency of site occupation is regarded as a consequence of diversifying resource exploitation and, at the same time, focusing on certain foods (Bar-Oz 2004; Munro 2004; 2009; Davis 2005; Stutz et al. 2009).
In this chapter we will attempt to avoid the causative prejudgements expressed in much of the BSR literature, by first concentrating upon actual evidence (if any) of a broadening of the subsistence spectrum (cf. the contrast between Flannery 1969 and Flannery 1986, together with the relevant discussion in Zeder 2012).

Optimal Foraging Theory (OFT)

Optimal Foraging Theory was adopted, from its origins in behavioural ecology, into archaeological theory in the 1980s (see Zeder 2012 for detailed discussion). Smith (1983, 626) set out the central proposition of this approach as follows:

> […] Most foraging models assume that foragers will be selected [by evolutionary processes] to behave so as to maximise the *net rate of return* (of energy or nutrients) *per unit foraging time*. This assumption seems reasonable under a variety of conditions, including the following: (1) available food energy is in short supply ([Darwinian] fitness is energy-limited); (2) specific nutrients are in short supply (fitness is nutrient-limited); (3) time for adaptive nonforaging activities is scarce (fitness is limited by time available for nonforaging activities); or (4) foraging necessarily exposes the forager to greater risks (fitness costs due to predation, accident, climatic stress, etc.) than do nonforaging activities […]. [original italics]

Zeder (2012, 242) has noted that early modelling, "[…] following OFT core principles, universally situated broad spectrum resource diversification within a context of resource depression – whether due to post-Pleistocene environmental change or human population growth". We will not start from this premise.

Mobile Hunting and Gathering

Mobility in hunter-gatherers has been tackled from a number of different perspectives. From the standpoint of OFT, it is regarded as a fundamental behaviour of hunter-gatherer societies only sacrificed as a last resort, in response to population packing and a resulting reduction in preferred high ranking resources (Zeder 2012; Stiner et al. 1999; 2000; Stutz/Munro/Bar-Oz 2009). One of the theoretical consequences of any reduction in mobility, therefore, is that it would incur extra costs in terms of lowered foraging efficiency and so the adoption of broad spectrum diet diversification must be seen "within a context of resource stress" (Zeder 2012, 253).

Various authors have tried to calculate environmental and other thresholds controlling mobility. Binford argued that in resource-poor areas people will move frequently, while the converse is true in areas where richer sources are available. Having considered a relatively large number of ethnographic accounts, he calculated that mobility would cease only once the 'packing threshold' had reached 9.098 people per 100 km^2 (Binford 1999; 2001). Under such instances they would adopt a more sedentary lifestyle occupying a central place or base camp for a significant part of the annual cycle.

The importance of mobility to hunter-gatherers was echoed by Kelly (1995) who saw that sedentism was most likely to result when population density reached saturation point. However, he also maintained that if resources were concentrated in rich patches it would make greater ergonomic sense to situate a residential camp between distant patches and organise logistical forays (logistical mobility) from that central base, effectively reducing mobility (residential mobility). This result has been simulated in detail by Jansen/Hill (2016), who confirm that more clumped resources in a more patchy environment should lead to much higher return rates compared to more dispersed and less patchy environments, given an adaptive and complex mobility pattern (often with reduced residential mobility overall) based upon intimate knowledge of the landscape.

Other related models of mobility put forward by Binford (1980) also link low residential mobility (greater sedentism) with highly logistical systems of hunting and gathering that allowed foods to be collected in bulk and transported back to residential camps. This situation is slightly complicated by the fact that some forager groups are known to employ both high and low residential mobility patterns (e.g. the San), depending on mitigating risk factors and local environmental conditions (Bousman 2005). Connected to these systems is the concept of circulating and radiating mobility patterns (Binford 1983). Expressed in essence, radiating mobility strategies are those in which hunter-gatherers can be shown to move between one of several specialised camps and a more permanent base camp. In a circulating strategy, mobility involves regular relocation of the base camp itself. One might note that it is not logically necessary for the two to be mutually exclusive.

Interpretation and Theory

We have set out above a very brief and superficial characterisation of the archaeological foraging theory which has been developed to deal predominantly with late Pleistocene and early Holocene hunter-gatherer groups. We have already noted our reservations over the apparent stress upon 'forced' responses to 'negative conditions' in much of the literature. We would also suggest that the application of these theories to archaeological cases will not always be easy; real societies involve so many variables, with different individuals/groups doing different things at different times for different reasons, making it difficult to disentangle a 'compacted' archaeological record. We therefore intend, wherever possible below, to proceed carefully (but, in the interests of concision, not always explicitly) as follows: (a) we will use the published body of theory to identify parameters which could be relevant in our particular circumstances; (b) we will identify what types of evidence might help characterise the state of the parameter in question; (c) we will see whether we have such types of evidence at Taforalt; (d) we will examine such evidence, to decide how robust it may be in the context of characterising the state of the parameter in question; (e) we will remark upon that evidence; and (f), only if it appears reasonable to do so (and in many cases our conclusion will have to be 'not proven' or 'not yet proven'), we will apply the evidence to the available theories or, otherwise, to our own suggestions.

We also hope that, even in those 'not proven' cases, we may be able to suggest analyses that could be carried out in the future, at Taforalt or at neighbouring sites, to improve our understanding of LSA behaviour in this region.

It is fitting that we end this subsection with an alternative vision of late Pleistocene foraging, again expressed in the words of Zeder (2012, 242):

> […] As more and more examples of the BSR are found in resource rich areas where no case can be made for an imbalance between population and available resources, however, it is becoming increasingly difficult to attribute diet diversity and resource intensification to resource depletion. Models that portray humans in a one-way adaptive framework in which they scramble to respond to the negative impact of deteriorating climate or unbridled population growth are being called into question as alternative perspectives emerge that portray humans as actively modifying environments to meet fundamental economic and social goals. […].

18.2 OPPORTUNITIES AND LIMITATIONS OF THE TAFORALT EVIDENCE

Previous and Current Data Collection

The Ruhlmann excavations served primarily to demonstrate the general potential of the site. The Roche excavations were extensive but stratigraphic control and definition were poor, even confused; publication of the Grey Series results was (and remains) patchy, of the Yellow Series results, almost non-existent. Nevertheless, if we now concentrate upon the more reliable stratigraphic and geographic generalities in Roche's work, a modicum of patterning emerges – sometimes useful in pursuing our own objectives, sometimes merely tantalising.

Our own approach has sought the best available stratigraphic control during what must be understood as small-scale excavations in relatively limited and dispersed parts of this large cave (see **Chapter 2**). We have attempted to counterbalance the bulk extraction of Roche with our precision sampling, in most cases focusing upon understanding the development of detailed vertical record sequences. We have been able to bring to bear a much wider range of technical approaches than previously available but it must be recognised that, for many topics, our sample sizes are still small. Similarly, whilst we began with a detailed set of objectives (**Chapter 1**) and kept these continually under review, the need to advance slowly (both due to physical constraints and section instabilities and to the need to try to avoid total excavation of key units where only small volumes survived) means that we could not always take the best samples to address a particular matter of interest. Therefore, the degree to which our results can be taken as representative of the whole site, of a particular time interval, or even of a particular cultural/behavioural practice, must not be overstated.

Site Geography and Sequence

As explained in **Chapter 2**, the LSA Iberomaurusian at Taforalt occurs in two highly distinctive sedimentary units: a Grey Series (GS) made up almost entirely of ashy deposits, and an underlying Yellow Series (YS) made up predominantly of fine sands and silts with a little clay. Today, the main surviving areas of Grey Series are restricted to the south (left looking inwards) side and the back of the cave. Geographically, our excavations were located strategically in various areas designated as 'Sectors' to maximise sampling of the cave's stratigraphy (**fig. 2.10**). The largest samples of the GS sequence examined were in Sectors 8 and 10. In S8, the surviving (top-truncated) Grey Series comprised a maximum thickness of approximately 4 m of dominantly anthropogenic deposits (burnt limestone and the resultant comminuted debris, ash, charcoal, bone and snail shell debris, etc.). The strong anthropogenic input and the lenticular nature of the deposits has led us to describe them as midden-like, although, given the size and complexity of deposit, it might be more realistic to describe the phenomenon as a hyper-midden. It should be emphasised that these deposits were by no means homogeneous and were themselves made up of differently structured deposits that reflected different processes of accumulation. We also sampled extensively the older LSA units in the upper YS sequence, specifically where this was best preserved in Sectors 3, 8 and 9. In S8, the YS interval containing the occupation material consisted of an approximately 1 m thickness of often finely laminated material.

A further area of GS deposits was preserved at the back of the cave in Sector 10. Here, our excavations revealed a series of structured burials and their associated objects (see **Chapter 15**), in amongst a loose matrix of sediments containing lithic artefacts and other derived/disturbed occupation debris.

Potential for the Identification and Comparison of Activity Areas

The total area investigated in our project is tiny in comparison to that dug by Roche and our individual interventions are too small (save in Sector 10) to allow much insight into the macro-structure of activity areas. In terms of horizontal area of deposits, we have excavated in many squares in non-contiguous sectors (**fig. 2.10**). This contrasts markedly with the very substantial quantities of GS and YS deposits removed by Roche in his archaeological investigations. The Sector 10 excavation actually represents the largest contiguous area of GS deposits addressed during our work (5.5 m^2) but this still only represents a small proportion of the original burial areas, most of which were excavated in the 1950s. Unfortunately, the only comprehensive record of the early work at the site comes from the volume based on Roche's 1957 doctoral thesis (Roche 1963); often without full analysis of contemporary field records, notebooks and section drawings, it is difficult to interpret some of his results. Also no detailed study has yet been undertaken of the extensive artefact collections in Rabat Museum which are still sealed in large wooden storage boxes mostly marked with only basic information of his *Niveaux* (*I*, *II*, *III*, etc.). Nevertheless, despite these shortcomings, it is possible to glean some general information on the spatial distribution of the 1950s finds. In **figure 2.5** are illustrated plans of the approximate horizontal limits (as defined in his published text) of Roche's *Niveaux*; we explain in **table 2.4** and the accompanying text in **Chapter 2** how the published data can be related to the original excavation units (as shown in the unpublished site archive). In further discussion on the human activities in the cave (below), we will use the resulting schema (broadly, three main collecting stratigraphic intervals, plus two additional locally identified units, together with three main zones, outer, middle and inner cave, plus the burial areas) to refer to some of these distributions.

It should be noted in passing that the area and volume of surviving GS deposits (and of the very youngest YS deposits) in the cave is now relatively restricted and any future work should take preservation of this valuable archaeological resource into consideration.

Site Taphonomy

Understanding site taphonomy (the processes of formation, incorporation and preservation of assemblages in deposits) is a vital step in the interpretation of archaeological data. At Taforalt, of particular note are the marked differences between the Yellow Series and Grey Series sediments.

The gentle wash processes responsible for relatively slow accumulation of most of the YS would not greatly have influenced the dispersal or post-depositional sorting of the larger faunal or lithic remains in the archaeological layers. Nevertheless, some winnowing of exposed surfaces in the YS will have occurred, as for example evidenced in the distribution of charcoal fragments which are often size-sorted or finely laminated and there are only rare examples of ash or other traces of *in situ* burning. In addition to gentle dilation of finds, some degree of vertical separation is also visible, with individual occupation layers of relatively concentrated activity separated by 'natural' sediments with only the occasional presence of artefacts; if the latter represent gaps in occupation, it seems unlikely that these were for any great length of time. Since the YS shows dominantly geogenic deposition, some information concerning external environmental factors can be expected to have survived in the sediments themselves, as well as within the contained assemblages of biological material.

The GS/YS boundary, a wholly anthropogenic feature, can be characterised as sharp, irregular and erosive, indeed demonstrably transgressive in the available exposures. The GS marks a major change in deposition, with evidence of very rapid accumulation in much of the lower GS being distinguished by stonier deposits, and sometimes even by stone openwork, where fine sediment has either been removed by wash or never existed, or was at least underrepresented, in the first place. Larger pieces of fauna, often remarkably complete, can sometimes be found trapped in the stony matrix, whilst smaller remains might have been displaced through available openwork. The lowest units in the GS (L28-L29 and their equivalents) are a little less stony and, at least near the base, contain some material mixed up from below; it is also possible that the sedimentation rate was at first a little slower than in the rest of the lower GS, although the radiocarbon data are not decisive on this point (**Chapter 4**). The main, stony, body of the lower GS is in contrast to the upper GS where depositional rates appeared to have slowed markedly, and there is evidence of increased trampling (fracture of more vulnerable bones, shells and lithic artefacts). Since the GS shows dominantly (almost exclusively) anthropogenic deposition, little information concerning external environmental factors can be expected to have survived in the sediments themselves; even the contained assemblages of biological material usually display bias due to deliberate or inadvertent human activity, effects which must be understood before any environmental signal can be identified.

The contrasting sedimentation rates, already predictable from the nature of the deposits themselves, have been estimated more exactly in **Chapter 2**, using the radiocarbon data from **Chapter 4**. Apart from short spurts of accumulation during periods of particularly strong human activity, typical YS wash deposits show a sedimentation rate of c. 0.17 m per thousand years (actually, quite a strong rate for such fine sediments, indicating ample sediment supply). In contrast, the lower and middle parts of the GS accumulated rapidly, at c. 4.00 m/ky overall (possibly a little slower near the base, as suggested above), and the upper part more slowly, at c. 1.11 m/ky, with the average GS rate being c. 1.82 m/ky, thus over ten times faster than the typical YS rate. Allowance for sedimentation rates is important (both in terms of the taphonomic effects of likely near-surface residence times and of the relative abundance in a given stratigraphic interval of geological, biological and artefactual components) and has been made wherever possible during our analyses.

Sector 10 exhibits a different taphonomic history from the GS in Sector 8. We have argued (with the detailed reasoning set out in **Chapter 2**) that the matrix of habitation debris is unlikely to represent a 'normal' deposit and that there is evidence to suggest that at least some of the ashy sediments were deliberately imported from further out in the main cave chamber. The objects found in the burial area must therefore comprise an admixture of imported and *in situ* archaeological material, although there is no doubt from the articulated nature of the human bones that the skeletons were buried intact and often in pits.

As a general proposition, the range of mineral-dominated materials (both geological and biological) in the cave assemblages is wide, with excellent states of preservation. This matches expectations for a large cave site, with a substantial bedrock buffer, in an environmental context likely to have been, on long-term average, relatively warm and dry (see below). Except in some less protected zones nearer the actual entrance, the scale of the site, and probably also its altitude, have reduced interference from (non-human) bioturbation effects and the lithostratigraphic definition is usually good. Such a context, however, is not conducive to the preservation of 'soft' organic matter; if not charred, most organic matter is poorly structured and diffused throughout the sediments. Special cases can nevertheless be found, with persistence, in which highly informative organic matter (e.g. bone collagen and genetic material) can be retrieved from their primary sources.

18.3 CLIMATIC AND ENVIRONMENTAL CONTEXT

General Background

The period covering the LSA Iberomaurusian at Taforalt was one of fluctuating worldwide climate characterised by sharp oscillations in temperature and rainfall (COHMAP members 1988; Wengler/Vernet 1992; Penaud et al. 2010). At a global scale, these can be recognised in the Greenland Ice core event stratigraphy (Rasmussen et al. 2014) as a sequence of dated interstadial (warming) and stadial (cooling) episodes, commonly referred to as Dansgaard-Oeschger cycles. Short, sharp cooling events, independent of ice records, have been identified in marine cores where they are known as Heinrich Events (HE) or, as broader periods, Heinrich Stadials (HS), marked by iceberg debris discharged into the North Atlantic. According to the Greenland event stratigraphy, the Late Glacial consisted of a prolonged stadial (Greenland Stadial 2 or GS2) which began around 23,220 cal BP (approximating to calendar years before CE 2000) and ended with an abrupt interstadial warming GI1 at c. 14,692 cal BP. Greenland Interstadial 1 has been divided into five sub-phases (e-a) (with phase c itself subdivided into three) and terminates with a return to colder conditions of Greenland Stadial 1 at c. 12,896 cal BP, roughly equivalent to the Younger Dryas (YD). However, most (but not all) modern publications (e.g. Turu et al. 2018, reporting a study from as far south as central Spain) diverge slightly from the NGRIP scheme for GI1 by recognising an initial short "Oldest Dryas" or "Pre-Bølling" phase, which has no formal Greenland equivalent; it is probably still sensible to heed the warning from Rasmussen et al. (2014, 25) that such an initial cool phase is "poorly defined" and perhaps not distinct from HS1 and the end of GS2. Indeed, the temporal positions of the HE and HS intervals are somewhat complicated as they rely on oceanic data and cannot be tied directly to the Greenland ice core chronology. According to some recent estimates HE2 occurred at c. 24,856-24,127 BP and HE1 at c. 17,678-16,744 BP (Andrews/Voelker 2018). The above dates for HE1 do not tally precisely with those from the nearest core located in the Alboran Sea (Combourieu Nebout et al. 2009) but, comparing the pre-2002 calibration used by these authors with results relying upon the most recent OxCal data, we suggest that the beginning of "HS1" (here a complex and relatively lengthy interval not restricted to a single cold water input, cf. Bazzicalupo et al. 2018) in ODP Leg 160 Site 976 could be taken back to 17.9 ka (thousand years ago). It also appears that the old and new calibration curves broadly converge by 14.8 ka, the date suggested for the end of "HS1" in the western Mediterranean, and show no significant divergence thereafter. There is less agreement on the timing of the Last Glacial Maximum (LGM), covering the period when glaciers reached their maximum extent in the Northern Hemisphere, there being no accepted type-site for this phenomenon. For some authors the LGM can be equated with GS3 at c. 27,540-23,340 ka (Hughes / Gibbard 2014), while estimates based on truly global ice volumes and astronomical criteria, have yielded limits of c. 26.5-19 ka (Clark et al. 2009). We have preferred to use the latter (**fig. 18.1**).

The effects of global climatic change in this period in NW Africa may be inferred from a number of proxy records. Against a brief phase of increased humidity at around 37,000 years ago, based on dated travertines and fluvial sediments on the northern edges of the Moroccan Sahara (Weisrock et al. 2008), a return of markedly cooler, drier conditions is indicated by the re-growth of local ice caps in the mountains of Morocco (Awad 1963; Hughes et al. 2004). Although not very tightly dated, glacial advances marked by moraines, have also been recorded in the High Atlas at 22.0 ± 4.9 ka and 12.3 ± 0.9 ka (Hughes et al. 2018) indicating cold but sufficiently damp periods for snow. At lower altitudes periods of global cooling seem to have been associated with increased continental aridity (Moreno et al. 2005). Evidence interpreted as reflecting Heinrich Events (HE1 and HE2) and the Younger Dryas (YD) can be found in marine cores from the Atlantic Iberian margins (Turon et al. 2003; Naughton et al. 2007; Penaud et al. 2010) and the Mediterranean Sea (Cacho et al. 1999; Combourieu Nebout et al. 2002; 2009; Fletcher / Sánchez Goñi / Peyron / Dormoy 2010). A proxy for more arid conditions is also revealed in pollen sequences from the Alboran Sea cores which show a rise in steppic plant species during the last glacial (*Artemisia*, Chenopodiaceae and *Ephedra*) and, conversely, increases in deciduous and evergreen oaks during some of the interstadials when the climate improved (Sánchez Goñi et al. 2002). Other proxies for more arid conditions come from increased windborne dust from the Sahara recorded in the marine cores, input that peaked in intervals attributed to HE1 and the Younger Dryas. As reported in **Chapter 2**, annual rainfall may have fallen to below 100 mm per year during intervals correlated with certain Heinrich Events (Sepulchre et al. 2007).

Much the same pattern is reflected in the few land pollen records that extend back into the Pleistocene from lakes in the Middle and High Atlas. One of the most detailed comes from Lake Ifrah (1610 m amsl) in the Middle Atlas (Cheddadi et al. 2009). It confirms that between about c. 29,000 cal BP and c. 24,000 cal BP the landscape was dominated by steppic vegetation (Gramineae, *Artemisia* and Chenopodiaceae) indicative of average rainfall of below 350 mm / year. According to Rhoujjati et al. (2010, 742), in the interval between about 23,000 cal BP and 20,000 cal BP, pollen values for drought-resistant vegetation remained high, although a spike in cedar presence at around 20,000 cal BP might indicate increased moisture levels at that time. One of the driest periods recorded at Lake Ifrah was between c. 19,500 cal BP and c. 12,000 cal BP with very low levels of organic matter in the lake deposits and the reconstructed climate record revealing that annual average precipitation did not rise above 300 mm / year, about a third of the current value (Cheddadi et al. 2009). Similarities have been noted at Ait Ichou swamp (1560 masl) also in the Middle Atlas mountains, where records show an early predominance of dry herbaceous steppe (*Artemisia* and Chenopodiaceae) from c. 25,000 cal BP (Tabel et al. 2016). In the same core, the period from c. 14,700 to c. 12,700 cal BP revealed a decline in aquatic plants thought to be linked to an increase in winter snow precipitation and greater water runoff in the summer (Tabel et al. 2016), thus, the high mountain version of a Mediterranean regime. At Lake Isli in the High Atlas, an increase in moisture is indicated between c. 24,000 and 22,000 cal BP (Zeroual 1995) but otherwise the picture is very similar, with a dominance of steppic vegetation during the last glacial. Most of these highland interior studies thus seem to show cool and relatively dry conditions until the start of the Holocene, but this may be subject to revision as further high resolution studies become available.

Evidence for phases of greater aridity during the last glacial also come from studies at lower altitudes. For example, cave microvertebrate records reveal the presence of gerbils (*Gerbillus* sp.) and jirds (*Meriones* sp.)

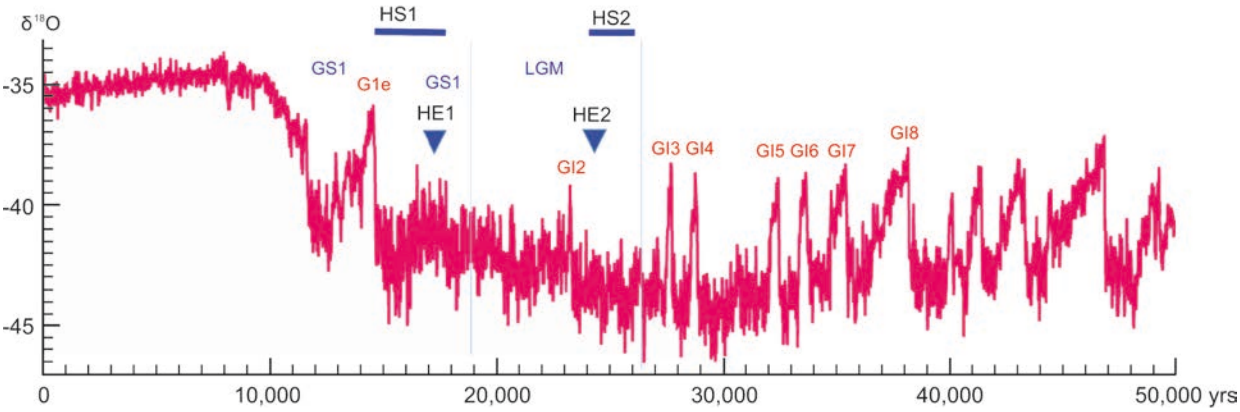


Fig. 18.1 NGrip Greenland Ice Core curve indicating GI (Interstadials) and relevant GS (Stadials). The vertical axis is a proxy for temperature variation as reconstructed from the Ice Core. HS1 and HS2 refer to Heinrich Stadials 1 and 2 (cold events recorded in the oceanic cores but with no precise equivalents in the Ice Core data – after Bazzicalupo et al. 2018). The LGM (Last Glacial Maximum) follows the chronology of Clark et al. (2009).

at Kehf el Hammar in northern Morocco (Barton et al. 2005) which lies at c. 97 m amsl. The layers from which these were found have been dated to c. 16,000 cal BP and imply a semi-arid climate at this time, possibly correlated with HE1.

A return to more humid conditions, at least at lower altitudes, is indicated in NW Africa from around 15,000 cal BP. It is also believed to mark the onset of the African Humid Period which was eventually characterised by the greening of the Sahara (DeMenocal et al. 2000). The humid interstadial is manifest in marine core evidence in both the Atlantic and western Mediterranean. In the western Mediterranean, high-resolution records have been used to relate this sequence to the north European Late Glacial scheme of Oldest Dryas-Bølling-Allerød-Younger Dryas (Rodrigo-Gámiz et al. 2011). They show a fluctuating climate between 14,670 and 12,890 cal BP, and unlike the European record, the 'Allerød' (later phase of GI1) seems to have been at least as warm (if not warmer) than the 'Bølling' phase, and perhaps with a short intervening cooler/drier period (**fig. 18.1**). In other associated marine records this humid phase is marked by an elevated abundance of temperate pollen taxa from Mediterranean forests (Combourieu Nebout et al. 2002; 2009; Sánchez Goñi et al. 2002) and a reduction of some clay mineral associations linked to the mobilisation of aeolian dust (Bout-Roumazeilles et al. 2007). Marine core data off the Atlantic coast of Africa have also confirmed a marked increase in humidity at the beginning of this period, with inferred forest growth based on evidence from the hydrogen isotopic composition of leaf waxes (Shanahan et al. 2015). Evidence for broadly synchronous changes marking the start of the interstadial followed by the YD cooling may be found in speleothems from northern Tunisia (Genty et al. 2006).

Amongst the few climate models that have been developed for NW Africa during the Late Glacial, Moreno et al. (2005) have proposed clear contrasts between Dansgaard-Oeschger dry stadials and humid interstadials. During the latter, such as in GI1, conditions of enhanced humidity would have been facilitated by a weakening of winds from the northwest and a northwards advance from its present position of the African Monsoon system (see also Rodrigo-Gámiz et al. 2011). Recent, more generalised climatic models for North Africa show that, under conditions more humid than today, the Sahara desert belt would have contracted considerably with the monsoon belt shifting to 28° N compared to its current maximum extent of 18° N (Drake et al. 2012; Scerri/Drake/Jennings/Groucutt 2014).

Reconstructing Local Conditions

Proxy evidence for reconstructing the climatic and environmental history of the area around Taforalt is relatively limited, so that we have had to rely partly on developing theoretical approaches in order to supplement the available data. Other limiting factors that present inevitable challenges when evaluating terrestrial records concern the scales (regional and global) of possible correlation. For one thing, there would have been noticeable time lags between quasi-global atmospheric and oceanic changes (no matter how abrupt) and their full effects on the local environment on land, whilst another important consideration is that temperature and humidity will be represented by different types of evidence, at different levels of accuracy. Since it is likely that temperature would have been a less important variable than humidity for humans, animals and plants in the northeast Moroccan context, it should be a priority to make some general observations about the latter variable. Nevertheless, in terms of local sub-aerial deposits, we note the work of Bartz et al. (2017) as an illustration of the difficulties of disentangling periods of aridity (wind transport of sand) from subsequent periods of minor stream reorganisation of aeolian deposits (wetter phases), especially given the likelihood of hindrance to understanding from periods of non-deposition and erosion. We simply have no truly continuous sequences within 'walking distance' of Taforalt, possible but as yet untested small-scale closed basin deposits within the Zegzel catchment being the only prospect for the future. Another important factor is related to local topography (see below) and altitude of the site, which will have had an important influence on meteorology and microclimate. The cave itself is certainly the best local repository of palaeoenvironmental information currently known but the survival of relevant evidence is uneven, some units at Taforalt showing only sparse preservation; even when present, the assemblages may be biased by human behaviour. Thus some of the climatic correlations suggested below, although supported by proxy evidence, must remain of a preliminary nature until further data become available.

Climatic Seasonality

Today, the northeastern corner of Morocco is characterised by a highly seasonal Mediterranean climate of warm, dry summers and cool, wet winters (Knippertz et al. 2003). Further to the west, Knippertz et al. define the Atlantic sector in which winter precipitation is generally controlled by storm tracks arriving off the North Atlantic, linked to the North Atlantic Oscillation (NAO). In contrast, in the Mediterranean sector winter rainfall patterns show low correlation with the NAO and stronger associations with cyclones over the western Mediterranean (Barrott 2015; Gat/Carmi 1970). Unfortunately, terrestrial palaeoseasonality data are currently lacking for the present region but evidence from elsewhere (further east) in the Mediterranean zone in North Africa reveals that, in the later part of GS2 (16,600-14,700 cal BP), more arid conditions even than during the preceding period (including much of the LGM) prevailed with much greater seasonality than expected (Reade/O'Connell/Barker/Stevens 2018). The climatic signal for seasonality has been reconstructed on the basis of oxygen isotope analysis ($\delta^{18}O$) of caprine and bovine tooth enamel and is attributed to a slight reduction in winter rainfall and a strengthening of arid summer air masses (Reade/O'Connell/Barker/Stevens 2018). Regrettably, there is no information covering the immediately following period of GI1, although by c. 12,600 cal BP data suggest that there was a subsequent reduction in aridity in the Younger Dryas and continuing into the Holocene. Thus, far from a relatively stable climate, it appears that there were significant changes in the magnitude of climatic seasonality throughout the late Pleistocene and Holocene in North Africa. In the case of the Haua Fteah, a plausible argument has been made that changes in the seasonal climate in the late glacial may have affected the seasonal supply of floral and faunal resources and impacted on human subsistence patterns (Barker et al. 2010). It remains unknown to what extent northeastern Morocco was also affected by marked climatic variability. In future, evidence concerning annual or even decadal variability in the regional climate might eventually become available, for example from lake varve deposits, speleothems or inshore marine cores. With this information to hand, it may be possible to distinguish between periods of less predictability with environmental stress (increased variability) as opposed to conditions of greater predictability (less variability).

Particulars of the Local Environment

Before turning to specific details of the Taforalt record, it is worth considering in more detail how aspects of the local environment may have exerted important influences on human occupation of the area. Propositions derived from established geographical and ecological theory will add useful background.

To begin with, it should be noted that the nature of the landscape around Taforalt reveals a highly diverse topography (see Chapter 1), ranging from upland plateaux, via rocky slopes or steep talus, to deeply incised valleys; further afield, there is a wide coastal plain to the north and interior plains to the south (cf. figs 1.1 and 12.15). Each of these loci would have provided contrasting sets of environmental conditions and micro-habitats offering a range of resource opportunities. In addition to this, the Taforalt inhabitants would have had access to several major drainage basins, particularly the Moulouya which is North Africa's second-most extensive river system. Apart from providing a communication corridor through the landscape, the Moulouya gravels were also a major source of lithic raw materials for toolmaking. Today, a variety of cherts can be found along quite a length of the valley; survey also shows the pebbles occur in predictable fashion in concentrations and in sizes that would have made them easy to transport back to the cave (Chapter 12).

The site of Taforalt lies at 720 m amsl and the surrounding uplands of the Beni Snassen allow for a diversity of micro-habitats defined by altitude, slope and aspect. Altitudinal zonation may often result in complex patterning. Ecological factors such as evenness or clumpiness may vary with altitude. In lower latitudes with seasonal climate and low annual rainfall (as in the Taforalt area), discontinuities in substrate and habitat factors tend to make low altitude plant communities more patchy (clumpy), whilst variation in topography and aspect tend to cause patchy communities at higher altitude, normally with an intermediate altitude zone having more continuous (even), rich and diverse plant communities (cf. Salman 2016). Such zonation will inevitably shift altitudinally in response to background climate changes. In addition to the influence of topography, it is useful to note the difference today between adjacent areas to the north of the uplands and those to the south, which are more arid and in places exhibit temperature extremes similar to desert environments. As such, this would have had a major effect on the distribution of the local flora and fauna, assuming a seasonal 'Mediterranean' climate throughout much of the period of interest.

This leads on to an interesting point concerning how some upland areas in Morocco served as species refugia in the Quaternary. The concept of a 'refugium' (an area in which it is likely that one or more species have survived for at least a whole glacial-interglacial cycle, a 'phylogeographical hotspot') is certainly worth considering here. As a general proposition, mountainous areas always have higher biodiversity, especially in plants, than do plains. Even though the Beni Snassen highlands have not been singled out in recent publications in respect of plant species and communities (although this area might qualify for some reptile and amphibian species), other mountainous areas in Morocco (a country with high endemism and the second highest plant species diversity in the Mediterranean basin) have been and they can serve as useful models here:

> On a smaller scale, climatic and topographic heterogeneities induced by mountainous or insular conditions have played a crucial role […]. Of the [total of 52] refugia identified [in the Mediterranean basin], 33

> are situated in Mountain ranges, notably the High and Middle Atlas, the Rif Mountains in north Morocco, […]. Mountain ranges and nunataks have played a determining role in the survival of small and isolated populations of herbs and shrubs, even mesothermic ones, during glacial periods. […]
> The local 'biogeographical stasis' of a plant species or of some populations is therefore linked to the capacity of the mountain range to provide a wide diversity of micro-habitats, notably: (1) between sheltered and relatively humid gullies, and exposed and relatively dry ridges, (2) from south- to north-facing slopes or vice versa, or (3) between different altitudinal locations. These refugia appear to have been different microhabitats occupied by species at different periods, a refugium within a mountain range being in fact dynamic. (Médail/Diadema 2009, 1339)

Other aspects relevant to discussions about the local environment at Taforalt concern the geographic distribution of available resources. In less topographically variable landscapes, one would expect these to be quite widely separated depending on the horizontal extent of habitat but, in the uplands, different habitats can be seen as more closely 'squeezed' together according to vertical location. Thus, for hunter-gatherers, rather than travelling long distances 'on the flat', one might just have to rise or drop, say, a hundred metres in altitude to find a different habitat with other resources. Another potential advantage of the uplands is that the ripening of plant foods must have varied according to altitude and topography and this would theoretically have had the effect of extending the growing season and lengthening the period over which seasonal foods could be harvested. Further advantages would be gained from the mosaic of closely spaced habitats with many resources located in small but concentrated patches. To this can be added the proposition that food resources would have been strongly predictable in such environments, assuming a detailed local knowledge of range and patchiness, which would have enabled a degree of resilience even to moderate environmental shifts. This can be contrasted with the lower predictability of certain resources (notably mobile game) on the more open plains.

Despite the clear compensations of living in upland landscapes, inevitably there were also some disadvantages. These would have included the uneven nature of the terrain, which would have made some routes tiring and hazardous. In such cases, accidents would be expected to happen, with trauma to elements of the lower limb perhaps being the most likely to be related to movement over rough terrain. Just three examples of healed trauma to any element of the lower limb were noted in the pathology report for the individuals excavated in the 1950s: a traumatic depression of the tibial plateau, and healed diaphyseal fractures of a fibula and metatarsal (J. Dastugue in: Ferembach 1962, 142). This seems a rather low incidence, even for obviously healed breaks alone, and the collections might therefore reward further study on this issue.

Environmental Evidence from Taforalt Itself as Proxies for Climatic Changes through Time

A series of episodes, either cool (usually but not always dry) or warmer and more humid, can be identified in the Taforalt sequence based on environmental proxies. A strong caveat must be indicated here, in that the majority of evidence types will have been affected by human behaviour, increasingly blurring any climatic signal upwards through the sequence.

For the early period, just preceding the Iberomaurusian, a cool phase can be recognised during the interval S8-Y4spit3 and, more obviously, during equivalent deposits in Sector 9 (S9(E)-CTX11 and beneath). This is indicated by raised levels of aeolian silt ('dust') which would have become mobilised in windier, drier conditions (at least in the continental interior, if not at Taforalt itself). Although there are no precise dates for this phase, a ^{14}C date of 21,436-20,882 cal BP in S8 and another of 22,166-22,569 cal BP for CTX10 in S9 (from deposits already containing LSA artefacts) both just post-date the silt input, suggesting that it lay within the time range of Heinrich Event 2 or the LGM; a *terminus post-quem* for the silt phase in S9 of 26.1 ± 2.0

(OSL-TAF09-22: Barton et al. 2016) is broadly in agreement. There are few signs of human activity in the cave during this period. Both above and below S8-Y4spit3, reptile evidence (**Chapter 11.2**) appears to indicate an abundance of forms typical of well-vegetated landscapes, with conditions warm enough to sustain Chameleon, Moroccan Glass Lizard and various frogs. There is a slight drop in species abundance in the intervening spit3, perhaps suggesting a local reduction in diversity during this cooling rather than a major overturn in fauna. S8-Y4spit2 also shows a YS peak in evergreen oak (**Chapter 5**).

When silt deposition had diminished, it was replaced with slightly coarser material (with a mode in the fine sands), typically, in the S8-Y4spit2 to S8-Y2spit2 interval, showing the laminated structure resulting from sheet wash. Whilst such structure does suggest a weakening of aridity, it is not a very precise climatic indicator. No additional evidence of major environmental change is indicated until S8-Y2spit1 when a further period of deposition of plausibly windblown silt is recorded. The implied renewed phase of cool, dusty, dry climate is fairly well-dated to around 17.4-16.7 ky cal BP and may correlate with HE1. Overall, there are few other signs of disruption to the environment during this period although conditions clearly became damper again, if probably remaining at least cool, as evidenced by deformation structures in the sediments and the eventual erosional unconformity at the top of this unit (**Chapter 2**). Within S8-Y1, wash lamination returns. It is also interesting to note the presence of a small number of freshwater molluscan taxa, including *Galba truncatula* and, near the top of the Series, ostracods (**Chapter 8**). In both cases these probably indicate localised damp patches/surfaces within the cave rather than particularly marked increases in humidity or other significant climatic changes. Indeed, the top of the YS sediments is characterised by a rise in juniper/thuja charcoals which indicate (human access to) locally arid environments with sclerophyllous scrubland. Other indicators of open environmental conditions come from large alcelaphines (including the kongoni or hartebeest [*Alcelaphus buselaphus*]), large bovines and rhinoceros, present in some of the upper YS units in S8 (**Chapter 9**). These animals indicate (human access to) regionally open grassy plains or grassland steppe in association with some parkland, bushland, *maquis* scrub mosaics and thickets (Kingdon 1997) and may relate to the plains areas further inland, as mentioned above.

With respect to wood charcoal evidence (**Chapter 5**), cold/dry periods are not apparent, probably largely because these intervals are very poor in identifiable charcoal. The dominance of juniper/thuja, low representation of pine and presence (diminishing upwards) of evergreen oak in the YS in general would seem to indicate relatively dry conditions. The tendency towards aridity is also seen in other charred plant remains, dominantly annuals and small shrubs (**Chapter 6**).

In the phytolith evidence (**Chapter 7**), the YS (LPAZ-TAF-1) is dominated by grasses of shifting proportions of C_3 types, indicating open environments. However, there is a small rise in C_4 types towards the end of, or just after, the likely HE2 correlate (S9(W)-U2), and a clearer peak close to the likely HE1 correlate (S8-Y2spit1), in each case suggesting even greater aridity. A wider range of phytoliths (including woody types – noting that these are often underrepresented due to low biogenic silica levels in these taxa) is present in S8-Y1, either suggesting 'improving' conditions (greater humidity and possibly even some warming) or, perhaps also, the already increasing effects of human plant selection. It should be noted that, in LPAZ-TAF-1, the proportion of long cells to short cells suggest some diagenesis in this part of the sequence.

Jeffrey (2016) studied three samples of jird (*Meriones* sp) teeth from different levels within the LSA interval in the Yellow Series, analysing their oxygen and carbon isotope compositions. She concluded that northern Morocco did not experience hyper-arid conditions during the Late Pleistocene, the Taforalt samples suggesting slightly higher precipitation than at present on the basis of $\delta^{18}O$ levels. However, one may note that none of her samples actually came from any of the silt-rich units in the YS. In contrast, from the same sample set, Jeffrey did deduce from her $\delta^{13}C$ results a small contribution from C_4 vegetation and probable reduced evapotranspiration, which she interpreted as indicating slightly lower temperatures than at present.

The strong transformation in sediments at the beginning of the Grey Series can be primarily attributed to an increase in anthropogenic activity, rather than to a shift in climate. Nevertheless the approximate dating of this sedimentary change (remembering that it is demonstrably slightly time-transgressive) at around 15,000 cal BP coincides broadly with the beginning of Greenland Interstadial 1e (GI1e) and a global rise in temperatures and humidity. That there might have been a slight time lag in these changes is suggested by the presence of Barbary ground squirrel (*Atlantoxerus getulus*) near the base of the GS, perhaps implying a persistence of cool, dry conditions. One may also note the presence of the Moorish gecko, which would indicate some dryness (**Chapter 11.2**). Amongst the phytoliths (**Chapter 7**), there is an increased xeric C_4 component indicating cool, arid conditions, in the lowest GS sample (S8-MMC106), a component which involves phytolith types which are different from those immediately below and above and which should therefore represent at reliable environmental signal. At the same time juniper/thuja charcoal at the base of the GS, representing up to 90 % of the charcoal counts, is combined with only a sporadic presence of true woodland species of pine, evergreen oak and maple. This suggests (human access to) a very open heliophilous forest, indicative of drier environments found in areas of the Mediterranean today. This information is tantalising, potentially indicating a period of raised aridity, itself possibly equivalent to the "Oldest Dryas" or "Pre-Bølling" in Europe. However, the context of these finds, in the basal interval of the Grey Series, where sedimentation was still quite slow and human activity was demonstrably mixing disparate material, must cause us to restrict our interpretation here to what we will call a 'poorly defined possibility', especially given the significance of the behavioural implications which might attach (see below).

Although various proxies for changes may be observed in the representation of wood charcoal species through the GS sequence, it is unclear how much of this was due to preferential selection of fuel wood and how much to a dominance of particular species in the environment. Certainly, the re-appearance of cedar in S8-G93, followed by strengthening in cedar and deciduous oak by S8-G89 suggests that there might have been increasingly (or intermittently) cool and moist conditions in the upper part of the GS (**Chapter 5**). The episode in S8-G89 to G88 (approximately equivalent to the interval above S8-MMC12) may be associated with the onset of the Younger Dryas. One may also note the return of the Moorish gecko towards the top of the GS, which would suggest habitat with increased aridity, possibly present at a different altitude at this time or during a short period in an overall fluctuating climate phase (**Chapter 11.2**). In passing, we may mention that Merzoug (2017) suggests a Younger Dryas phase (which should largely postdate the surviving Taforalt sequence) that, at the High Plateau site of Columnata (Tunisia), shows slightly different animal food procurement, with a marked increase in small game (gazelles, lagomorphs) and the freshwater mussel *Unio* sp.; whilst Merzoug acknowledges the particular geomorphological context, she believes that there is also a climatic signal here. Generally speaking, the environmental proxies for most of the Grey Series imply that conditions were comparable to those of today, with a mixture of juniper/thuja and pine typical of Meso- and Thermo-Mediterranean vegetation, indicative of relatively low moisture requirements. This having been said, the most marked shift in the wood charcoal representation occurs between S8-G96-5 and S8-96(2) (approximately equivalent to the S8-MMC80 to MMC50 transition), where an assemblage dominated by juniper/thuja gives way to one dominated by lowland pine, a change which is plausibly a marker of slightly increased humidity. In other charred plant remains (**Chapter 6**), the general increase in diversity, upwards through the GS, may have a climatic implication, although selection by humans is again likely to be the dominant factor. In respect of mollusca (**Chapter 8.1**), there is again a marked shift in species representation at the S8-MMC80 to S8-MMC50 (MAZ-2 to MAZ-3) transition which probably had an environmental causal component, although not one that is yet clear. On the basis of stable carbon and nitrogen isotope ratios from bone (**Chapter 17**), game animals from the GS (undifferentiated) do not usually show evidence of the degree of aridity typical of modern Mediterranean (summer) conditions, although this is a rather small sample, in the present context not controlled for specific stratigraphic level. In the phytolith evidence (**Chapter 7**), it is again necessary to note the likelihood of strong effects from human selection of plants. The lower half of the GS (up to S8-MMC80) shows the most temperate interval in the sequence, with the lowest water stress (LPAZ-TAF-2). The rise in dendritics in the lower half is likely to represent anthropogenic accumulation of grass inflorescences. In LPAZ-TAF-3, the phytolith signal becomes more 'noisy', with erratic spikes in C_4 types but also increases in woody types, suggesting variable but not necessarily cool conditions. Towards the top of the GS (from S8-MMC-9 upwards, LPAZ-TAF-4, approximately equivalent to S8-G88) there are signs of increased aridity, although not as severe as indicated by the C_4 peaks in the YS phytoliths.

To recapitulate, the raised silt contents in S8-Y4spit3 and S8-Y2 (and their respective correlates in S9) may be related to HE2 and HE1 respectively. The expected rise in temperature and/or water-availability at c. 15,000 cal BP may have been affected by a time lag as suggested by an apparent continuation (or even a stiffening) of relatively dry conditions at the base of the Grey Series but this remains only a 'poorly defined possibility'. Thereafter a progressive rise in humidity and temperatures in the GS appears to be followed by a return to cooler conditions at the top of the profile, which is tentatively linked to the Younger Dryas. One may also note that, on the basis of wood charcoal comparisons (**Chapter 5**), stronger climatic fluctuations at the end of the Pleistocene would have been more evident at Taforalt than on the coastal plain.

Environmental Evidence from Taforalt Itself as Proxies for Environmental Buffering through Time

Given the date range, the variation in each environmental dataset reported in this volume seems somewhat 'dampened', an effect that might imply a contribution from humans making use of altitudinal range. There is a marked degree of 'conservatism' in most of the biological evidence used here as environmental proxies, both in the sense of persistence of certain taxa within large parts of the sequence and of presence of taxa in the sequence which are still recorded in the vicinity today. This 'conservatism' itself might suggest that the physical setting (in particular, the topographic diversity) provides an environmental buffer, especially with respect to the range of habitats continuing to be available for human exploitation. The only alternative to this conclusion would be to suggest that absolute climatic variation was somehow dampened in the Beni Snassen; there is no obvious mechanism by which this could come about and, in any case, this idea would not fit well with the more continuous regional records, such as pollen from the higher Atlas lakes.

It is also necessary to note that the woody vegetation is well adapted to aridity. For instance, juniper, pine and oak can stand several very dry-cold years and still produce fruits, especially if they are old trees with deep roots. They will minimise water loss by reducing the mass of branches, also reducing flower and fruit production, or even stopping flowering altogether. Even during the drier periods, there would have been most of the normal tree taxa around but growing more like shrubs and so, at least at some altitudes, producing less resources. In contrast, during wet years or episodes, more branches would be produced and treetops would engage with others to form a canopy, resulting in a forest, as today in favoured areas around Taforalt. Thus, woody, mostly slow-growing plants would have persisted, only producing good yields at environmentally suitable altitudes, whilst small, fast-turnover plants would have 'moved' by preferential propagation into suitable patches. Mobile animals, and humans, would follow the resources. Such a picture seems a reasonable fit with the apparently dampened variation seen in most of the environmental proxies at Taforalt.

18.4 NATURE OF OCCUPATION AND DISTRIBUTION OF ACTIVITIES

Continuity vs Discontinuity at Taforalt

One of the questions originally posed at the beginning of this volume was whether there was really sustained, continuous occupation at Taforalt. The answer depends partly on the chosen scale of analysis. As we have seen, at a very coarse scale it is possible to show that the Iberomaurusian habitation of the cave began at around 23,000 cal BP and lasted until at least 12,600 cal BP (the top of the GS sequence being truncated). At this scale, the issue is complicated by the facts that, in the YS, some units like S8-Y3 are strongly anthropogenic, while others such as S8-Y2 and Y1 show a lower intensity of activity. Nevertheless, despite this variability, nowhere does there seem to be a substantial gap in occupation marked by the total absence of charcoal, lithic artefacts or bone debris. Moreover, the appearance of slightly denser, as opposed to more sparse, archaeological evidence is also reflective of other factors, such as changes in sedimentation rates (see below). Equally, it must be remembered that we have only had access to the upper YS towards the 'sides' of the main cave chamber. There could have been many more localised 'activity' areas, that would fit stratigraphically within what look like more homogeneous 'low-presence' intervals in S8; in this respect, it is worth noting that there is a strongly anthropogenic lens in Sector 9 (S9(E)-CTX10) that is most unlikely to be physically continuous or strictly contemporary with S8-Y3, on the other side of the cave.

Of the four techno-typological artefact Phases recognised in S8 at Taforalt (**Chapter 12**), the lowest (earliest) occurs in Y4spits2-1, Y3 and Y2spits5-2 (and their correlates in Sectors 3 and 9). Despite some minor variation within these units, there is no evidence to suggest major cultural shifts or breaks in occupation. The contrast with the overlying Transitional or Mixed Phase (Y2spit1) is rather fuzzy and in our opinion could be ascribed to a mixing of artefacts from below and above. The top of this phase is at the Y1/Y2 boundary where there is a slight change in lithic techno-typology and a clear stratigraphic hiatus (erosional unconformity). However, as we can demonstrate an archaeological presence both immediately above and below this unit, as well as within it, we can reasonably propose an overall continuity of habitation, even though we cannot prove the nature of the lithic assemblage (transitional or a mixed combination of Phases, or including both effects). This does not rule out the possibility that the cave was abandoned for short periods during the YS units (probably seasonally and, at the other extreme, over longer timescales of up to a century or two). The culturally defined Middle Phase is found from S8-Y1 and continues upwards into the overlying GS sediments S8-G100 to G97 (and correlates). The heavier use of microliths is linked with a period of continued cave occupation that spanned the main sedimentological transition from the Yellow to Grey Series. Above this, beginning in S8-G96 and persisting into the uppermost surviving Unit S8-G88 (and correlates), there is a huge proliferation in microlithic forms of different shapes. In sum, although significant variations in techno-typology are signalled throughout the sequence, there does not seem to have been an obvious lengthy break in occupation between the Lower, Middle and Upper Phases or, indeed, within any of these Phases. Nevertheless, it seems likely in our opinion that occupation was more intermittent during the YS than in the GS, even though there appears to be no evidence that the cave was abandoned for any great length of time.

The question of continuity can also be examined from the point of view of sedimentation rate and potential gaps in deposition. In **Chapter 2** we referred to the stratigraphic record which indicates a relatively unbroken sedimentary sequence. This does, however, allow for small stratigraphic gaps notably in the uneven nature of the YS/GS boundary and the missing top of the YS deposits. In Barton et al. 2013, it was noted that there was a clear erosive boundary between Units Y2 and Y1 but uncertainty surrounds the length of gap represented. At the same time, it can be shown that sedimentation rates across the whole sequence varied considerably: for example in the YS it fluctuated between episodes of relatively rapid and more gradual deposition, followed by extremely fast accumulation in most of the lower GS and then a slowing down near its top. On average, GS sedimentation was over ten times more rapid than in the YS, affecting the relative density of finds in different units. Nonetheless, even when such variables are taken into account, there does not appear to be any definite evidence for lengthy sterile intervals when people were totally absent from the cave. With respect to the dominantly anthropogenic Grey Series, had the cave been vacated for as little as 25-30 years, one would expect lenses of yellower 'earthy' material some 5 mm thick to have developed; in fact, not only are there no such lenses in the current exposures, there are not even any significantly more 'earthy' intervals which might have resulted from human or in-faunal disturbance of natural lenses. The very most one sees (even during fine excavation with a small air-jet) is occasional intervals of very localised wash reorganisation of fine human debris (ash, charcoal, etc.).

One may consider what might have been the effects of environmental and climatic changes on human continuity of occupation of the cave. It is instructive here to note that signs of human presence (either in the form of artefacts or charcoal) are found in all of the LSA Iberomaurusian units. This holds true even for those units where sedimentation rates slowed most dramatically (which generally include fewer finds) and at other times where environmental changes/deterioration are suspected. For example, during particularly notable phases of aridity, such as the time interval of HE1, or in drier cooler periods at the beginning of the Younger Dryas time interval, definite signs of human presence have been documented. The only interval when LSA humans may have been absent or when a significant reduction in activity may have taken place is during the earliest parts of the LGM (i.e. before the first presence of the Iberomaurusian at Taforalt). We have been considering only continuity here; the issue of potential environmental and climatic effects upon the nature of human occupation is an entirely different matter, which will be addressed below.

One cannot complete this section without acknowledging a major puzzle, which is obviously present but which has so far been avoided in discussion (the colloquial 'elephant in the room') – the onset of the Grey Series in its own right. For example, it is possible to see that the latter resulted from a huge increase in human activity, perhaps due to a number of smaller bands aggregating, since it is hard to envisage a sufficiently abrupt increase in population growth within a single group. It is yet more difficult to explain how a total transformation in behaviour, employing new knowledge and skills, could have occurred at this time and against a background of continuity in the lithic artefact assemblage (Middle Phase) across the YS/GS boundary. What then, were the other things that must have occurred at this time, to invoke such radical responses in human behaviour? Were they entirely localised or were they symptomatic of far-reaching changes that occurred at other sites in the Maghreb? These and other questions will receive further attention in subsequent sections of this chapter.

So far, the majority of the discussion has focused on the Sector 8, which represents the most complete sequence of Iberomaurusian deposits in the cave. However, we cannot leave the question of continuity without again mentioning the finds from the Roche excavations which covered very extensive areas of the site, from the entrance to the back of the cave (near GS-S10). In terms of the spatial and stratigraphic distribution of finds, we can note, for instance, that there were around four to five times more retouched tools and flakes recovered at the front of the cave than at the back, a trend that is repeated in all levels of his excavations. Nevertheless, in terms of continuity, Roche seems not to have identified any breaks or marked diminution in human activity during the Iberomaurusian in the GS.

Intra-site Assemblage Variability and Tool Function

Here we consider intra-site variation of the artefact assemblages following typological and technological criteria and, where relevant, stratigraphic provenance. We also provide some observations on the possible function of tools.

As we have remarked, the lithic assemblages can be sub-divided on techno-typological and stratigraphic criteria into three or possibly four Phases. According to the lithic analyses, the key features in the Lower Phase (S8-Y4spit2 to Y2spit2) include the occurrence of obtuse-ended backed bladelets and bladelets with 'Ouchtata' retouch (fine marginal retouch), as well as a low but perceptible presence of the microburin technique. The Transitional or Mixed (S8-Y2spit1) and the Middle Phases (S8-Y1 to G97, this top limit being equivalent to the top of L28 and of MMC96) are characterised by an increase in certain microliths, such as convex-backed bladelets, and one of the most distinctive features is the presence of *La Mouillah* points (type 62), which account for a third of all microliths in the Middle Phase. The microburin technique is clearly in evidence. We have already noted the fact that no major changes occur in lithic techno-typology across the GS-YS boundary. Finally, the Upper Phase (S8-G96 to G88) reveals, in addition to a continuation in the manufacture of convex-backed bladelets, greater quantities of pointed straight-backed bladelets and the presence of small segments as well as other microlithic types. There is a reduction in the number of microburins and a notable absence of *La Mouillah* points.

Further insights into variation come from the analysis of the technology and *chaîne opératoire*. A notable feature of the Lower Phase is the prevalence of single platform blade/let cores with the majority of blanks being relatively narrow and having unidirectional scars on their dorsal surfaces. Butts are characterised by punctiform/linear types. In the Middle Phase, single platform blade/let cores are again common but this time with more examples of opposed platform cores and, for the first time, a few cores-on-flakes. The blade/lets in this Phase are on average significantly wider and thicker than before. In addition to blade/lets with punctiform/linear butts, there are twice as many examples of plain butts compared to the underlying units. Most blanks have unidirectional dorsal scars, with a small, yet perceptible increase in the proportion with bidirectional opposed dorsal scars. In the Upper Phase, a general decrease in the number of cores can be observed but always with single platform blade/let cores forming the majority. Cores-on-flakes reach their highest number in this Phase. The blade/lets characteristically have unidirectional dorsal scars and mainly punctiform butts. As in the Middle Phase, the blade/lets tend to be wider and thicker than those in the Lower Phase. As well as the changes mentioned above, retouch lateralisation varies on the microliths with a tendency for the tools in the Upper and Middle Phases to be retouched along their left margin (62 % and 80 %, respectively). In contrast, microliths in the Lower Phase are mostly retouched along their right edge (63 %). Similar figures are also reflected in the retouch lateralisation on microburins.

Considering the variables of the techno-typology as a whole, we note that some of the changes are likely to be related to the intensity of raw material use. One such example is the observed increase in the occurrence of cores-on-flakes in the Upper Phase. We have suggested that this might be due to re-cycling activities with large flakes being used for extracting blanks for making the smaller microliths. Other noticeable trends are described in **Chapter 12**. They include a general change in the overall length and width of microlithic forms through time as referred to above. Such differences may have been linked to function, with different combinations of microliths being used as multiple or single components in composite handles or shafts. Changes in the hafting methods may have called for an increased dependence on multiple microlith insets which could explain the greater number of small segments and other tiny microliths towards the top of the sequence. The only presently known example of a haft from North Africa comes from Columnata in Algeria (probably in a later context than Taforalt) and suggests that slotted bone handles were regularly used with small lithic insets arranged in a row (Cadenat 1960). Clearly, use-wear analyses of the Taforalt microlithic tools would be a worthwhile future project. Despite a cursory examination, none of the microliths showed evidence of any mastic or remains of hafting materials. Given the prevalence of charred plant materials in the Iberomaurusian Grey Series, there are no records of flakes or blades with macroscopic gloss, although, despite the abundance of grass phytoliths, charred grass seeds (the harvesting of which is the most common cause of archaeologically reported 'sickle gloss') are not common at Taforalt.

Despite the raw material being dominated by fine grained cherts throughout there is nevertheless some small degree of variation between the different identified Phases (**Chapter 12**). To begin with, the YS (Lower Phase) displays the narrowest range of lithic materials favouring brown and reddish-brown cherts over other cherts with relatively small quantities of local limestone and a few examples of basalt flakes. The lower part of the Middle Phase (top of the Yellow Series) sees a significant broadening of the range of cherts which continues up into the Grey Series, with moderate quantities of limestone and no basalt. Features of the GS Upper Phase remain broadly comparable but one of the distinctive features is the greater use of locally obtained limestone, presumably selected for reasons of expediency. The implication of these observations will be further discussed below.

Excluded thus far has been any mention of the lithic artefact assemblage from Sector 10 near the back of the cave. Broadly speaking, the variation in microlithic and other tool forms, matches most closely the finds from the GS Upper Phase of S8. However, this is complicated by recognition that the deposits in this area of the cave may also have been deliberately emplaced by humans (see below), resulting in an admixture of both earlier and contemporary GS sediments (containing artefacts). Although the stratigraphy is difficult to interpret here, Roche's earlier work suggests that the brown sediments underlying the GS seem to have included large quantities of microburins and *piquants trièdres* (possibly *La Mouillah* points). These are also typically numerous in the Middle Phase (YS-GS) of S8 and may suggest an overlapping chronology with the brown sediments in both the early excavations towards the back of the cave and in our work in Sector 10.

Bone tools are another important category of artefacts found at the site, with well over 600 reported from the GS. The majority of these came from the Roche excavations, throughout the cave, whilst most of our examples are from the short interval represented in Sector 10, and therefore stratigraphically inseparable. Although the majority of tools are pointed they reveal morphological variability with some displaying characteristic asymmetrical profiles and some being much bigger and thicker than the rest. Work on the functional aspects of the assemblage is currently in progress but initial information (**Chapter 13.1**) suggests that, far from having a uniform function (e. g. as projectiles), they probably served a multiplicity of purposes. Many of them are fragmented with only the tips, bases or midshafts preserved. Apart from indicating that they were probably damaged in use, it is apparent from the different stages of manufacture that they were also undoubtedly made at the site. The shape of the tips can provide information about their likely usage, with the majority of pointed examples having tip diameters of <2 mm. When combined with data on the midshafts, which usually show asymmetric profiles, it seems likely that they were primarily used in delicate tasks, such as piercing or incising leather. It is also possible to draw parallels with ethnographic tools used in basket-making (see below). Thus, on present evidence, it appears that tools were manufactured at the cave and were mainly, if not exclusively, used for domestic tasks. Although further detailed study is still required there does not seem to be much variation in bone tool form according to the spatial distribution of finds in the GS.

Other expressions of intra-assemblage variability come from heavy grindstones, described in **Chapter 14.2**. Although all of the recorded examples in our excavations came from S10, it is clear from the Roche excavations that these artefacts were actually distributed more widely, vertically as well as horizontally, from the burial areas at the back right through to the front of the cave. In terms of vertical distribution, the majority (55 %) originated from his upper division of the GS. A further interesting observation from his data is that there was a distinction made between grindstones (and related objects like pestles) carrying traces of red ochre pigment and those without. According to Roche (1963), those displaying traces of red pigment tended to occur closer to the back of the cave, whilst those without colorant but with evidence of utilisation were found towards the entrance. Thus, we can tentatively infer that the grindstones exhibiting traces of red ochre, including ones from our excavations, were clearly employed, or ended up being used, for producing powdered colorant. For those lacking traces of pigment we can postulate that they were used for other tasks, possibly related to pulverising acorns and other nuts or for processing soft plant materials. Clearly further use-wear studies on these objects (from the Roche collections) will be necessary in order to test these speculative suggestions.

Another example of variation, plausibly subsistence-related, comes from the very large accumulations of burnt rock fragments observed in the GS. Given that the enormous rock volume could not be explained as originating from a single source such as roof fall, surveys and experiments were undertaken (Chapter 2) which demonstrated that this accumulation was the result of deliberate activity. It appears that the stones were intentionally imported for their pyrolithic properties (of heat retention and radiation, as well as resistance to fragmentation). Of the three principal burnt rock types found at Taforalt, experiments showed that each responded very differently to heating and rapid cooling (simulated in their use as 'boiling stones'). The most efficient was a fine-grained limestone which, although only moderately good for heating water, was not prone to breaking up or contaminating the water. The least efficient was speleothem which tended to shatter after single use and left the water extremely gritty and polluted. A further interesting observation was that the ratio of speleothem to limestone changed markedly through time suggesting conscious refinements by humans in selecting the best rocks for this purpose (see further discussion below). Although we cannot know the exact motives for heating the stones (whether for warmth, or cooking, or some other purpose), we can reasonably surmise that the Taforalt people were well aware of the properties of different rocks for heat transfer and the superior pyrolithic qualities of limestone which made it suitable for repeated cycles of heating.

Finally, there is circumstantial evidence for another change in technology that appeared within the Grey Series. This concerns the use of woven grass fibres, presumably connected with basketry, and comes from a combination of preserved material including charred remains, phytoliths and bespoke bone tools. Even today, in this area of Morocco, traditional baskets are made out of esparto grass (*Stipa tenacissima*), variously transliterated as '(h)alfa(h)' from Arabic and 'awri / ari / iwri' from Amazighe, and huge increases in grasses are recorded in the Grey Series, including charred roots which are common waste products of manufacturing baskets. In addition, we have also recovered fragments of rolled fired clay that we speculate may have been used for lining baskets (e. g. practical for boiling technology, storing water, and for stockpiling foods). If basketry was embellished in this way, then it is possible that only the clay fabric would have survived decay or destructive burning. This might also fit the alternative scenario in which basketry containers were used for boiling and cooking activities, inferred from the presence of many heated stones. The carrying of water to the site, so far unmentioned, is unlikely to have been facilitated by the use of heavy baskets but ethnographic data recorded recently in the Beni Snassen (Ismail Ziani, pers. comm.) indicate that light esparto containers can be made waterproof using a special technique to flatten the leaves. It is possible that water was brought to the site in ostrich eggshell containers. Hundreds of burnt and unburnt ostrich eggshell fragments in the Iberomaurusian units testify to their regular use (assuming that we are not being misled by the survival of only a few shells in the form of many fragments, the exact spatial distribution and likely recovery patterns not being apparent in Roche's publications); so far there is little if any evidence for manufacture of

eggshell beads. Other options would also have been available, of course, including animal hides, whether or not tanned.
With respect to the Roche excavations, we have already noted that there were around four to five times more retouched tools and flakes recovered at the front of the cave than at the back. In the lower front part of his excavation (*Niveau C*) Roche also noted a huge deficit in cores (seen in the ratio of all stone retouched tools to cores and in the ratio of unretouched flakes to cores), as compared to all other areas and levels. Unfortunately, most of these figures are based on best estimates and there is very little linking documentation to verify these claims but it does allow a tantalising glimpse of the cave as a massive repository of archaeological and behavioural evidence.

Human Burials

Age of Taforalt Burials

Excavations in Sector 10 have revealed a rich concentration of burials (**Chapter 15**), in addition to those recovered in the 1950s and reported by Ferembach (1963). Assuming that burials were progressively added, starting in the back recesses and then building outwards and upwards, it is likely that those discovered first were slightly younger than those examined by our team in Sector 10. Unfortunately, there are no secure dates from the 1950s excavations to test this proposition. In contrast, direct AMS dates have been obtained on six of the individuals in Sector 10 (**Chapter 4**). All samples had good collagen preservation. Age estimations range from 15,086 cal BP to 13,993 cal BP (at 95.4 % confidence). The small standard error of the Taforalt individuals (except perhaps Individual 7) implies they could have died within as little as 200 years of one another.
So far all of the burials seem to be confined to the GS deposits. Although none have yet been located in the YS deposits, it is possible that further examples await discovery in the deeper recesses of the cave beyond our present excavations. The stratigraphic position of the burials suggests that the interments took place after the start of the GS accumulation, although how long afterwards is still a matter of conjecture. Certainly from the point of view of the actual radiocarbon measurements it appears likely that the burials belong to the equivalent of the later Middle Phase of the archaeological sequence in Sector 8 but it is also plausible that there is some overlap with the earliest part of the Upper Phase. The start of the Upper Phase coincides with the stony S8-G96 that begins at some point before 14,156-14,855 cal BP. Even without these caveats it is nevertheless clear that the pooled mean ages of the burials would qualify Taforalt as the earliest well-dated assemblage of this nature (see below) in Africa.

Nature of the Human Burial Evidence

There are several reasons for arguing that Taforalt qualifies as a cemetery. The first is that the burials have been set aside in an area near the back of the cave, where the natural light levels are reduced, with a relatively low roof giving only limited access, and making it unsuitable for habitation. It was also physically partly separated from the rest of the cave by the occurrence of some very large naturally fallen boulders. Moreover, it is important to note that the funerary area is a discrete zone, not only because of the human burials (which are mostly set in relatively tight clusters, separated by gaps) but also because the sedimentary matrix has a completely different structure (e.g. common high-angle tip lines) from the compositionally similar, but much less homogenised, sediments in the rest of the cave. There is reason to suspect that the GS sediments in this part of the cave may have been introduced artificially rather than accumulating through 'natural' depositional site formation. If this were the case, it implies some considerable and ongoing organisational effort, which may also have involved initial preparation of the underlying surface (see Chapter 2). It is noteworthy that Ruhlmann's north trench passed very close to the later-defined "*Nécropole I*" without finding an *in situ* burial, whilst, only four years later, Blondeau spotted skeletons eroding out of the top of the old section. It seems unlikely that these facts were either the result of poor observation by Ruhlmann or of serendipity. The geometry of the cave here, with its locally low sloping roof (down northwards), would have provided a broad 'guide' to activities, in both the distant and recent past, simply by way of easily available headroom. Future analysis of the unpublished archives will be necessary to show whether or not the cemetery edge migrated 'outwards' (broadly southwards) as the deposits accreted below that sloping roof, as would be expected if 'headroom' was indeed a guiding factor. In any case, it seems reasonable to suggest that, at most times, it is likely that there was a well-defined perimeter to the cemetery (even where there were no pre-existing limestone blocks), although, due to the old excavations, we cannot now know whether there was a visible demarcation of any sort on the ground at any level.

The second reason is more related to the actual treatment of the dead, which suggests that, in this part of North Africa, a complex set of funerary traditions had already developed probably soon after 15,000 cal BP. The nature of the burial evidence is discussed in detail in Chapter 15. Earlier studies by Ferembach and others have provided information on the methods of interment at Taforalt: some of the bodies were buried in pits and many of them lay in a supine or semi-reclined position with their heads facing the cave entrance, rather fancifully interpreted as 'in the direction of sunrise' (Roche 1953). Subsequent information has been added on the special treatment of some of the cadavers (Mariotti et al. 2009). Osteological analyses have revealed the occasional presence of cut marks on bones, implying the deliberate removal of soft tissues and possible dismemberment of at least a number of the corpses. Thirteen of 28 burials described by Mariotti et al. also showed signs of intentional ochre staining of the bones and crania that is interpreted as having been carried out *post-mortem* and, with the evidence of grindstones, implies copious use of red ochre in preparing the individuals for burial. Another feature common to the great majority of the crania was the removal of one or typically both upper central incisors, referred to as dental evulsion. However, given signs of remodelled bone around the dental sockets, it is clear that the extraction of the teeth took place *ante-mortem* and was therefore a convention practised on the living rather than the dead and not directly related to the burial process (Humphrey/Bocaege 2008; De Groote/Humphrey 2016; and see Chapter 16).

Several other factors have also become apparent through our own study (Chapter 15). In particular, we have been able show fairly conclusively that all of the burials in S10 were primary single inhumations and that any apparently associated disarticulated bones were likely incorporated from adjacent disturbed burials. This is an interesting observation because it contrasts markedly with some of the burials excavated in the 1950s (Mariotti et al. 2009; Belcastro/Condemi/Mariotti 2010). Those burials included bones that were clearly manipulated after death and decomposition (extensive cut marks and ochre dying), signalling the practice of secondary inhumation. It remains to be seen whether the two methods were used contemporaneously at Taforalt or if the practice of burying disarticulated and specially treated bones was a slightly later cultural development, as implied by the presumed sequential filling of burial spaces. Another interesting idea to emerge from our newer work is that some of the bodies appear to have been so tightly contracted as to suggest that they were bound or wrapped in some form of protective covering or matting for burial. We have also been able to confirm that many of the bodies were deliberately placed in either seated or semi-reclining positions, and that adults were typically buried with their heads facing towards the cave's entrance. An additional aspect is that all but one of the undisturbed burials from S10 were accompanied by funerary items. Except for Individual 14, these are normally confined to a few objects, at least amongst those which we can confidently pick out, such as bone points (Individual 1), horse teeth (Individuals 1 and 12) and isolated marine shells (Individuals 6, 12 and 14). The association of red ochre with burials in S10 seems to have been limited to staining on potential grinding stones either covering or contained in some of the burials (Individuals 8, 9 and 14). The only other recurrent feature, similarly observed in previously excavated areas, is the association of horn cores that were often placed on top of the burials and perhaps acted as grave offerings or markers. In one case, the horns were elaborately arranged as a group of three in a circle with the tips of horns pointing outwards from a large centrally placed stone. In other cases, it is conceivable, due to the very loose nature of the deposits, that some smaller grave items might have moved or have been incorporated in sediments forming the pit backfill. Such examples might include fragments of iron oxide (e. g. haematite) and other metallic ores retrieved from S10.

Determining the size of the cemetery has been a matter of debate for many years. Originally, it was believed that there were as many as 183-186 individuals in 28 multiple graves (Ferembach 1963). This figure was substantially revised by Mariotti et al. to an estimated minimum number of 35-40 adults and adolescents (2009, 347); however, this did not take into account infants and juveniles, so the actual figure will need further revision in due course. As stated above, our excavations in Sector 10, adjacent to and partly underlying the "*Nécropole II*" excavations, have uncovered the remains of a further 14 individuals. If these are representative of the cemetery as a whole, then the graves were carefully stacked with new burials inserted above older ones (although our dating evidence does not suggest much of a gap between the S10 individuals). In the newly excavated area there appear to be separate sets of densely clumped burials in pits with sediments devoid of human remains in between them.

Special mention should be made here of the infant burials recovered in the recent excavations. These comprise six of the 14 recorded individuals in S10; we would note that there are three perinatal burials but no definite mother-child associations. Such a high proportion is slightly unusual for early cemeteries, for example in the European Mesolithic, where infant remains are rare either for cultural reasons or due to lack of preservation. Even in the Upper Palaeolithic, where small burial groups are known, the occurrence of infants is relatively uncommon (Irish et al. 2008; Zilhao 2005). At Taforalt preservation conditions were good and special care was taken in our retrieval methods. Although a greater diversity was displayed in the positioning of the infant bodies, it is clear that they shared some of the features of the adult burials, such as being placed in shallow pits, sometimes in a seated position and with limited grave goods. A unique trait so far is that two of the infants (Individuals 8 and 9) were found directly beneath sizable grindstones, in a distinctive greyish-blue colour. It seems clear from the extraordinary care taken over the infant burials that they had already gained a recognisable status within the community. Similar methods of marking infant burials with stones have been reported at Ifri n'Ammar (Mikdad / Moser / Ben-N'cer 2002), which lies not far from Taforalt.

An obvious line of enquiry considering the spatial and chronological proximity of the burials in Sector 10 and apparent clustering of some groups of individuals is whether the series incorporates family groupings or closely related individuals. These types of questions can be explored through the study of ancient DNA. DNA analysis of nine individuals from Sector 10 yielded nuclear DNA sequences for 5 individuals and mitochondrial DNA sequences for six infants and one adult (van de Loosdrecht et al. 2018). Four of the infants had unique mitogenome sequences, excluding the possibility that they were closely maternally related. In contrast, Individuals 8 and 9 had identical mitogenome sequences, indicating that they could be maternally related. Nuclear DNA sequences also indicated a higher genetic relatedness between Individuals 8 and 9 than between other pairs of individuals from Sector 10. Taken together the genetic evidence suggests that these two individuals were siblings (van de Loosdrecht et al. 2018). In light of this relationship, it is of particular interest that the two burials were found close together and that these were the only two infants positioned directly below ochre stained grey-blue coloured stones. In this case the close familial relationship of the two infants was mirrored in a shared and distinctive funerary tradition, suggesting that the burial was conducted by the same members of the community, most likely family members.

18.5 SUBSISTENCE

In order to examine subsistence strategies in the Iberomaurusian and whether any significant changes occurred in dietary and related behaviour over time, we need first to establish what plant and animal resources were available and to what extent each was exploited.

Vertebrate and Invertebrate Resources

A variety of large vertebrates has been reported from the Yellow and Grey Series in S8 (**Chapter 9**). Of those identified to species, the most common was Barbary sheep, followed by Cuvier's gazelle and a few examples each of a large equid, and probable remains of kongoni or hartebeest. These were found widely distributed within the YS and GS deposits. The few examples of large bovines and rhinoceros in S8 were restricted to basal units of the Grey Series and the underlying YS. Except for Barbary sheep which prefers broken ground, the rest of the larger fauna are more typical of open grassland or steppe, and imply that they may have come from different habitats from the Barbary sheep (see also the isotopic data discussed in **Chapter 17**). To these species can also be added from the GS in S10, a very large bovine (either aurochs or giant buffalo), probable wild ass, and a wild pig. The latter is of interest because it tends to prefer woodland habitats, unlike the rest of the fauna. Carnivores are relatively rare in the assemblage but include in S10 parts of red fox, common or golden jackal, a bear, cheetah and an as yet unidentified medium-sized canid. Some or all of the carnivores may have been deliberately placed with the burials (see above), as with the very large bovine represented by a skull and horn cores.

Butchery traces have been observed on ungulate bones from many levels in S8 and in S10 and attest to the fact that these animals were routinely brought back to the cave for processing (**Chapter 9**). Signs of burning are also present on the bones, although these are surprisingly restricted (7.9 %) in the GS deposits considering the large amounts of ash and burnt stone recovered from the same layers. There is relatively little evidence of carnivore or rodent gnawing, especially in the GS, which may reflect the high levels of human activity in these layers. In addition to ungulates, other potential sources of meat protein come from birds such as the great bustard and ostrich, the former displaying cut marks (**Chapter 10**). Both of these species are represented by skeletal remains in S10. Partridge is also mentioned in Roche (1963). Other resources that could have been eaten included lizards (**Chapter 11.1**), hedgehogs, porcupines, tortoises, lagomorphs, and possibly fish (all mentioned in Roche 1963). According to Roche, the lagomorphs were concentrated towards the back of the cave, perhaps more in the upper two-thirds of the sequence of the Grey Series. Roche noted the presence of barbel (*Barbus*) in *Niveaux III* and *IV* (broadly the middle 'B' of his three main excavation units); there are still barbel (small catfish) in the Zegzel, according to the IUCN (International Union for Conservation of Nature). Roche also referred to the presence of freshwater crabs (*Potamon* sp.). It is interesting to note that Merzoug (2017) has only recognised an increase in lagomorph and freshwater resource exploitation in more easterly parts of the Maghreb from the Younger Dryas onwards.

It should be stressed that in addition to their food value, many of these animals would have provided essential raw materials for everyday subsistence needs including skins and hides (clothing and shelter), sinew (binding), hooves, fish scales (glue), fish, bird and mammal bones (toolmaking), and even porcupine quills (delicate incision work).

Molluscan Resources

Very large numbers of land snails have been recorded from the Grey Series sediments; indeed our estimates suggest that the GS midden deposits as a whole may have contained up to 60 million shells (Chapter 8). Analyses also show that the assemblage from S8-GS contains only a narrow diversity of species, all five of which are known to be edible. Evidence that these gastropods were deliberately selected for eating by the cave's human inhabitants comes from the observation that almost all the shells appear relatively fully grown, juvenile stage remains being very rare. Similarly, the combination of species is also unlikely to represent a natural death assemblage, as the molluscs have slightly different habitat requirements (e. g. modern *Alabastrina soluta* is much more frequent in hollows in the limestone cliff close to the cave than the other examples). But the main reason for assuming they were eaten is due to the fact that as many as 60 % of the shells in the GS show signs of burning, most probably the result of cooking or from disposal activity following consumption (Taylor et al. 2011; Chapter 8). In comparison to the GS, the top metre of the YS examined contains a much broader range of molluscs that would fit the criteria for an assemblage that had accumulated largely by natural processes. Some 83 % of the YS molluscs are tiny shells of species not considered edible. Larger edible snails are not entirely absent in the YS, with a few large shells of *Otala punctata*, *Helix aspersa* and *Alabastrina soluta*, suggesting they were sometimes consumed. However, this could not have been on the same scale as in the GS, where molluscs seem to have been specifically selected for food and brought to the cave for processing.
A survey of modern molluscan occurrences around the cave and down the Moulouya Valley has revealed one location, at a lower elevation and 25 km NW of Taforalt, where large numbers of *Dupotetia dupotetina* were aestivating on scrubby vegetation. With up to 100 on one bush, one could easily have gathered 2,000 in a short time. Modern *Alabastrina soluta* is also frequent in hollows in the limestone cliff close to the cave, although this species is not among the most frequent in the Iberomaurusian assemblage.

Plant Resources

An enormous abundance of charred plant remains has been recorded in the GS deposits. These consist of 22 identified plant taxa and provide direct evidence for the largescale gathering of local plant foods (Chapters 5 and 6; Carrión Marco et al. 2018; Morales 2018). In particular they show a prevalence of edible plants such as acorns from the Holm oak and pine nuts belonging to the Maritime pine. Other edible plants included juniper, terebinth pistachio, wild pulses (lentils, peas and vetches), as well as fruits such as elderberry, ephedra and rose hip. The nuts and legumes are rich in carbohydrates and fats and would have provided a broad range of nutrients. Despite modern interference with vegetational patterns, many of these plants are typical of Mediterranean climate and would have grown in the vicinity of the site. The majority would have ripened in the autumn but an extended seasonality due to altitude may have meant that collection could have continued up until November (Chapter 6); some of the other plants such as pulses and wild oats were more likely harvested in the late spring and summer (see also below). In contrast, and despite similar treatment and flotation of samples from the occupation horizons in the YS, the density of macro-botanical remains and wood charcoals is manifestly lower than in the GS. For example, while oak and pine remains are regularly present throughout the GS, only one identifiable fragment of oak and none of pine has been recovered in the YS samples.

Potential for Non-Fossilised Resources

Several other potential foods would certainly have been available in the patchwork of habitats near the cave. These could have included birds eggs (not only ostrich), honeycombs, insects and their grubs, as well as geophytes (underground storage organs) and other soft plant foods that are not preserved by charring (such as leaves, flowers, sap, etc.). All of these may be found in Mediterranean environments today (Blondel / Aronson 1999), although none has thus far been attested in the Iberomaurusian deposits.

18.6 BEHAVIOURAL CHARACTERISTICS AND CHANGES IN THE LSA IBEROMAURUSIAN AT TAFORALT

Evidence of Broad-Spectrum Subsistence Patterns

General Measures of Diet Breadth

As noted above, at Taforalt, indications of significant broadening of the dietary base comes from spectacularly abundant carbonised plant remains in the Grey Series, made up mainly of sweet acorns and pine nuts but including juniper, wild pulses and berries. In addition to plant resources, a steep increase is also recorded in the presence of edible molluscan species. The increase in the exploitation of these foods is emphasised by contrasting the very low presence of any such evidence in the underlying YS sequence (Chapters 6 and 8). According to diet-breadth models, a rise in small species such as reptiles (lizards, snakes, tortoises), amphibians (frogs), fish and birds might also be predicted. At Taforalt, remains of such species are definitely present, recorded in both our work and by Roche beforehand, particularly in the GS. Work is ongoing with respect to analysis of the extant collections.

Nutritional Value

Nutritional values for different categories of food are relatively difficult to calculate with any accuracy. Starting from a given food (sub-)species, many different parameters are relevant: individual characteristics (e.g. age, season, immediate meteorological history), collection parameters (selection of 'best', blanket collection, etc.), parts eaten, cooking degree and technique, other preparation (e.g. drying), storage conditions and time, etc. The values reported in table 18.1 should therefore be taken as broad guidelines only.
The potentially high nutritional value of the plant foods evidenced at Taforalt is clear. Ripening times would require that harvesting took place in the summer and autumn but this does not preclude the possibility that they were also stored for future consumption (see below).

Species	Common name	Nutritional value (g/100 g)			Calories (100 g)
		Carbs	Lipids	Protein	
Quercus ilex	Holm Oak acorn	53.0	10.5	3.0	
Quercus sp. [1]	(US) acorn (raw)	40.8	23.9	6.2	387
Quercus sp. [1]	(US) acorn (dried)	53.7	31.4	8.1	509
Pinus pinaster	Pine nut	5.0	51.1	33.2	
Pinus sp. [1]	(US) Piñon nut (raw)	14.3	67.9	14.3	679
Pinus sp. [1]	(US) Pine nut (dried)	13.1-19.3	61.0-68.4	11.6-13.7	629-673
Juniperus phoenicea	Juniper	18.0	4.0	5.0	
Pistacia terebinthus	Terebinth pistachio	5.0	61.0	4.0	
Lens sp. [3]	Wild pulse	58.0	2.0	26.0	
Avena sp. [2]	Wild oat	55.0	8.0	20.0	
Sambucus nigralebulus	Elderberry	55.0	1.0	7.0	
Mollusca [1]	Snails (raw flesh)	2.0	1.4	16.1	90
Helix sp. [1]	Snails (cooked)	1.0	1.0	10.0	45
Cuniculus sp. [1]	Wild Rabbit (raw)	0.0	2.3	21.8	114
Cuniculus sp. [1]	Wild Rabbit (stewed)	0.0	3.5	33.0	173
[1]	Ground lamb (NZ) (raw)	0.0	12.4	20.3	193
[1]	Ground lamb (NZ) (braised)	0.0	11.3	22.6	192
[1]	Game meat goat (raw)	0.0	2.3	20.6	109
[1]	Game meat goat (roasted)	0.0	3.0	27.1	143
[1]	Game meat (US) antelope (raw)	0.0	2.0	22.4	114
[1]	Game meat (US) antelope (roasted)	0.0	2.7	29.5	150

Tab. 18.1 Nutritional value of food sources likely to be relevant to the Taforalt case. – (Data sources: [1] United States Department of Agriculture 2018; [2] Sosulski/Sosulski 1985; [3] Urbano/Porres/Frías/Vidal-Valderde 2007; remaining data from Debussche/Cortez/Rimbault 1987; Gonçalves Ferreira/da Silva Graça 1963).

Although of lower nutritional value than many plants, the snails would have been relatively easy to collect (**Chapter 8**) and would have formed a stable additional dietary component and a highly predictable food resource.

This brings us to a consideration of the "resource rank", a concept used in most OFT models to indicate the net return (say, in calories) once the travel, collection and processing 'costs' have been deducted. It is often assumed in archaeological cases that a moderate-to-large and abundant game animal will have been the highest-ranked resource – at Taforalt, this would be the *Ammotragus lervia* (Barbary sheep/aoudad[67]). It is patent that meat would have been a very important component of the Taforalt diet; indeed, analysis of the stable isotopes in human bone from S10 (**Chapter 17**) shows that these individuals all had access to reasonable amounts of animal protein. However, predictability (in time and space) must be an important parameter here, since this weighs upon the effort needed to acquire the resource at a reliable rate. Similarly, the degree to which a resource can be stored will affect its ranking, since the 'cost' of alternatives may be extremely high in certain seasons. It may therefore be a mistake to assume it is necessarily inefficient to include resources which, at first sight, might appear to be 'lower-ranked'.

As a thought experiment, consider 100 g of a mix of 50 % acorns and 50 % pine nuts (taking the "raw" figures from **tab. 18.1**); this would give us 533 calories, together with 10.3 g of protein and 45.9 g of lipids; if we could add wild pulses, for instance, even the protein level would rise. We do not have data for the *A. lervia*, our default 'highest-ranked' resource, but, judging from an analogue of domestic lamb (cooked),

67 This is the europeanised (by transliteration) name most commonly used, said to derive from the Tashelhit (southwestern Morocco) *aoudad* or from the wider Amazighe *udad* or *audad*; the Arabic name is usually transliterated as *arui* (giving Spanish *arrui*).

we would need at least twice as much meat to reach the same caloric and basic nutrient levels; using leaner 'game meat' figures, the relative values for equal weights of the plant 'mix' would rise to about five times that of the meat. Was catching *A. lervia* twice, or five times, as predictable as harvesting the acorns and pine nuts? Very probably, it was not. Were all members of the available population equally able to bring back the different resource types? Very probably, they were not. Did the meat resource require less than half, or a fifth, the processing time than the plant resource? Possibly, it did. How well could the respective resources be stored? The plant resource was probably more easily stored than the meat, although dried/smoked meat or even a composite (akin to pemmican) could have provided more durability, given extra preparation effort. Our thought experiment is perhaps even more appropriate when one remembers that meat resources would certainly have become significantly leaner through the winter, bringing the topic of storage of alternative lipid sources to the fore. The 'efficiency' problem – the real one, actually faced by the inhabitants of Taforalt – was not even this simple, since they needed to plan to survive (at least) and they therefore needed to understand the risks and opportunities presented by the entirety of their dynamic subsistence base.

Potential Resource Depression

High-Ranking Resource Depression

Barbary sheep are now less common in the wild than in introduced populations. Acevedo/Cassinello/Hortal/Gortázar (2007, 588) note:

> Of special concern is the aoudad, an African generalist ungulate, which has been successfully introduced outside its African range as a game species in USA and Spain. There, it has adapted formidably to Mediterranean-like regions, where food resources are abundant, in contrast with the desert lands occupied in its native African range. In these areas, the abundance of resources, along with the scarcity of competitors and predators, results in high birth rates and a quick spread of the population.

The natural ecology of *A. lervia* is not well reported in the professional literature; the more accessible North African populations are often held (and assisted) in special reserves (after a c. 80 % reduction in their historical range), whilst the very successful populations introduced (usually originally for hunting purposes) in other parts of the world do not necessarily display 'native' behaviour. At least in introduced populations (e. g. in the US and Spain) *Ammotragus* show seasonal habitat preferences, if available: woodlands during summer, grasslands during autumn and winter, protective rocky slopes during spring (main birthing season) (Johnston 1980). *A. lervia* seem to cope well in forested (but still accidented) areas in Northern Tunisia but, again, not within their wholly natural range; however, in an area poor in plant species in Bou Hedma National Park, they have been observed to be predominantly grazers at all seasons (some two-thirds of the annual diet), with browsing concentrated in the autumn and forbs (herbaceous flowering plants other than grasses) eaten in the winter (Ben Mimoun/Nouira 2015). In southeastern Spain, peaks in introduced *A. lervia* density are positively related to dense pine forest, clear/open shrubland, bare rock, natural grasslands and old abandoned fields (Belda et al. 2011). Local observation (Mohammed M'Ansor, pers. comm.) suggests that *A. lervia* in the Beni Snassen SIBE (cf. **Chapter 1**) are very partial to acorns. It may therefore be concluded that *Ammotragus* are notably non-selective in their forage and will eat most things, depending upon availability and season (Cassinello 1998); this is "a generalist herbivore with very flexible diet" (Ben Mimoun/Nouira 2015, 3).
Extracts form Ogren's (1965) observations of introduced *Ammotragus* in New Mexico (USA) are relevant here:

"[…] the chaps and manes tend to break up the outline […] particularly effective as camouflage" (p. 74); "[…whilst they] frequently travel along the bottom of the gorge and drink from the Canadian River, they often appear to be 'nervous' while at this level, and at the slightest provocation will bound up the sides of the gorge. Much of their time is spent along the walls of the gorge. When seen feeding, they were usually just under the cap rock or on benches along the walls of the gorge" (p. 78); "B. sheep inhabit the areas of best range condition which are best able to withstand use" (p. 78); "[the animal] can best be evaluated by stating it was found to possess a quality which might be termed great adaptability" (p. 79); "[One of the] hardiest and most easily propagated [animals]" (p. 79).

Ogren (1965) also reported a number of hunters' comments, for example:

"Our party thought the hunt was very challenging and one has a lot of respect for the B. sheep as a game animal" (Mr. Darlen, Los Alamos, p. 76); "[An] excellent game animal. We need an animal that will reproduce fast […] and be harder to take than deer" (L. Parkham, Albuquerque, p. 76); "The table qualities are excellent. My wife is especially critical of game […] yet the B. sheep was always a welcome item on the on the table. I should also like to put in a plug for the excellent keeping qualities of this meat in frozen storage" (Mr. Weber, Socorro, p. 77).

Noting that, during much of the Grey Series at Taforalt, the vegetation cover would have been significantly denser, with more closed tree cover, than at present, one might have wondered whether such conditions could have proved a disadvantage for *A. lervia*, had only modern Moroccan populations been used as analogues. However, the wider observations around the world show this to be a very adaptable animal, unlikely to be hindered by anything less than severe shifts in vegetation cover, certainly not moderate changes in the relative proportion of woodland. As long as rocky outcrops remained available as safe havens, the Barbary sheep would have coped admirably.

Biodemographic modelling of the relationship between modern central-place hunters (for instance, many human groups) and their prey commonly involves parameters (derived from a combination of empirical and biologically reasonable estimates) such as: game species carrying capacity; prey fecundity; animals killed per hunting group encounter (variable depending upon different potential kill technologies for humans); encounter rate (game species density and hunter travel distance); hunts per hunter per time interval; spatial spread of hunting effort (a compound parameter that is usually not independent of others); and diffusivity of prey species. Such models will normally result in predictions of an "extinction envelope" around a central place (with close correspondence to observed outcomes in real cases), together with an asymptotic solution for sustainability overall, a solution which will also depend upon whether there are 'conservationist' cultural mechanisms, for instance, to preserve some areas unhunted (cf. Levi et al. 2011).

The passive parameter of 'diffusivity' may be too simplistic, especially for more mobile prey species. Most prey are not passive food units to be located and eaten by a predator: they respond to the pressure of predators by adjusting when and where to feed, by increasing their vigilance and/or by moving to safer habitats in order to avoid being killed. This holds true at all scales of predator/prey interactions. "[…] Hundreds of studies have shown that prey tend to avoid areas with more predators […]" (Sih 2005, 240).

Therefore, although *A. lervia* may be susceptible to ambush predators (including humans), due to their generally small ranges, bimodal movement preference ('dawn & dusk' at least during warmer weather), tendency to 'freeze' (relying upon camouflage) when first alerted and habitual use of certain trails, these animals are unlikely to be unaware of the risks or incapable of behavioural modification under particular stress.

The fact that so many of the extant populations of *A. lervia* have been introduced for modern (gun) hunting purposes is of interest in its own right (see above). On La Palma Island (Canaries) after introduction for this reason, it was found that the animal was too detrimental to the native flora; whilst it has now been pushed back to the inaccessible walls of a volcanic caldera, the authorities have so far failed to eradicate them entirely, even with professional hunters in helicopters. A similar case can be seen with the European mouflon (*Ovis orientalis musimon*) in the Rhineland region, again originally introduced for hunting purposes. The animals have flourished and can be observed in fairly large groups today. They seem to thrive in a region defined by scoria cones (East Eifel Volcano Field) and the form of their hooves (very similar to those of *Ammotragus*) is well adapted to moving over the slopes which, when not covered by vegetation, are formed of loose lava 'scree'.

Predator-avoidance is most common/marked in birthing female herbivores; for instance, active predator (canids) avoidance (involving moving to poorer grazing) is practiced by bighorn sheep (ecologically similar to aoudad and suffering competition from introduced populations of the latter) during lambing season (Fiesta-Bianchet 1988). Where general predator-risk (pumas, which also hunt introduced aoudad) areas are not avoided entirely, bighorn sheep choose the most difficult terrain (e. g. precipitous cliffs and rocky hillsides) (Villepique et al. 2015).

The image "landscape of fear" has been introduced to describe how fear, a response learnt from previous close calls, can alter an animal's perception of the locational distribution of risk and thus its use of an area as it tries to reduce its vulnerability to predation (cf. Laundré/Hernández/Ripple 2010). The following example (Laundré 2010, 2995) involves a multi-decade study, in topographically varied and very 'patchy' landscape in Idaho and Utah, of pumas and mule deer, although it has been shown to be a pattern seen in many predator/prey pairs.

> When active, pumas spent significantly less time in open areas of low intrinsic predation risk than did deer. Pumas used large patches [where they are probabilistically more difficult for prey to spot] more than expected, revisited individual large patches significantly more often than smaller ones, and stayed significantly longer in larger patches than in smaller ones. The results supported the prediction of a negative relationship in the spatial distribution of a predator and its prey and indicated that the predator is incorporating the prey's imperfect information about its presence.

Clearly, if prey animals acquire additional information about the location, or 'starting point', of a predator (such as a central-place human hunter), that location and its immediate environs will deserve a particularly strong red-flag in the "landscape of fear".

With a static base camp, local resource depletion may be a balancing factor (leading to asymptotic conditions), without additional population competition (neighbouring groups) or environmental decline.

Other factors might also have affected the value of *A. lervia* to the Taforalt inhabitants. We are currently unable to estimate many of the relevant parameters (encounter rates, pursuit costs, failure rates, handling (transport, butchery) costs, etc.), although empirical studies would seem to indicate that larger prey are usually more costly to acquire overall. Alternative currencies (to simple nutritional gains), such as social and political gains, may have played a part; these often require special skills, knowledge or technology, the primary gain usually accruing to only a few individuals. Significant levels of acquisition specialisation would perhaps imply complex patterns of intra-group sharing and/or exchange.

Given the signs for increased dietary breadth in the Grey Series, it is perhaps surprising that, at least superficially, this does not seem to be reflected in any dramatic changes in the availability of meat protein from *A. lervia*, which continued to be hunted throughout this period. Indeed there are no obvious indications of a reduction in exploitation of this animal as a source of meat but, critically, any heavy hunting of the sheep locally may quickly have depleted the resident population and led to greater time/costs involved in hunting these animals (assuming they had moved farther away). Although not noticeable in the statistics recorded in the GS (Chapter 9) it is likely in our opinion that persistent hunting near the cave would have gradually depleted the local animal populations, placing an effective upper cap on available meat from this source. Once the *A. lervia* populations had reached equilibrium in numbers with the local human pressure, the inhabitants of the cave would have been forced to hunt further afield, so this may have been a stimulus in developing alternative food-acquisition strategies. In any case, the accidented nature of the landscape with its mosaic of different habitats probably allowed a large core of the Barbary sheep to maintain breeding numbers in the Beni Snassen mountain range still relatively close to the cave. In the wider region, Merzoug (2017) confirms that Barbary sheep remained the primary game (especially on higher land) throughout the LSA, perhaps with a particular concentration upon this species in the 'Early Iberomaurusian' (pre-HE1) at sites such as Tamar Hat and Taza 1 (Algeria). She also notes that, in her study material, the butchery techniques remained broadly the same across 'Early' and 'Recent' phases of the Iberomaurusian.

Dropping Environmental Productivity Overall

The Taforalt data do not suggest an obvious and significant period of deteriorating environmental productivity within the LSA Iberomaurusian timescale, such that this eventuality would seem an unlikely driver for greater diet breadth or 'intensification'. At a very broad scale, it would appear that the overall environmental productivity was probably a little lower during most of the relevant Yellow Series than in most of Grey Series time. This having been said, it will still be necessary to discuss further the possible drivers for specific behavioural shifts at Taforalt (see below).

"Operating Outside the OFT Box"

The theoretical possibility of a decline in local populations of *A. lervia* has already been explored above. If humans continued to hunt this species in any quantity, it is plausible that increased predation pressure could have produced a reduction in human foraging efficiency, as local sources of the sheep dried up and the costs of hunting them increased. There are some trends from the site to suggest that butchery marks were more common on the Barbary sheep in the GS than in the YS. However, there is no evidence for actual 'depression' in the overall numbers of Barbary sheep in the GS (**Chapter 9**), nor any signs of intensive processing of adult sheep bones for marrow, and perhaps grease, that could be interpreted as a response to a reduction in overall numbers.

It is also conceivable that current dietary models exaggerate the dichotomy between so-called high- and low-ranking food categories. For instance, it would certainly be erroneous automatically to classify sweet acorns and pine nuts as 'lower-ranking' foods purely on calorific grounds. Although harvesting costs need to be taken into consideration, these plants are very rich sources of energy and protein and it is possible that their rise in abundance in the GS was more to do with environmental factors and increased availability rather than as a result of a diminution in other higher-ranked foods. In addition, significant improvements or innovations in harvesting and processing techniques could well have influenced foraging behaviour, generating better yields and making some collectable foods more attractive than before (see next section).

Thus, in examining the question of resource depression, we can see no obvious evidence for this in respect of the *A. lervia* population, even though we do accept the possibility that increased predation levels may have led to rising costs of hunting, as distance from the cave to the animal resources increased. An even greater effect, however, may have been an amplification in the resource abundance resulting from a stabilisation of the climate and a return to warmer and more humid conditions at the beginning of the Greenland Interstadial, soon after 15,000 cal BP. If the vegetation cover became significantly denser and more closed than at present (**Chapter 6**), this could have produced a wide range of plentiful and predictably available resources that would have made a broader spectrum diet more attractive. In these circumstances it might be possible to recognise Taforalt as yet another example of a group of hunter-gatherers "operating well outside the OFT box" (Zeder 2012, 248).

Evidence of Economic Intensification

It is now pertinent to consider the question of whether any of the changes described in the LSA Iberomaurusian sequence (including the obvious shift from Yellow Series to Grey Series and the further modifications within the GS itself) can reasonably be interpreted as evidence for economic intensification. Here, we are mainly concerned with behaviours to do with increasing economic productivity and resource yield, rather than those concerning a forced increase in foraging effort or related aspects. We would reiterate that we find the concept of 'intensification' useful to cover any deduced process of 'concentration in activity/output', without the automatic implication of decreased efficiency (the manner in which this term is normally used in OFT theory). Similarly, we use the term 'productivity' without any automatic implication of increased efficiency. In attempting to estimate intensification and productivity, taphonomic effects must be taken into account as much as possible, effects described in each chapter of this volume and summarised in **Section 18.1** above.

Productivity can be expressed, albeit rather coarsely in the form of 'raw output', as a measure of relative abundance through time, which can be estimated where (in the Sector 8 columns) we have sufficient data in the form of counts, sample volumes and sedimentation rates. It should be remembered that the 'productivity' numbers thus calculated (see individual **Chapters**) are essentially dimensionless comparative indices, valid only within each specific category of material; it is the relative change (often best expressed with respect to the Yellow Series situation as a background or 'benchmark') that is of importance here. Since our overall counts for most types of data are quite small for most individual stratigraphic units, we will often restrict comment below to the simple YS/GS comparison, only sometimes being able to divide the GS into lower and upper portions (broadly at the boundaries between S8-G96/95, S8-L24/23 and S8-MMC80/50) and more rarely still to consider finer stratigraphic intervals.

The most obvious change across the GS/YS boundary is the enormous increase in the evidence of burning (burnt stone, from blocks to powder, ash, charcoal and other charred plant remains, lithic artefacts and debris, land mollusca, bone debris, etc.). Our first estimates in Sector 8, suggested that there was at least a ten-fold increase in charcoal particles across this boundary (as reported in **Chapter 5**). More detailed analysis (the results of which are shown in **fig. 8.5**) now suggest that, once sedimentation rates are taken into account, the occurrence of charcoals in the lower portion of the GS may show a rise in the approximate range of 100- to 200-fold, although the occurrence, again relative to the YS, is only just over 50-fold in the upper portion of the GS (in this more aggressive context – slower sedimentation, more trampling, greater burning intensity, etc. – where attrition of these fragile remains would have been strongest). **Figure 8.5** also shows that small, still recognisable bone fragments are three times more likely to be burnt in the GS than in the YS. The human input of material, especially burnt material, is so great in the GS overall that it is all but impossible to isolate macroscopically a significant geogenic element at any level (**Chapter 2**).

In terms of thermally altered carbonate rocks and pyrolithic processes (**Chapter 2**), productivity is expressed both in the number of imported stones (of lithologies more or less 'exotic' to the cave and proximal cliffs themselves) and in the degree to which these stones have been burnt. In the uppermost unit of the Yellow Series (Y1), stones are almost exclusively of the various 'speleothem' types of the cave bedrock, whilst the burn index (rising with both proportion burnt and degree of burning) reaches about 30 % of maximum, demonstrating that there is already a significant human presence. In the lowest GS, the burn index rises to over 50 % of maximum; speleothem is still dominant but now dolostone is present in quantities much too great to have been easily available actually within the cave. As one moves further up the sequence, the burn index creeps up a little, whilst the 'imported' lithologies, both dolostone and calc-limestone steadily increase. These trends accelerate upwards, reaching an index of nearly 100 % (most stones burnt to a very strong degree) and complete dominance of 'exotic' lithologies, especially the calc-limestone, in the upper portion of the GS. Overall, the Grey Series comprises several thousand tonnes of material, imported or at least placed/reorganised by humans, a factor largely responsible for the approximately ten-fold increase in bulk sedimentation rate, as compared with the rates in the Yellow Series.

Charred plant remains (other than wood charcoals; **Chapter 6**) show a 50-fold increase passing into the GS compared to the YS. The highest productivity (reaching a 69-fold increase) is seen in the very stony units (the 'upper' part of the 'lower' portion of the GS), a presence which may well be showing a taphonomic effect (protection for these fragile remains within a very rapidly accumulating and stable stone framework) but which may also reflect a strong increase in the preparation of acorns. The productivity in this category of finds falls off somewhat (to around a 30-fold increase) in the upper portion of the GS but this is plausibly again due to attrition.

Phytolith numbers (**Chapter 7**) represent a relatively low background in the YS, with a moderate rise (by perhaps two orders of magnitude) only within an undisturbed hearth. After the mixed interval at the very base of the GS, general numbers rise to about double the abundance in the YS hearth, that is, some 200-fold. Moving upwards to a point after the very stony interval in the GS (i. e. to MMC50-46), the abundance continues to rise, perhaps to some three orders of magnitude higher than the YS background but, even allowing for uncertainties in sedimentation rate, certainly at least 500-fold. These escalating numbers must correspond to increasing human import of vegetable matter (probably dominated by monocots, grasses in particular). The top of the GS shows a down-turn, to a level again only some two orders of magnitude above the YS background, plausibly interpreted as a moderate reduction in human input, perhaps as a cultural response to the climatic conditions slipping towards the Younger Dryas (GS1).

Data on edible molluscs are set out in **Chapter 8**. **Figures 8.5** and **8.6** refer to total molluscan abundance expressed as apical counts. In terms of MMC units, the GS can be divided into three broad intervals: the lower part MMC105-96, the middle part MMC95-80 (which contains many stones) and the upper part MMC50-2; the MMC units in the YS can be treated here as a single interval. Taking the YS occurrence as the 'benchmark', productivity in the lower GS increases 23-fold, in the middle GS 29-fold and in the upper GS 39-fold. It can thus be seen that there is a steady increase in apical 'productivity' upwards through the four intervals, the greatest changes occurring at the YS/GS boundary and again into the MMC2-50 interval at the top of the sequence – and this last observation despite probable increasing attrition of these fragile remains. Counts are also available for total molluscan fragments greater than 0.5 mm in size in the Grey Series, from which productivity levels may be calculated; since YS data are not available, we will set the lower GS figures at an arbitrary '23' (to facilitate comparison with the apical counts) to act as the 'benchmark', which produces figures of 43 for the middle GS and 56 for the upper GS. The upward increasing productivity in edible molluscs in the GS is therefore confirmed with this second (not directly dependent) set of data.

Whilst there are too few remains from Sector 8 to justify any finer stratigraphic divisions, large mammal bones (**Chapter 9.1**) show more than a threefold increase in the GS compared to the YS, whilst **figure 8.5**, adjusted for sedimentation rates, suggests perhaps a 30-fold increase in smaller fragments of animal bone (not counting obvious microfaunal species). Again adjusting for sedimentation rate, the GS increase in butchery marks is about sixfold (i. e. about double the increase in basic bone 'productivity').

Unfortunately, we do not have sufficiently numerous data on the bird fauna in Sector 8 (**Chapter 10**) to estimate any intensification in human predation. However, one may note that, judging from the 1950s finds (for which we have only the coarsest estimates of sample volumes excavated), ostrich eggshell fragments at least seem to maintain their abundance through the GS, even in the face of the likely upward increase in attrition of vulnerable finds.

Using lithic artefacts in their archaeostratigraphic Phases (Chapter 12) as proxies of intensification (see tab. 12.4), we can show that marked differences in productivity can be seen in the total numbers of lithics in the Upper Phase (that is, everything except the lowest part of the GS) of the GS (about a 35-fold increase overall and perhaps as high as a 53-fold for the upper, finer-grained and slower-accumulating, half of this Phase, that is, the upper part of the GS as defined in this Section 18.8), compared to the numbers in the Lower Phase (used here as the 'benchmark') which occurs entirely in the YS. Splitting the Middle Phase into two at the YS/GS boundary, the YS interval shows only a 2.5-fold increase compared with the 'benchmark' YS below, whilst the GS intervals already shows more than a 40-fold increase (thus, approximately a 17-fold increase expressed locally across the boundary). With respect to total retouched tools, and again using the Lower Phase as the 'benchmark', there is a twofold increase in the highest (Middle Phase) YS, a 24-fold increase in the lowest (Middle Phase) GS, and a 19-fold increase in the Upper Phase. In passing, we may also note the intensification of burning/heating effects seen on lithic artefacts, with 36 % of specimens burnt in the Lower Phase, 43 % in the Middle Phase and 82 % in the Upper Phase. Further analysis of productivity in the main lithic artefact collections is given in Section 12.5. Finer lithic debris has also been recovered (although rendered more and more difficult to identify as artefacts due to increasing burning upwards in the GS) from the mollusc column, the counts being shown in figure 8.5; allowing for sedimentation rates and noting that the trace is quite jagged, it is still possible to recognise that, on average, there is at least a 30-fold increase in the GS as compared with the YS. A similar pattern of increase, reaching a multiple of over 50 in the Upper Phase, can be seen in the 'productivity' of larger unclassifiable lithic debris. It should also be remembered that, during the 1950s excavations in the Grey Series, over 600 well-characterised bone tools and over 400,000 lithic artefacts were recognised (probably a rather conservative figure, given the recovery/recognition techniques used).

The other aspect of intensification is resource yield (which may or may not involve adjustments in efficiency), a parameter which is very much more difficult to estimate.

The huge increases in productivity of pyrolithic processes have already been noted above. However, the sequence within the Grey Series deserves further consideration here. As might be expected in a context of rising activity levels involving burning/heating, the sedimentation rate is high and rising towards the top of the lower portion of the GS. However, this rate quickly falls away (to a quarter of the peak rate, albeit still over six times the rate in the bulk of the YS) in the upper portion of the GS, plausibly largely due to the change of preferred lithology for stone heating. Single stones of the calc-limestone, although always requiring import from outside the cave, can be heated for very many more cycles than the other types, and heated to much higher temperatures before disintegration. The clearly increasing bias towards this lithology is therefore a good example of increasing efficiency, certainly with respect to stone import effort but also probably to heat retention and transmission. In basic 'yield' terms, there would have been a considerable nett gain in useful calories.

Another example of intensification can be deduced from the proportions (with respect to all typed artefacts) of unretouched bladelets amongst the lithic collection (Section 12.5), which drops from 20 % in the Lower Phase, to 16 % in the Middle Phase and to 12 % in the Upper Phase. Various supporting observations (such as the reverse stratigraphic trend in the ratio of unretouched bladelets to retouched artefacts, most of which are on elongated supports) suggest that this is a true reflection of the more exhaustive use of available bladelet blanks. This is perhaps not such a clearly explicable example of increasing 'yield' (in useful lithic tools derived from given quantities of at least 'intermediate' raw material, that is, blanks). For instance, the relative frequencies of total diagnostic artefacts to undiagnostic knapping debris are 48.9 % in the Lower Phase, 40.4 % in the Middle Phase, and 21.6 % in the Upper Phase, which might suggest that more untested (including poorer quality) chert pebbles were being brought to the cave in the Upper Phase, a factor which could have affected the need to intensify the retouching of available bladelets. Nevertheless, it must surely be counted as efficient to use what one has to hand, if it will serve the purpose adequately, rather than to revisit distant raw material sources. Whether or not it would have been more efficient to test pebbles at source, in the first place, or to bring them 'in bulk' for testing at the cave would depend very much upon the circumstances of resource access, group size/composition and sequence of activity which applied in the actual case(s), factors which we cannot estimate with any confidence.

Again, we do not have sufficiently numerous data on bone artefacts in Sector 8 (Chapter 13) to estimate any increase in productivity. However, once again one may note that, judging from the 1950s finds (for which we have only the most coarse estimates of sample volumes excavated), both bone 'points' and total bone implements seem to increase in numbers upwards through the GS, save for a slight drop at the top of the GS nearer the back of the cave and an intriguingly high count of bone 'points' at the base of the GS in the best-lit area at the front of the cave. A similar observation can be made concerning the marine shell manuports recovered in the 1950s, which, save for a sudden peak in *Dentalium* at one point (which could well represent the remains of a single complex strung artefact), suggests a general increase upwards through the GS. The same pattern shows in the 1950s finds of grinding implements (Chapter 14). Roche's short commentary (1963) might imply a slight increase in curiosities and baubles, and possibly even colourants, upward through time in his excavations of the Grey Series.

In sum, these various proxies indicate an increase in productivity, yield and sometimes even efficiency over time: intensification without obvious signs of loss of efficiency or other stressed conditions. Data are not always in a form where we can quantify intensification (and any such effect may sometimes be masked by locally difficult taphonomy) but, when they are, we always see at least some economic intensification upwards from the Yellow Series and through the Grey Series.

Seasonality

Evidence for seasonally-organised activities is particularly evident in the Grey Series. Here a number of independent sources suggest that the people at Taforalt exploited a wide array of seasonally available foods that may have enabled them to subsist at the site for much of the year. Up to 90 % of the total meat supply would have come from medium-size ungulates (mainly *A. lervia* but also perhaps gazelle); it is clear from age of death estimates on young *A. lervia* and gazelle (Chapter 9.1) that these animals were killed and butchered from April into October. According to a separate study of growth cementum bands on a small sample of *A. lervia* teeth (Chapter 9.2), the hunting season may have extended into the winter, with the majority of such examples coming from the GS. Thus there would appear to be reliable evidence that *A. lervia* were available within reach of the cave from at least April until October and possibly well into the winter. Although the majority of protein in the diet probably came from meat, it is nevertheless apparent that plant foods also contributed significantly to the diet. Pine nuts, acorns and other fruits must have been available locally in huge quantities and were harvested seasonally. Based on current ripening patterns these could have been collected routinely from at least the spring until as late as November; indeed some plants (acorn, pine nuts, some legumes) could have been gathered unripe, pending processing and/or storage, extending the period of harvesting yet further (Chapter 6). Taking geography as well as season into account (see 'radiating mobility' below), the plains north and south of the Beni Snassen would have been rich in food (such as annual grains from legumes and wild cereals, as well as the gazelle already mentioned) but predominantly during spring and early summer; even today, the region around Oujda has abundant wild annual legumes, similar to those evidenced at Taforalt, at that time of year (Ismail Ziani, pers. comm.). From studies of the edible molluscs (Chapter 8) it is likely that these were collected and consumed seasonally rather than being eaten year round. The contribution of other sources of meat protein (for example, from birds such as bustard) is not known, though it is likely that they would have made welcome supplements, albeit of currently uncertain overall importance, to the other seasonally available foods. Some foods may even have been at their best in winter (e. g. barbel and other freshwater resources), whilst underground plant organs (tubers, bulbs, roots) are often most nourishing in spring, although collectable all year round. Since leaves are mostly produced during the wetter season, it is quite possible that leaves and stems were consumed during winter and spring. It is reported that, in recent times in the El Jadida region, the majority (85 %) of wild edible plants (mostly herbaceous young leaves and stems) were collected from early winter until spring (Tbatou / Belahyan / Belahsen 2016; see also Powell et al. 2014 for plant collection in wider areas in Morocco and comments on combatting micro-nutrient deficiencies). Although many food sources involve more or less seasonal primary availability, small game (e. g. lagomorphs) would probably have been available through much of the year including the winter. In a setting such as this, small game, with intrinsically high fecundity and population recovery rate, may be present in high local densities, thus ensuring greater encounter rates (especially if snaring, trapping and / or burrow-hooking are used).

A further matter of relevance in considering seasonality may be the relationship of the surrounding landscape to the site itself. We have already drawn attention to the fact that Taforalt lies at an elevation of 720 m amsl, in a highly varied landscape ranging from coastal plains to upland plateaux. While the site lies more or less in a semi-arid zone (probably showing a generally 'Mediterranean' seasonality pattern throughout the Iberomaurusian), it would always have provided potential access to a wide range of ecozones, arranged vertically and closely spaced in relation to the cave. Under such circumstances it is plausible to envisage a difference in ripening patterns that would have staggered the 'normal' seasonality of given resources according to altitude and aspect; trees and shrubs ripen over longer periods than do annual plants, first the top branches and afterwards the ones in the shade, earlier at the bottom of the slopes and later towards the highlands. In theory, this would have enabled the occupants of Taforalt to exploit the landscape in a deliberately selective way, effectively extending the length of time during which foods could be harvested. One would also note that, in this seasonal climate, water availability in the drier months would favour Taforalt, close to its probably persistent spring-line.

Whilst primary availability of food resources sometimes points to particular seasons of acquisition, other factors would have buffered the human population against shortages. Storage of food stuffs, implying some form of preparation, would have been essential to create secondary availability, involving a potentially wide and varied range of activities, each with different, but necessarily positive, efficiency balances of yield against effort. Such 'base-camp' tasks would have been facilitated by appropriate division of labour (see below), without affecting the efficiency of ungulate hunting (cf. Zeder 2012, 243). All these issues will be explored further below.

Mobility

It seems likely that, in most of the Yellow Series, some form of high mobility strategy was exercised, with the lowest average productivity in artefacts in the Lower Phase and tools attesting to short, intermittent stays at the site (Chapter 12). During this same phase, Taforalt may have served as a task site belonging to a more distant residential base camp or may simply have supported the activities of a small residential unit that frequently moved from one location to the next (representing circulating mobility). In this Phase at Taforalt, the raw material is dominated by fine grained cherts sourced from gravels of the Moulouya and its tributaries and originating from no more than 10-20 km from the cave. Relatively easy accessibility, perhaps as a function of relatively mobile lifestyles and a developed knowledge of the landscape, is indicated by the liberal use of available raw material, shown by cores capable of further reduction and high numbers of unmodified discarded blanks, careful conservation and use of available raw materials not being necessary under those circumstances.

In the uppermost YS (Middle Phase), there appears to be no great change in overall mobility, perhaps still organised around a circulating pattern of residency. However, a very strong pointer towards changing mobility patterns is seen with the astonishingly abrupt jump in lithic artefact productivity actually within the Middle Phase (the lithic repertoire itself showing no significant break), together with the shifts in nearly all other cultural traits, across the Yellow Series / Grey Series boundary.

The Upper Phase assemblages in the GS seem to have been the product of very low residential mobility, with evidence for foods and other resources being regularly transported back to the central location of Taforalt. Indications further suggest that there was a progressive reduction in mobility even within the Grey Series sequence itself. Making allowance for the very stony nature of the lower half of the containing sediments, there is nonetheless a major difference in the productivity of lithic artefacts, with much greater numbers of lithics in the upper interval, suggesting that the cave became increasingly frequently occupied and plausibly for relatively long periods of time. This is also indicated through the increased use of locally available lithic raw materials. Indeed, one of the notable features of Upper Phase is the growing reliance on limestone cobbles probably sourced from just outside the cave, primarily for the purposes of pyrolithic practices described above. Large quantities of these rocks were available, as indicated by clusters of introduced pebbles and cobbles in the Grey Series. A relatively high proportion of struck flakes and basic tools are made of this material but many show no clear signs of flaking and, apart from various heating processes, stones probably served a variety of other functions, including uses as pounders, hammerstones, anvils and small-scale structural markers / boundaries. One aspect of continuity with the Middle and Lower Phases is in the persistent use of the relatively high quality cherts from the Moulouya gravels; it is clear that this was probably the most accessible source of good knapping material and as such continued to be exploited.

We will further consider this issue in the continued discussion below but it would already appear reasonable to suggest that the Grey Series at Taforalt would seem to fit the 'radiating' model outlined in Section 18.1. One must nevertheless not forget the fact that these were true hunter-gatherers, the robusticity of their skeletal remains (at least in the earlier part of the GS in S10; cf. Chapter 16) remaining high, indicating individual mobility, albeit at measurable levels probably biased in this accidented terrain.

Division of Labour

A gendered interpretation for dietary diversification has been advocated by some authors (Starkovich / Stiner 2009). At Taforalt, obvious advantages can be seen in sharing food- acquisition responsibilities, with men, women and children (and different age groups) perhaps being able to forage for different resources. Less evident, however, is whether men and women ate differently. There are no clear signs, for example from isotopic studies of human bone to indicate dietary differences, all individuals (of both sexes) tested from S10 benefiting from a highly uniform, or standardised, diet (Chapter 17); the number of individuals included in the present work is too small and there are other uncontrolled variables, such as growth and health status, that could impact on variation. Less obvious issues, such as the expected quicker weaning of infants allowed by an increase in starchy foods, might also be relevant.

In any case, consideration of most available ethnographic parallels shows that, although the patterns of division of labour vary (normally following group risk-perception norms and sometimes – even often – in a manner which could not be predicted from evidence at merely 'archaeological grade') between different hunter-gatherer groups, very significant divisions there usually are, as summarised in the following examples. In a 2004-06 field study amongst the non-sedentary Hadza (Tanzania), an egalitarian yet highly role-dichotomised society near the median value of warm-climate foragers for numerous cultural traits, female foraging has shown a mixture of expected and less obvious characteristics:

> […] Hadza women eat and share over 800 kilocalories outside of camp per person/day. They regularly give and receive food, including gifts of honey from men. Breastfeeding women are more likely to give gifts and give more gifts than non-breastfeeding women. When they bring nurslings with them outside of camp, they forage less kilocalories per hour. Post-menopausal women eat less relative to what they forage, are less likely to receive gifts, rest less and forage more than pre-menopausal women. Although Hadza women describe their foraging workload as most difficult during late pregnancy, no significant differences in eating, sharing, resting or foraging are observed for pregnant women. (Fitzpatrick 2018, Abstract)

Fitzpatrick adds that even allowing for off-site consumption, Hadza women still, on average, bring more food back to camp than do men, although not necessarily always a full range of nutritional requirements. It is also noteworthy that Hadza children spend much time foraging from a very early age, whilst women may sometimes forego particular activities, promising relatively high returns but requiring skill and/or strength, to work with a team of children to achieve even greater returns from an easily collected resource (such as berries). Both the differences between the sexes and the involvement of children seen in the Hadza (in relatively mobile groups using patchy, rich, varied and predictable resources in topographically varied terrain) seem to be much less developed amongst the !Kung (Botswana) (in more sedentary dry-season camps with less predictable resources in a rather flat and monotonous landscape) – once strong enough, !Kung children are often expected to contribute by staying in camp to crack mongongo nuts (Hawkes/O'Connell/Blurton Jones 2018).

One solid finding in this context from the Taforalt skeletal material is that femoral robusticity in women is certainly not lower than in men (see Chapter 16), demonstrating clearly what ethnographic parallels would lead us to expect, namely, that women were definitely moving around this rugged terrain on a regular basis.

Risk Management and Storage

One of the correlatives of largescale harvesting of perishable and highly seasonal resources (particularly fruits, such as acorns and pine nuts) is that they produce potentially large food surpluses which, if not consumed immediately, could have been wasted. Wherever possible, preparation and storage of any surplus would have constituted a vital element of risk management.

Those technologies involved in food preparation and preservation are well evidenced in the Grey Series. The best candidate for a local technological innovation is perhaps the recognition of calorific benefit seen in the shift to the use of heated calc-limestone in the upper GS. Whilst the nature of all excavations to date at Taforalt have not been conducive (for varying reasons) to the recovery of specific built structures in the GS, it is plausible to suggest that the wide variety of evidence for the increasing use of heating/burning may well imply greater diversity and complexity in pyrolithic and associated processes (principally, various approaches to de-husking, detoxification, drying, cooking, etc.), a topic with clear potential for future technological studies. Grinding and pounding tools are present throughout the GS and, whilst these were commonly used to powder ochre towards the back of the cave, they may well have been employed dominantly in food preparation further forwards in the site. We have deduced the use of woven fibres, based upon charred remains, phytoliths and appropriate bone tools, implying baskets, mats and cordage (Chapters 6, 7 and 13.1). There are even traces of what may have been composite materials, involving organic fibres and clay (Chapters 2, 3 and 14.1). Again as a suggestion for future work, although usually recovered from difficult (oxidising) contexts, it might be possible to identify organic residues on grindstones or on/within clay fragments. Another possible method, complementing the use of moveable basketry or skins, would have been storage in hand-dug pits, perhaps lined with matting or designed to hold basket containers, although the very few small pits found to date (in the 1950s) are more plausibly interpreted as waste disposal features (Chapter 2). Local informants have told us that unprocessed acorns can be stored for six months in esparto baskets; our own comparative collections of acorns would suggest that they only blacken and become inedible after about a year. Again, the 'shelf life' of flour is approximately a year, depending on storage conditions, whilst roasted legumes can be kept for over a year. Seeds of grasses can be stored for longer periods, as can processed (dried) fruit. In all these cases, the key is to protect the food from damp and vermin. Indeed, it is said that the only difficulty in preserving well prepared jerky for 3-5 years is keeping it sufficiently dry, a point which recalls the advantage in hanging such materials close to a more or less continuous source of heat and smoke.

Storage implies at least use of 'persistent places' but not necessarily sedentism, since groups may leave some stored goods at particular sites for later retrieval. Storage may be characterised by the 'loading' (timing) of the effort involved. Back-loaded resources (e.g. acorns and pine nuts) are 'cheap' to procure and store but much effort is involved in processing them before eventual consumption. Front-loaded resources (e.g. fish, meat and many roots) are 'expensive' to procure and process before storage but, once stored, do not take a lot of time to prepare for eating. Groups contemplating storage, especially if they are somewhat mobile, will be sensitive to the risk of not being able to use stored reserves. While overall handling time for back-loaded resources may be higher than it is for front-loaded resources, the latter are clearly more risky for more mobile foragers because the costs (and even chances) of not using stored reserves is relatively high. If back-loaded resources are stored instead, not much is lost even if the stores are not used. Tushingham/Bettinger (2018) have developed a theory of "storage defense", based upon these principles, characterising some American west-coast pre-agricultural groups as showing "expansive territorialism" (front-loaded resources dominantly stored, with larger and/or more complex groups, kin based ownership of private property and outward expansion of land base, often including raiding of neighbours) or "intensive territorialism" (back-loaded resources dominantly stored with localised broadening of diet and major investment of physical effort, involving smaller rather introverted groups). This is an interesting dichotomy (with implications for degrees of sedentism and territoriality) but, at Taforalt, until we have more direct evidence concerning storage, we cannot tell whether front-loaded (e.g. dried meat, acorn flour, processed pine nuts or other de-husked seeds) or back-loaded (e.g. acorns, pine cones or other plant foods, more or less as collected) resources were favoured for storage. One might even speculate whether risk might best be managed by using both types of storage in a situation tending towards sedentism, possibly with sufficiently well established territoriality and 'storage defense' capability.

A picture is thus building of a relatively complex and extensive cultural group in the Grey Series at Taforalt. Group size is obviously a risk in its own right, with respect to the potential exhaustion of local resources. However, a larger group may allow more diverse approaches, such as multiple simultaneous hunting and gathering groups, using personnel with different skill sets, targeting a wider breadth of resources, such collective flexibility helping to manage risk overall. With a secure and reliable home base, it might even have been the case that longer distance forays would have been less risky. We have noted how the surrounding landscape would appear to have presented a diverse mosaic of microhabitats (perhaps shifting altitudinally with minor changes in climatic factors and even seasonally) which would have represented relatively predictable foraging patches. We can identify gross habitat differences; for instance, there would be clear specialisation in more open habitats for hunting some mammals (e.g. *A. lervia* in the highlands, gazelle in the lowlands), compared with woodland resources for the principal food plants. With respect to plant species, holm oaks and terebinth pistachio grow better on north-facing slopes, whilst juniper and pine do better on south-facing slopes. In fact, the diverse range of foodstuffs (and other useful materials) for which we have evidence probably implies a much deeper knowledge of the available local patch choices than would be expected in a very high mobility group. As a comparison, at least with respect to animal species exploitation, Merzoug notes (2017 but otherwise unpublished) a tendency towards diversification at Afalou Bou Rhummel (Algeria) through the interval 15-13 cal ky BP, during more or less the Taforalt GS timescale.

Evidence of Increased Sedentism

The arguments suggesting an increasingly 'central place' subsistence economy at Taforalt have been discussed in some detail above. If sedentism is defined, very loosely, as "the occupation of central places or base camps through a significant portion of an annual cycle" (Zeder 2012, 253), then there is strong evidence in the Grey Series, onwards from a date of c. 15,000 cal BP, that this behaviour can be recognised at Taforalt. Probable indicators of sedentism have been deduced from the archaeological record (cf. Henry 1985; Boyd 2006), although most researchers are quick to point out that no single characteristic is diagnostic of sedentism and that different combinations of traits seem to occur in different groups of later hunter-gatherer across the globe. Even the definition of sedentism given above begs the questions of what constitutes 'significant' and of the extent to which the archaeological record will allow accurate recognition of this cultural threshold.

We may therefore note, in the context of Taforalt, the various indicators usually cited in the context of the onset of sedentism. The sheer scale, in thickness and area, of the deposits in question suggests a relatively large group (see also below); the lack of geogenic sediments in the 4 metre GS sequence and the continuity and progression in the various lines of evidence of behaviour all point towards strong persistence of site use. Again, the richness in contained artefacts and midden debris is remarkable; there are increasing expedient lithic tools (local limestone), as well as increases in the representation of unclassified debris and debitage as compared with well-typed retouched tools, all factors suggesting permanence. We have some evidence of *A. lervia* hunting (probably the principal prey species) during many months of the year and the surrounding environment certainly provided the potential for more continuous foraging, using diverse and often predictable food resources, both animal and plant – the cave was most strategically placed in this respect. There is little evidence for formal habitation structures at Taforalt but excavations to date have not addressed the issue of the organisation of space in this rather difficult, stony-ash context. The one zone in the cave that is entirely spatially distinct comprises the cemetery areas at the back, such activity, both in numbers of burials (many of them demonstrably primary) and evidence of ritual (including special grave goods), having shown at least a degree of persistence and possibly some 'development' through time. Some of the burials had plausible markers (including rocks above some adults and 'blue stones' over infants), if not actually at the surface, at least in a manner to discourage later disturbance. The relationship between individual members of the group can be further tested through DNA studies; recent investigation (Loosdrecht et al. 2018) has indicated direct sibling relationships between at least two of the sampled human individuals showing that related kin were buried together in the cave (see above). The gathering of enormous quantities of stone for various pyrolithic purposes, the continual preparation of the burial ground and the grinding of large quantities of red ochre in conjunction with burials – all are examples of activities that would have required very considerable expenditure of energy. There are indeed relatively heavy grinding tools, although these could have been cached between site visits. As an adjunct to such seasonally abundant resources as nuts, fruits and seeds (sweet acorns, pine nuts, juniper berries, terebinth pistachio, etc.), wild pulses and wild oats, we have argued for very significant food storage. Storage pits are a common feature of early settlement sites, although Wendrich/Holdaway 2018 have shown that such pits can also be hidden from sight. At Taforalt, we have very little evidence for pits and we believe much of the storage would have been above-ground, in baskets and skins. There are suggestions of the possibility of clay-coated basketry, relatively fragile containers which would certainly not have been portable. Since Taforalt is a large and rather obvious cave (for any human or animal moving down the valley), it is difficult to see how above-ground storage could be secured without requiring storage defense capability. It is noteworthy that few pit-forms that have been recognised to date seem best suited to waste disposal towards the outer part of the site, another common indicator of more permanent habitation.

A cumulative argument in this context involves the high prevalence of caries among the individuals buried at the back of the cave (see below), an observation which points to a regular intake of plants rich in carbohydrates, such as acorns. A routine consumption of acorns cannot be achieved unless there is storage (see above).

Most lines of bioarchaeological evidence do not indicate sedentism *per se*. In the literature, they are used comparatively (i. e. on either side of a transition) to indicate a change in the level of 'stress' to which a population is exposed, traditionally considered to increase during uptake of sedentism (normally conflated with onset of food productions). At Taforalt, we cannot make these comparisons, as we do not have data from before any possible transition.

Less consideration is usually given to the potential disadvantages of living in groups, especially co-habiting for considerable periods at close quarters in a cave. One of these must have been susceptibility to infectious diseases, which are easily transmitted between adults and children living in close proximity. That the humans at Taforalt display a high incidence of dental caries is considered to be indicative of a broader range of negative health impacts; indeed, we have concluded: "Although there is uncertainty of the directionality between oral pathology and systemic health […], the high prevalence of oral pathology recorded at Taforalt can be interpreted as an indication of overall poor health status with increased disease load and mortality" (Humphrey et al. 2014, 958). Dental caries is an infectious disease that is spread by close physical contact between infected and non-infected individuals and indirect contact through behaviours such as sharing of food utensils (cf. Chapter 16). It is clear from these occurrences that by about 15,000 cal BP, *Streptococcus mutans* or other causative agents of human dental caries, must have been widely present in North African human populations. High caries prevalence has been closely linked to frequent consumption of plant foods rich in fermentable carbohydrates, associated with a shift in the composition of oral bacteria (Humphrey et al. 2014). De Groote/Morales/Humphrey 2018 now argue that high caries rates are probably characteristic of the Iberomaurusian as a whole, suggesting that both subsistence patterns and cariogenic bacteria were broadly shared, the main points of comparison being the large cave site of Taforalt and the much smaller and less intensively occupied rock shelter of Afalou Bou Rhummel (Algeria). This suggests that by that time people might have been living regionally at sufficiently high density to increase the likelihood of spreading disease. One assumes that the Taforalt population would also have suffered from many other infectious diseases but these are much less likely to leave unambiguous traces on the human skeleton, particularly if individual succumb before any skeletal or dental manifestations of the disease have time to develop. Two derived allele states, that are thought to be associated with an increased resistance to leprosy, tuberculosis and other mycobacterial diseases, are found in some individuals from Taforalt (van de Loosdrecht et al. 2018), suggesting previous exposure to these highly infectious diseases; the Taforalt population themselves (rather than simply some line in their forebears) may even have been directly exposed to these risks.

Another, albeit lesser, disadvantage in more sedentary living, especially in caves such as Taforalt, would have been competition from other species. It should be mentioned in this context that Arambourg (in: Roche 1963) continued to note evidence of predator competition (e.g. hyaenas, leopards, etc.) and potential carnivore scavengers (e.g. various small canids) in most GS levels of the cave. In our own work (**Chapter 9.1**), a relatively low count of carnivore-gnawed bones in Sector 8 YS drops even further in the GS but does not disappear entirely. It would therefore seem that humans at Taforalt were very much able to hold their own.

There appears to have been a slight shift in the relationship between humans and micromammals (especially rodents). We have already noted that, after adjustment for sedimentation rates, microfaunal bone fragment counts (plausibly dominated by micromammals) show a two- to threefold decrease from the YS to the GS (**fig. 8.5**). On the other hand, larger bone fragments in the YS show little modification, whilst there is a small percentage of rodent-gnawed bone in the GS (**Chapter 9.1**). Thus, if many micromammal and other small species tended to practice avoidance of 'persistent humans' in the GS, a few seem to have taken advantage of the concentrated food sources, gnawed bone leaving an archaeological trace but grains and dried fruits perhaps pilfered more prejudicially in the eyes of the human inhabitants but invisibly to us.

As already noted, it is often difficult to prove sedentism from the archaeological record. Many factors in the Grey Series at Taforalt are highly suggestive, whilst other supposedly diagnostic indicators are lacking. There are even ample reasons to suspect that at least significant groups maintained considerable targeted, sometimes seasonal, mobility. Conversely, it is entirely plausible to envisage a core of the group (possibly including the young and old) remaining at the cave throughout the year. One might suggest a series of related groups that perhaps aggregated at the site during the summer and autumn, when available resources were plentiful, fissioning at other times of the year. Taking the parameter we are trying to assess as being more of a continuum, from extremely mobile to extremely sedentary, there is perhaps sufficient evidence to suggest that the Taforalt case falls a little into the 'more sedentary' half of the scale, certainly more so than might have been expected simply from the late Pleistocene context.

Population Levels

Given the importance of demographic pressure in arguments concerning the BSR, is there any evidence that this is likely to have been a major factor in setting into motion changes recorded in the Grey Series? In answering this question we have already considered and discounted the most obvious proxies such as a decline in the number of primary prey species (*A. lervia*). However, it may be no coincidence that it is from about 15,000 cal BP onwards at Taforalt that we also note increases in 'productivity' and general 'intensification' in the exploitation of edible plants and other foods. In theory, any rise in population would have carried risks but there may have been considerable benefits too (see above). Although we can argue that there was a general rise in demography during this period it is nonetheless difficult to recognise any signs of the population out-stripping local resources or that they were experiencing resource stress.

Another possible indicator of a general population increase with reduction in residential mobility may come from signs of increasing regionalisation in lithic assemblages towards the end of the Pleistocene and early

Holocene across the Maghreb (Hogue 2014). Lubell/Sheppard/Jackes (1984) have used this to argue that distinctive regionalised styles developed as populations moved into more stable territories and saw greater need to maintain their own identity. This is less clearly demonstrated at Taforalt, although distinctive point types such as *Aïn Kéda* points, segments, isosceles and small scalene triangles do appear more common in the Upper Phase, perhaps linked with the emergence of local stylistic groupings. There is little evidence of group signalling in the region, through adornment or 'art', although, of course, we know nothing of the treatment of perishable organic substrates (including the human body). In respect of group identification, much has been written about tooth evulsion but, since more or less all burial sites in the region show this practice in more or less the same way, it is difficult to see how 'others' would be differentiated from any given 'in-group'; perhaps this practice served the opposite purpose, to unify groups across the region.

If population levels were indeed rising regionally (even if not to levels that would produce substantial stress), this may have produced some feed-back with respect to sedentism. For instance, because it is plausible to argue for reliance upon significant food storage in the Taforalt Grey Series, it is equally plausible to suggest that an increased, even permanent, level of safeguarding might have been a sensible precaution (although we stress that there is no obvious evidence of inter-group conflict).

A Special Place

One question not yet fully addressed is why Taforalt was singled out as a location for habitation. Amongst the reasons set out by Roche (1963, 45) was that it lay close to a permanent spring providing a constant water source. He also felt that the cave occupied a good defensive position and sat close to a number of important communication routes in the Beni Snassen mountains. Furthermore, the natural geology provided a range of raw materials useful to the inhabitants of the cave. While some of these features are of questionable relevance (there is no evidence for warfare or interpersonal violence that might suggest a truly defensive function, though we have noted that significant food storage might have proven a temptation for others), in our view one of the most significant of these would have been the likely presence of a natural springline. While the actual emergences were probably closer to the present village than the cave (see Chapters 1 and 2), a persistent springline on the hillside above the cave would certainly have afforded advantages in providing running water for humans and local fauna/flora alike. Another important consideration, not fully realised by Roche, were the topographic factors that offered a mosaic of habitats in the vicinity of the cave. As we have already outlined, this would have bestowed great benefits in increasing the diversity of edible resources but also possibly in extending availability of various plant and animal foods throughout the annual cycle. In addition, it can be noted that today there are predictable resource-rich patches around the cave and in the neighbouring areas of the Moulouya basin and there is no reason why these should not have existed in thermo-Mediterranean environments in the past. Thus, it is clear that one of the main advantages of the site is that it lay near the junction of multiple resource zones, and it was this that enabled a subsistence economy, based on a wide range of plentiful and predictably available resources, to prosper and to support an at least partially sedentary, culturally stable community for several thousand years.

Hunter-gatherer culture usually involves some subsistence 'currencies', additional to basic energy and nutrients, resulting in what more recent OFT modellers tend to call "adaptive non-foraging activities". That is not to say that such activities need be non-practical, putting stress on the society's resources. For instance, competition for prestige can often go hand in hand with a sharing strategy that ultimately provides additional risk management to even out procurement irregularities. In this context, one may wonder whether Taforalt might have benefitted from cultural aspirations that could have made it a regionally 'special place' in the GS period. No other site of similar scope and scale has (yet) been discovered in the general vicinity, whilst the burial evidence alone is remarkable. Recognised status as a 'special place' could give an additional risk management advantage, allowing individuals to join or leave the central group with ease (carrying outwards, or gaining inward, a measure of 'prestige'), in order to balance at least minor stresses. Such status could also have allowed gatherings of additional bands, perhaps even of different 'tribal' groups, to engage in exchange of various sorts – materials, information, personnel. Larger gatherings (often in the winter season) used to occur in many hunter-gatherer groups, including some in the Kalahari and Australia, even involving participants from different language groups. Future research into genetic, and isotopic and trace element analysis, of bones and teeth might provide some insight into breadth of human interactions at Taforalt.

Continued Longer-Distance Links – Travel or Trade?

If we adopt a 'central place foraging' model as the most plausible with our current Taforalt data, there are obvious resource distance implications, although these are mostly mitigated by the special location of the cave. However, the 'predictability' of the actual cave (location, water and food stores) in its own right would have made longer distance travel less risky.

There is a need to look more closely at very mobile large and herd game to see whether or not it declines over time. Our current sample sizes are too small but the possibility of decline (which might suggest reduction in longer-distance hunting) could usefully act as a null-hypothesis for future studies. So far, we only have great bustard (*Otis* sp.) in S10 in the relatively early GS (although sufficient bird collections have not yet been established and studied for most of the LSA sequence). With respect to the 'mountains vs. plains' question, one may note the definite persistence, if not actual modest increase on average through time, in ostrich eggshell in the 1950s collection. Belcastro/Condemi/Mariotti 2010 note much eggshell with ochre on a (skeletonised) burial putatively later in the Taforalt sequence than the S10 examples. The issue of great bustards and ostriches is important but probably much more complex (meaning, secondary products, hunting areas) than simple dietary considerations (cf. Chapter 10). All that can be said at present is that, on the available isotopic data (Chapter 17), there is no evidence of a marine dietary contribution, at least during the relatively short time interval represented by the S10 burials.

The one category which we can be certain were derived from some distance comprises (non-fossil) marine shells and it is noteworthy that these are reported in Roche (1963) in all *Niveaux*/levels of the GS. The question as to whether these were fetched directly from the sea shore during trips from Taforalt or were exchanged with a coastal group remains to be studied. It is germane that Merzoug (2017) notes that, in Mediterranean coastal sites, there is a marked increase in marine shell exploitation (as food as well as for ornamentation) in the 'Recent Iberomaurusian' (an interval which Merzoug starts from around the time of HE1). Again with respect to near-coast sites, certain heavy duty items, such as grinding stones, may have been brought in from distance; Sari (2012, 37) reports the presence of such items at Afalou Bou Rhummel and Tamar Hat (Algeria) that derive from outcrops some 30 km distant.

Environmental Triggers and Forcing

The general correspondence between the veritable explosion in human activity during the Grey Series, involving an increase in productivity continuing up through most of that interval, and the slightly more humid and environmentally productive last interstadial (GI1) is clear. It seems indisputable that the relatively benign environmental conditions permitted, even nurtured, the Taforalt GS phenomenon for over two millennia. But did these conditions actually trigger the cultural phenomenon? The short answer to this question is that, whilst wholly plausible, we still cannot be sure.

As an alternative scenario, was there a short period (a very few centuries only) of raised aridity, even perhaps also involving slightly cooler conditions, in this region, dating from around 15,000 cal BP, a period possibly equivalent to the "Oldest Dryas" or "Pre-Bølling" in Europe? Is the apparent evidence of (at least access to) arid biotopes (Barbary ground squirrel, Moorish gecko, C_4 phytolith component, juniper/thuja charcoal) at the base of the GS referable to such a period? One may hypothesise that, since human societies are usually rather 'conservative' or 'risk-averse', a short, sharp dose of environmental forcing might have been enough, or even have been necessary, to precipitate a major behavioural shift (but, notably, without an accompanying change in lithic typology), almost immediate thereafter found by the local population to be full of new potential, as conditions markedly improved into the interstadial – a form of 'pre-adaptation', perhaps. This might be a rather attractive story, promising to reconcile many of the behavioural models we have been discussing. However, the arid indicators noted above are demonstrably part of a mixed assemblage; the evidence in hand at Taforalt is simply not yet solid or precise enough.

For the moment, we have no compelling explanation(s) for the onset of the GS, even if an environmental change (whether immediately for the better or temporarily for the worse) seems likely to have contributed. We are able to note that such specific cultural traits as full development of pyrolithic techniques or instigation of a formal cemetery area do not seem to appear until a few centuries after the beginning of this period, such that they cannot themselves have been triggers in their own right, even if they probably acted as accelerators. It is frustrating that such a key issue in the development of Iberomaurusian culture should remain elusive. This is all the more reason why future proactive research, at Taforalt and neighbouring sites, should seek more reliable and detailed data on the possible combinations of cultural and environmental factors likely to be most directly responsible for this major behavioural shift.

Niche-Construction

In this chapter, we have considered various OFT possibilities, with the addition of forcing factors, as possible explanations for the broadening of dietary spectrum at Taforalt. These include explanations particularly for dropping mobility, intensification, diversification and resource depression, none of which seems particularly convincing in the case of Taforalt, only bearing in mind the uncertainty noted above in the environmental setting at the very start of the Grey Series. An alternative set of explanations that might better fit the development of a broadening resource spectrum has been developed in relation to Niche Construction Theory (NCT). This has been described as a purposeful behaviour "that seeks to shape the environment in ways that directly and in the long-term promote the viability of the groups that practice this behavior" (Zeder 2012, 258).

It is worth stressing from the outset that any suggestions of broadening resource spectra in the Iberomaurusian of North Africa should not be confused with extreme forms of niche construction, namely, incipient food production or other nascent agricultural practices leading to a 'Neolithic Stage'. At Taforalt, for example, there is no compelling evidence for the precocious domestication of either plants or animals. One may note in passing that the Maghreb was a secondary centre of agricultural biodiversity and no species was certainly domesticated here in the earlier Holocene; in any case, when domesticates did arrive in North Africa, local populations usually kept exploiting wild plants and animals, with domesticates playing only a minor role (Morales 2018). Where changes are observed in the Iberomaurusian, such as a rise in the exploitation of land snails, there is no sign of deliberate strategies to enhance locally the abundance or quality of molluscan resources (Taylor et al. 2011; Chapter 9); unlike Lubell (2004a), we do not see such changes as necessarily setting a group on the trajectory leading to domestication. Another potential food source that might have offered opportunities for management or domestication was the Barbary sheep. However, despite the ubiquitous nature of this animal at Taforalt, present in the majority of LSA levels, there is nothing to suggest it was under proximal control, as might be shown by layers (or even individual aggregates) of dung or linear postholes to imply deliberate corralling or penning, as are reported in the Sahara in the Early Holocene (di Lernia 2001). Even the best known claim for Iberomaurusian Barbary sheep management, made by Saxon et al. (1974) concerning the site of Tamar Hat (Algeria), has more recently been dismissed: in a re-analysis of the original bone collection, Merzoug/Sari (2008) state categorically that this is a hunted assemblage.

Examples of suggested NCT from the Levant and Anatolia (see Zeder 2012 and contained references) show that the cumulative effects, although falling well short of domestication, sometimes resulted in profound modification of environments and the associated biota, which again does not seem to have been the case at Taforalt.

Nonetheless, other observations, said to be characteristic of human niche-construction, seem familiar from our Taforalt studies. Zeder (2012, 258) makes the following points:

> […] From a NCT perspective, for example, broad spectrum resource diversification is not likely to occur in marginal environments or in regions where (as a result of environmental change or demographic growth) human groups are pushing up against regional carrying capacity. Rather the BSR is more likely to take root in highly productive 'resource rich' ecosystems where there is an abundance of densely distributed and highly predictable resources of potential economic value. In particular, environments having a mosaic of eco-zones that support diverse arrays of abundant and seasonally predictable resources can be recognized as providing high probability settings for the BSR. This combination of abundance and predictability […] makes it possible for human groups to reduce mobility, or give up residential mobility altogether, usually settling in logistical locations at the confluence of multiple eco-zones where different members of the group (men, women, and children) can access different sets of resources at different times of the year. The broadening of the resource base seen among BSR economies is, then, not a response to resource depression, but rather the result of people taking advantage of environmental opportunity.

It is straightforward to see how a niche-construction scenario could lead to ideas of ownership and territoriality, increased sedentism, more complex division of labour, growing (but still not stressed) population and deepening social complexity. The problem, however, is the degree to which NCT has explanatory power in its own right. For instance, Zeder (ibid.) speaks of "this 'rich environment' critical test", yet it is not obvious what she means by this – in what way is this a "test"? It is simple to imagine (with ample ethnographic parallels as to plausibility) that children might be sent off to keep birds away from estivating snails or rodents from temporary piles of pine-cones, until such time a sufficient group could be mustered to bring the 'crop' back to the cave, or that transitory pools might be created in the river bed with just a low stone dam (extremely unlikely to be preserved in the context of the Zegzel), to encourage catfish or other aquatic resources – these are subtle yet productive forms of niche-construction but how do we prove such practices? It must be recognised that it will usually be very difficult to identify a robust signal of niche-construction in the archaeological record in pre-agricultural contexts (cf. Smith 2015), even if ethnographic parallels seem to suggest that hunter-gatherers will usually find ways to improve their environment.

However, one potential aspect of niche-construction which might be open to more accurate testing is the deliberate disturbance of the landscape by the use of broadcast fires (the deliberate setting and management of fire for clearance and regeneration purposes). Bird/Bird/Codding (2016) suggest that foraging strategies that depend on intermediate disturbance (broadcast fires) to maintain immediate foraging efficiency can feed back to increase patchiness, habitat heterogeneity, incentives towards storage and the opportunities of sedentism; although these authors use specifically Australian (and to a lesser extent Asian and American) data in their modelling, they suggest that the deliberate production of "pyrodiversity" may be a characteristic of the BSR in many other regions. Nevertheless, it should be noted that, whilst deliberate landscape fire regimes have so far failed to be proven from areas such as Palaeolithic Europe (cf. Daniau/D'Errico/Sánchez Goñi 2010), such regimes are indeed suspected to have occurred during the moister parts of the late Last Glacial (especially during the last interstadial) in Southwest Asia (Anatolia, the Levant and neighbouring regions) (Turner et al. 2010). In the Taforalt context, the possibility of such a use of fire would need to be tested in the future through the examination (e.g. by studies of micro-charcoals, infrared spectroscopy FTIR and sediment magnetic properties) of persistent exterior sediment traps, for instance, in closed depressions in the general Zegzel catchment. The only possibly suggestive tendency so far noted at Taforalt is the increasing presence of pines among the wood charcoals during the Grey Series (see Chapter 5), since pines are pyrophyte plants, their seedling growing better after a fire, contrary to the case with junipers and thuja (araar). Indeed, oaks, which show a slight increase again towards the top of the GS, are also pyrophytes.

The Taforalt Evidence Relevant to Foraging, Procurement and Other Behavioural Theories – Conclusions

In considering subsistence and other behavioural evidence from Taforalt (see the summary in fig. 18.2), we have consistently failed to find signs of the sort of constraint-driven, almost mechanistic processes that seem to have been proposed in some early models of Broad Spectrum Revolution and Optimal Foraging Theory. In particular, we cannot see any strong effects plausibly attributable to either 'demographic stress' or 'persistent environmental deterioration'. We do indeed see broadening of the resource spectrum into the Grey Series, even if, due to past excavations and our own sampling strategies to date, we do not have sufficiently detailed evidence to judge just how broad. Niche-construction models seem to fit very well with the 'background' suggested by our data, although we still lack the evidence to move on this count from possibility to likelihood. This having been said, optimisation in foraging activities is an intuitively attractive proposition, both in terms of 'rational behaviour of individuals' and biological evolution ('fitness') overall, and simply cannot be dismissed out of hand. Subsistence models work best in identifying topics which should, or at least might, be relevant, driving us to acquire more appropriate and reliable evidence towards the discovery of what 'actually happened' in specific cases. Models work worst when they are allowed to drive interpretation, irrespective of paucity of data.

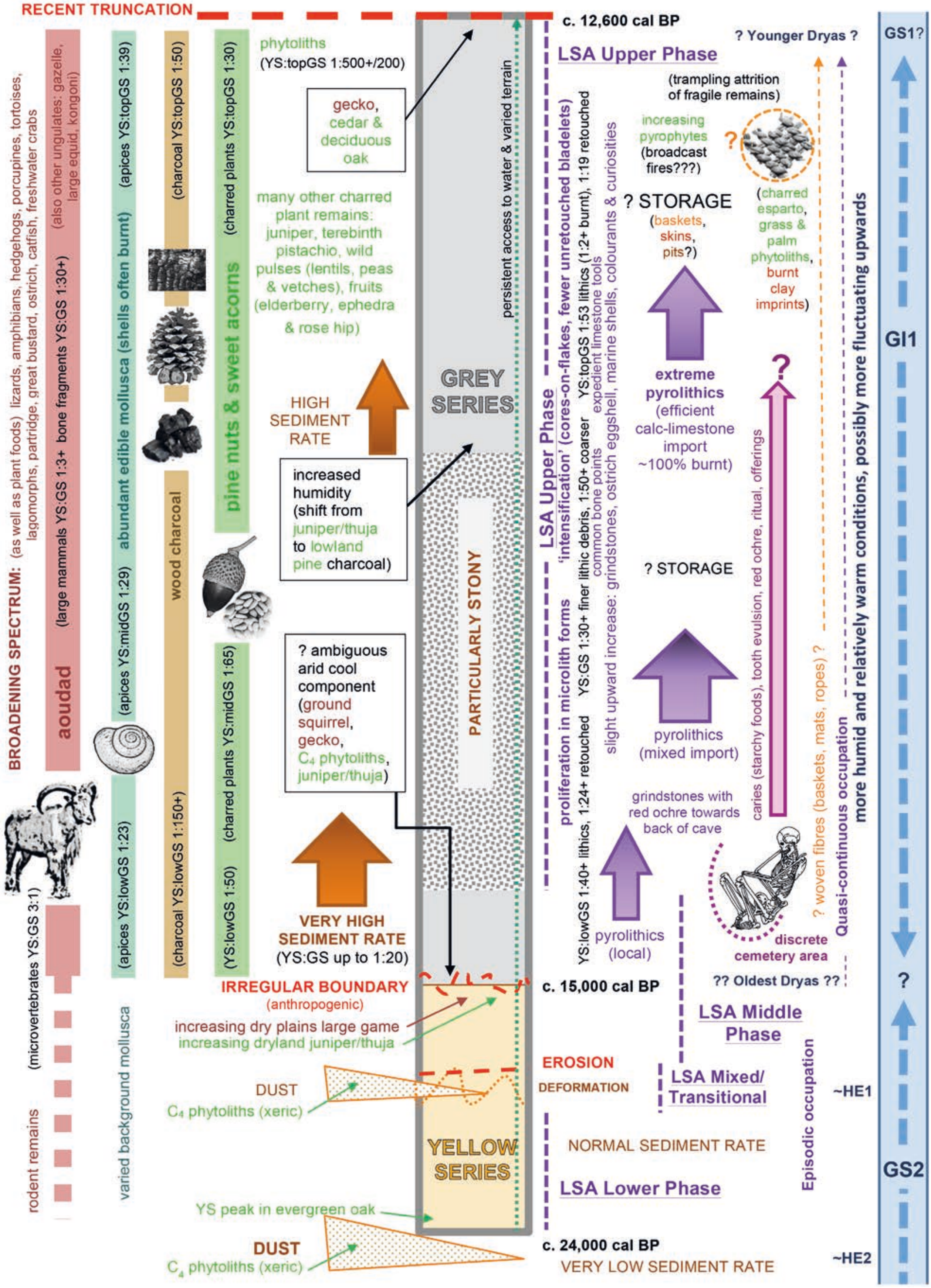


Fig. 18.2 Summary of main subsistence and other behavioural evidence from Taforalt, against the environmental background.

18.7 BEFORE AND AFTER TAFORALT

Iberomaurusian Origins

Little is known for certain about the origins of the Iberomaurusian. The impression that the techno-complex appeared suddenly in the region is not refuted here. Indeed at Taforalt an abrupt change in the lithic assemblage occurs in S9-CTX10 at around 22,166-22,569 cal BP, following a brief hiatus in site activity that coincided with a climatically arid phase. The underlying units (S9-CTX11 and 12) contain a distinctive 'adze industry' which seems to share no obvious techno-typological or functional similarities with the Iberomaurusian (Barton et al. 2016). However, the difficulty at present is that there are no other sites in Morocco with a comparably detailed archaeological record and the adze industry has not yet been recognised elsewhere, with the possible exception of Ghar Cahal in the north (Bouzouggar, pers. obs.). Apart from major innovatory change in bladelets and backed tools, there are few other characteristic indicators signalled at the start of the Iberomaurusian. At Taforalt, we can remark on a number of absences in the early phase such as grindstones, large burnt stones, a scarcity of pigment use and no burials. All of these, including the portable nature of the toolkits, seem to point to a relatively mobile lifestyle in the early Iberomaurusian. It would be interesting to know if people at this time moved to and from the coast. Some support for contemporary occupation of the coastal zone comes from Tamar Hat in Algeria which has some of the earliest dates for the Iberomaurusian (Hogue/Barton 2016) and, like Taforalt, seems to reflect evidence of ephemeral use.

Some further detail comes from the study of archaeogenetics. Mitochondrial consensus sequences of the Taforalt individuals belong to the U6a (n = 6) and M1 (n = 1) haplogroups and the divergence time of both haplogroups is calculated to ~24,000 BP (van de Loosdrecht et al. 2018). This is in remarkably close agreement with the age of the currently known earliest Iberomaurusian and may imply a back-into-Africa dispersal at this time by people with a distinctive microlithic backed bladelet tradition. Initial analysis of the genetic profile of Taforalt suggests substantial Natufian-related (63.5 %) and sub-Saharan African-related (36.5 %) ancestries (van de Loosdrecht et al. 2018). A subsequent study has proposed an alternative scenario, whereby West Africans derived part of their ancestry from a Taforalt-related group, allowing for a local North African component in the ancestry of Taforalt (Lazaridis et al. 2018). Neither study found support for gene flow from the Epi-Gravettian or other related Epipalaeolithic European populations into the Taforalt population, making it unlikely that Italy or Spain were the sources of such movements. Equally, the available dating for the Iberomaurusian is as early, if not earlier than, the Epipalaeolithic in Northeast Africa, so this would appear to rule out a simple influx of populations from Libya, Egypt or the Levant. Therefore, all that can safely be said for now is that the Iberomaurusian is a widespread phenomenon in the Maghreb that could represent a mainly indigenous development. In contrast to other regions of North Africa, it appears to have replaced or grown out of an underlying base-line of MSA traditions. This is unlike Libya or areas further east, where the Epipalaeolithic directly overlies industries of the 'Upper Palaeolithic'.

Into the Holocene

Although any potential signs of later activity at Taforalt, beyond about 12,566-12,713 cal BP, were erased in the 20th century, there is strong evidence that an Iberomaurusian-like tradition continued in eastern and northern Morocco into the Holocene (Bouzouggar et al. 2008; Barton et al. 2008; Linstädter/Eiwanger/Mikdad/Weniger 2012). One of the most important local sites is that of Ifri Oudadane which lies at the coast about 70 km northwest of Taforalt. This rockshelter has a long sequence of occupation extending

from c. 11,000 to 5,700 cal BP, including the transition to the Neolithic at around 7,600 cal BP (Linstädter et al. 2015). The pre-Neolithic levels were identified as Epipalaeolithic and had elements in common with the Iberomaurusian. These included a bladelet technology with a toolkit dominated by backed bladelets, some geometric microliths as well as notched and denticulated pieces. Rich palaeobotanical evidence from the Epipalaeolithic levels indicated a relatively humid climate with dominance of riparian forest and the xerothermophilous scrub composed mainly of wild olive and mastic (Zapata et al. 2013). The archaeological assemblage contained ample evidence for the exploitation of a mixture of marine and terrestrial resources. The former included seabirds, marine turtles, fish and shellfish but the diet was supplemented with large herbivores (*A. lervia*, *Gazella*, bovids) and land snails, with rabbits/hares comprising the second most important prey (after birds) (Linstädter et al. 2015; Roski 2015). The diet was therefore varied and probably opportunistic, with no obvious signs of a fluctuation in high-ranking resources. Preliminary impressions suggest that the early Holocene was marked by an increase in forest cover (Combourieu Nebout et al. 2009), which may have led to raised mobility levels and changes in the patterns of land use by hunter-gatherers that included a greater focus on coastal marine resources (Linstädter/Eiwanger/Mikdad/Weniger 2012). Other Holocene Epipalaeolithic sites in this area, including inland locations (but see the animal resources mentioned above from Columnata; Merzoug 2017), await publication and should provide a more comprehensive test of these conclusions (see Linstädter 2008).
Recent archaeogenetic analysis has shed further light on this transition, demonstrating genetic similarity between Early Neolithic Moroccans from the site of Ifri n'Amr or Moussa (~7,000 BP) (a site usually known as "Ifri n'Ammar" in studies of the LSA levels) and the Later Stone Age from Taforalt. This implies long-term genetic continuity in the region and supports the proposition that Early Neolithic traditions in parts of North Africa arose through the adoption (or, rather, accretion onto existing options) of incoming technology and domesticated stocks/strains by local populations. In contrast, the genetic makeup of Late Neolithic Moroccans from the site of Kelif el Boroud (~5,000 BP) (a site usually known as "Ifri el-Baroud" in studies of the LSA levels) has an Iberian component, supporting the model of an Iberian migration into the Maghreb at this time (Fregel et al. 2018).

18.8 FINAL THOUGHTS AND FUTURE DIRECTIONS

In this volume, we have made the case for Taforalt being a special site, formed within a very large cave in a favoured location, attracting, first, repeated Later Stone Age Iberomaurusian visits but then, after around 15,000 cal BP, sufficient human presence to create very substantial volumes of grey ashy deposits (Grey Series), including notable cemetery areas.
This sequence of 'yellow-geogenic' followed by 'grey-anthropogenic' sediments seems to be a theme repeated at many sites in the region. Though the scale of such deposits may have varied from site to site, ashy sediments have been described in the Iberomaurusian at La Mouillah (Roche 1963), El Khenzira (Ruhlmann 1936), Dar es-Soltan 1 (Ruhlmann 1951), Contrebandiers (Roche 1963), Ifri el-Baroud (Görsdorf/Eiwanger 1999), Kehf el Hammar (Barton et al. 2005) and Ifri n'Ammar (Nami/Moser 2010). However, current radiocarbon evidence is insufficient to allow a differentiation between sites in the dating of the shift. There would be important connotations in knowing whether the appearance of middens (*escargotières*) was indeed a regionally synchronous phenomenon and to identify any likely factors that might have given rise to such activity; synchrony itself might suggest (but would not prove) an environmental contribution. However, although we now know much more about the sedimentary formation processes and midden behaviour at Ta-

foralt, it remains unclear whether the accumulation of grey deposits at other sites in the region is indicative of the same or merely similar activities. For instance, we have noted that, unlike Taforalt (or, at least, unlike those parts of the GS deposits we have been able to observe ourselves), some sites (e. g. Ifri el-Baroud or Ifri n'Ammar) feature areas of very densely packed snail shells with little intervening sediment matrix. What gave rise to such variation? Was this due to taphonomic factors, or were these more like the shell middens observed at coastal locations, reflecting a different emphasis on subsistence practices, or were environmental conditions marginally different in these instances? These are some of the questions that would benefit further investigation and qualification. For the present, we may observe that the systematic collection of plant foods, the use of red ochre, of grindstones and items of organic equipment, such as bone tools, have been recorded in the grey ashy layers at several of the Iberomaurusian sites mentioned above. These broad similarities may, of course, mask more subtle differences but we would suggest that any apparent variation could also be due to a lack of research or recent small area excavation.

One possible line of future enquiry concerns aspects of behaviour that might only offer low archaeological visibility and therefore be overlooked in the excavation record. A case in point concerns the traces left by storage containers used to conserve foods and other materials through part of the year. Circumstantial evidence for storage activity at Taforalt comes from the association of large quantities of carbonised nuts and other fruits and an abundance of burnt, non-comestible grass stems that would have been ideally suited for manufacturing corded grass baskets. We have also drawn attention to the possibility that there was an established knowledge of ceramic technology which would have allowed pits to be lined with grasses and fire-hardened clay, or even free-standing containers of such a compound material, although the only evidence so far relates to the copious presence of tiny clay fragments and some larger clay pieces containing plant fibres. To search for highly fragile organic remains of course requires specially dedicated methods of micro-excavation but we would suggest that only by systematically adopting this excavation approach will it be possible to uncover delicate and fragmentary evidence of basketry or of incipient clay technology. This would also have to be undertaken in conjunction with excavation of wider horizontal units than we were able to examine at Taforalt, in order better to understand subtle site structure and use-area differentiation.

Rare finds, such as the animal figurines at Afalou and a stylised horn fragment in baked clay at Tamar Hat (both in Algeria), may represent the end products of a more widespread fired clay technology which also occurs at sites like Taforalt. Instead of zoomorphs in clay, a stylised representation of Barbary sheep was here found on a stone grindstone (Chapter 13.2), implying the significance of these animals in the artwork of the Iberomaurusian.

One example of a technology that we had barely considered when starting our excavations at Taforalt was the detail of pyrolithic usage. This is something that has not been reported before in the Iberomaurusian and would have gone unnoticed had we not observed distinctive patterns in the use of natural, burnt rock material in the archaeological deposits. In this volume we make the case that the burnt stones formed part of a sophisticated heating technology (whether for cooking or other purposes); we would expect that this activity was not limited to Taforalt and suggest that this might be a fruitful area of enquiry at other Iberomaurusian sites. Were similar methods used elsewhere for example? Did development in their use coincide with the formation of middens? How did the available lithologies interact with both the ergonomic and the taphonomic implications? Again, how structured would the evidence appear in wider area excavations? These are questions which would benefit from further investigation.

Another subject that we were unable to investigate in sufficient detail in this volume was the matter of use-wear of struck lithic artefacts and other stone tools. Given the well-preserved nature of artefacts at Taforalt, and in some cases evidence for use, we would recommend that a systematic examination of these pieces be undertaken in future. An interesting theme of research would be the use of red pigment in conjunction with stone artefacts. We have reported in this volume on the presence of ochred grindstones and the use of pigment is widely known in the Iberomaurusian (Sari 2012). Red pigment has also been observed on materials as diverse as bone tools (**Chapter 13.1**), human bone (Mariotti et al. 2009) and tortoise scutes (only at Ifri n'Ammar). Such occurrences require a range of studies from elemental and mineralogical analyses for sourcing purposes, to the microscopic examination of surfaces of ochre fragments, grindstones and individual tools themselves. This information would add considerably to the overall understanding of tool-using behaviour in the Iberomaurusian.

Whilst attention is always most drawn to evidence of change, conservative behaviours also deserve more study if we are to understand the whole more fully. As we have noted at Taforalt, there was no great modification in the microlithic bladelet technology or in the hunting of the main game animal (Barbary sheep) across the yellow-grey transition.

In sum, much remains still to investigate both at Taforalt and at other sites identified in the area or awaiting prospection. How would it affect interpretation if another cave were to be located in the vicinity of Taforalt? Would the archaeology look the same or might different activities be expected? Cautionary tales from the Near East Epipalaeolithic (cf. the strongly differing subsistence trends – dominant 'Big Game' in one, 'BSR' in another – in neighbouring and largely contemporary sites near Moghr el-Ahwal, Lebanon; Edwards/Garrard/Yazbeck 2017) are a reminder of the relatively narrow view that can be built up on the basis of a single site, no matter how thoroughly it has been studied.

We started our research by addressing a number of basic questions. Some of these we have been able to answer, in whole or in part. However, our work has perhaps proven the most useful by achieving sufficient insight to allow the formulation of a host of other interesting questions for the future.

APPENDIX 2: LITHOSTRATIGRAPHIC DESCRIPTIONS

SECTOR 3

SECTOR 3	General	Roche (1976) – Equivalent to currently available section. Note that Roche recognised the ‘Epipalaeolithic/Aterian transition’ between his Levels 17 and 18 (at a depth of more than 95 cm in the current log below), a proposition which now appears markedly incorrect [SNC]. SNC 2003: “On the H/I line in Squares 18-19, E-W face, observer looking north; local zero in SNC observations at -3.69 (m below Site Datum). Stratigraphy generally very diffuse, apparently due to bioturbation at all fine-to-medium scales.” SNC 2003: “E-W section H/I in Squares 18-21, observer looking north; SNC photos west 17 to 19 east; closer west 20 to 23 east.” SNC 2003: “By the 19/20 point (about 1 m east of the main SNC log), the stratigraphy is very heavily affected by rockfall; the darker units in the logged material seem to be grossly represented by fine grit bands further east.” SNC 2006: “Log line at the 18/19 boundary (equal to the right hand side of Roche 1976 fig.1), x 108.912, y 108.288, z -3.721 (m below Site Datum); colours all very dry; March photos 1-20 in 17-18 (plus edge of 19). Note that Roche fig.1 has squares “17” and “18” labelled wrongly (reversed); Roche’s stated thicknesses seem excessive and certainly do not fit the section drawing. Note that Roche’s radiocarbon sequence came from this section.” SNC 2006: “Simon Blockley (tephra) sampling in Sector 3 H/I at 18/19 boundary; photos 1 and 2.” Lithostratigraphic unit notation example for this column: S3[0-6], etc. (with ‘-03’, etc., if needed).
SECTOR 3	[0-6]	Roche 1976: “*Niveau X. Argiles pulvérulentes jaune-clair. Traînée cendreuse à la base. Epaisseur: 0.10 m.*” [On section H/I line at 17-18, apparently continuous across section but the base of “*Niveau VIII*” (part of Grey Series) appears undulating, possibly erosive - not clear.] [NB. In 1971, Roche still had *Niveau X* as part of the Grey Series.] SNC 2003: “Interval 0-6; buff carbonate silt, with white flecks; charcoal. Looks a little like Raynal’s Layer 5 (in Sector 2) but does not correlate.” SNC 2006:”Buff carbonate silt; equal to Roche 10; dry 7.5YR 6-7/4; charcoal at base, as suggested by Roche; in the Sector 3 section, this unit rises eastwards (out of cave) with the light buff material disappearing, i. e. a drip basin, as suggested by Courty; also lost into cave by 16/17 line.” S3[4-6] charcoal OxA-26484 13,980 ± 80 BP <TAF08-5820>.
	[c. 6-93]	Roche 1976: “*Les niveaux XI-XVI présentent un pendage moyen de 5° Est.*” SNC 2006: “The general ‘bifurcating’ of charcoal beds of Roche does not exist; the impression is mostly due to burrow disturbance.”
SECTOR 3	[6-20]	Roche 1976: “*Niveau XI. Série de petites couches alternées de sables argileux jaunes et grisâtres, se terminant en biseau aigu. Epaisseur maximum: 0.30 m.*” SNC 2003: “Interval 6-20; light reddish silt with small stones; charcoal flecks in places; many burrows (slightly browner colour).” SNC 2006: “Light red silt, dry 6YR 6/6 at top, greyer downwards 7.5YR 5/4, more orange between 5.5YR 5/6; equal to Roche 11 (wedging out westwards into cave); rather more charcoal in the lower part (below local height 13); micro-bedded couplets of greyer and more orange at < 1 cm intervals.”
	[20 down]	SNC 2006: “All the beds in this sequence rise steadily into the cave towards Sector 6; cf. photographs.”
SECTOR 3	[20-31]	Roche 1976: “*Niveau XII. Terres brunes, plus compactes que les précédentes, englobant des blocs de petite et moyenne dimension provenant de la voûte. Epaisseur moyenne: 0.20 m.*” [On section drawing H/I line at 17-18, irregular, ‘pinched’ morphology.] SNC 2003: “Interval 20-31; mid-brown silt, quite stony; common charcoal.” SNC 2006: “Brown (7.5YR 4/4, a little redder at base), quite stony (3-5 cm, 10 cm rare here but up to 30-40 cm further east); equal to Roche 12; approximately equivalent to sample <316> in Y3 (Yell03[74-80]) of Sector 8, possibly a little younger; much charcoal; unit rises westwards towards Sector 6; RNEB reports some Iberomaurusian found at approximately this level on the top of the Sector 3-6 ‘corner’, west of the current log.” SNC 2006: “Charcoal OxA-16264 15,355 ± 65 BP <TAF06-5412> at [22]. Charcoal OxA-16265 15,585 ± 65 BP <TAF06-5413> at [30].”
	[c. 31-53]	Roche 1976: “*Niveau XIII. Terres brun-noir où sont incluses des trainées cendreuses. Epaisseur maximum: 0.20 m.*” [On section drawing, apparently discontinuous lenticular forms.]
SECTOR 3	[31-39]	SNC 2003: “Interval 31-39; light brown silt and fine grit, bedded; charcoal.” SNC 2006: “Light brown silt, 7.5YR 5/4 or lighter; partially equivalent to Roche 13.”
SECTOR 3	[39-40]	SNC 2003: “Interval 39-40; charcoal-rich band; disturbed by 3-4 cm diameter burrows.” SNC 2006: “Charcoal-rich; partially equivalent to Roche 13.”
SECTOR 3	[40-45]	SNC 2003: “Interval 40-45; light brown; 3-4 cm diameter burrows.” SNC 2006: “ Light brown, very similar to [31-39]; partially equivalent to Roche 13.”

SECTOR 3	[45-47]	SNC 2003: "Interval 45-47; charcoal-rich band; disturbed by 3-4 cm diameter burrows." SNC 2006: "Charcoal-rich; partially equivalent to Roche 13."
SECTOR 3	[47-53]	SNC 2003: "Interval 47-53; light brown." SNC 2006: "Light brown, very similar to [31-39 etc.]; partially equivalent to Roche 13."
	[c. 53-78]	Roche 1976: "*Niveau XIV. Série de fines couches rubannées grises, noirâtres* […]" (p. 155) "[…] *à l'intérieur desquelles sont incluses de fines trainées cendreuses. Epaisseur maximum: 0.40 cm.*" [On the section drawing, lenses shown.]
SECTOR 3	[53-58]	SNC 2003: "Interval 53-58; stratified material, dark brown in top 1 cm, lighter band, relatively dark at base; charcoal-rich; common small burrows. This is a **marker bed**, traceable as rising to the northern corner of Sector 6 (but higher than the sediment still present in the N-S section described by SNC on the 16/17 line, in Squares I and J), where it is lost; this **marker** may therefore lie (notionally) above all units observed in Sector 2." SNC 2006: "**Marker bed**; base 7.5YR 3/3; approximately equivalent to the top of Roche 14; correlates with sample <315> in Y5 (Yell03[110-112]) of Sector 8." SNC 2006: "Charcoal sqI19 OxA-16266 20,500 ± 90 BP <TAF06-5414>, the lateral equivalent of the [58] interval here (slightly higher in I19), base of this **marker bed**, equivalent to the upper limb of Unit S8-Y5. Also, bifurcating again into the cave by the 16/17 line in H/I face."
SECTOR 3	[58-93] General	SNC 2003: "Interval 58-93; looks similar to Raynal's *Ensemble I* in Sector 2; actual correlation unsure."
SECTOR 3	[58-65]	SNC 2003: "Interval 58-65; reddish to light brown gritty silt, lighter at top; common burrows." SNC 2006: "Gritty, silty upwards; partially equivalent to Roche 14."
SECTOR 3	[65-68]	SNC 2003: "Interval 65-68; dark, very gritty material; charcoal; becoming very stony / gritty and thickening eastwards (in sqs20-21)." SNC 2006: "Extremely gritty (3.0-0.5 cm mostly), thickening eastwards; westwards, several charcoal lenses, less gritty or grit concentrated at base; partially equivalent to Roche 14." SNC 2008: "MSA side-scraper found by AOH."
SECTOR 3	[68-77]	SNC 2003: "Interval 68-77; light buff at top, browner downwards; gritty silt and small stones." SNC 2006: "Silty, gritty; partially equivalent to Roche 14."
SECTOR 3	[77-78]	SNC 2003: "Interval 77-78; darker brown band." SNC 2006: "Disturbance from burrowing in sq18; darker, charcoal; partially equivalent to Roche 14."
SECTOR 3	[78-84]	Roche 1976: "*Niveau XV. Terres grises compactes, enrobant de petits blocs tombés de la voûte. Epaisseur maximum: 0.30 m.*" [Nothing in particular shown on section drawing.] SNC 2003: "Interval 78-84; light at top, browner downwards; stony silt." SNC 2006: "Silty, stony (5-10 cm but very large blocks [1 m] eastwards; minor discontinuous charcoal lens at 78; equal to Roche 15."
SECTOR 3	[84-93]	Roche 1976: "*Niveau XVI. Terres grises, compactes, présentant la même structure rubannée que celle du niveau XIV. Certaines trainées cendreuses atteignent une longueur de 0.50 m. Epaisseur: de 0.14 m à 0.40 m.*" "*Epipaléolithique très ancien.*" [Nothing particular shown on the section drawing.] SNC 2003: "Interval 84-93; several lenses of darker brown material; subject to penecontemporaneous burrowing." SNC 2006: "Darker, 7.5YR 4-5/3; several cemented bands; more diffuse charcoal; equal to Roche 16; might be approximately equivalent to sample <314> in Y7 (Yell03[150-160]) of Section 8."
SECTOR 3	[93-120]	Roche 1976: "*Niveau XVII. Terres grises, compactes, non rubannées. Epaisseur moyenne: 0.16 m. Ce niveau correspond à l'occupation épipaléolithique la plus ancienne de la grotte. Il est directement superposé au niveau XVIII qui appartient à l'Atérien supérieur.*" "*Epipaléolithique très ancien.*" [On the section drawing, the basal unit 18? Looks a bit more stony, perhaps.] SNC 2003: "Interval 93-120; light coloured carbonate powder with small to large stones; common older speleothem (floor?) fragments." SNC 2006: "The base of Roche 17 is equivalent to the [106] level on SNC log (within this light concreted material, although this particular level is more concreted and thus more visible in sq17, west of SNC log; there is also a discontinuous < 1 cm wavy very light grey lens with charcoal at this level)." The Aterian-Epipalaeolithic contact said to be dated by *Helix* Gif 2276 32,370 +1890 - 2470 BP (Roche 1971) [SNC: unreliable].
SECTOR 3	[120+]	SNC 2003: "Interval 120+; heavily concreted material (stalagmitic floor or material cemented to underlying floor?)."

SECTOR 3	20/21 General	SNC 2006: "Log line at the 20/21 boundary on the H/I line. z -3.508 (m below Site Datum)." Lithostratigraphic unit notation example for this column: S3-20/21[0-10], etc.
SECTOR 3	20/21 [0-10]	SNC 2006: "Stony silt."
SECTOR 3	20/21 [10-12]	SNC 2006: "Platy small stones, gritty, some browner, a little charcoal; patchy, slightly disturbed; much more charcoal in zones further east; correlates with sample <317>, top C14 date in Y2spit1 (Yell03[26-30]) in Sector 8."

SECTOR 3	20/21 [83-89]	SNC 2006: "Main **marker bed**; correlates with sample <315> in Y5 (Yell03[110-112]) of Sector 8."

SECTOR 3	AOH 2009	2009 field data from Anna Oh (reported in Oh 2011, figs. 2.5, 7.1 and A2). AOH noted that most of the "Epipalaeolithic" artefacts came from the top 35-40 cm; she did not report explicitly the position in this Sector of the MSA/LSA transition but, in her fig.7.1, she appeared to show two 'groupings' (indicated by brackets alongside the section drawing) of "human occupation levels", the upper covering her interval [top-55] and the lower her intervals [62-100]; note that AOH reported (to SNC) an MSA side-scraper from a level identified by SNC with his [65-68] interval, whilst LSA material was certain at least down to his 45 level.] SNC 2008: SNC photos 1068-85, showing OSL Nos. 10 to 13 (upwards); AOH excavation approximately in sqI19, nail at top/east side x 109.060 y 108.280 z -3.670 (m below Site Datum); SNC photos 4521-4525, 4528-4531. Lithostratigraphic unit notation example for this column: S3-AOH09[0-8], etc.
SECTOR 3	[5(above zero)-0]	AOH 2009: "5YR 3/4; silty, cemented, some charcoal pieces."
SECTOR 3	[0-8]	AOH 2009: "7.5YR 4/4." S3-AOH09[4-6] charcoal OxA-26484 13,980 ± 80 BP <TAF08-5820>.
SECTOR 3	[8-29]	AOH 2009: "7.5YR 3/2; granular silty layer." [Some stones shown in schematic section; OSL-TAF08-13 20.0 ± 1.7 ka BP (multigrain), 18.2 ± 1.4 ka BP (single-grain), from near base at c. 6-20.] AOH 2008: "S3-AOH09[11-13] (top Roche XII) charcoal OxA-26639 14,800 ± 60 BP <TAF08-6159>."
SECTOR 3	[29-30]	AOH 2009: "10YR 2/1; charcoal smeared layer." S3-AOH09[28-30] charcoal OxA-26640 16,170 ± 65 BP <TAF08-6633>. S3-AOH09[28-30] charcoal OxA-26641 16,165 ± 65 BP <TAF08-6633 duplicate>.
SECTOR 3	[30-35]	AOH 2009: [No description] AOH 2008: "S3-AOH09[30-32] (Roche XIII mid) charcoal OxA-26642 16,030 ± 65 BP <TAF08-6646>."
SECTOR 3	[35-36]	AOH 2009: "10YR 2/1; charcoal-smeared layer."
SECTOR 3	[36-40]	AOH 2009: "10YR 2/2; some charcoal flecks, silty." AOH 2008: "S3-AOH09[38-40] (Roche XIII base) charcoal OxA-26643 17,070 ± 75 BP <TAF08-6705>."
SECTOR 3	[40-44]	AOH 2009: [No description but ornamentation on schematic section suggests dark sediment over 'black' charcoal, few stones; lenses pinching out eastwards; OSL-TAF08-12 22.9 ± 2.2 ka BP (multigrain), 20.2 ± 1.8 ka BP (single-grain), at c. 47-55 (but within this S3-AOH09[40-44] sloping unit).]
SECTOR 3	[44-53]	AOH 2009: [No description but ornamentation on schematic section is the same as for the [36-40] interval.]
SECTOR 3	[53-55]	AOH 2009: "10YR 2/2; charcoal-rich bed pinching out towards the mouth of the cave." [A stone shown on schematic section.] [Fig.2.5 annotated to correlate with Y5 (Sector 8 WARD 2003); reported in text as confirmed by SNC, therefore equivalent to the base of the [53-58] unit in the SNC log, correlated with the upper limb of S8-Y5.]
SECTOR 3	[55-68]	AOH 2009: [No description but relatively dark brown ornamentation on schematic section; OSL-TAF08-11 28.4 ± 2.8 ka BP (multigrain) at approximately mid-interval at c. 65-68 (but within this sloping unit).] AOH 2008: "S3-AOH09[58-60] (Roche XIV mid) charcoal OxA-26644 22,580 ± 110 BP <TAF08-6858>."
SECTOR 3	[68-69]	AOH 2009: "10YR 2/2; charcoal pieces, silty layer." [Lens pinching out eastwards on schematic section.]
SECTOR 3	[69-71]	AOH 2009: [No description but relatively dark grey ornamentation on schematic section.]
SECTOR 3	[71-77]	AOH 2009: "7.5YR 4/4; silty clay layer, small pebbles."
SECTOR 3	[77-102]	AOH 2009: "5YR 4/6." [A larger stone shown on schematic section near base; OSL-TAF08-10 31.3 ± 2.5 ka BP (multigrain) at approximately mid-interval at c. 84-93.]
SECTOR 3	[102-117]	AOH 2009: "7.5YR 5/6; silty, some slightly sandy bits; some parts of the layer cemented." [OSL-TAF09-01 39.8 ± 3.9 ka BP (multigrain) from very near base.]
SECTOR 3	[117-120+]	AOH 2009: "Hard cemented base; possible flow stone layer."

SECTOR 4

SECTOR 4	General	SNC 2003: "N-S section on the 21/22 line, in Squares H, G and part F; local zero in SNC observations at 3.61 m below Site Datum; SNC photos 26-27, observer looking east. Stratigraphy generally very diffuse, apparently due to bioturbation at all fine-to-medium scales." Lithostratigraphic unit notation example for this column: S4[0-12], etc.
SECTOR 4	[0-12]	SNC 2003: "Interval 0-12; light reddish brown gritty sediment; dispersed charcoal."
SECTOR 4	[12-13]	SNC 2003: "Interval 12-13; strong orange stain."

SECTOR 4	[13-33]	SNC 2003: "Interval 13-33; light brown stony material; dispersed charcoal; some burrows; very diffuse boundaries."
SECTOR 4	[33-45]	SNC 2003: "Interval 33-45; darker brown to red-brown, stony; large land mollusc shell; diffuse charcoal; very diffuse boundaries."
SECTOR 4	[45-57]	SNC 2003: "Interval 45-57; another cycle of similar sediment; bone in very poor condition (cf. *Alcelephas* tooth); very diffuse boundaries."
SECTOR 4	[57-89]	SNC 2003: "Interval 57-89; bedded brown stony material (more stony than above); probably contains several cycles of sedimentation; very diffuse boundaries."
SECTOR 4	[89-93]	SNC 2003: "Interval 89-93; discontinuous lighter lenses over continuous chocolate brown; probably correlates with the [53-58] **marker bed** in Sector 3 (overall easterly dip); very diffuse boundaries."
SECTOR 4	[93-105]	SNC 2003: "Interval 93-105; light brown, becoming redder downwards; generally stony with many 5-10 cm platy stones near base; very diffuse boundaries."
SECTOR 4	[105-117]	SNC 2003: "Interval 105-117; light brown silt with small stones; very diffuse boundaries."
SECTOR 4	[117-125]	SNC 2003: "Interval 117-125; brown to red-brown, very stony material, with large slabs and blocks (including floor speleothem fragments); very diffuse boundaries."
SECTOR 4	[125-155]	SNC 2003: "Interval 125-155; complex of beds with very common small stones, patchily mid-brown, red-brown and light brown; generally stonier than units above level [117]; common shell fragments; very diffuse boundaries. On current evidence (still weak), the [155] level might correlate with the base of Raynal's *Ensemble I* in Sector 2 (equivalent to the [93] level in Sector 3)."
SECTOR 4	[155-200+]	SNC 2003: "Interval 155-200+; mid- to light brown; very gritty, very large rocks (50-100 cm); commonly strongly cemented, increasingly so downwards; very diffuse boundaries."

SECTOR 5

SECTOR 5	General	COURTY 1989: "Fine lamination is totally absent in the thick units occurring near the porch [entrance]. They show a well-developed channel microstructure and consist of densely packed, well-rounded aggregates (300-500 µm). Associated with the dense clay-rich fine fraction are travertine fragments of various degrees of alteration, well-rounded phosphatic nodules, quartz sand grains and fragments of red soils (Figure 11.4f) [caption: "Brown micro-aggregated fabric resulting from intense mixing by biological activity. Epipalaeolithic layers near the porch of the cave."]. [...] Near the porch, decalcified sediments have been intensively disturbed by biological activity, probably earthworms, whereas effects of runoff are not discernible." (p. 225) SNC 2003: "Western corner of Sector 5, roughly the centre of Square F22; local zero in SNC observations at 3.75 m below Site Datum." Lithostratigraphic unit notation example for this column: S5[0-10], etc.
SECTOR 5	[0-10]	SNC 2003: "Interval 0-10; light brown stony silt; very diffuse boundaries."
SECTOR 5	[10-20]	SNC 2003: "Interval 10-20; quite strongly cemented stony material; very diffuse boundaries."
SECTOR 5	[20-45]	SNC 2003: "Interval 20-45; cycles of light brown to reddish material; very diffuse boundaries."
SECTOR 5	[45-48]	SNC 2003: "Interval 45-48; stratified brown material with stony/gritty lenses; very diffuse boundaries. Correlates with the 45-57 interval in Sector 4."
SECTOR 5	[48-101]	SNC 2003: "Interval 40-101; cycles of bedded material, small to medium stones, becoming darker downwards; very diffuse boundaries."
SECTOR 5	[101-104]	SNC 2003: "Interval 101-104; light carbonate silt over chocolate brown **marker bed**; diffuse boundaries. Correlates with the [89-93] interval in Sector 4."
SECTOR 5	[104-160]	SNC 2003: "Interval 104-160; light brown, stony, with large stones and blocks; possibly a distinct brown band with grit at c. 130; very diffuse boundaries."
SECTOR 5	[160+]	SNC 2003: "Interval 160+; light brown cemented material; very diffuse boundaries."

SECTOR 6

SECTOR 6	North General	SNC 2006: "In sqsJ17/18; April photos 45-53; the sequence has its own local Unit numbering; section drawing in E-W plane. Lots of minor angular unconformities seen in the N-S section in sqJ18 from top of S6-(N)17 upwards; requires more detailed study." Lithostratigraphic unit notation example for this column: S6-(N)1, etc.

SECTOR 6	(N)1	Excavators 2006: "Unit S6-(N)1; light brown silt, with frequent charcoal (small fragments) and frequent small mammal bone; good bedding at base of S6-(N)1 (marking boundary with S6-(N)2) in a lens 10 cm laterally, 5 cm thick." SNC 2006; "Whole unit drawn as at least 9 cm thick (top truncated by recent excavation)."
SECTOR 6	(N)2	Excavators 2006: "Unit S6-(N)2; light brown silt." SNC 2006: "Drawn as c. 6 cm thick. Charcoal sqK19 OxA-16263 13,975 ± 60 BP <TAF06-5411>, local Unit S6-(N)2, just above S6-(N)3&4."
SECTOR 6	(N)3&4	SNC 2006: "Units S6-(N)3&4; similar to but not correlated with Raynal 5 (in Sector 2)."
SECTOR 6	(N)3	Excavators 2006: "Unit S6-(N)3; whitish silt deposit (not consistent)." SNC 2006: "Drawn as 2-3 cm thick, rather contorted."
SECTOR 6	(N)4	Excavators 2006: "Unit S6-(N)4; reddish silt." SNC 2006: "Drawn as c. 10 cm thick, rather wavy. Top of this unit was marked by the excavators (on the section drawing) at a z value of between "-2.77 and -2.80"; this must be an error by one metre, i.e. the z values should be at -3.77 and -3.80 (m below Site Datum)."
	(N)5-14	SNC 2006: "Units S6-(N)5-14 similar to Raynal 6-11 but not correlates; clearly very erosive base, with local 'basins'/'troughs' again (cf. Sector 2); lots of internal lensing and stratigraphic discontinuity."
SECTOR 6	(N)5	Excavators 2006: "Dark brown silt." SNC 2006: "Unit S6-(N)5; truncated (and lost completely northwards) by S6-(N)3&4. Drawn as 9-10 cm thick."
SECTOR 6	(N)6	Excavators 2006: "White silt." SNC 2006: "Unit S6-(N)6; truncated (and lost completely northwards) by S6-(N)3&4. Drawn as up to 4 cm thick in E-W section." SNC 2006: "Charcoal sqK18 OxA-16262 15,995 ± 65 BP <TAF06-5410>, local Unit S6-(N)6, just below S6-(N)3&4."
SECTOR 6	(N)7	Excavators 2006: "Marker horizon, comprising charcoal band, light grey silt, charcoal band set." SNC 2006: "Unit S6-(N)7; truncated (and lost completely northwards) by S6-(N)3&4; probably equivalent to the marker bed S8-Y5. Drawn as up to 5 cm thick in E-W section."

SECTOR 8

SECTOR 8	Grey Series general	Roche (1963): Ashy *Niveaux I-X*; ashy material, with discontinuous stony lenses, many burnt stones and hearths, charcoal, land snails (often in lenses, mostly crushed but more intact in places); 'chocolate' alteration zone at base of grey ashy series deeper into the cave (westwards); locally variable dips (sometimes undulating) but main dip out (eastwards) to the southeast; Roche sub-divisions (SNC very sceptical) would comprise a series of wedges. mostly dipping and thickening E-SE. COURTY 1989: "It is only in the upper part of the Epipalaeolithic sequence in the thick layered ash units at the base of the necropolis that calcium carbonate ash crystals become abundant (Figure 11.4e) [caption: "Mildly disturbed calcitic ashes forming thick accumulations in the upper part of the Epipalaeolithic sequence."]. There they form an essential constituent, associated with abundant, highly burnt sheep droppings [SNC very sceptical] and fire-cracked exploded travertine [bedrock] fragments." (p. 225). Cf. SNC general photos (2003) 35-48. Lithostratigraphic unit notation example for this column: S8-G88, etc.
SECTOR 8	Upper Grey Series	S WARD 2003: "topped by lime mortar (added by French Army to secure stability above the sediments)". SNC 2003: "E-W section in the c.A file at Square c. 24, looking south; SNC photos 71-80." SNC 2003: "Section excavated by S WARD in Square B23"; local zero deduced (from surveyed find distributions) to have been c. -0.30 ± 0.1 (m below Site Datum). SNC photos 101-103 of completed sampling.

SECTOR 8	G88	S WARD 2003: "Fairly uniform ashy silt; light/medium grey colour; inclusions of fragmented shell; angular blocks up to 7 × 7 × 4 cm (making the deposit quite gritty, with a contrast between the silt and grit fabric of the unit); unconsolidated; numerous charcoal pieces less than 1 cm; large fragments of bone but no evidence of smaller bone fragments; few lithic flakes; subdivided: G88-1 – 3 cm thick horizontal subunit; largely concreted and upper zone somewhat intermixed with overlying lime mortar; small lens of sediment (not a hearth) in upper 1 cm of subunit, slightly darker grey than surrounding sediments; G88-2 – mid-grey colour, generally average G88 sediment; thickening locally inwards (westwards) with inward dip of base; sample SW200B1 above SW200B2; G88-3 – hearth subunit, lens thickening quickly outwards (left partially *in situ*); light grey colour; some large blocks (whitened at the edges of the subunit); some fragments (only 1 cm^3) within; sample SW201; G88-4 – similar to G88-2 but slightly lighter in colour; locally inward dip; sample SW200B3; G88-5 – light grey ash layer; not a hearth but a convenient boundary between G88 and G89." SNC 2003: "Interval 0-25; ashes and small charcoal fragments; horizontal to slight westerly dip (separated into 5 subunits during excavation); nodular ashy concretions; grit and angular limestone 5-10 cm; moderate shell content; large bones." Charcoal sqB23 OxA-13479 10,935 ± 40 BP <TAF03-200>. Charcoal OxA-34434 10,855 ± 50 BP <TAF03>.
SECTOR 8	G89	S WARD 2003: "Basically the same as G88-4 in sedimentary features, with no obvious changes within the thickness observed; higher proportion of broken shell fragments, small bones, charcoal and small angular pieces of limestone (less than 0.5 cm^3); matrix very soft and unconsolidated; uniform mid-grey colour; rare large limestone fragments; occasional large charcoal fragments; 2 samples, SW202upper over SW202lower, one from each of the two excavation spits [SNC: the latter may have been labelled '203']; a few unbroken mollusc shells in spit 2; spit 2 may have encroached slightly upon G90 (i.e. crossed the real boundary); locally dipping inwards." SNC 2003: "Interval 25-42; uniform mid-grey unit; a little softer than above, fine stones; more broken shell and more bone than above." S8-WARD03-G89spit1 charcoal sqB23 OxA-13480 10,950 ± 45 BP <TAF03-202>. S8-WARD03-G89spit2 charcoal sqB23 OxA-13516 11,065 ± 45 BP <TAF03-203>.
SECTOR 8	G90	S WARD 2003: "Similar to G89 but a little darker; more obvious fragments of charcoal; laminations, thickening towards cave wall; two instances of localised red silts within the laminated series (without signs of cementation or weathering); subdivided: G90-1 – excavated as two spits 1 and 2, samples as SW204 above SW 205; spit 2 contains a little ashy – material from a lens appearing near the inner (western) section; more stony than G89; G90-2 – complex set of generally inward-dipping lenticular subunits, dug separately as 'spits' [SNC: from section drawing, the true stratigraphic order is youngest: spit 1 / sample SW206, spit 3 / sample SW208, spit 2 / sample SW207, spit 4 / SW209 oldest]; more fragments of charcoal in this subunit; more strongly laminated than in G90-1; similar to a midden, extremely rich in shells, charcoal, and small bone fragments but only very few lithics; possible burrow on outward side (fill not included in samples)." SNC 2003: "Interval 42-100; inclined, sloping down westwards (separated into 2 subunits during excavation); finely laminated ash (including spicular forms on bedding planes, especially at base, which could indicate grasses or fine leaves burnt *in situ*); more obvious charcoal than above; more medium stones at top but not very stony downwards; shell lenses and small bone fragments; burrows of 3 and 15 cm diameter; at level 85, discontinuous lens of reddish 'fired earth' just west of logged section." S8-WARD03-G90-1spit1 charcoal sqB23 OxA-13517 10,990 ± 45 BP <TAF03-204>.
SECTOR 8	G91	S WARD 2003: "Slightly darker than G90-4 [*sic*, probably referring to G90 in general] but not much difference overall, although G91 is not obviously stratified [laminated]; lens pinching out towards the cave centre line and also inwards; sample SW210." SNC 2003: "Lens only on east side of excavation (not in the line of the log); grey material lacking the fine stratification of G90."
SECTOR 8	G92	S WARD 2003: "G92 subdivided: Spit 1 similar to G91 but with more limestone blocks; lighter grey, more ashy material on the outward side; sample SW211; sharp upper boundary dipping outwards; Spit 2 more ashy than above; stronger ashy lens on inward side (possible hearth); poorly microstratified, with possible traces of churning; overall pinching out outwards; common charcoal fragments but rare lithics; sample SW212; Spit 3 is blocky; limestone cobbles slightly imbricated with their dips into the cave; the entire subunit dips inwards; sample SW213." SNC 2003: "Interval 100-130; stony burnt hearth, stones dipping slightly down westwards; strong light-coloured ashy lenses; upper surface truncated/eroded (down to north by 45°)."

SECTOR 8	G93	S WARD 2003: "Subdivided: G93-1 – similar to G92spit3 but dipping slightly outwards; slightly lighter in colour; a slight increase in 'soil' in this subunit (browner colour against the grey ash); interpreted as a true environmental change, with increased fine sediment reaching the cave from outside; samples SW214 and SW215; G93-2 – still quite blocky but a darker colour than G93-1; samples SW216 and SW217; tooth bagged (with surrounding sediment) for possible ESR dating, located close to boundary between two subunits." SNC 2003: "Interval 130-160; grey stony material with lenses of very slightly browner (mineral matrix) material (separated into two subunits during excavation), sloping 15° eastwards; upper surface truncated/eroded (down sharply to north)."
SECTOR 8	G94	S WARD 2003: "Slump feature [? SNC]; darker in colour than G93-2; more strongly stratified (with some back-stratification); common burnt bone, lithics, etc.; very common shell fragments, charcoal and lithic fragments; spit 1 with sample SW218; spit 2 with sample SW219; lower boundary cutting sharply down outwards locally." SNC 2003: "Interval 160-185; grey, well laminated (possibly slightly washed) material, dipping mostly eastwards but with a few localised cross-dips down to the west in places; moderately stony; dense shell/bone/charcoal/lithic artefact lenses."
SECTOR 8	G95	S WARD 2003: "Subdivided: G95-1 – increase in bone fragments compared with G94; large charcoal and shell fragments; more burnt lithics; large blocky pieces of fire-cracked stone (more common than in overlying units); including strong bands of broken shell and bone, horizontal or dipping only slightly outwards; spit 1 / sample SW220, spit 2 / sample SW221; G95-2 – small lens of extremely friable, lighter grey (ashy) material; spit 1 / sample SW222, spit 2 / sample SW223; G95-3 – extremely dense subunit of broken shells, almost midden-like; shells are large aligned horizontally, with fragments no larger than 1 cm³; charcoal fragments, together with bone, lithic and limestone fragments, all commonly burnt; occasional very fine lenses of ash but also possible infiltration from above; fairly horizontally bedded, although exposed along the axis of a 'hump' [convex-up]; shell survival suggests that the component lenses are not hearths but, rather, material on the periphery of such features; sample SW224." SNC 2003: "Interval 185-215; cycles of ash over gritty debris (shell, burnt bone, charcoal, burnt stone), with ash-dominated cycles at top becoming grit-dominated downwards; almost horizontal but with a very minor easterly dip in places; rich in bone, burnt stone and burnt lithics in upper part; resembles a typical midden (cone of dejection) accumulation."
SECTOR 8	G96/1	S WARD 2003: "At top, some mixture of cobbles and shell fragments from the G95-3 subunit; downwards, only with occasional cobles and still rich in shell fragments; most of the stones are relatively small 3-4 cm³; still very friable but still matrix-supported; very ashy but fractionally browner in colour, suggesting more input from outside cave; reasonably stratified, dipping slightly out of cave; sample SW225." SNC 2003: "Interval 215-235; quite well bedded, down very slightly eastwards; very ashy material (but just a little browner colour in places, suggesting slower sedimentation and mineral input); some stone, relatively small, but matrix-supported; shell."
SECTOR 8	G96/2	S WARD 2003: "more stony and clast-supported; still shell fragments, some bone fragments and a few large pieces of charcoal (although possibility of infiltration from G96-1); fairly horizontal bed but with an upper boundary dipping slightly out of the cave; cobble show signs of burning and have random (jumbled/natural) orientations; sample SW226." SNC 2003: "Interval 235-250; upper surface dips eastwards by 10° (more sharply than bedding angle in G96/1); clast-supported, stones 5-10 cm; some shell, charcoal (some large fragments) and bone, stone still heavily burnt." S8-G96-2A charred seed OxA-34435 12,420 ± 55 BP. S8-G96-2B charred seed OxA-34436 12,145 ± 55 BP.
SECTOR 8	G96/3	S WARD 2003: "Greater quantity of earth within this subunit (derived from outside the cave), colder to the touch and retaining more water; still with common cobbles but supported by a matrix of ash and shell fragments; thinning towards cave wall; sample SW227." SNC 2003: "Interval 250-260; 'earthy' (mineral sediment-rich) ash."
SECTOR 8	Medial Segment of Grey Series	SNC 2003: "E-W section on the C/B line in sq c. 20 (i. e. about 3 m west of upper sequence excavated by S WARD), described from top down."
SECTOR 8	G96/4	S WARD 2003: "Cobble/clast supported (dominated by clasts 7-15 cm³), with very little fine matrix (possibly infiltrated from above); dipping into the cave; cobbles are rounded/sub-rounded and consistently burnt (powdery white on the surface); low levels of charcoal, bone and lithic fragments; friable and unstable in section; not sampled." [SNC: possibly sampled later, as section drawing seems to show SW1.] SNC 2003: "60-70 cm thick; powdery stony sediment, clast-supported, 10-15 cm diameter modal size, edge-rounded (apparently disturbed/reworked), heavily burnt."

SECTOR 8	G96/5	S WARD 2003: "Cobbly with patches of matrix-support and clast-support; most clasts are sub-angular and quite large (5-6 cm^3); contains a brownish fine silty lens and generally cool (damp) to the touch; thin lenses of charcoal quite abundant, although not as hearth features; common lithics and bone fragments but very little shell debris; slight dip into the cave; sample SW228." SNC 2003: "30 cm thick; brownish silty ash; few patches of clast-support but mostly matrix-supported, many cobbles but more angular than above (does not appear to have been moved and therefore does not show strong edge-rounding); thin charcoal lenses."
SECTOR 8	G96/6	S WARD 2003: "More clast-support by cobbles but still some matrix, brown and silty (possibly some infiltration from G96-5); strong archaeological component (lithic, bone, shell, charcoal); some subunits dipping northwards towards the cave axis; not sampled." SNC 2003: "Thickness c. 15 cm [NB S8-G96/1-5 recorded as about 1.4 m thick overall; cf. the same thickness in the general G96 basal exposure, described below]; similar to G96/5 but more clast-support; still normal matrix and small stones; bedding slightly down to the east but also with a 20º dip component northwards."
SECTOR 8	Base of Grey Series	SNC 2003: "Sample sequence excavated by S WARD, E-W section on the C/B line in Square 21; SNC photos 24-25. Note that when WARD recorded multiple samples from a single subunit, these were usually laterally adjacent (and thus broadly equivalent) not superstratified." SNC 2003: "Sample sequence excavated, E-W section on the C/B line in Square 21; after sampling; SNC photo 81." SNC 2003: "E-W section 1.5 m further south (towards the cave wall) than the section in the underlying Yellow Series; local zero in SNC observations at -4.58 (m below Site Datum) (note that this demonstrates strong southerly dip of base of Grey Series, although units are more or less horizontal, rarely dipping slightly down eastwards, in the E-W plane); intervals recorded [by SNC] with zero at the base and counting upwards."
SECTOR 8	G96 (general)	SNC 2003: "Interval 60-200; alternations (see subdivisions above) between ash and coarse burnt stone, with a few finer sediment lenses; sharp local cross-beds in some places; stones up to c. 15 cm; shell, bone."
SECTOR 8	G97	S WARD 2003: "Composite hearth; fine-grained, grey and highly friable; many fragments of charcoal (macro & micro); some rounded pebbles [SNC: burnt limestone] and some coarser sediment but mainly very ashy; small broken shell fragments and lithics (including a backed piece); samples SW4, SW31, SW36, SW50." [SNC: the inclusion of sample SW50 and its approximate geometry, as shown on the excavation block diagram, would suggest sharp northward dip of the base of this unit close to the original exposure (before excavation), perhaps as a 'scoop' into underlying units.] SNC 2003: "Interval 40-60; grey-brown ashy silt, some cross-beds; burnt stones, bone, large charcoal fragments." Charcoal OxA-13477 sqB21 12,675 ± 50 BP <TAF03-36>.
SECTOR 8	G98	S WARD 2003: "Similar matrix to other units in the G90s series above; lenses pinching out northwards but dipping towards the cave wall; composed of three ashy hearth subunits (G98-1, -3 and -5), separated by two grey-brown earthy lenses (G98-2 and -4); similar levels of charcoal in all subunits but some concentration within the ashy lenses, which are also lightly concreted; lithics not common; G98-1 / samples SW38 and SW41, G98-2 / sample SW46, G98-3 / samples SW48 and SW53, G98-4 / samples SW58, SW61, SW63 and SW73, G98-5 / sample SW89." [SNC: the geometry of samples for all the subunits for G98, as shown on the excavation block diagram, suggests that reliance should not be placed upon stratigraphic integrity/apparent order within this interval; S WARD himself noted "lenses difficult to sample".] SNC 2003: "Interval 20-40; stratified hearths, white/grey ash, black charcoal; quite sharp local cross-beds; artefacts, bone, shell."
SECTOR 8	G99	S WARD 2003: "Transition to the 'natural' sequence below (red beds [Yellow Series]); yellow-brown, silty and very soft/friable; higher level of sub-angular pebbles [limestone] in comparison with G97 and G98; very porous/degraded limestone fragments 4-5 cm^3; shell fragments; samples SW90, SW100, SW108 and SW109." SNC 2003: "Interval 3-20; grey-brown ashy silt with corroded stones; bone; 7.5YR 5/2." Charcoal sqB21 OxA-13478 12,495 ± 50 BP <TAF03-90>.
SECTOR 8	G100	S WARD 2003: "Blocks (cobbles) with brown matrix; larger bone fragments and more lithics than G99; likely to be a mixture of Grey and Yellow Series; sample SW118." SNC 2003: "Interval 0-3; stony interface with the Yellow Series below; bones." Bone sqC23 OxA-24109 12,605 ± 55 BP <TAF04-466>.
SECTOR 8	Yellow 2003 Series	Roche (1963): In fig.9 (longitudinal section), the contact between the Grey and Yellow Series drops c. 4 m between H6 (inwards) and A24 (outwards) but levels out to nearer the horizontal further west. SNC 2003: "E-W section, rather sloping between D/C and E/F lines, in Square 21 at top, passing into Square 22 downwards, observer looking south; SNC photos 82-86 (86 is a detail of the **marker bed** in the interval 110-112, lying between the two plastic bag marks in the wider photos). SNC photos 87-89 showing sampling by E. Rhodes; the OSL sample position (OSL-TAF03-14) showing partially in SNC photo 86, just to the right of Rhodes's abdomen, is centred on the **marker bed**." SNC 2003: "SNC description of E-W section on D/C line at the boundary between Squares 20 and 21; local zero in SNC observations at -3.93 (m below Site Datum). Cf. also SNC photos 24-25 at C/D21." Lithostratigraphic unit notation example for this column: S8-Yell03[0-15], etc.

SECTOR 8	Yell03[0-15]	SNC 2003: "Interval 0-15; stony brown silt with large bone fragments; equivalent to Unit Y1 of Sector 8 sample sequence excavation by WARD."
SECTOR 8	Yell03[15-19]	SNC 2003: "Interval 15-19; light brown stony silt."
SECTOR 8	Yell03[19-22]	SNC 2003: "Interval 19-22; mid-brown silt with charcoal."
SECTOR 8	Yell03[22-26]	SNC 2003: "Interval 22-26; light brown to gingery silt."
SECTOR 8	Yell03[26-30]	SNC 2003: "Interval 26-30; brown silt; charcoal, much bone, artefacts (apparently Iberomaurusian); source of large environmental sample <317>; overall horizontal but wavy over 2 m lateral scale, rising and dropping by 10-15 cm; appears to be multiple, subunits splitting and fanning eastwards. This unit possibly correlates with the strong bone grouping on the E-W section at the Square 16/15 boundary above the Deep Sounding (S)[25-35]." Charcoal sqD20 OxA-13519 13,905 ± 55 BP <TAF03-317>.
SECTOR 8	Yell03[30-53]	SNC 2003: "Interval 30-53; orangey light brown silt with a slightly browner band (archaeological?) at 48; well bedded; flecks of charcoal."
SECTOR 8	Yell03[53-56]	SNC 2003: "Interval 53-56; orangey and mid-brown banding; gritty silt; carbonate crusts; charcoal."
SECTOR 8	Yell03[56-67]	SNC 2003: "Interval 56-67; stony brown silt, more or less horizontal bedding."
SECTOR 8	Yell03[67-70]	SNC 2003: "Interval 67-70; gritty silt, horizontally bedded; charcoal, bone, shell."
SECTOR 8	Yell03[70-74]	SNC 2003: "Interval 70-74; stony brown silt."
SECTOR 8	Yell03[74-80]	SNC 2003: "Interval 74-80; several bands of brown gritty silt, horizontal bedding; bone, charcoal, shell; source of large environmental sample <316>." Charcoal sqD20 OxA-13518 17,085 ± 65 BP <TAF03-316>.
SECTOR 8	Yell03[80-95]	SNC 2003: "Interval 80-95; mid-brown silt; better stratified eastwards, wedging out westwards; bioturbation structures."
SECTOR 8	Yell03[95-100]	SNC 2003: "Interval 95-100; brown silt; artefacts; bioturbation structures."
SECTOR 8	Yell03[100-110]	SNC 2003: "Interval 100-110; blotchy dark brown, true thin chocolate brown bands (with very thin carbonate bands above) further west but apparently a little disturbed on description line; dipping here eastwards by 6°, by over 10° further west; charcoal, shell, bone, artefacts; bioturbation structures."
SECTOR 8	Yell03[110-112]	SNC 2003: "Interval 110-112; white/cream over dark chocolate brown; **marker bed**, correlates with the [101-104] interval in Sector 5; source of large environmental sample <315>." Charcoal sqD20 OxA-13607 22,200 ± 90 BP <TAF03/315>.

SECTOR 8	Yellow Series WARD 2003	Descriptions during excavation by S WARD 2003 in B/C22. Lithostratigraphic unit notation example for this column: S8-WARD03-Y1, etc.
SECTOR 8	Y1	S WARD 2003: "About 10 cm thick, thinning to c. 6 cm thick into cave; contains cobbles 3-4 cm; matrix is yellow/red fine carbonate; quite rich in lithics, bone and some teeth; rich in charcoal; lower boundary not very distinct at the front (north side) of the square but clearer change evident at the rear – more reddish colour in Y2 below; sample SW168. There is a small (c. 30 × 26 cm) hearth feature in the centre of Square B/C22; apparently surrounded by fire-cracked stones; sediment within hearth is brown/dark brown with pockets of lighter coloured ash; alongside, some burnt mammal and bird bones, and quite a large lithic (c. 3 × 8 cm); some pockets of charcoal and ash surround the hearth unit; sediment underneath hearth is reddened." Ostrich eggshell sqC22 OxA-14349 12,690 ± 55 BP <TAF04-657>.
SECTOR 8	Y2spit1	S WARD 2003: "About 15-20 cm thick, slightly lensing out into cave; redder colour and fewer stones and cobbles than Y1; brown hearth-like lenses; generally less finds than in Y1 (lithics, bones, etc.); still finding some microburins in Y2spit1 and some backed blades throughout; still quite high in charcoal; sediment is damper, apparently with a higher soil content. Sequence in more detail: (top) lighter (yellowish) band c. 1 cm thick; an red/orange band c. 2 cm thick; a yellow sandy/gritty layer; (base) a darker reddish band (higher in charcoal than overlying thin yellow and orange bands). Environmental samples taken from quadrants B and D."

SECTOR 8	Y2spit2	S WARD 2003: "About 10 cm thick; consistent reddish brown colour but with occasional yellow (more gritty) lenses and very small (c. 5 cm^2) patches; fewer artefacts than in Y2spit1, although still some lithics (backed pieces, cores, flakes, etc.); still some bone (1 animal jaw bone found); broken shells are quite a significant component (mixture of large & small fragments); marine shell (perforated, 'periwinkle' appearance) (Quadrant B), alongside three other marine shells (not perforated), all small and thick-walled; large cube (c. 3 cm^3) of haematite (Quadrant A); sediment darker red colour with slightly more charcoal in it than in Y1 (not very much more); slightly damper than Y2spit1 and a little more gritty; no ashy lenses evident; slightly more stony than in Y2spit1, in particular with more flat carbonate material (very crusty and light)."
SECTOR 8	Y2spit3	S WARD 2003: "About 10 cm thick; slightly darker reddish-brown than Y2spit2; more stone than in Y2spit2 (especially in quadrant D where large blocks are found); less stony in the other quadrants however, with most of the stones comprising flat carbonate crusty material and pieces of stal [speleothem]; more large blocks of stone within this spit as well; 1 jaw bone found on quadrant A/B border near the centre of the 1 m square + *Ammotragus*; 1 horn[core] of *Ammotragus* in Quadrant A."
SECTOR 8	Y2spit4	S WARD 2003: "About 10 cm thick; very similar in texture to Y2spit3, although slightly less blocky; fewer lithics than in Y2spit3 but still significant amount of bone and charcoal; less of the platy carbonate material than in the overlying Y2 spits; sediment is darker (damper and less oxidised) at the rear of the square and appears slightly higher in clay content; large platy boulder (c. 50 cm breadth, c. 20 cm width, c. 15 cm depth) intruding on A and B quadrants."
SECTOR 8	Y2spit5	S WARD 2003: "About 10 cm thick but care taken to respect stratigraphic boundary at base; definite decrease in lithics (only 2 pieces recorded as separate finds) but still good quantities of bone fragments (possibly even an increase in bone, especially in larger bone fragments); colour of sediment darkens to an almost deep red wine colour; still quite clayey (possible small increase in clay level); significant material (bones and some lithics) beneath the large platy boulder intruding on quadrants A/B (reported in Y2spit4), perhaps a particular activity area."
SECTOR 8	Y3	S WARD 2003: "Dated to 17.9 ka (uncorrected); unit about 2-3 cm thick relating to the first marker set by SNC; sediment becomes a little lighter in colour and clay content decreases; texture more sandy and gritty; common bone but very few lithics (only lithics found are flakes); some of the bones large and thick (couple prepared for potential U-series dating); some areas of the band appear to be quite quickly concreted with many of the artefacts covered with a tufa-like coating (very gritty); common charcoal; hard to trace moving southwards towards the rear of the sequence."
SECTOR 8	Y4spit1	S WARD 2003: "About 10 cm thick; orange brown sediment; more clayey at rear of square with small (10-20 cm^2) lenses of lighter (slightly more orange than red) gritty/sandy material similar to that in Y3 (but not a continuation of that unit); still large amounts of charcoal; relatively common large fauna compared to lithics and small fauna; some backed pieces, cores and flakes but much fewer overall than in overlying layers; the proportion of tools to flakes has increased, suggesting this was a place of tool usage rather than tool manufacture; ashy lens/small hearth (photos taken) found between quadrants A/B; 1 backed piece within the hearth; generally a lens of ash (white) with a band of charcoal beneath but no obvious basal reddening; quite a lot of stones in the spit especially the re-appearance of the platy carbonate material (as seen in overlying layers), typically 5 cm^2 × 0.5 cm thick; cobbles increase within this level."
SECTOR 8	Y4spit2	S WARD 2003: "About 10 cm thick; similar to Y4 spit1 but a general (relative) decrease in fauna and increase in lithics; still finding some cores and a few backed pieces; decrease in number of flakes; no other changes from Y4 spit1."
SECTOR 8	Y4spit3	S WARD 2003: "About 10 cm thick; sediment a little darker in colour than in Y4 spits1 & 2 and more clayey; still common charcoal; fewer archaeological finds overall (now down to about 5-10 per 10 cm spit depth, compared to av.10-15 in Y4 upper spits, 15-25 in Y2, 30-50 in Y1, etc.); general relative increase in lithics compared to fauna; less stony at the rear of the square and generally more archaeological finds."
SECTOR 8	Y4spit4	S WARD 2003: "Quadrant B: sediment a reddish brown cave-earth; very few artefacts (flakes) and only a couple of bone fragments (nothing diagnostic); 1 backed lithic found at base of Y4spit4 [SNC: anomalously low]. Quadrant A: far back right of section was significantly darker than nearer face of section + seems to be an increase in charcoal; small ashy patch, hearth-like, at the border between quadrants A/B (ash was separated and sample taken for Phytoliths); as in Quadrant B in that base of Y4spit4, patchy dark areas [disturbed Y5?]; slightly more common charcoal than in Y4spit3; also slightly more rock frags, occasional medium-sized (4-6 cm^3); no evidence of microfauna; 2 whole land snail shells (2.5 cm^3), as well as a few smaller (0.5 cm^3) semi-crushed land snail shells."
SECTOR 8	Y5	S WARD 2003: "c. 1-3 cm thick (becoming more patchy and thin going into cave); dark brown colour generally, black in patches (almost soil-like); quite moist to the touch; the unit is extremely patchy in quadrants A/B, although forms a more continuous band in quadrants C/D; unit is overlain by a thin (c. 0.5 cm thick) band of distinctive gritty/sandy yellow sediment; where Y5 is patchy, this yellow is found covering it; sediment was excavated from areas certain to be representative of Y5, rather than taken out in bulk; few bone frags (parts of relatively large bones) (Quadrant A); 3 lithic flakes found in Quadrant A; in Quadrant B, again very patchy and difficult to distinguish between Y4spit4 and Y5."

SECTOR 8	Yellow 2006 Series	SNC 2006: "April photos 3-35; April photos 54-63 after sampling; log in excavated square; base of Grey Series at zero in sqC22, x 103.207, y 105.515, z -4.113 (m below Site Datum); same local datum used by SB for microtephra sampling; sampling face, observer looking south." SNC 2008: "Zero nail resurveyed: x 103.179, y 105.719, z -4.020 (m below Site Datum)." Lithostratigraphic unit notation example for this column: S8-Yell06[0-17], etc.
SECTOR 8	Yell06[0-17]	SNC 2006: "Interval 0-17; rather uniform, moderately stony brown silt, internally well bedded; locally, dip 2° south but also 6° west (down into cave) but, more generally, subunits have a > 2° down eastwards (out of cave), i. e. there is a local minor rise; generally dispersed charcoal, 1-3 mm mode; localised white-above-black / brown lenses appear to be *in situ* hearth material; base colour 7.5YR 6/4 or greyer, with white flecks; equivalent to Unit Y1 of Sector 8 WARD 2003 and to Yell03[0-15]." SNC 2008: "Ostrich eggshell [04-659] [12,690 ± 55] at unspecified level in Unit Y1."
SECTOR 8	Yell06[17-20]	SNC 2006: "Interval 17-20; slightly [*sic*] very fine gritty silt; 7.5YR or a little redder 6/6; contains charcoal; equivalent to the top of Unit Y2 of Sector 8 WARD 2003." SNC 2006: "Charcoal sqC22 OxA-16267 14,005 ± 60 BP <TAF06-5415> at [18], in the very top of Unit Y2, first centimetre of reddish brown material."
SECTOR 8	Yell06[20-23]	SNC 2006: "Interval 20-23; patchy cementation; variously cream to mid-brown."
SECTOR 8	Yell06[23-27]	SNC 2006: "Interval 23-27; at least two ginger (5YR 5/8) over light (7.5YR 7/6) cycles, with thicker light subunits and the ginger subunits (implying alteration?) usually < 1 cm; very slight contortions, with ruptured elements often disposed as small 'troughs' 10 cm long (almost dish structures), seen in both N-S and E-W section; relatively stone-free, very uniform silt (possibly originally loessic?), with very little clay (will not make a plastic roll); whole unit thickening into cave (aven input?); charcoal; equivalent to the "red / orange" level in spit1 of Unit Y2 of Sector 8 WARD 2003 and to Yell03[22-26]; similar to Raynal 5 (in Sector 2) but not a direct correlate." SNC 2006: "Charcoal sqC22 OxA-16268 14,515 ± 60 BP <TAF06-5416>, in Unit Y2 at [27]."
SECTOR 8	Yell06[27-31]	SNC 2006: "Interval 27-31; stonier (fine grit) silt with weak cement; mid-brown; charcoal, artefacts; equivalent to base of spit1 of Unit Y2 of Sector 8 WARD 2003 and to Yell03[26-30]."
SECTOR 8	Yell06[31-45]	SNC 2006: "Interval 31-45; slightly gritty, purer silt, with some stones; mid-brown (slightly greyer than 7.5YR 5-6/4); at level [34] (< 1 cm thick), contains slightly more gingery band, which is becoming much grittier into cave; at [36] level, pure silt mudclasts 1-3 mm; at [42] level (< 1 cm thick), another gingery band; approximately equivalent to spit2 of Unit Y2 of Sector 8 WARD 2003." SNC 2006: "Charcoal sqC22 OxA-16272 14,630 ± 60 BP <TAF06-5421>, in the middle of Unit Y2 at [37]."
SECTOR 8	Yell06[45-50]	SNC 2006: "Interval 45-50; silt, with silt clasts (probably very small scale bioturbation); less stony than units above and below; gingery (5YR 6/6); approximately equivalent to spit3 of Unit Y2 of Sector 8 WARD 2003; interval Yell06[31-50] combined approximately equivalent to Yell03[30-53]."
SECTOR 8	Yell06[50-64]	SNC 2006: "Interval 50-64; quite gritty silt with small stones, sometimes as platy elements in bands; strongly banded; mid-brown but with lighter and gingery bands internally; charcoal and lithics throughout; approximately equivalent to spit4 and part of spit5 of Unit Y2 of Sector 8 WARD 2003 and to Yell03[53-70]." SNC 2006: "Charcoal sqC22 OxA-16269 15,790 ± 60 BP <TAF06-5417>, lower in Unit Y2 at [58]." SNC 2008: "Ostrich eggshell sqC22 OxA-14350 16,660 ± 70 BP <TAF04-1734>, at unspecified level in spit5A of Unit Y2." [OSL-TAF08-16 22.7 ± 1.9 ka BP]
SECTOR 8	Yell06[64-69]	SNC 2006: "Interval 64-69; platy stony silt; slightly to very cemented; brown; equivalent to base of spit5 of Unit Y2 of Sector 8 WARD 2003 and to Yell03[70-74]."
SECTOR 8	Yell06[69-72]	SNC 2006: "Interval 69-72; silty sediment very rich in charcoal; possibly banded; brown to grey 7.5YR 5/3-4; equivalent to Unit Y3 of Sector 8 WARD 2003 and to Yell03[74-80]." SNC 2006: "Charcoal sqC22 OxA-16270 16,285 ± 65 BP <TAF06-5418>, in Unit Y3 exactly, at [70] (NB spider silk contamination); the [71] level here correlates with the level for the sample <316> date."
SECTOR 8	Yell06[72-97]	SNC 2006: "Interval 72-97; silt, slightly gritty in places, with a few smaller stones in bands; very silty, with probably bioturbated silt clasts (lighter) throughout but particularly silty in the [86-90] interval, very little clay (no plastic roll); light brown (7YR 6/4); perhaps less stony and lighter in colour than the [50-72] interval; much less charcoal than above (mostly < 1 mm); approximately equivalent to spit1 and spit2 and part of spit3 of Unit Y4 of Sector 8 WARD 2003 and to Yell03[80-95]." SNC 2008: "Ostrich eggshell sqC22 OxA-14351 16,695 ± 70 BP <TAF04-1927>, at unspecified level (depth -4.42 m below Site Datum) in spit1 of Unit Y4 in sqC22." [SNC: may be incorrect stratigraphic unit - possibly S8-Y2.] SNC 2006: "Charcoal sqC22 OxA-16242 16,630 ± 75 BP low carbon yield <TAF06-5419>, in upper part of S8-Y4 at [78]." SNC 2006: "Charcoal sqC22 OxA-16273 17,515 ± 75 BP <TAF-06-5422>, in the middle of S8-Y4 at [86]."

SECTOR 8	Yell06[97-106]	SNC 2006: "Interval 97-106; banded, darker bands at [97] and [104] levels; generally very diffuse limits to subunits; dark bands 7.5 YR 3-4/4; common bioturbation (channels mostly vertical <1 mm wide up to 2 cm long), lighter, slightly redder features than ground colour; cream speckles; common charcoal; approximately equivalent to part spit3 of Unit Y4 of Sector 8 WARD 2003 and approximately to Yell03[95-100]." SNC 2006: "Charcoal sqC22 OxA-16271 20,420 ± 90 BP <TAF06-5420>, base of S8-Y4 at [97] (assumed to be below 'LGM')." [OSL-TAF08-14 26.2 ± 2.0 ka BP] [OSL-TAF08-15 29.7 ± 2.7 ka BP]
SECTOR 8	Yell06[106-116]	SNC 2006: "Interval 106-116; strongly banded sequence consisting of the following subunits: [106-107] light-over-dark couplet, with a reddened base; fragmented in places by bioturbation; [107-108] normal brown silty sediment; [108-109] light-over-dark couplet, with a reddened base; fragmented in places by bioturbation; [109-110] normal brown/gingery silty sediment; [110-112] slightly darker; [112-114] mid to light brown silty sediment; [114-116] major dark band, with light cap; slightly stony; 1-2 mm zone of slightly concreted material at very base; this subunit is a **marker bed** that can be traced widely around sections. The dark subunits (7YR 1/5/2 plus true black) often look washed but, in places (where there is white ashy material above and reddening below), there are true *in situ* hearth elements; approximately equivalent to spit4 of Unit Y4 and to Unit Y5 of Sector 8 WARD 2003 and to Yell03[100-112]; the strong and persistent [114-116] interval is certainly equivalent to at least part of S8-Y5 and to Yell03[110-112]. The [114-116] interval here is probably equivalent to the general level of the sample <315> date." SNC 2006: "Charcoal <5423> [failed], in the upper element of the S8-Y5 pairing (itself with multiple lenses; very poor individual charcoal survival, mostly smeared), at [107]." SNC 2006: "Charcoal sqC22 OxA-16274 20,630 ± 90 BP (2 very small samples, all rather poor in large charcoals, smearing) <TAF06-5424>, near base of S8-Y5 at [114]."

SECTOR 8	Grey 2008 Series	SNC 2008: Additional charcoal samples from main sagittal (longitudinal) section. Lithostratigraphic unit notation example for this column: S8-08-G99.
SECTOR 8	G99	SNC 2008: "Basal Grey Series; additional charcoal samples in sqC22, <6840>, <6841>." Charcoal sqC22 OxA-22904 12,490 ± 50 BP <TAF08-6840>. Charcoal sqC22 OxA-22787 12,545 ± 55 BP <TAF08-6841>.
SECTOR 8	Yellow 2008 Series	SNC 2008: "Photos 0927-0949 150408; photos 1107-1118 of base of sequence 170408; log taken within excavated notch (tape not quite vertical but, looking eastwards, at right angles to bedding, which dips generally southwards and a little eastwards); zero in Square C22, x 103.785, y 105.277, z -3.931 (m below Site Datum); re-surveyed carefully to give x 103.716, y 105.268 and z -3.980 (m below Site Datum) (preferred co-ordinates); a find measurement at the 212 level on the tape gave a z value of -6.08; same local datum used by AO for microtephra sampling; sampling face, observer looking south. The 'general finds' (GF) bag numbers are noted in most cases; some of individual charcoals in separate plastic bags were inserted into one or other of the paired sediment sample series." SNC 2008: Additional charcoal samples from main sagittal (longitudinal) section. Lithostratigraphic unit notation example for this column: S8-Yell08[0-2], etc.
SECTOR 8	Yell08[0-2]	SNC 2008: "Interval 0-2; probably rather disturbed [cf. GF0-2/5746]."
SECTOR 8	Yell08[2-12]	SNC 2008: "Interval 2-12; obvious ashy hearth material in lowest 2 cm (probable phytolith content); equivalent to Unit Y1 (top missing) of Sector 8 WARD 2003 and to Yell03[to-15] and Yell06[to-17]. [GF2-4/<5783>; GF4-6/<5790>; GF6-8/<5793>, charcoal sample; GF8-10/<5894>; GF 10-12/<5932>, charcoal sample]" SNC 2008: "Additional charcoal samples in sqC22, <6842>, <6844>, <6845>". Charcoal sqC22 OxA-22905 12,665 ± 50 BP <TAF08-6842>. Charcoal sqC22 OxA-22788 12,850 ± 55 BP <TAF08-6844>.
SECTOR 8	Yell08[12-16]	SNC 2008: "Interval 12-16; equivalent to the top of Unit Y2 of Sector 8 WARD 2003 and to Yell06[17-20]. [GF12-14/<5938>, charcoal sample; GF14-16]" SNC 2008: "Additional charcoal samples in sqC22, <6852> at height equivalent to 13 level, <6853> at height equivalent of 12 level." Charcoal sqC22 OxA-22907 14,230 ± 55 BP <TAF08-6853>. Charcoal sqC22 OxA-22906 14,135 ± 55 BP <TAF08-6852>.
SECTOR 8	Yell08[16-18]	SNC 2008: "Interval 16-18; light-coloured cemented material, equivalent to Yell06[20-23]. [GF16-18/<5954>, charcoal sample]"
SECTOR 8	Yell08[18-23]	SNC 2008: "Interval 18-23; ginger red and cream bands, plastic deformation, rolls and over-thrusts, floating charcoal; equivalent to the "red/orange" level in spit1 of Unit Y2 of Sector 8 WARD 2003 and to Yell03[22-26] and Yell06[23-27]. [GF18-20/<59079>; GF20-22/<5980>; GF22-23+/<6006>, charcoal sample]" SNC 2008: "Additional charcoal sample in sqC21, <6854> at height equivalent to [23] level." Charcoal sqC21 OxA-22908 14,110 ± 55 BP <TAF08-6854>.

SECTOR 8	Yell08[23-28]	SNC 2008: "Interval 23-28; small stones and grit; artefacts, charcoal; equivalent to base of spit1 of Unit Y2 of Sector 8 WARD 2003 and to Yell03[26-30] and Yell06[27-32]. [GF23-26/<6008>, charcoal sample; 26-28 none]"
SECTOR 8	Yell08[28-30]	SNC 2008: "Interval 28-30; silty interval, quite pure in places; top surface very sharp and irregular (possibly through 'plastic indentation' from stones above); etched bone find <6013>; equivalent to part of spit2 of Unit Y2 of Sector 8 WARD 2003 and to part of Yell06[31-45]."
SECTOR 8	Yell08[30-33]	SNC 2008: "Interval 30-33; gingery, very gritty; equivalent to part of spit2 of Unit Y2 of Sector 8 WARD 2003 and to part of Yell06[31-45]. [GF30-32/<6018>, charcoal sample; GF32-33+/<6041>, charcoal sample]" SNC 2008: "Additional charcoal sample in sqC21, <6855> at height equivalent to [33] level (but note proximity of modern mollusc cluster)." Charcoal sqC21 OxA-22909 14,140 ± 55 BP <TAF08-6855>.
SECTOR 8	Yell08[33-38]	SNC 2008: "Interval 33-38; silty interval; equivalent to part of spit2 of Unit Y2 of Sector 8 WARD 2003 and to part of Yell06[31-45]. [GF33-35/<6045>; GF35-37/<6049>, charcoal sample; GF37-38/<6060>, charcoal sample]"
SECTOR 8	Yell08[38-40]	SNC 2008: "Interval 38-40; strong ginger band; equivalent to part of spit2 of Unit Y2 of Sector 8 WARD 2003 and to part of Yell06[31-45]. [GF38-40/<6095>, charcoal sample]"
SECTOR 8	Yell08[40-44]	SNC 2008: "Interval 40-44; light ginger-coloured; approximately equivalent to top of spit3 of Unit Y2 of Sector 8 WARD 2003, approximately equivalent to middle of Yell03[30-53] and top of Yell06[45-50]. [GF40-42/<6109>; GF42-44/<6125>, charcoal sample]" SNC 2008: "Additional charcoal sample in sqD21, <6856> at height equivalent to [41] level."
SECTOR 8	Yell08[44-48]	SNC 2008: "Interval 44-48; indurated, light cream-coloured; approximately equivalent to bottom of spit3 of Unit Y2 of Sector 8 WARD 2003, approximately equivalent to bottom of Yell03[30-53] and bottom of Yell06[45-50]. [GF44-46/<6129>; GF46-48/<6130>, charcoal sample]"
SECTOR 8	Yell08[48-57]	SNC 2008: "Interval 48-57; approximately equivalent to spit4 and part of spit5 of Unit Y2 of Sector 8 WARD 2003 and to Yell03[53-70], equivalent to Yell06[50-64]. [GF48-50/<6139>, 2 charcoal samples; GF50-52/<6146>, charcoal sample; GF52-54/<6185>, 2 charcoal samples; GF54-57/<6206>]"
SECTOR 8	Yell08[57-61]	SNC 2008: "Interval 57-61; quite strongly cemented, platy small stones; equivalent to base of spit5 of Unit Y2 of Sector 8 WARD 2003 and to Yell03[70-74] and Yell06[64-69]. [GF57-61/<6234>]"
SECTOR 8	Yell08[61-64]	SNC 2008: "Interval 61-64; cemented; bone and charcoal [charcoals in cemented sediment set in foil and individually bagged, [6233, 6235]); equivalent to Unit Y3 of Sector 8 WARD 2003 and to Yell03[74-80] and Yell06[69-72]. [GF61-64/<6248>]"
SECTOR 8	Yell08[64-68]	SNC 2008: "Interval 64-68; small limestone clasts, silty, very silty at base; small coprolite, bone, charcoals, Iberomaurusian lithics; approximately equivalent to part of spit1 of Unit Y4 of Sector 8 WARD 2003 and to the top of Yell03[80-95] and of Yell06[72-97]. [64-66/<6267>, charcoal sample; GF66-67/<6282>; GF 67-69/<6302>]"
SECTOR 8	Yell08[68-71]	SNC 2008: "Interval 68-71; very common patches of grit and small, platy stones; archaeological traces, including Iberomaurusian microlith; approximately equivalent to part of spit1 of Unit Y4 of Sector 8 WARD 2003 and to upper parts of Yell03[80-95] and of Yell06[72-97]. [GF68-71/<6317>, 2 charcoal samples]"
SECTOR 8	Yell08[71-74]	SNC 2008: "Interval 71-74; silty interval; approximately equivalent to part of spit1 of Unit Y4 of Sector 8 WARD 2003 and to middle parts of Yell03[80-95] and of Yell06[72-97]. [GF71-73/<6363>, 2 charcoal samples; GF73-74/<6371>, 3 charcoal samples]"
SECTOR 8	Yell08[74-77]	SNC 2008: "Interval 74-77; very common, small platy stones, gritty patches, some larger stones (c. 10 cm); approximately equivalent to part of spit1 of Unit Y4 of Sector 8 WARD 2003 and to middle parts of Yell03[80-95] and of Yell06[72-97]. [GF74-77/<6414>, 3 charcoal samples]"
SECTOR 8	Yell08[77-93]	SNC 2008: "Interval 77-93; silty, strongly so at top; dispersed charcoal flecks; less obviously banded/laminated; approximately equivalent to parts of spit1 and spit2 and part of spit3 of Unit Y4 of Sector 8 WARD 2003 and to middle-lower parts of Yell03[80-95] and of Yell06[72-97]. [GF77-79/<6427>, charcoal sample; GF79-81/<6430>, charcoal sample and backed microlith; GF81-83/<6466>, charcoal sample and tiny lithic flakes; GF83-85/<6476>, charcoal sample; GF85-87/<6485>, flint debris; 87-89 none; GF89-91 none, charcoal sample; 91-93 none]"
SECTOR 8	Yell08[93-99]	SNC 2008: "Interval 93-99; diffuse banding; fine (< 5 mm) platy limestone; approximately equivalent to part of spit3 of Unit Y4 of Sector 8 WARD 2003 and approximately to Yell03[95-100]; equivalent to Yell06[97-106]. [GF93-95/<6532>, charcoal sample and lithic chips; GF95-97/<6543>, 2 charcoal samples and lithic chips, MSA side scraper <6544>, cf. 'Non-Levallois Flake Industry'; GF97-99/6568, 2 charcoal samples]"
SECTOR 8	Yell08[99-105]	SNC 2008: "Interval 99-105; showing darker/lighter banding; approximately equivalent to spit4 of Unit Y4 and to upper Unit Y5 of Sector 8 WARD 2003 and to Yell03[100-112]; equivalent to Yell06[106-112]. [GF99-1-1/<6569>, charcoal sample, fragments of speleothem & calcite at base; GF101-103/6593, charcoal sample and lithic]" SNC 2008: "Additional charcoal sample in Squares c.D20-19, 6927 at height equivalent to [101-2] level."
SECTOR 8	Yell08[105-107]	SNC 2008: "Interval 105-107; strong light band, with totally cemented patches; equivalent to Yell06[112-114]. [GF105-107/<6603>]"

SECTOR 8	Yell08[107-109]	SNC 2008: "Interval 107-109; dark band, **marker bed**; partially equivalent to the upper subunit of Unit Y5 of Sector 8 WARD 2003 and to Yell03[110-112] and Yell06[114-116]. [GF107-109/<6631>, 2 charcoal samples]"

SECTOR 8	Grey Series TAYLOR & BELL 2017	Descriptions during environmental (principally molluscan) sampling by I BRACK 2009 and V TAYLOR 2010 (sequence revised by V TAYLOR & M BELL 2017, by M BELL 2018) in sqsA-C/23. Local zero (surveyed by SNC) is -0.315 (m below Site Datum). Lithostratigraphic unit notation example for this column: S8-MMC1, etc. The correlations between the MMC column and the Hogue 2010 sequence (and the SNC 2009 description of that sequence) are here correct, whilst those given in Taylor/Bell 2017 are incorrect. Similarly, the present descriptions and correlations supersede those in Taylor 2014.
SECTOR 8	MMC1 [37-40] MMC2 [40-45] MMC3 [45-45.7] MMC4 [45.7-50]	I BRACK 2009: "Grey coloured ashy, loose sediment with inclusions; lacks obvious stratigraphy and shows some evidence of disturbance."
SECTOR 8	MMC5 [50-55] MMC6 [55-58] MMC7 [55-58] MMC8 [58-60] MMC9 [60-62] MMC10 [63-67] MMC11 [67-71] MMC12 [64-69]	I BRACK 2009: "Horizontal stratigraphy is becoming visible; inclusions present - lithics, animal bone, shell, charcoal; charcoal lens at base of MMC6; MMC7 lens of crushed shell on interior portion of column; MMC10&11 only present in front portion of the column; MMC12 lens of crushed shell."
SECTOR 8	MMC14 [64-69]	I BRACK 2009: "Darker grey coloured ashy sediment; rich in shell and charcoal - links to L4/5 in adjacent lithics column [HOGUE 2010]."
SECTOR 8	MMC13 [63-84] MMC15 [69-74] MMC16 [74-75] MMC17 [75-77] MMC18 [77-79] MMC19 [79-80]	I BRACK 2009: "Bowl shaped feature comprising light coloured, ashy sediment and few inclusions; MMC15&16 hearth layers associated with the bowl shaped feature in sample MMC13; abundant charcoal and calcined bones present in some layers; white chalky stone fragments and large white stones present in the base of MMC17; MMC18 ashy lens containing more whole shells than overlying layers."
SECTOR 8	MMC20 [80-83] MMC21 [83-86] MMC22 [86-92] MMC23 [92-98] MMC24 [98-102]	I BRACK 2009: [No description] SNC 2010: Top of MMC20 correlates with the L5/L6 boundary of HOGUE 2010; cf. SNC photos 6957-6962.
SECTOR 8	MMC25 [102-116]	I BRACK 2009: "Distinctive coarse layer with coarse fragmented and whole shells, heat-affected rock and charcoal - Equivalent to lithic column L6 [HOGUE 2010] [SNC: incorrect]." SNC 2010: MMC25 is a pocket pendant from below the L6/L7 boundary of HOGUE 2010; MMC25 wedges out eastwards; cf. SNC photos 6963-6967.

SECTOR 8	MMC26 [105-110] MMC27 [110-115] MMC29 [115-122] MMC30 [122-125]	I BRACK 2009: "Homogeneous mid-grey ashy sediment with some inclusions."
SECTOR 8	MMC28 [116-134] MMC31 [128-138]	I BRACK 2009: "Light coloured ash layers with frequent whole and fragmented burnt shell."
SECTOR 8	MMC32 [132-138] MMC33 [138-142] MMC34 [142-145] MMC35 [145-148] MMC36 [148-152] MMC37 [152-155] MMC38 [155-158] MMC39 [158-161] MMC40 [161-164] MMC41 [162-164] MMC42 [164-166] MMC43 [166-168] MMC44 [168-170] MMC45 [170-178]	I BRACK 2009: "Mid-grey ashy-silt sediments with few inclusions; sediments are dipping towards the back of the cave; possible wash beds. MCC41 pocket of brown-grey sediment which lacks any inclusions."
SECTOR 8	MMC46 [178-184] MMC47 [184-196] MMC48 [191-197] MMC49 [197-200] MMC50 [200-205]	I BRACK 2009: "Deposit contains frequent faunal remains (not burnt), heat affected rocks, charcoal and fragmented shell. MMC47 relates to lens with less fragmented shell than layers above and below. Top of MMC46 equal to lithic column L14/15." SNC 2010: Top of MMC46 correlates with the L14/L15 boundary of HOGUE 2010; cf. SNC photos 6968-6974.
SECTOR 8	MMC80 [200-208] MMC81 [208-218] MMC82 [218-228] MMC83 [228-238] MMC84 [238-246] MMC85 [246-254] MMC86 [254-264] MMC87 [264-271]	V TAYLOR 2010: "Distinctive horizon with up to 90 % large, angular, heat affected limestone fragments; clast supported with fine sediment and charcoal between clasts; number of large rocks reduces at base as part of transition to underlying silty layer."

SECTOR 8	MMC88 [271-276] MMC89 [276-281] MMC90 [281-286] MMC91 [286-294]	V TAYLOR 2010: "Homogeneous 7.5YR 5/3 brown sterile silt layers. MMC91 shows more stone as part of transition to rocky layer below." SNC 2010: MMC88-90 (continuous beds, thickening to 15 cm and more; including some patches of washed material, laminated, with charcoal and shell; earthier and a little more stable eastwards but still under-compacted; colour becoming less homogeneous) correlates with the L25 of HOGUE 2010; cf. SNC photos 6989-6992.
SECTOR 8	MMC92 [294-306] MMC93 [306-316] MMC94 [316-325] MMC95 [325-333] MMC96 [333-345]	V TAYLOR 2010: "Clast supported horizon similar to that seen at 2.20 m; up to 70 % large, angular, heat-affected limestone fragments with grey-brown ashy silt in between clasts; clasts are less frequent and sediment shows a pinker colour towards base."
SECTOR 8	MMC97 [345-348] MMC98 [348-351] MMC99 [351-354] MMC100 [354-359] MMC101 [359-362] MMC102 [362-365] MMC103 [365-368] MMC104 [368-371] MMC105 [371-374] MMC106 [374-376]	V TAYLOR 2010: "Silty pinkish-grey (7.5YR 6/2) and brownish grey (7.5YR 5/2) sediment with gravel grade stone up to 4 cm; frequency of stone gradually increases reaching 35 % in basal Grey Series; sandy sediment in MMC99 and lens of Yellow Series in MMC100 suggesting mixing between basal Grey and Yellow Series sediments. Transitional zone." SNC 2010: MMC96-102 (localised ash lenses, dipping southwards by 15°, suggesting the edge of a true cone of dejection) correlates with the finer interval of L28 of HOGUE 2010; MMC103-106 correlates with the stonier interval of L29 of HOGUE 2010; cf. SNC photos 6981-6988.
SECTOR 8	Yellow Series TAYLOR & BELL 2017	SNC 2010 photos 6666-6672.
SECTOR 8	MMC107 [376-379] MMC108 [379-382] MMC109 [382-389] MMC110 [389-392]	V TAYLOR 2010: "Reddish yellow (7.5YR 6/6) silty sediment with some sand and up to 10 % small stone, some of which may be heat affected; frequent faunal remains and lithics - Equal to Y1 [WARD 2003]."
SECTOR 8	MMC111 [392-397] MMC112 [396-399] MMC113 [399-401] MMC114 [401-404] MMC115 [404-407] MMC116 [407-409] MMC117 [409-412] MMC118 [412-418]	V TAYLOR 2010: "Start of unit Y2 [WARD 2003]; yellowish red (5YR 5/8 and 5YR 6/8) silt with sand; contains distinctive layer ["red/orange" level in spit1 of Unit Y2 of Sector 8 WARD 2003, similar to, but not correlating with, Raynal 5 in Sector 2] (samples 112 and 113) which is slightly redder in colour and appears to be sterile of artefacts; tabular calcite present below 4.19 m."

SECTOR 8	MMC119 [418-420]	V TAYLOR 2010: "Stony band; reddish yellow (5YR 6/8) layer with up to 40 % stones; frequent calcite crust up to 1 cm in depth."
SECTOR 8	MMC120 [420-424] MMC121 [424-430]	V TAYLOR 2010: "Yellowish red (5YR 5/8) silty sand with infrequent small gravel grade stone."
SECTOR 8	MMC122 [430-437] MMC123 [437-439] MMC124 [439-441]	V TAYLOR 2010: "Yellowish red with silty sediment with some sand; 50 % stone inclusions up to 10 cm; increasingly stony at base - transitional zone with underlying stony band."
SECTOR 8	MMC125 [441-445]	V TAYLOR 2010: "Distinctive stony band. Reddish yellow (5YR 6/8) with gravel grade 40 % stones up to 4 cm." SNC 2010: "MMC125 probably equivalent to S8-Y3."
SECTOR 8	MMC126 [445-448] MMC127 [448-450] MMC128 [450-452] MMC129 [452-456] MMC130 [456-466]	V TAYLOR 2010: "Sediments dipping towards cave wall; up to 40 % gravel grade stone in places; whole land snail shells are observed in the lowest levels. The sequence continues below the limit of excavation for some distance." SNC 2010: "MMC130 at base is equivalent to lower part of S8-Y4."

SECTOR 8	Grey Series SNC 2009	Descriptions during excavation by J HOGUE 2009 in sqA24 (measurements on the A24/23 line in the SW corner of the excavation); local zero is -0.310 (m below Site Datum). 2009 SNC photos 4474-4476 hearth bulk sampled as <8087>; 4493-4501 upper Grey Series. SNC photos: 4593-4601, wash series scale in L13, mollusca at top of L6 ("L10" not showing in these shots); 4602-4608, 'pit' feature in section on the west side of the square; 4609-4615, fractured units, scale at base of L3. Lithostratigraphic unit notation example for this column: S8-SNC09-L1, etc.
SECTOR 8	MORTAR [c- 10 to 3]	SNC 2009: "Lime mortar, with varied dolomite clasts (mostly 6-15 cm); very slight dip 2°-4° into cave; made floor."
SECTOR 8	L1 [3-6/7]	SNC 2009: "Trampled facies; many local microfaults and fractured discontinuities (containing sub-recent pottery, etc.); formerly a laminated interval/zone."
SECTOR 8	L2 [6/7-14]	SNC 2009: "Structure only locally laminated, mostly disturbed (churned); ashy; 10YR 6/1; contained a hearth; rather diffuse lower boundary."
SECTOR 8	L3 [14-38]	SNC 2009: "Slightly better bedded than L2 (same colour), with various good charcoal-rich lenses; slightly irregular and undulating; many small stones and common grit; bone fragments; only 2° dip into cave and 5° to south (towards cave wall)."
SECTOR 8	L4 [38-39]	SNC 2009: "More compact than L3; lens with more grit and charcoal at base of L4."
SECTOR 8	L5 [39-46]	SNC 2009: "Rather fractured (treadage); shell at all angles; some medium stones throughout, larger stones at base; very rich in charcoal (containing a hearth); pockets of dense shell and charcoal; low bedding angle (cf. L3); 10YR 5-3/1; equivalent to MMC14 of TAYLOR & BELL 2017."
SECTOR 8	L6 [46-66]	SNC 2009: "Variable bedding, fractured in places, better laminated in others; ashy; 10YR 5-6/1; lithics; stony lenses with charcoal, fractured shell and bone fragments, especially at base; contains a hearth; thin and very restricted (5-10 cm laterally) light ash lenses; wavy base, with charcoal concentration; L5/L6 boundary equivalent to 19/20 boundary, base equivalent to MCC25 (a lens pendant from the boundary in question."
SECTOR 8	L7 [66-85]	SNC 2009: "Almost homogeneous; fractured or poor lensing; no sorting; poor bedding sloping <6° into cave."
SECTOR 8	L8 [85-100]	SNC 2009: "Poorly bedded, fractured towards contained hearth; moderate stone content, rather burnt; some shell and bone lenses; colour has speckles of charcoal and orangey bone fragments; dipping 8° into cave and 8° to the south (towards cave wall); L8/L9 boundary equivalent to MMC32/33 boundary." Bone OxA-27276 11,410 ± 55 BP <8552>.

SECTOR 8	L9 [100-110]	SNC 2009: "Very compact ash lens; tiny charcoal, bone and shell lenses included; mostly well laminated; relatively sterile of lithics; small stones; quite dark grey in places; pocketed or undulating base; 10° dips into cave and southwards; top L9 equivalent to top MMC33." SNC 2009: "On western side of square, strong turbation phenomena, with ash and cemented ash clasts, some browner grey (more mineral) zones, large disturbed area of charcoal-rich material, vertical steps in boundaries, fabric unlaminated; probably a dug feature, a small backfilled 'pit' (otherwise a large burrow). NB – heights of underlying units given as if they continued straight through this 'pit' feature."
SECTOR 8	"L10"	SNC 2009: "Red silty lithorelics at base of L9."
SECTOR 8	L11 [110-120]	SNC 2009: "Uniform grey, laminated material; bedding slightly concave-up, dipping 10° into cave; shell fragments commonly on bedding planes; thin ashy lenses; sterile of lithics."
SECTOR 8	L12 [120-122]	SNC 2009: "Similar to L11 but much more charcoal, bone and shell on bedding planes; generally darker; c. 8 cm thick on east side, with lithics in a small cut feature."
SECTOR 8	L13 [122-130]	SNC 2009: "Similar to L11."
SECTOR 8	L6-L13	SNC 2009: "L6-L13 form a group of related units, apparently showing wash bedding."
SECTOR 8	L14 [130-135]	SNC 2009: "Top of L14; some stone but the main change is increased colour in the matrix (probably increased mineral) &.5YR 5/2; compact."
SECTOR 8	L14 [135-143+]	SNC 2009: "Main L14 (not bottomed at this time); increasingly stony, angular fragments and rounded burnt clasts; common shell; bone and lithics present; L14/15 boundary equivalent to MMC45/46 boundary."
SECTOR 8	L9-L13	SNC 2009: "L9-L13(L14) equivalent to MMC33-45; this wash sequence more compact than units affected by treadage above and below. Top MMC46 is equivalent to the L14/L15 boundary."
SECTOR 8	Grey Series SNC 2010	Descriptions during excavation by J HOGUE 2009 in sqA24 (measurements on the A24/23 line in the SW corner of the excavation); new local zero is at base, measurements given upwards; SNC photos 6651-6665. Lithostratigraphic unit notation example for this column: S8-SNC10-L15, etc.
SECTOR 8	L15 [94-89]	SNC 2010: "Quite stony; 4-5 cm thick; washed unit, charcoal and shell horizontal; overall unit dipping into the cave."
SECTOR 8	L16 [89-64]	SNC 2010: "Massive unit; stones at all angles; slightly earthy fine matrix but the whole looks disturbed (in antiquity)."
SECTOR 8	L17 [64-58]	SNC 2010: "Similar to L19; poor bedding, no washing; stones; common bones; possibly slight dip eastwards, out of cave."
SECTOR 8	"L18"	SNC 2010: "L18 was a disturbed pocket, not represented in the section described."
SECTOR 8	L19 [58-54]	SNC 2010: "Stonier and less well structured than below; no obvious horizonality; charcoal throughout."
SECTOR 8	L20 [54-42]	SNC 2010: "Some larger stones; slightly earthy but with localised lenses of material like L21 below; bones lying flat."
SECTOR 8	L21 [42-37]	SNC 2010: "Laminated and slightly washed; dark grey; much more shell and charcoal than below; good continuous exposure across section, more or less horizontal but, if anything, sloping locally slightly outwards; L21/22 boundary equivalent to some level in MMC51-54 (interval) (i.e. "intra-MMC57" column)." [SNC: the comment concerning a possible correlation with the MCC column is an error.]
SECTOR 8	L22 [37-34]	SNC 2010: "Slightly more compact and finer than below; transitional boundary."
SECTOR 8	L23A [34-0]	SNC 2010: "Poorly structured; slightly brown 'earthy'; common medium stone; common bone; appears stratified but not greatly washed; some lenses but laterally discontinuous; almost horizontal, slight dip westwards, into cave."
SECTOR 8		SNC 2010 description resumed, with measurement downwards from local zero.
SECTOR 8	L23B [0-16]	SNC 2010: "A little more larger stone than above; still light, slightly brown 'earthy' colour; short lenses, including ash laminae, dipping slightly eastwards, out of cave."
SECTOR 8	L24 [16-51]	SNC 2010: "Coarse scree (6-10 cm diameters), almost perfectly clast-supported; large bone and charcoal fragments, very common; more fine matrix at base (with a patchy grey to earthy colour), some air-space near top; most stone is burnt; very minor internal bedding, probably indicating 3-4 accumulation events; more or less horizontal."
SECTOR 8	L25 [51-72]	SNC 2010: "Larger stones at top and some especially large ones at base but the central interval is matrix-supported; very fine gritty, slightly earthy, quite compact (the grit is probably supplying most of the support); local grit lenses, horizontal; more charcoal and artefacts towards the base, amongst stones; there may have been a more stable (long-lasting) surface at/near to top of this unit but no real alteration/weathering; L25 equivalent to MMC88-90 interval."
SECTOR 8	L26 [72-100]	SNC 2010: "Very coarse (10-14 cm diameters); perfect clast-support in most places; mostly burnt stone; very irregular fabric, stones at all angles; common air-holes; common snails and charcoal in relatively large fragments."
SECTOR 8	L27 [100-108]	SNC 2010: "Large stones but in an earthy (not very gritty) matrix; large bones; common charcoal."
SECTOR 8		SNC 2010: "The base of L27 is followed outwards into sqsC23/24 in which the sequence below continues downwards."

SECTOR 8	L28 [108-143]	SNC 2010: "Good matrix-support; only rare small stones; generally moderately clear stratification, with very slight dip to ESE out of cave; common ash, greyish, slightly crushable (i. e. not totally collapsed spicular structure); charcoal and fine grit; elongate objects (e. g. bone fragments) horizontal; slightly more coherent ashy (lighter) lenses nearer top; some larger stones pressed into top surface; appears to be a comparatively slow accumulation, with better stratification as one proceeds further into the cave; finer (central) interval in L28 equivalent to MMC96-102 interval."
SECTOR 8	L29 [143-160]	SNC 2010: "Very stony, partially clast-supported; common bone and charcoal; very irregular base, appearing disturbed, even 'dug over'; stonier interval of L29 equivalent to MMC103-106 interval."
SECTOR 8	Yellow Series SNC 2010	Descriptions during excavation by J HOGUE 2009 in sqsC23/24 (measurements continuing on local datum downwards from Grey Series above). SNC photos 6333-6448. Lithostratigraphic unit notation example for this column: S8-SNC10-L30, etc.
SECTOR 8	L30 [160-171]	SNC 2010: "Stony dense light yellow silt; common bone; lithics."
SECTOR 8	L31 [171-180]	SNC 2010: "Bright orange silt and stones, with cream flecks; charcoal present."
SECTOR 8	L32 [180-185+]	SNC 2010: "Very dense silt; common charcoal and cream flecks; appears to be near the top of the Y2 sequence."

SECTOR 8	Grey Series HOGUE 2010	Descriptions during excavation by J HOGUE 2009/10 in Square A24 (leaving some 0.75 m lateral separation with the TAYLOR & BELL 2017 (collected 2009) sampling column). [Some correction by SNC of claimed correlation with S WARD 2003 GS units.] Lithostratigraphic unit notation example for this column: S8-JH10-L1, etc.
SECTOR 8	MORTAR [0-35] L1[35-41]	J HOGUE 2010: "Lime mortar at surface, over L1 trample (equivalent to top of G88)."
SECTOR 8	L2[41-52] L3[52-82] L4[82-83] L5[83-88]	J HOGUE 2010: "Mid brownish grey (10YR 5/2); slightly gritty ashy-silt series; churned and fractured fabric; frequent small (< 5 mm) mollusc shell fragments; moderate charcoal flecks; with bioturbation (10 cm in scale) throughout deposits; middle context (L3) looser and less compressed; less friable mid-grey specked ash towards bottom (L5); and mollusc shell and charcoal lens (L4); lenticular in nature." [SNC: equivalent to bulk of G88 and to G89.] S8-JH10-L2 bone sqA25 OxA-24111 10,680 ± 45 BP <TAF09-7319>. S8-JH10-L3 charcoal sqA24 OxA-23404 10,870 ± 45 BP <TAF09-7525>. S8-JH10-L4 bone sqA24 OxA-24112 11,165 ± 45 BP <TAF09-7997>.
SECTOR 8	L6[88-104] L7[104-116] L8[116-132] L9[132-137]	J HOGUE 2010: "Mid-grey (7.5YR 5/1); speckled ashy-silt series; variably bedded fabric; with abundant small snail shell pieces; frequent charcoal flecks and large (> 20 mm) charcoal pieces; occasional large burnt limestone fragments; interstratified with very fine ash 'hearth' deposits; clear boundary; L5/L6 contact is equivalent to the contact between the bottom of MMC19/17 and top of MMC20; equivalent to bottom of G88, G89 and top of G90." [SNC: equivalent to G90 and probably G91.] SNC 2009, photos 4246-4259 of hearth (bulk recorded as <7369>). S8-JH10-L6 bone sqA24 OxA-24113 11,540 ± 50 BP <TAF09-8289b>. S8-JH10-L6 charcoal sqA24 OxA-23405 11,615 ± 50 BP <TAF09-8275>. S8-JH10-L8 charcoal sqA24 OxA-23406 11,445 ± 55 BP <TAF09-8590>. S8-JH10-L8 charcoal sqA24 OxA-23407 11,465 ± 50 BP <TAF09-8590 duplicate>.
SECTOR 8	L11[137-151] L12[151-160] L13[160-179] L14[179-181]	J HOGUE 2010: "Light grey (7.5YR 7/1); 'sterile' very fine ash series; compact; finely laminated; dipping into cave; occasional charcoal flecks; small mollusc shell fragments; sometimes forming discreet very thin lens; few faunal remains; occasional medium size limestone fragments near base (L14); equivalent to G91 and G92." [SNC: equivalent to G92 and upper half of G93." SNC 2009: photos 4549-4551. S8-JH10-L11, OSL-TAF09-24 18.3 ± 1.2 ka BP (multigrain), 17.4 ± 1.0 ka BP (single-grain). S8-JH10-L11 charcoal sqA24 OxA-23408 11,545 ± 55 BP <TAF09-8849>.
SECTOR 8	L15[181-187]	J HOGUE 2010: "Horizon of large (60-120 mm) burnt limestone fragments (c. 40 %); with interfiling dark grey; loose; charcoal (60 %), mollusc shell (30 %) silt matrix; poorly bedded; L14/L15 contact equivalent to top of MMC46; and equivalent to top of G93." [SNC: equivalent to mid-G93.] S8-JH10-L15 charcoal sqA24 OxA-23409 11,890 ± 55 BP <TAF10-9159.
SECTOR 8	L16[187-198] L17[198-208] L19[208-217] L20[217-225]	J HOGUE 2010: "Mid brownish-grey (10YR 5/2) slightly sandy-silt deposits; poorly sorted; churned and fractured fabric; frequent small mollusc shell fragments; frequent charcoal flecks; frequent medium-large cindered limestone fragments; frequent animal bone fragments; often forming concentrated clusters; less churned towards base of unit; fewer limestone fragments; numerous terrestrial snail shell fragments; equivalent to bottom of G93, G94 and top of G95." S8-JH10-L17 bone OxA-27277 12,040 ± 55 BP <9368>. S8-JH10-L19 bone OxA-27278 11.945 ± 55 BP <9494>. S8-JH10-L20 bone OxA-27281 12,210 ± 55 BP <9578>.
SECTOR 8	L21[225-231]	J HOGUE 2010: "Mid grey (7.5YR 5/1) slightly sandy-silt; moderately well-bedded; with numerous small mollusc shell fragments; clear boundary; L21/L22 contact equivalent to intra-MMC57; and equivalent to intra-G95." [SNC: the comment concerning a possible correlation with the MCC column is an error.]

SECTOR 8	L22[231-238] L23[238-270]	J HOGUE 2010: "Mid grey (7.5YR 5/1); firm; slightly sandy-silt; moderately sorted; relatively homogeneous; occasional charcoal flecks; very small mollusc shell fragments (<2 mm); and animal bone fragments; occurrence of limestone fragments medium-large (40-120 mm) towards the bottom of the deposit (L23); matrix sits in-between clasts in underlying deposit; equivalent to bottom of G95 and top of G96." S8-JH10-L23 bone OxA-27280 12,290 ± 55 BP <9775>.
SECTOR 8	L24[270-306]	J HOGUE 2010: "Rubble horizon; consisting of medium-large (40-150 mm) burnt limestone fragments; loosely packed; lithic artefacts and animal bone orientated vertically; voids between rocks towards base of deposit; clear boundary; equivalent to intra-G96." S8-JH10-L24 bone OxA-27279 12,310 ± 55 BP <9881>.
SECTOR 8	L25[306-321]	J HOGUE 2010: "Very distinct mid brown (7.5YR 5/2); 'sterile' sandy-silt; occasional charcoal flecks; increasing in proportion towards base; occasional small shell fragment; occasional medium-large limestone clasts; matrix sits in-between clasts in top of underlying deposit; equivalent to intra-G96." S8-JH10-L25 charcoal sqB24 OxA-23410 12,405 ± 55 BP <TAF10-10052>.
SECTOR 8	L26[321-348] L27[348-354]	J HOGUE 2010: "Rubble horizon; consisting of medium-large (40-150 mm) burnt limestone pieces; loosely packed; with numerous voids; mid brownish-grey (10YR 5/2); loose; slightly sandy-silt; infilling between clasts; frequency of rocks decreasing towards base (L27); clear horizon; equivalent to bottom of G96."
SECTOR 8	L28[354-381]	J HOGUE 2010: "Mid brownish-grey (10YR 4/4); homogeneous compact ashy-silt; well sorted; frequent charcoal flecks giving speckled appearance; occasional small mollusc shell fragments; occasional recent disturbance from carpenter [mason?] bees; equivalent to G97 and G98." S8-JH10-L28 charcoal sqB24 OxA-23411 13,060 ± 65 BP <TAF10-10319>.
SECTOR 8	Transition Zone L29[381-398]	J HOGUE 2010: "Mid brown (7.5YR 4/2) firm gravely sandy-silt matrix; interlocking with large dolomite clasts (60 % of deposit) from the make-up of the cave; infrequent evidence of burning; occasional charcoal flecks; equivalent to G99 and G100." Cf. SNC 2010 photos 6831-6834 base of Grey Series.
SECTOR 8	Yellow Series HOGUE 2010	Lithostratigraphic unit notation example for this column: S8-JH10-Y1, etc.
SECTOR 8	Y1[398-411]	J HOGUE 2010: "Mid brownish-yellow (10YR 6/6); cemented; silty-sand; moderate medium (20 mm-60 mm) stones occurrences; frequent large animal bone fragments; numerous lithic artefacts; notable absence of mollusc shell; localised brown/black charcoal lenses and ashy hearth deposits; equivalent to L30, Yell06[0-17] and Yell08[2-12]." SNC 2010: "Y1 equivalent to MMC107-110 interval and J HOGUE L30." S8-JH10-L30 Bone OxA-27282 12,730 ± 60 BP <10710>.
SECTOR 8	Y2spit1	J HOGUE 2010: "Middle yellow-red (5YR 7/6), contains occasional charcoal flecks; infrequent lithic artefacts; higher grit content at top and towards base; approximately equivalent to L31, L32, Yell06[17-31] and Yell08[12-28]." [Limit of excavation 423.] SNC 2010: "Y2 spit2/spit1 (arbitrary spit boundary) approximately equivalent to MMC114/115 boundary and J HOGUE L31." S8-JH10-L31 Bone OxA-27283 12,875 ± 60 BP <10847> [possibly a Y1 object disturbed downwards into Y2spit1).
SECTOR 8		SNC 2010 photos of entire A24 (archaeological) and A23 (MMC) sequences.

SECTOR 9

SECTOR 9		Test excavation northwest of the inner (west) end of Ruhlmann's Trench (Squares O21/22). SNC 2006: "Northeast-facing section (viewed by looking SW, into cave) in sqO21/22; z -4.044 (m below Site Datum) at the very top of the section drawing. The very gritty material near rocks in this area has significant microfaunal content." O REESE 240907 section drawing: the entire section shown as 1.13 m thick (starting at z -4.12 (m below Site Datum)). Lithostratigraphic unit notation example for this column: S9-U1, etc.
SECTOR 9	Unit 1	SNC 2006: "Mostly anthropogenic, with at least 3 charcoal trails in generally mid- to darker brown gritty silt; much large charcoal, possibly *in situ* heating in places; burnt stone and bone; said to contain LSA in quantity; rather irregular base, perhaps a little erosive." SNC 2006: "Charcoal OxA-16260 18,005 ± 75 BP <TAF06-5407>, base of LSA Unit 1." O REESE 240907 section drawing: Unit 1 shown as between 5-10 cm thick, lowest at -4.24 m; dispersed charcoal and one stronger burning lens; fine stones.

SECTOR 9	Unit 2	SNC 2006: "Lighter gritty material; some bone; isolated charcoal." SNC 2006: "Charcoal OxA-16240 18,185 ± 75 BP <TAF04-1133>, Unit 2." O REESE 240907 section drawing: Unit 2 shown as between 7-17 cm thick, lowest at -4.35 m; dispersed charcoal, quite stony.
SECTOR 9	Unit 3	SNC 2006: "Dark brown 'earthy' material; slight reddening at the base; traceable right across the section, although fading southwards; said to contain side-scrapers, as well as typical LSA material." O REESE 240907 section drawing: Unit 3 shown as up to 8 cm thick, shown as lens pinching out southwards, lowest at -4.40 m. SNC 2009: "Unit 3 hearth (above the lens known as '3a') in sqP24, sample <TAF09-7441> of hearth (burnt stone, lithics, charcoal)". Not clear whether '3a' is a lens in the top of what had been called Unit 4 in sqO21/22 or still a part of Unit 3. SNC photos 4303-4312.
SECTOR 9	Unit 4	SNC 2006: "Increasingly stony and gritty, light to medium brown; chert flake; said to contain MSA but few finds. The charcoal lenses show very slight dip towards the cave wall, slightly stronger dip out of cave; they, and the cleaner beds between them, fan out (each thickening) to the northeast." O REESE 240907 section drawing: Unit 4 shown as up to 57 cm thick, lowest at -4.92 m; major block band in centre of Unit, blocks in the order of 20 × 50 cm.

SECTOR 9		Section at outer (east) end of Ruhlmann's Trench. SNC 2009: "At northeast end of trench, looking northwest; log co-ordinates recorded as [20] level = x 117.840, y 100.453, z -3.787 (m below Site Datum), in sqQ27. At this point, the beds slope down slightly into the cave (southwestwards), suggesting that there was a talus at the cave entrance; all units show poor but continuous bedding; there is quite a lot of finest bioturbation 'furring'. Microfaunal and OSL samples. Depths approximate, measured directly down-section." SNC 2009: photos 4526-4527 showing microfaunal samples. Lithostratigraphic unit notation example for this column: S9-09[8-16], etc.
SECTOR 9	[8-16]	SNC 2009: "Possibly disturbed".
SECTOR 9	[16-19]	SNC 2009: "Gritty silt, mid-brown".
SECTOR 9	[19-25]	SNC 2009: "Light brown above, traces of grey and 'chocolate' brown at base with charcoal".
SECTOR 9	[25-32]	SNC 2009: "Gritty silt, mid-brown, slightly reddened at top".
SECTOR 9	[32-40]	SNC 2009: "Gritty, brown".
SECTOR 9	[40-42]	SNC 2009: "'Chocolate' brown".
SECTOR 9	[42-44[	SNC 2009: "Gritty, brown, including Iberomaurusian backed bladelet".
SECTOR 9	NB. [35-45]	SNC 2009: "Microfaunal sample <TAF09-8491>, backed bladelet at the base; also OSL-TAF09-20 18.64 ± 1.73 ka BP".
SECTOR 9	[44-49]	SNC 2009: "'Chocolate' brown with some bedded lenses".
SECTOR 9	NB. [16-49]	SNC 2009: "Unit 1 in sqsO21/22 probably correlates with the lower part only of this 16-49 interval."
SECTOR 9	[49-70]	SNC 2009: "Gritty, light brown; correlating with Unit 2 in sqsO21/22".
SECTOR 9	[70-78]	SNC 2009: "Gritty, mid-brown; traces of charcoal and lithics; correlating with Unit 3 in sqsO21/22".
SECTOR 9	[78-90]	SNC 2009: "Slightly gritty, light brown; correlating with part of Unit 4 in sqsO21/22".
SECTOR 9	NB. [70-80]	SNC 2009: "Microfaunal sample <TAF09-8492>, including several Iberomaurusian backed bladelets [*sic*] and charcoal; also OSL-TAF09-21 25.05 ± 2.28 ka BP".
SECTOR 9	[90-92]	SNC 2009: "Silt, yellow brown".
SECTOR 9	[92-98]	SNC 2009: "Silt, dark 'chocolate' brown, charcoal".
SECTOR 9	[98-102]	SNC 2009: "Silt, yellow brown".
SECTOR 9	[102-103]	SNC 2009: "Silt, dark 'chocolate' brown, strong charcoal; the layer is discontinuous northeastwards (outwards) but, southwest of the large rock, it is much stronger, with bedding lenses, hearth material and lithics".
SECTOR 9	[103-106]	SNC 2009: "Silt, yellow brown".
SECTOR 9	[106-120]	SNC 2009: "Silt with small stones".
SECTOR 9	NB. [110-120]	SNC 2009: "Microfaunal sample <TAF09-8493>; no obvious archaeology or charcoal; only a little bone; carbonate-rich, perhaps some eucladioliths; speleothem fragments; corroded small limestone clasts common; also OSL-TAF09-22 26.05 ± 1.98 ka BP". P Ditchfield: "Iberomaurusian backed bladelet found 140410 <TAF10-11057> at about this level." [SNC: problematical – not *in situ*?]
SECTOR 9	[120-124]	SNC 2009: "Silty, light-coloured".
SECTOR 9	[124-128]	SNC 2009: "'Chocolate' brown with charcoal".
SECTOR 9	[128-154]	SNC 2009: "Angular clast of ancient speleothem/calcite in a very light silt (including decomposing speleothem); common bird and micromammal bones, mollusca; a few larger bone fragments and one lithic chip near base; larger stones appearing downwards; very compact; rare stalactite fragments".

SECTOR 9	NB. [140-150]	SNC 2009: "Microfaunal sample <TAF09-8494>; no obvious archaeology and few bones; many small limestone clasts; also OSL-TAF09-23 28.28 ± 3.09 ka BP". SNC 2010; "Fine silty sand (15 cm above main speleothem collapse, sqQ27, 5.626 m below Site Datum) with apparent rhizoliths/soil nodules in carbonate".

SECTOR 9		**Section near outer (east) end of Ruhlmann's Trench.** SNC 2016: "Near northeast end of trench, looking northwest; log co-ordinates recorded as [0] level = x 117.868, y 101.437, z -3.535 (m below Site Datum)." The sequence reported here continues well below the LSA, the lower material being included to assist in correlation. SNC 2016: general photos 3467-3469 showing "old" microfaunal samples and some "old" OSL samples to the 'east' (right). Lithostratigraphic unit ("context") notation example for this column: S9-16-CTX1, etc.
SECTOR 9	[0-18]	SNC 2016: "Missing interval (excavated/collapsed prior to 2003)."
SECTOR 9	CTX1 [18-34]	SNC 2016: "Compact gritty silty loam; 7.5YR 6/4; angular small stones; partial matrix-support; internal planar bedding, dipping gently into cave (W)."
SECTOR 9	CTX2 [34-40]	SNC 2016: "Similar to CTX1 but with traces of burning affecting limestone (more powdery) and colour 5YR 3/3; charcoal flecks; irregular in section (cannot cut flat); fragmented and patchy cemented ash at base in [39-40] interval (this interval being counted incorrectly in CTX3 during excavation). Equivalent to S9-09[19-25]."
SECTOR 9	CTX3 [40-50]	SNC 2016: "[40-43] interval, silty fine sand, with colour strengthening to 'orangey' 5YR 5/6; [43-50] interval, gritty silty loam, 7.5YR 5/4; diffuse, possibly turbated, boundary between these two subunits; gritty but more 'weathered' than in CTX1 and with fewer stones, matrix-supported; 'orangey' subunit at top might be a hearth but more probably a natural wash input."
SECTOR 9	CTX4 [50-61]	SNC 2016: "[50-54] interval, lensing out westwards; dark hearth remnant 7.5YR 4/3; Taf09-OSL20 passed through the equivalent of this subunit, in the interval S9-09[35-45]. [(50)54-61] interval; very similar to lower subunit of CTX3; 3 cm lens (pinching out eastwards) of more 'orangey' material near but not at base (2 cm of normal sediment at base); dispersed charcoal; slightly less dense than CTX3, stones dipping at all angles. Both subunits dip into the cave."
SECTOR 9	CTX5 [61-67]	SNC 2016: "Dense silty loam with slightly weathered fine grit; 7[*sic*]YR 6/4; slightly more gritty lenses and stringers, stronger at base." Charcoal sample OxA-35508 16,410 ± 70 BP <TAF16-14786>.
SECTOR 9	CTX6 [67-76]	SNC 2016: "Very similar to CTX5 but very slightly lighter, with slightly redder lenses included."
	N.B.	SNC 2016: "On the west side of the excavation, burrows have caused the slumping of a block containing the base of CTX3 (relabelled "CTX7" during excavation), hearth material of type CTX4 (relabelled "CTX8" during excavation) and a part of the top of CTX5. Further west still, CTX4 is in place, with CTX5 & CTX6 below (local gritty lens, used to form the boundary on the east side of the excavation, is uncertain)."
SECTOR 9	CTX9 [76-91]	SNC 2016: "Dense gritty silty loam; 7[*sic*]YR 6/4; common stalagmitic fragments; charcoal fragments, with charcoal sometimes in very fine stringers; well stratified in silty/gritty alternations; during deposition of this unit, sedimentation changes downwards to the horizontal. Lowest occurrence of LSA lithics, although burrows through CTX9 may have carried a few elements downwards. Equivalent to S9-U3." Charcoal sample <TAF16-15025> [failed]. Charcoal (flot) sample OxA-35509 19,230 ± 80 BP <TAF16-15374>.
SECTOR 9	CTX10 [83-86]	SNC 2016: "On the west side of the excavation, traces of brown sediment with strong charcoal (hearth), no more than 3 cm thick, lying within CTX9." Charcoal sample (hearth) <TAF16-15387> [too small?].
SECTOR 9	CTX11 [91-97]	SNC 2016: "Silt becoming dominant, dense, in places no stones or grit at all; matrix-support; 7[*sic*]YR 6/6; 'blotches' of CTX12 dragged upwards (bioturbation?); this is the first truly silty unit in this sequence."
SECTOR 9	CTX12 [97-99]	SNC 2016: "Up to 7 cm thick in places; brown powdery sediment; burnt limestone; charcoal; reddened at base (redder than the more 'orangey' wash lenses above); adze and flakes (local geologists (Oujda) suggest the raw material is a fine volcanic, although it might otherwise be a quartzite; fine sparkle and hackly fracture, tending to shallow steps; dark bluish grey 2G 4/10B). Cf. 'Non-Levallois Flake Industry'." SNC 2016: "Photos 3470-73; close-up across CTX12; scale top 1 cm into lowest S9-U3 equivalent; scale bottom 1 cm short of bottom if CTX14; note clean silt beds above and below CTX12." Charcoal sample (hearth) OxA-35510 20,520 ± 100 BP <TAF16-15495A>. Charcoal sample (east) OxA-35511 20,160 ± 90 BP <TAF16-15495B>.
SECTOR 9	CTX13 [99-105]	SNC 2016: "Almost clean silt; 5YR 6/6, with yellower streaks; very dense in places, elsewhere with a little grit, grittier westwards; may have a few laminations in places." Charcoal sample (S9-16-CTX13 base) OxA-35654 20,460 ± 90 BP <TAF16-15634>.
SECTOR 9	CTX14 [105-112]	SNC 2016: "Gritty silty loam; 5YR 5/4; relatively sharp upper and lower boundaries; good charcoal in a hearth subunit in the SE part of the excavation; dispersed charcoal powder/flecks elsewhere; still fakes in the 'adze' raw material. Hearth subunit equivalent to S9-09[102-103]." Charcoal sample (east) OxA-35655 20,520 ± 90 BP <TAF16-15668>. Charcoal sample <TAF16-15668b> [too small].

SECTOR 9	CTX15 [112-127]	SNC 2016: "Well bedded sequence of silty deposits, sometimes with stony, gritty or cleaner silt subunits; silt is 5YR 5/6; finer grit is quite corroded; especially strong silty lenses in the middle of this subsequence; becoming lighter at base 5YR 6/6."
SECTOR 9	CTX16 [127-134]	SNC 2016: "[127-131] interval; stony silt; 5YR 6/4; very common grit; charcoal specks; probably some ash, slightly cemented in places. [131-134] interval; ash (5YR 6/2-3) over dark sediment, sometimes black with strong charcoal component. Chips of 'adze' raw material but also a Levallois flake with facetted butt (presumed MSA) near base." Charcoal sample <TAF16-15877> [fail]. Charcoal sample (general finds) OxA-35656 23,170 ± 120 BP <TAF16-15876>.
SECTOR 9	CTX17 [134-170]	SNC 2016: "[134-138] interval; gritty; slightly greyed 5yr 5/4-6; some charcoal flecks may be associated with hearth above; relatively sharp lower boundary. [138-170] interval; stony silt; 5YR 5/6 and lighter; stones are often corroded speleothem fragments; some local concretions and eucladioliths; partial clast support; in the [145-146] interval, a slightly more dark brown band, possibly archaeological." Charcoal sample <TAF16-15932> [fail].
SECTOR 9	[170+]	SNC 2016: "Ancient speleothem shatter bed."

SECTOR 10

SECTOR 10		Roche (1963): Plate IIIB (section N7-Q9), appears to show strong lensing with some plastic deformation (stratigraphic level not recorded). Burials in northeastern corner of cave, towards the base of the Grey Series in this area. Current Campaign – dominated by excavation of human burials; deposits attributed to the Grey Series are defined in Chapter 2. SNC 2013: "Some of the grey ash-fill of burial features in S10 is strongly capable of being attracted by a magnet (paramagnetic?)." Lithostratigraphic unit notation example for this column: S10-sqO8-U1, etc.
SECTOR 10	Unit 0	SNC 2009 sqO8: "Grey ashy trample; masses of bone (including human fragments); ancient artefacts and modern objects."
SECTOR 10	Unit 1	SNC 2009 sqO8: "White contorted material turning pink at base; up to 4 cm thick and quite continuous; similar to Raynal 5 in Sectors 1 and 2 but not a certain correlate."
SECTOR 10	Unit 2	SNC 2009 sqO8: "Dark chocolate silt, including charcoal <8563> and a lithic <8564>; lens thickening southwards, possibly 5 cm or more; similar to Raynal 6-7 in Sectors 1 and 2 but not a certain correlate."
SECTOR 10	Unit 3	SNC 2009 sqO8: "white/pink/lightest orange; extremely carbonate-rich; corroded carbonate 'core stones', some possible eucladioliths but the bulk is mostly corroded ancient calcite; few bone fragments, no obvious artefacts; pieced by a few minor burrows; at least 30 cm thick. Reportedly (JB) cored by a palynologist in the past."
SECTOR 10		SNC 2009, small test-pit in sqsO7-P7; SNC photos 4552-4556; developed section facing east, out of cave; dug in brief episodes to avoid interference with burial excavations. Depths given as level below -2.35 (m below Site Datum). SNC photos 4570-4585.
SECTOR 10		SNC 2009 sqsO7-P7: "Slightly disturbed grey ashy material (bones and lithics) of basal Grey Series." Lithostratigraphic unit notation example for this column: S10-sqsO7&P7-U1, etc.
SECTOR 10	Unit 1	SNC 2009 sqsO7-P7: "Contorted 'cream' unit with plastic deformation structures; pink/ginger at base; less than 5 cm thick (top at -2.30 (m below Site Datum)); similar to Raynal 5 in Sectors 1 and 2 but not a certain correlate."
SECTOR 10	Unit 2	SNC 2009 sqsO7-P7: "Chocolate and grey/khaki material; bedded, normally laminated; minimal presence northwards ('right') but thickening southwards into an erosion trough (at least 14 cm thick); charcoal, lithics; similar to Raynal 6-7 in Sectors 1 and 2 but not a certain correlate."
SECTOR 10	Unit 3	SNC 2009 sqsO7-P7: "Lighter, 'orangey' material; cemented patches; stones, some angular, some rounded, calcite elements, cemented aggregates, stalactite fragments, all at rather irregular/random angles; charcoal, microfauna, some bones, lithics (MSA types where diagnostic, cf. finds <8730-8733>). Rises, before truncation, to c. 2.3 m below Site Datum. Appears similar to the Pink Series (Raynal 13-14) but not a certain correlate."
SECTOR 10	Unit 3a [6-18]	SNC 2009 sqsO7-P7: "Orangey carbonate-rich matrix; various creams, base matrix colour 5YR 7/6-8); many small clasts of calcite and dolomite (some extremely rounded, 1-10 cm diameter); very irregular bedding angles; cemented crusts, discontinuous laterally; lower boundary slightly irregular and diffuse; similarity to Raynal 13 confirmed."
SECTOR 10	Unit 3b [18-51]	SNC 2009 sqsO7-P7: "Slightly browner matrix; 5YR 5/4 to 6/6; much angular fine grit, often in wavy lenses; microfauna (mammals, birds, fish, mollusca); artefacts, scattered charcoal, rare burnt bone; no clear surfaces but archaeology probably at several levels; base somewhat diffuse but quite irregular, with variations on 10-15 cm (vertical) over 50 cm (lateral)."

SECTOR 10	Unit 3c [51 or higher down to as much as 65]	SNC 2009 sqsO7-P7: "Dense cemented material, with stones and grit; 5YR 7/6; microfauna; no obvious archaeology; small burrows (modern) near base; rounded dolomite at base (large rock or bedrock)."
SECTOR 10		P BERRIDGE 2009 sqB1 NE & NW: "Burial pit [Grey Series] cut through material resembling Upper Laminated Series over upper Raynal 13 (orangey)."

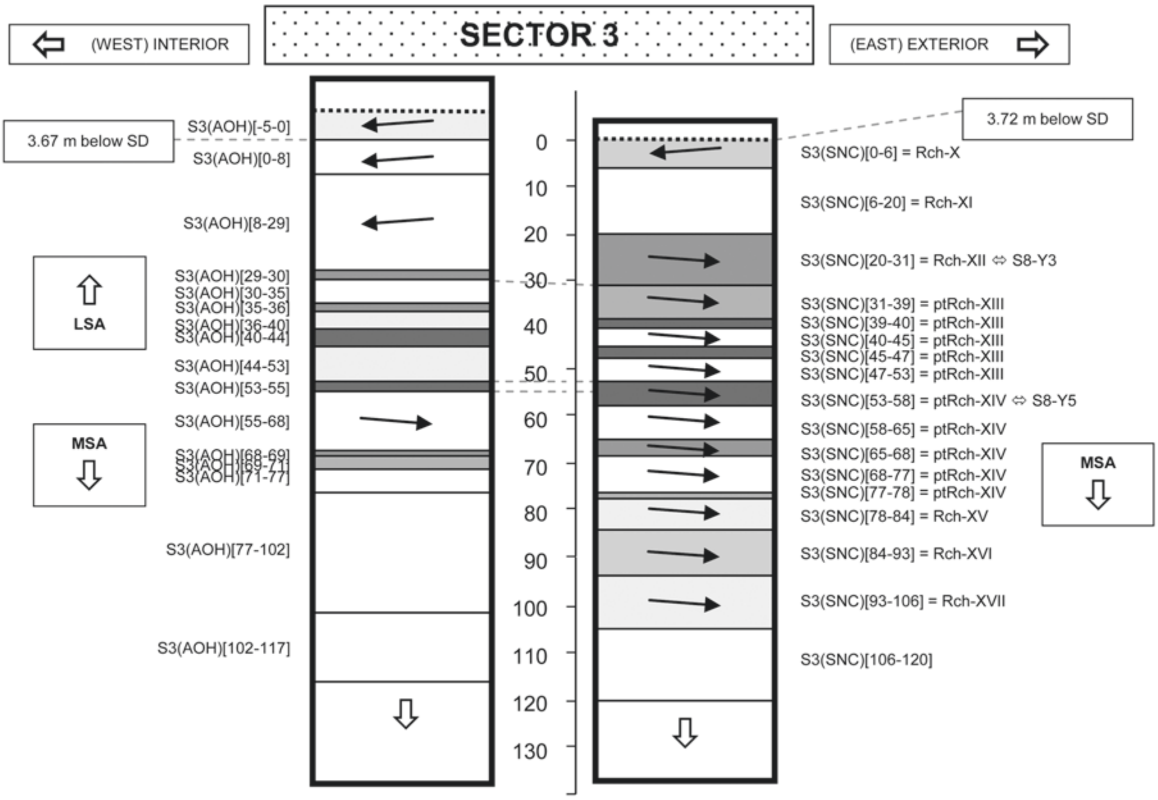
SECTOR 10		SNC 2016: "x = 118.428, y – 121.125, z = -1.798 (m below Site Datum)." SNC 2016: photos 3474-78; showing the yellowish material (including the hearth) with the 'Brown Layer' above (cf. nail at local zero)." Lithostratigraphic unit notation example for this column: S10-16[0-10], etc.
SECTOR 10	[0 to +51 or higher]	SNC 2016: "Unstructured grey ashy material (Grey Series); common large limestone fragments; absolutely no internal structure (no hearths); bottom 15 cm is 'earthier', with more mineral matrix; higher material has more molluscan fragments (unweathered alkaline context)."
SECTOR 10	[0-10]	SNC 2016: 'Brown Layer' (counted as the basal unit of the Grey Series in S10, equivalent to Roche's *Niveau IX*); earthier than above; many small stones, often corroded; variable colour (redder, yellower, browner, greyer, lighter/darker), either as blotches or as very local lenses, but a 'central' colour of 7.5YR 5-4/3; variously massive structure to locally high-angle bedded; various corroded bones, lithics, metallic ores; some reddish patches are corroded fallen wall speleothem; looks like 'made ground'; interstratified boundary with typical ashy grey sediment above (thin alternating lenses within a 5 cm thick transition).
SECTOR 10	[10-15]	SNC 2016: "Yellowish material; thinly stratified (laminated and lenticular); topped by a carbonate crust (probably a sub-surface reinforcement horizon due to decaying organics in the 'Brown Layer' above.
SECTOR 10	[15-18]	SNC 2016: "Locally, multiple ash lenses with charcoal at base (sampled <15944>); some dark brown Mn on partings; ash often burnt very efficiently, with little surviving charcoal; feature (possibly an *in situ* hearth but no convincing burning/heating at base) probably c. 60 cm in diameter."
SECTOR 10	[18 downwards]	SNC 2016: "Dense powdery sediment with corroded small stones; 10YR 5/4."

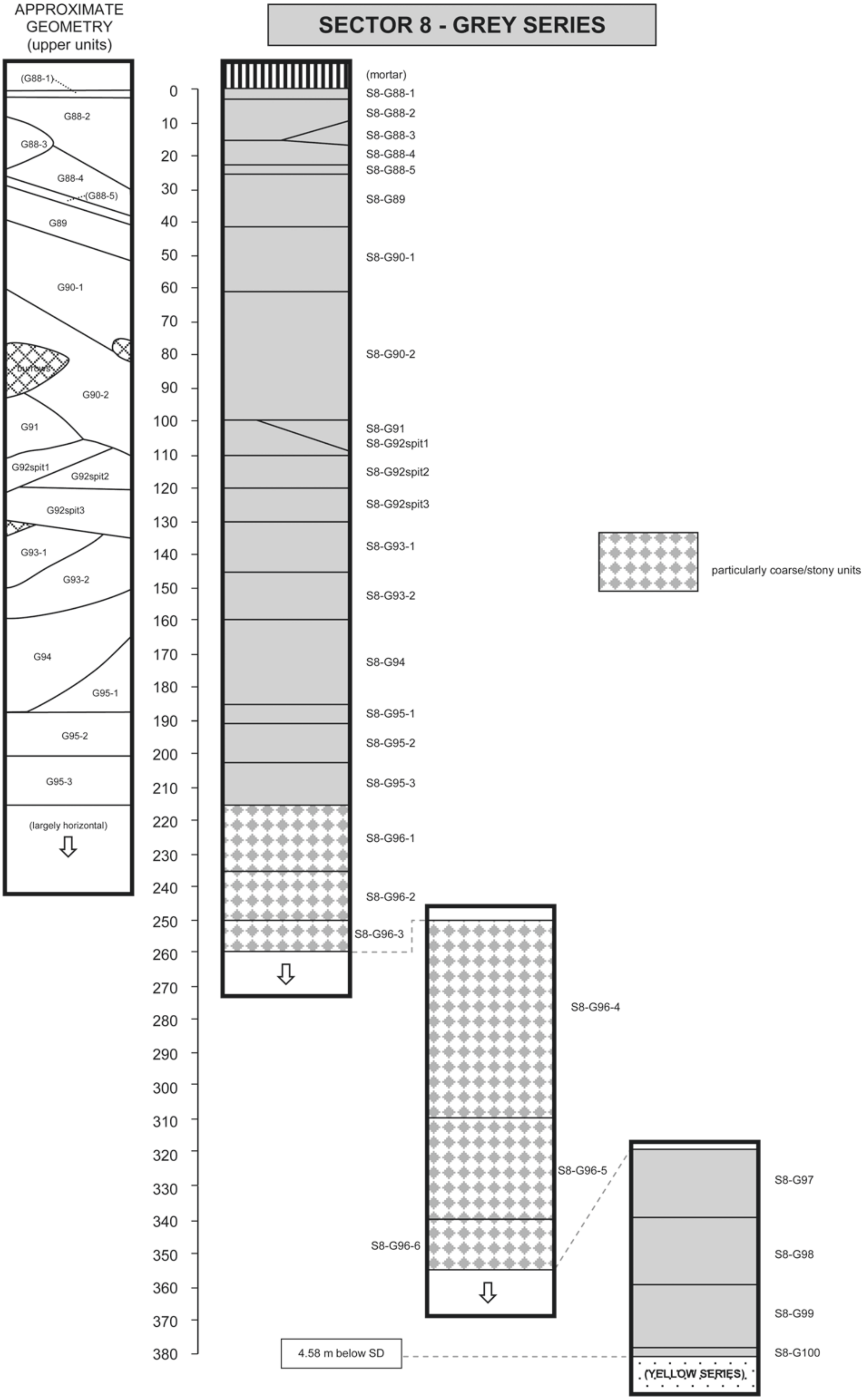
DEEP SOUNDING

DEEP SOUNDING (DS)	General (South)	SNC 2003 : "Southern side of the Deep Sounding (equivalent to inner end of Ruhlmann's southern trench), E-W section on c.F/E line, observer looking south at the boundary between Squares 14 and 15; local zero in SNC observations at 3.01 m below Site Datum." SNC 2003: "Southern side of the Deep Sounding, E-W section on c.F/E line, observer looking south at the boundary between Squares 14 and 15 as central point but photos panoramic both east and west from centre; SNC photos 90-100." SNC 2003; "Material laterally equivalent (further into the cave more or less on the line of Sector 8) to the top units of the Yellow Series." SNC 2008 ; "Towards the back of the cave (towards Sector 11), the Yellow Series seems to be subject to an angular unconformity with the overlying Grey Series (even though this boundary is altitudinally high compared with Sector 8), with the Yellow Series cut out progressively westwards. It is possible (even likely) that, in the 'SW lobe' of the currently accessible cave, Grey Series deposits overlie directly a yellowish alteration crust of the ancient calcite. Additional charcoal samples in sqD17, <6833> and <6834> in basal Grey Series, <6835> and <6836> in highest undisturbed Yellow Series." Lithostratigraphic unit notation example for this column: DS-(S)[5-8], etc.
		Grey Series (unstable). Base of GS (cf. S8-G99) Charcoal sqD17 OxA-22902 12,370 ± 50 BP <TAF08-6834>. Base of GS (cf. S8-G99) Charcoal sqD17 OxA-22784 12,660 ± 70 BP <TAF08 6833>. Base of GS (cf. S8-G99) Charcoal sqD17 OxA-22785 12,500 ± 55 BP <TAF08-6833 duplicate>.
DS	(S)[5-8]	SNC 2003 : "Interval 5-8; mid-brown gritty silt band." Charcoal sqD17 OxA-22786 12,200 ± 55 BP <TAF08-6836>; SNC 2008: "stratigraphically highest YS in this area". Charcoal sqD17 OxA-22903 13,045 ± 50 BP <TAF08-6835>.
DS	(S)[8-25]	SNC 2003 : "Interval 8-25; light brown gritty silt, lightly cemented; bone."
DS	(S)[25-29]	SNC 2003 : "Interval 25-29; mid-brown band, darker at base with ashes."
DS	(S)[29-31]	SNC 2003 : "Interval 29-31; light orange-brown, cemented at top (from ashes above?)."
DS	(S)[31-34]	SNC 2003 : "Interval 31-34; white cemented ashes."
DS	(S)[34-35]	SNC 2003 : "Interval 34-35; dark brown sediment."

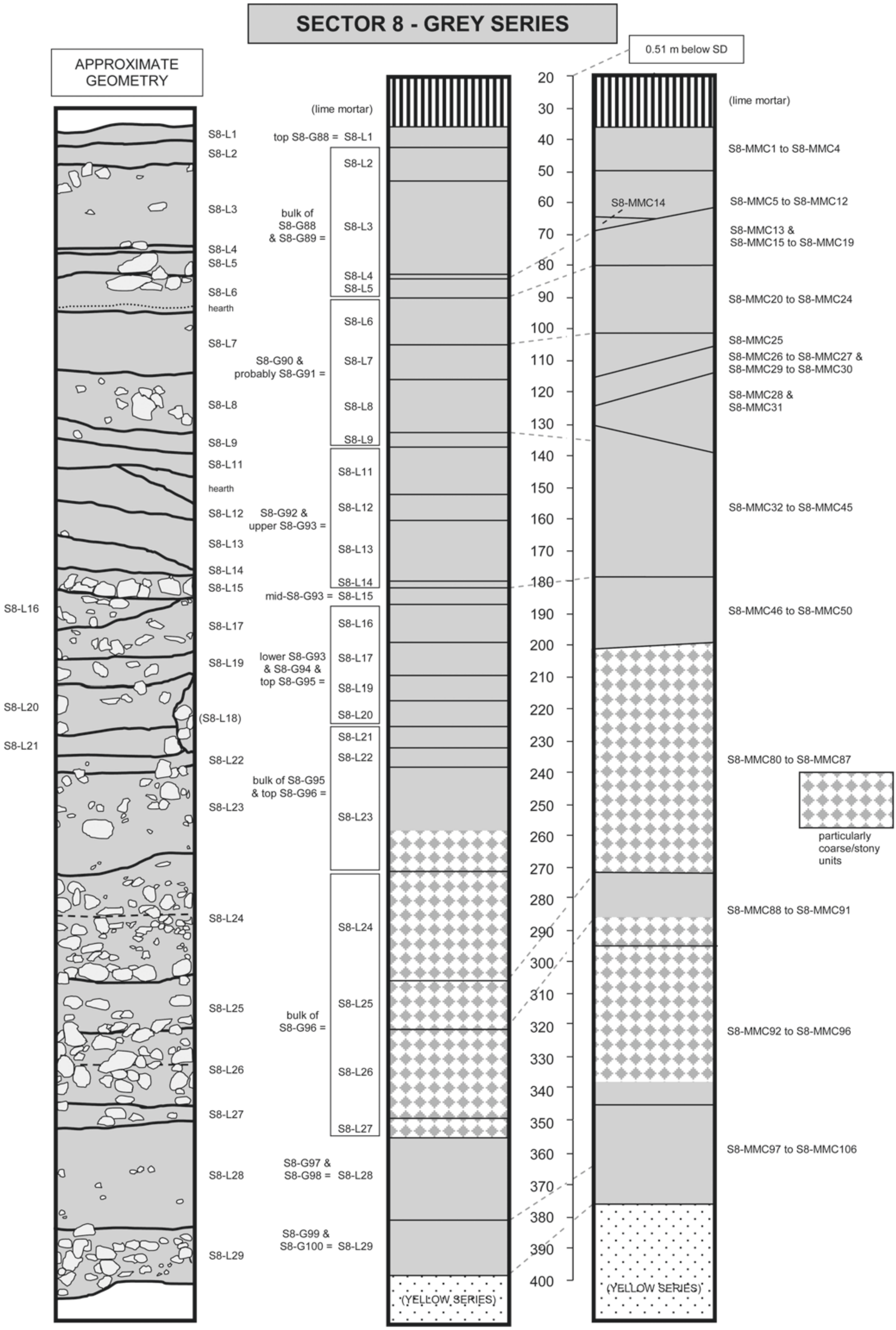
DS	(S)[25-35]	SNC 2003 : "Sample MF11 (S. Parfitt) in interval 25-35; much bone, both larger mammals & microfauna, shell, charcoal, burnt stone, artefacts. All these units dipping 5°-10° to east."
DS	(S)[35-44]	SNC 2003 : "Interval 35-44; light orange-brown; most cemented at the top; small pieces of charcoal throughout."
DS	(S)[44-45]	SNC 2003 : "Interval 44-45; dark chocolate brown lenses, capped by carbonate crusts."
DS	(S)[45-48]	SNC 2003 : "Interval 45-48; laminated brown, becoming lighter downwards; silty, stone burnt to a powder."
DS	(S)[48-49]	SNC 2003 : "Interval 48-49; whitish crust."
DS	(S)[49-52]	SNC 2003 : "Interval 49-52; dark brown to chocolate brown laminae. Probably the **marker bed**, correlating with the Yell [110-112] interval in Sector 8." [Equivalent to Unit S8-Y5]

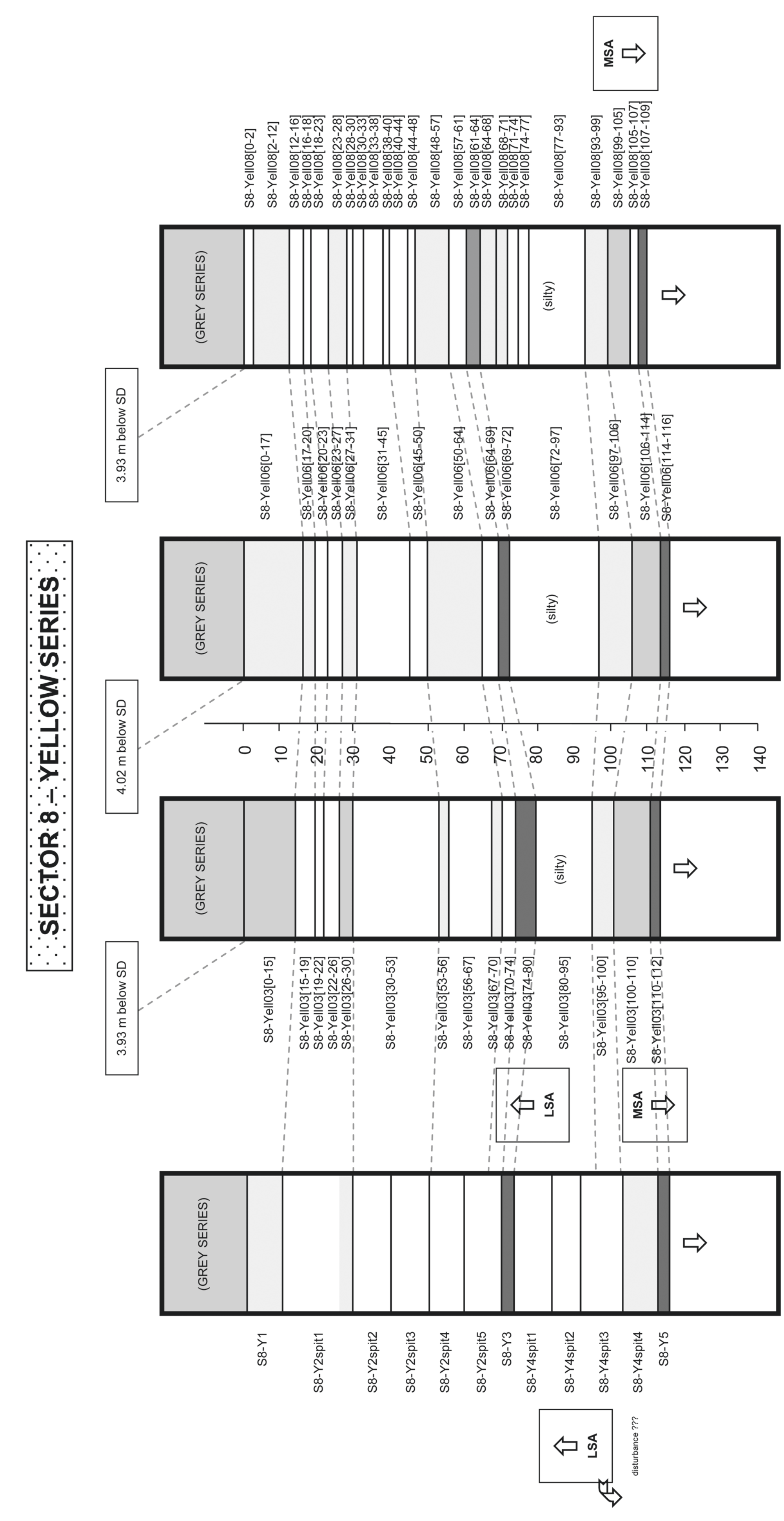
SCHEMATIC SECTIONS

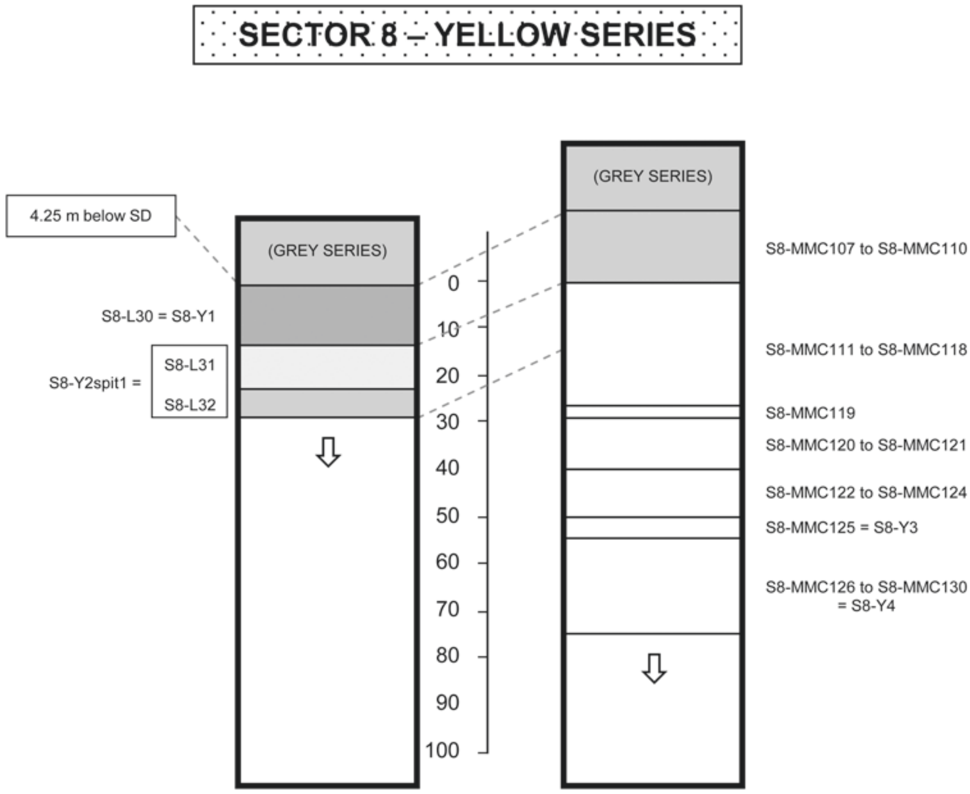


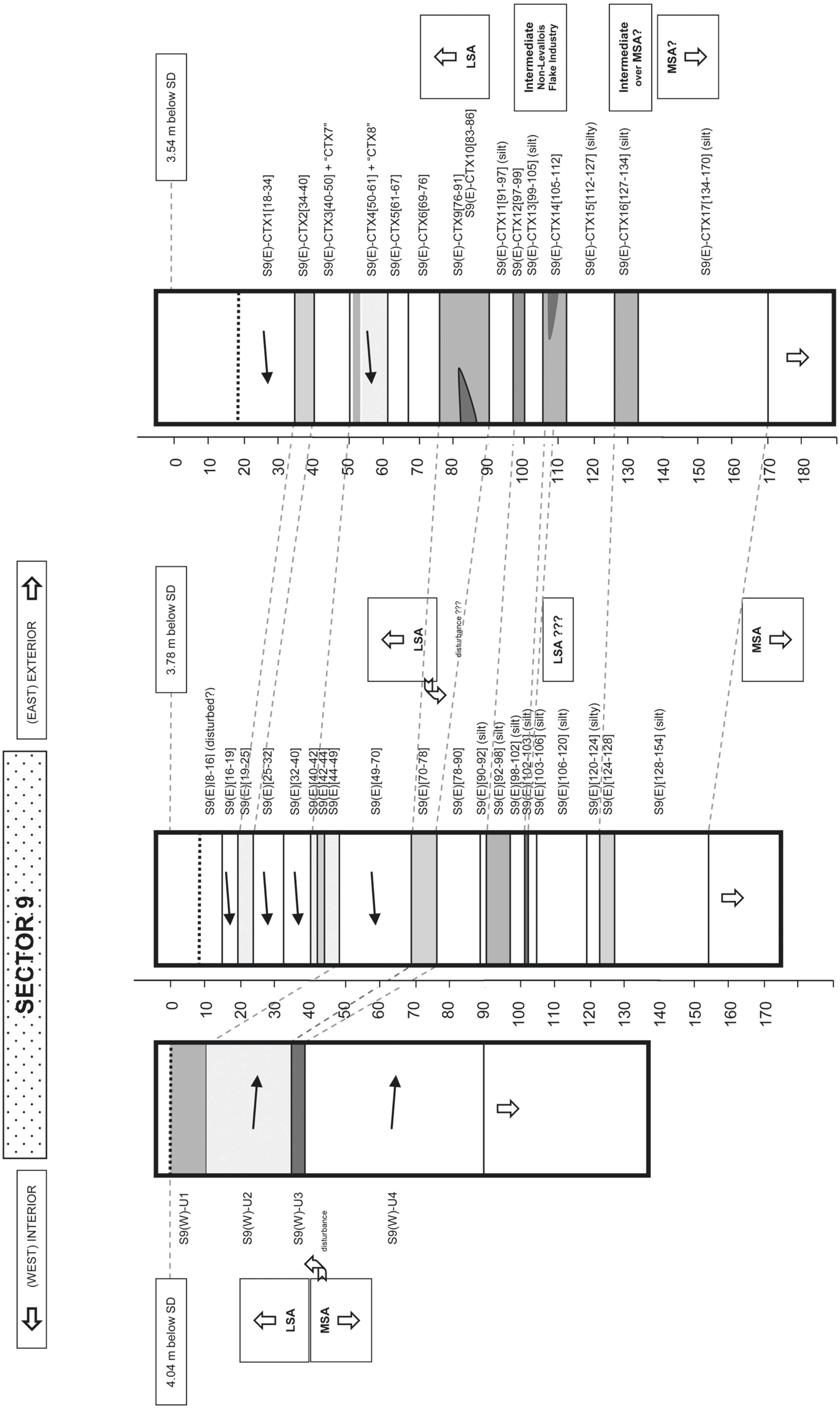


APPROXIMATE GEOMETRY (upper units)
SECTOR 8 - GREY SERIES
(G88-1)
G88-2
G88-3
G88-4
(G88-5)
G89
G90-1
G90-2
G91
G92spit1
G92spit2
G92spit3
G93-1
G93-2
G94
G95-1
G95-2
G95-3
(largely horizontal)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250
260
270
280
290
300
310
320
330
340
350
360
370
380
(mortar)
S8-G88-1
S8-G88-2
S8-G88-3
S8-G88-4
S8-G88-5
S8-G89
S8-G90-1
S8-G90-2
S8-G91
S8-G92spit1
S8-G92spit2
S8-G92spit3
S8-G93-1
S8-G93-2
S8-G94
S8-G95-1
S8-G95-2
S8-G95-3
S8-G96-1
S8-G96-2
S8-G96-3
S8-G96-4
S8-G96-5
S8-G96-6
S8-G97
S8-G98
S8-G99
S8-G100
(YELLOW SERIES)
4.58 m below SD
particularly coarse/stony units


SECTOR 8 - GREY SERIES
APPROXIMATE GEOMETRY
S8-L1
S8-L2
S8-L3
S8-L4
S8-L5
S8-L6
hearth
S8-L7
S8-L8
S8-L9
S8-L11
hearth
S8-L12
S8-L13
S8-L14
S8-L15
S8-L16
S8-L17
S8-L19
S8-L20
(S8-L18)
S8-L21
S8-L22
S8-L23
S8-L24
S8-L25
S8-L26
S8-L27
S8-L28
S8-L29
(lime mortar)
top S8-G88 = S8-L1
bulk of S8-G88 & S8-G89 = S8-L2 S8-L3 S8-L4 S8-L5
S8-G90 & probably S8-G91 = S8-L6 S8-L7 S8-L8 S8-L9
S8-G92 & upper S8-G93 = S8-L11 S8-L12 S8-L13 S8-L14
mid-S8-G93 = S8-L15
lower S8-G93 & S8-G94 & top S8-G95 = S8-L16 S8-L17 S8-L19 S8-L20
bulk of S8-G95 & top S8-G96 = S8-L21 S8-L22 S8-L23
bulk of S8-G96 = S8-L24 S8-L25 S8-L26 S8-L27
S8-G97 & S8-G98 = S8-L28
S8-G99 & S8-G100 = S8-L29
(YELLOW SERIES)
0.51 m below SD
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250
260
270
280
290
300
310
320
330
340
350
360
370
380
390
400
(lime mortar)
S8-MMC1 to S8-MMC4
S8-MMC14
S8-MMC5 to S8-MMC12
S8-MMC13 & S8-MMC15 to S8-MMC19
S8-MMC20 to S8-MMC24
S8-MMC25
S8-MMC26 to S8-MMC27 & S8-MMC29 to S8-MMC30
S8-MMC28 & S8-MMC31
S8-MMC32 to S8-MMC45
S8-MMC46 to S8-MMC50
S8-MMC80 to S8-MMC87
particularly coarse/stony units
S8-MMC88 to S8-MMC91
S8-MMC92 to S8-MMC96
S8-MMC97 to S8-MMC106
(YELLOW SERIES)


SECTOR 8 – YELLOW SERIES
3.93 m below SD
4.02 m below SD
3.93 m below SD
(GREY SERIES)
(silty)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
MSA
LSA
disturbance ???
S8-Y1
S8-Y2spit1
S8-Y2spit2
S8-Y2spit3
S8-Y2spit4
S8-Y2spit5
S8-Y3
S8-Y4spit1
S8-Y4spit2
S8-Y4spit3
S8-Y4spit4
S8-Y5
S8-Yell03[0-15]
S8-Yell03[15-19]
S8-Yell03[19-22]
S8-Yell03[22-26]
S8-Yell03[26-30]
S8-Yell03[30-53]
S8-Yell03[53-56]
S8-Yell03[56-67]
S8-Yell03[67-70]
S8-Yell03[70-74]
S8-Yell03[74-80]
S8-Yell03[80-95]
S8-Yell03[95-100]
S8-Yell03[100-110]
S8-Yell03[110-112]
S8-Yell06[0-17]
S8-Yell06[17-20]
S8-Yell06[20-23]
S8-Yell06[23-27]
S8-Yell06[27-31]
S8-Yell06[31-45]
S8-Yell06[45-50]
S8-Yell06[50-64]
S8-Yell06[64-69]
S8-Yell06[69-72]
S8-Yell06[72-97]
S8-Yell06[97-106]
S8-Yell06[106-114]
S8-Yell06[114-116]
S8-Yell08[0-2]
S8-Yell08[2-12]
S8-Yell08[12-16]
S8-Yell08[16-18]
S8-Yell08[18-23]
S8-Yell08[23-28]
S8-Yell08[28-30]
S8-Yell08[30-33]
S8-Yell08[33-38]
S8-Yell08[38-40]
S8-Yell08[40-44]
S8-Yell08[44-48]
S8-Yell08[48-57]
S8-Yell08[57-61]
S8-Yell08[61-64]
S8-Yell08[64-68]
S8-Yell08[68-71]
S8-Yell08[71-74]
S8-Yell08[74-77]
S8-Yell08[77-93]
S8-Yell08[93-99]
S8-Yell08[99-105]
S8-Yell08[105-107]
S8-Yell08[107-109]


SECTOR 8 – YELLOW SERIES
4.25 m below SD
(GREY SERIES)
S8-L30 = S8-Y1
S8-Y2spit1 =
S8-L31
S8-L32
0
10
20
30
40
50
60
70
80
90
100
(GREY SERIES)
S8-MMC107 to S8-MMC110
S8-MMC111 to S8-MMC118
S8-MMC119
S8-MMC120 to S8-MMC121
S8-MMC122 to S8-MMC124
S8-MMC125 = S8-Y3
S8-MMC126 to S8-MMC130
= S8-Y4


SECTOR 9
(WEST) INTERIOR
(EAST) EXTERIOR
4.04 m below SD
3.78 m below SD
3.54 m below SD
S9(W)-U1
S9(W)-U2
S9(W)-U3
S9(W)-U4
disturbance
LSA
MSA
S9(E)[8-16] (disturbed?)
S9(E)[16-19]
S9(E)[19-25]
S9(E)[25-32]
S9(E)[32-40]
S9(E)[40-42]
S9(E)[42-44]
S9(E)[44-49]
S9(E)[49-70]
S9(E)[70-78]
S9(E)[78-90]
S9(E)[90-92] (silt)
S9(E)[92-98] (silt)
S9(E)[98-102] (silt)
S9(E)[102-103] (silt)
S9(E)[103-106] (silt)
S9(E)[106-120] (silt)
S9(E)[120-124] (silty)
S9(E)[124-128]
S9(E)[128-154] (silt)
disturbance ???
LSA ???
S9(E)-CTX1[18-34]
S9(E)-CTX2[34-40]
S9(E)-CTX3[40-50] + "CTX7"
S9(E)-CTX4[50-61] + "CTX8"
S9(E)-CTX5[61-67]
S9(E)-CTX6[69-76]
S9(E)-CTX9[76-91]
S9(E)-CTX10[83-86]
S9(E)-CTX11[91-97] (silt)
S9(E)-CTX12[97-99]
S9(E)-CTX13[99-105] (silt)
S9(E)-CTX14[105-112]
S9(E)-CTX15[112-127] (silty)
S9(E)-CTX16[127-134] (silt)
S9(E)-CTX17[134-170] (silt)
Intermediate Non-Levallois Flake Industry
Intermediate over MSA?
MSA?

APPENDIX 6: CHARRED SEEDS / FRUITS (ETC.) DETAILS

	Yellow Series-G sample column									Grey Series-G sample column									
unit	Y4	Y4	Y4	Y4	Y2	Y2	Y1	Y1	Y1	G1OO	G99	G99	G99	G99	G98-5	G98-4	G98-4	G98-4	G98-4
square	BC22	BC22	BC22	C22A	BC22	BC22	BC22	BC22	BC22	BC22	B21	B21	C21	B21	B21	B21	B21	C21	B20
volume of sediment (in litre)	16	13	4	5.6	4	16.5	1.5	5.5	1	12.5	3.5	3.5	3.5	2	1.5	6	3.5	5	7
Avena sp. (wild oat), seed	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
cf. *Bromus* sp. (large seeded grass), seed	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cariophyllaceae, seed	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chenopodiaceae, seed	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cistaceae, seed	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ephedra sp., cone bract	1	-	-	-	-	-	2	3	-	-	-	-	-	-	-	-	-	-	-
Fabaceae (wild pulse), seed	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fumaria sp. (fumitory), seed	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
Galium sp. (bedstraw), seed	5	1	-	1	-	-	-	1	1	-	-	1	1	1	-	1	1	-	1
Juniperus phoenicea L., seed	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	1
Lens cf. *nigricans* (M. Bieb.) Godr., seed	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
Pinus pinaster Ait., seed	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-
Pinus pinaster Ait., seed scale	-	-	-	-	-	-	-	-	-	1		1	1	-	-	3	1	1	1
Pistacia terebinthus L., seed	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Poaceae, seed	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-
Quercus ilex L., cupule	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Quercus sp (acorn), cotyledon	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Quercus sp. (acorn), cupule	-	-	-	-	-	-	-	-	-	-	1	5	2	-	1	10	4	9	4
Quercus sp. (acorn), abscission scar	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	2
Quercus sp. (acorn), pericarp	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rosaceae, seed	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
Rubiaceae, seed	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sambucus nigra / ebulus L., seed	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Small seeded legume, seed	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1	-
Stipa tenacissima L., rhizome	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1	-	2
Tetraclinis articulata (arar), leaf	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vicia / Lathyrus sp. (wild pulse), seed	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Woody legume, seed	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Indet type rosaceae, seed	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Indet type rosaceae, fruit	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Indet seed	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	1	1
Indet fruit	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Indet nut	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
total	7	1	1	2	1	1	2	5	1	1	1	7	4	2	3	21	8	12	12
seed density per litre of sediment	0.375	0.07	0.5	0.35	0.25	0.06	1.33	0.9	1	0.08	0.28	2	1.14	1	2	3.5	2.28	2.4	1.71

Appendix 6 (part a) Macro-botanical remains from occupational levels in Sector 8, with numbers of seeds unless otherwise stated.

	Grey Series-G sample column																					
unit	G98-3	G98-2	G98-1	G98	G97	G96-5	G96-3	G96-3	G96-2	G96-1	G95-3	G95-2	G95-1	G95-1	G94-1	G94-1	G93-2	G93-1	G92	G92	G92	G91
square	B21	B21	B21	B21	B21	B23	B23	B23	B23	B23	B23	B23	B23	B23	B23	B23	B23	B23	B23	B23	B23	B23
volume of sediment (in litre)	0.5	2	2.5	1	1.5	3	5	3.3	1.5	6.5	10	5.5	5	5.5	6	7.5	13.5	7.5	8.5	7	7.5	7
Avena sp. (wild oat), seed	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
cf. *Bromus* sp. (large seeded grass), seed	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cariophyllaceae, seed	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chenopodiaceae, seed	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cistaceae, seed	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ephedra sp., cone bract	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fabaceae (wild pulse), seed	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-
Fumaria sp. (fumitory), seed	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Galium sp. (bedstraw), seed	-	1	1	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	1	-	-	4
Juniperus phoenicea L., seed	-	-	1	-	-	-	-	-	-	-	-	-	1	-	1	-	9	1	3	4	10	6
Lens cf. *nigricans* (M. Bieb.) Godr., seed	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pinus pinaster Ait., seed	-	-	1	-	-	1	-	-	-	-	-	2		-	1	-	-	-	-	1	2	-
Pinus pinaster Ait., seed scale	2	1	1	1	1	5	5	4	1	6	8	16	4	2	5	7	12	2	5	3	3	8
Pistacia terebinthus L., seed	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	2
Poaceae, seed	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Quercus ilex L., cupule	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Quercus sp (acorn), cotyledon	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Quercus sp. (acorn), cupule	1	4	1	6	2	6	28	7	1	16	15	22	4	2	6	8	26	10	16	15	2	2
Quercus sp. (acorn), abscission scar	-	-	-	-	-	1	-	-	-	-	1	-	1	-	-	-	2	-	-	-	1	7
Quercus sp. (acorn), pericarp	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	2
Rosaceae, seed	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rubiaceae, seed	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sambucus nigra/ebulus L., seed	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Small seeded legume, seed	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stipa tenacissima L., rhizome	-	1	-	1	-	1	1	-	-	1	1	1	1	1	1	1	1	5	9	6	3	2
Tetraclinis articulata (arar), leaf	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-
Vicia/Lathyrus sp. (wild pulse), seed	-	-	1	-	-	-	-	1	-	2	-	1	-	1	-	1	-	-	1	-	1	-
Woody legume, seed	-	-	-	-	-	-	-	-	-	-	2	-	-	-	2	-	-	-	1	-	-	7
Indet type rosaceae, seed	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Indet type rosaceae, fruit	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Indet seed	-	-	1	-	3	-	-	-	-	-	-	1	-	-	-	-	2	-	-	3	1	-
Indet fruit	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
Indet nut	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
total	4	7	9	8	6	15	34	12	2	25	27	43	11	6	17	17	56	18	36	33	31	41
seed density per litre of sediment	8	3.5	3.6	8	4	5	6.8	3.63	1.33	3.84	2.7	7.81	2.2	1.09	2.83	2.26	4.14	2.4	4.35	4.71	4.13	5.85

Appendix 6 (part b) Macro-botanical remains from occupational levels in Sector 8, with numbers of seeds unless otherwise stated.

Grey Series-G sample column

unit	G90-2	G90-2	G90-2	G90-2	G90-1	G90-1	G90-1	G89	G89	G88	G88
square	B23	B23	B23	B23	B23	B23	B23	B23	B23	B23	B23
volume of sediment (in litre)	7	6	5	6.5	5.2	6		5.5	4.5	16.5	1
Avena sp. (wild oat), seed	-	-	1	-	-	-	-	-	-	1	
cf. *Bromus* sp. (large seeded grass), seed	-	-	-	-	-	-	-	-	-	-	-
Cariophyllaceae, seed	-	-	-	-	-	-	-	-	-	-	-
Chenopodiaceae, seed	-	-	-	-	-	-	-	-	-	-	-
Cistaceae, seed	-	-	-	-	-	-	-	-	-	-	-
Ephedra sp., cone bract	-	-	-	-	-	-	-	-	-	-	-
Fabaceae (wild pulse), seed	-	-	-	-	-	-	-	-	-	-	-
Fumaria sp. (fumitory), seed	-	-	-	-	-	-	-	-	-	-	-
Galium sp. (bedstraw), seed	4	1	-	2	-	2	-	-	4	4	1
Juniperus phoenicea L., seed	6	4	7	5	1	2	1	1		2	-
Lens cf. *nigricans* (M. Bieb.) Godr., seed	-	-	-	-	-	-	-	-	-	-	-
Pinus pinaster Ait., seed	1	1	-	-	-	-	-	-	-	-	-
Pinus pinaster Ait., seed scale	11	14	18	10	2	1	-	2	1	3	1
Pistacia terebinthus L., seed	2	1	6	-	2	4	-	3	5	1	-
Poaceae, seed	-	-	1	-	-	-	-	-	-	-	-
Quercus ilex L., cupule	-	-	-	-	1	1	-	-	-	3	-
Quercus sp (acorn), cotyledon	-	-	-	-	1	-	-	1	1	-	-
Quercus sp. (acorn), cupule	3	3	10	7	4	3	-	4	4	4	-
Quercus sp. (acorn), abscission scar	2	7	6	1	-	1	1	1	2	2	-
Quercus sp. (acorn), pericarp	2	-	1	-	-	-	-	-	1	-	1
Rosaceae, seed	-	-	-	-	-	-	-	-	-	-	-
Rubiaceae, seed	-	-	-	-	1	-	-	-	-	-	-
Sambucus nigra/*ebulus* L., seed	-	-	-	-	-	-	-	-	-	-	-
Small seeded legume, seed	-	-	-	-	-	-	-	-	-	-	-
Stipa tenacissima L., rhizome	2	2	-	-	-	1	-	1	5	4	-
Tetraclinis articulata (arar), leaf	-	-	-	-	-	-	-	-	-	-	-
Vicia/*Lathyrus* sp. (wild pulse), seed	1	-	1	-	-	1	-	-	-	2	-
Woody legume, seed	4	-	1	-	-	-	-	-	-	3	-
Indet type rosaceae, seed	-	-	-	-	-	-	-	-	-	1	-
Indet type rosaceae, fruit	-	1	-	-	-	-	-	-	-	2	-
Indet seed	-	-	-	-	-	-	-	-	-	-	-
Indet fruit	1	-	-	-	-	-	-	-	-	-	-
Indet nut	-	-	-	-	-	-	-	-	-	-	-
total	39	34	52	25	12	16	2	13	23	32	3
seed density per litre of sediment	5.57	5.66	10.4	3.84	2.3	2.66		2.36	5.1	1.93	3

Grey Series-MMC sample column

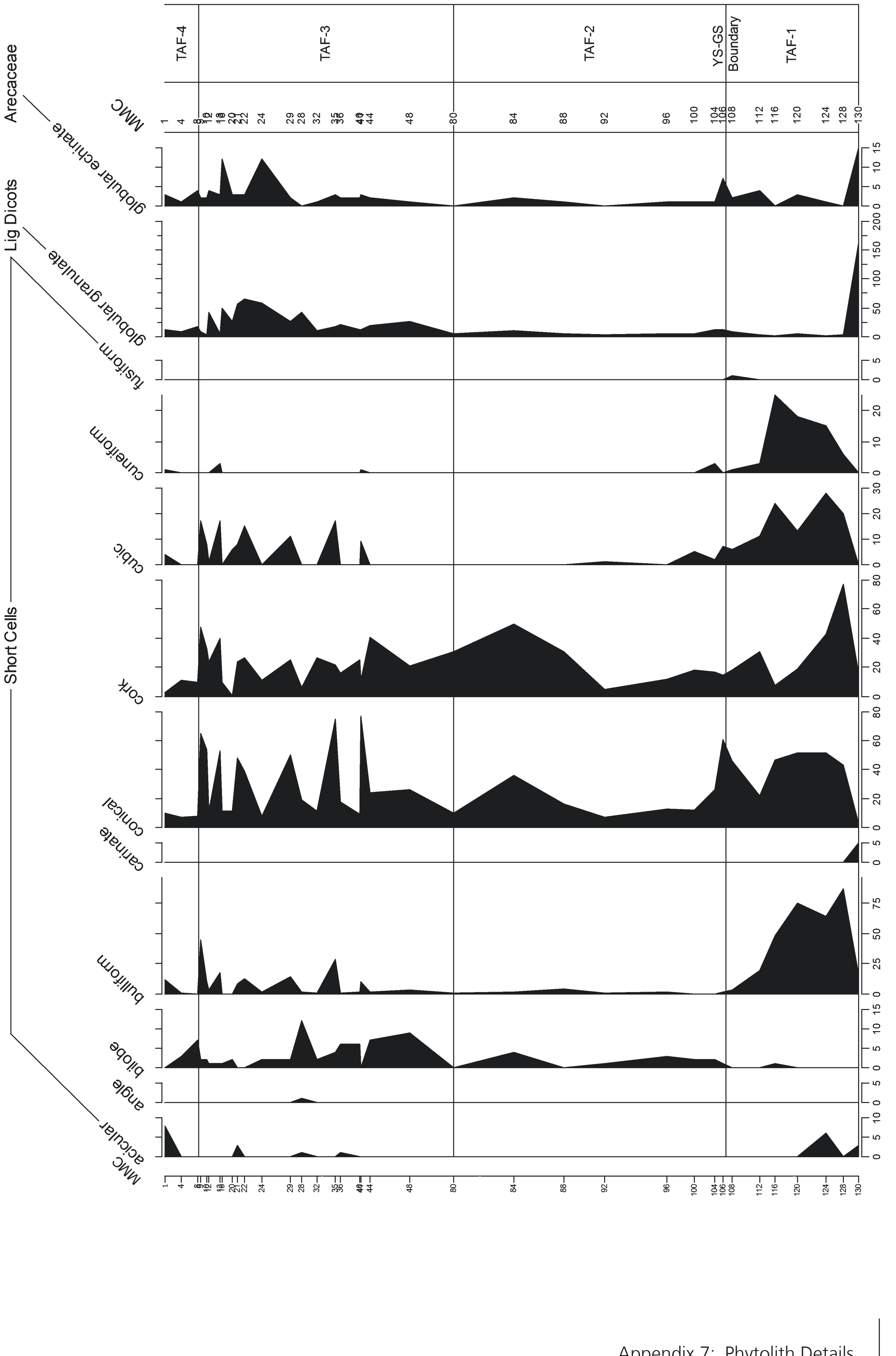
unit	2	3	4	5	6	9	10	13	14	15	16	17	18	19
square														
volume of sediment (in litre)	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Avena sp. (wild oat), seed	-	-	1	-	-	-	-	1	-	-	1	-	1	-
cf. *Bromus* sp. (large seeded grass), seed	-	-	-	-	1	-	-	-	-	-	-	-	1	-
Cariophyllaceae, seed	-	-	-	-	-	-	-	-	-	-	1	-	-	-
Chenopodiaceae, seed	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Cistaceae, seed	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ephedra sp., cone bract	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fabaceae (wild pulse), seed	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fumaria sp. (fumitory), seed	-	-	-	-	-	-	-	-	1	-	-	-	-	-
Galium sp. (bedstraw), seed	-	1	-	1	1	-	-	1	4	-	-	-	3	1
Juniperus phoenicea L., seed	1	1	1	-	2	-	-	1	2	2	1	1	2	1
Lens cf. *nigricans* (M. Bieb.) Godr., seed	2	-	-	-	-	-	-	-	-	-	-	-	-	-
Pinus pinaster Ait., seed	-	-	-	-	-	-	-	-	-	-	2	-	2	1
Pinus pinaster Ait., seed scale	-	1	2	1	2	-	1	3	6	10	4	4	-	6
Pistacia terebinthus L., seed	3	1	3	1	1	-	-	2	1	2	1	-	1	-
Poaceae, seed	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Quercus ilex L., cupule	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Quercus sp (acorn), cotyledon	-	-	-	-	3	1	1	1	-	-	-	-	-	-
Quercus sp. (acorn), cupule	-	-	1	-	1	-	-	-	-	3	-	-	-	1
Quercus sp. (acorn), abscission scar	-	1	3	1	1	-	-	2	-	-	-	1	2	
Quercus sp. (acorn), pericarp	-	-	1		1	-	-	-	1	-	-	-	-	-
Rosaceae, seed	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rubiaceae, seed	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sambucus nigra/*ebulus* L., seed	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Small seeded legume, seed	-	-	-	-	-	-	-	-	-	1	-	-	-	-
Stipa tenacissima L., rhizome	-	1	-	-	1	-	-	-	-	-	-	-	-	-
Tetraclinis articulata (arar), leaf	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vicia/*Lathyrus* sp. (wild pulse), seed	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Woody legume, seed	-	-	-	1	-	-	-	-	-	-	-	-	-	-
Indet type rosaceae, seed	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Indet type rosaceae, fruit	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Indet seed	-	1	-	1	-	-	-	-	3	2	-	-	-	-
Indet fruit	-	-	-	-	-	-	-	-	1	-	-	-	-	-
Indet nut	3	-	-	-	-	-	-	-	-	-	-	-	-	1
total	9	7	12	6	14	1	2	11	19	20	10	6	12	12
seed density per litre of sediment	9	7	12	6	14	1	2	11	19	20	10	6	12	12

Appendix 6 (part c) Macro-botanical remains from occupational levels in Sector 8, with numbers of seeds unless otherwise stated.

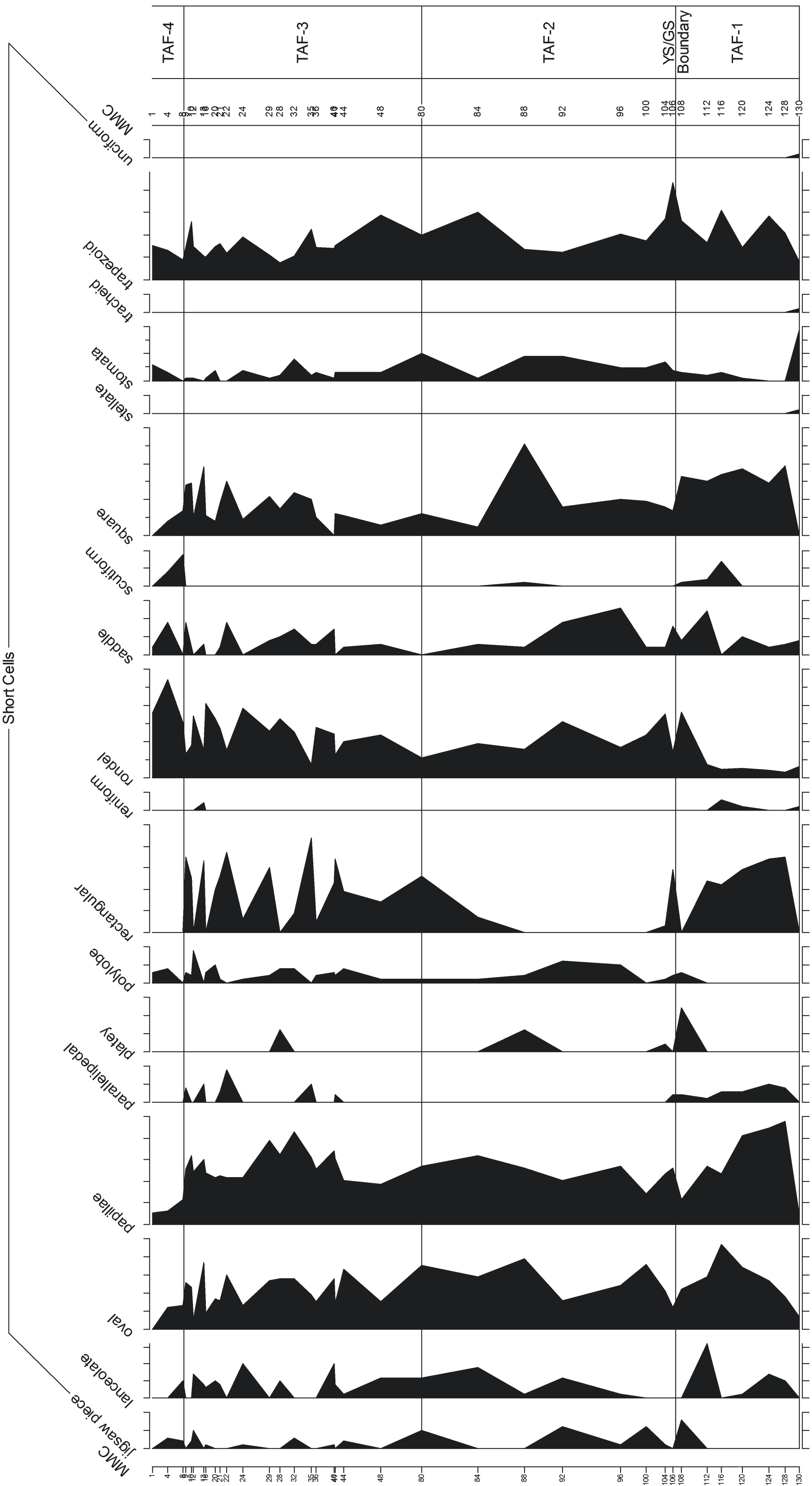
unit	Grey Series- MMC sample column																											YS-MMC	
	20	21	22	23	24	25	26	27	28	29	30	34	37	38	39	40	41	45	80	83	85	87	90	95	100	103	105	107	108
volume of sediment (in litre)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0.5	1	1	1	1	1	1	1	1
Avena sp. (wild oat), seed	-	2	1	-	-	-	-	-	-	1	-	-	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
cf. *Bromus* sp. (large seeded grass), seed	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cariophyllaceae, seed	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chenopodiaceae, seed	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cistaceae, seed	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ephedra sp., cone bract	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fabaceae (wild pulse), seed	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
Fumaria sp. (fumitory), seed	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Galium sp. (bedstraw), seed	-	1	-	-	1	-	-	-	-	-	-	-	-	1	-	-	1	-	1	-	-	-	-	-	-	-	-	-	1
Juniperus phoenicea L., seed	3	4	2	3	1	3	2	1	-	4	-	-	-	2	1	2	1	1	-	-	-	-	-	-	-	-	-	-	-
Lens cf. *nigricans* (M. Bieb.) Godr., seed	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pinus pinaster Ait., seed	-	1	1	1	2	-	-	1	-	-	-	-	-	-	-	-	1	-	-	-	-	1	-	-	-	-	-	-	-
Pinus pinaster Ait., seed scale	4	4	3	3	4	5	5	3	1	2	1	5	2	2	3	2	2	2	1	3	1	2	3	1	1	1	-	-	-
Pistacia terebinthus L., seed	1	-	-	1	1	1	1	1	-	2	4	-	1	2	-	1	3	-	-	-	-	-	-	-	-	-	-	-	-
Poaceae, seed	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Quercus ilex L., cupule	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Quercus sp (acorn), cotyledon	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Quercus sp. (acorn), cupule	5	6	2	3	1	2	2		-	2	-	-	-	-	2	1	1	-	1	3	3	5	-	7	-	2	2	-	-
Quercus sp. (acorn), abscission scar	-	4	2	2	1	2	1	3	-	2	-	1	1	1	2	1	2	-	2	-	-	-	1	-	-	-	1	-	-
Quercus sp. (acorn), pericarp	-	-	1	-	-	-	1	1	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Rosaceae, seed	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rubiaceae, seed	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sambucus nigra/*ebulus* L., seed	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Small seeded legume, seed	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stipa tenacissima L., rhizome	-	2	-	1	1	1	3	2	-	1	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Tetraclinis articulata (arar), leaf	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vicia/*Lathyrus* sp. (wild pulse), seed	-	-	-	-	-	-	1	-	-	-	-	-	-	1	2		1	-	-	-	-	-	-	1	-	-	-	-	-
Woody legume, seed	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Indet type rosaceae, seed	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-
Indet type rosaceae, fruit	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Indet seed	-	-	-	-	1	-	-	-	-	-	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Indet fruit	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Indet nut	-	-	-	3	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
total	13	25	13	17	14	14	17	12	1	14	6	6	7	11	12	8	14	3	5	7	4	8	4	9	1	3	3	2	1
seed density per litre of sediment	13	25	13	17	14	14	17	12	1	14	6	6	7	11	12	8	14	3	5	7	8	8	4	9	1	3	3	2	1

Appendices 6 (part d) Macro-botanical remains from occupational levels in Sector 8, with numbers of seeds unless otherwise stated.

APPENDIX 7: PHYTOLITH DETAILS

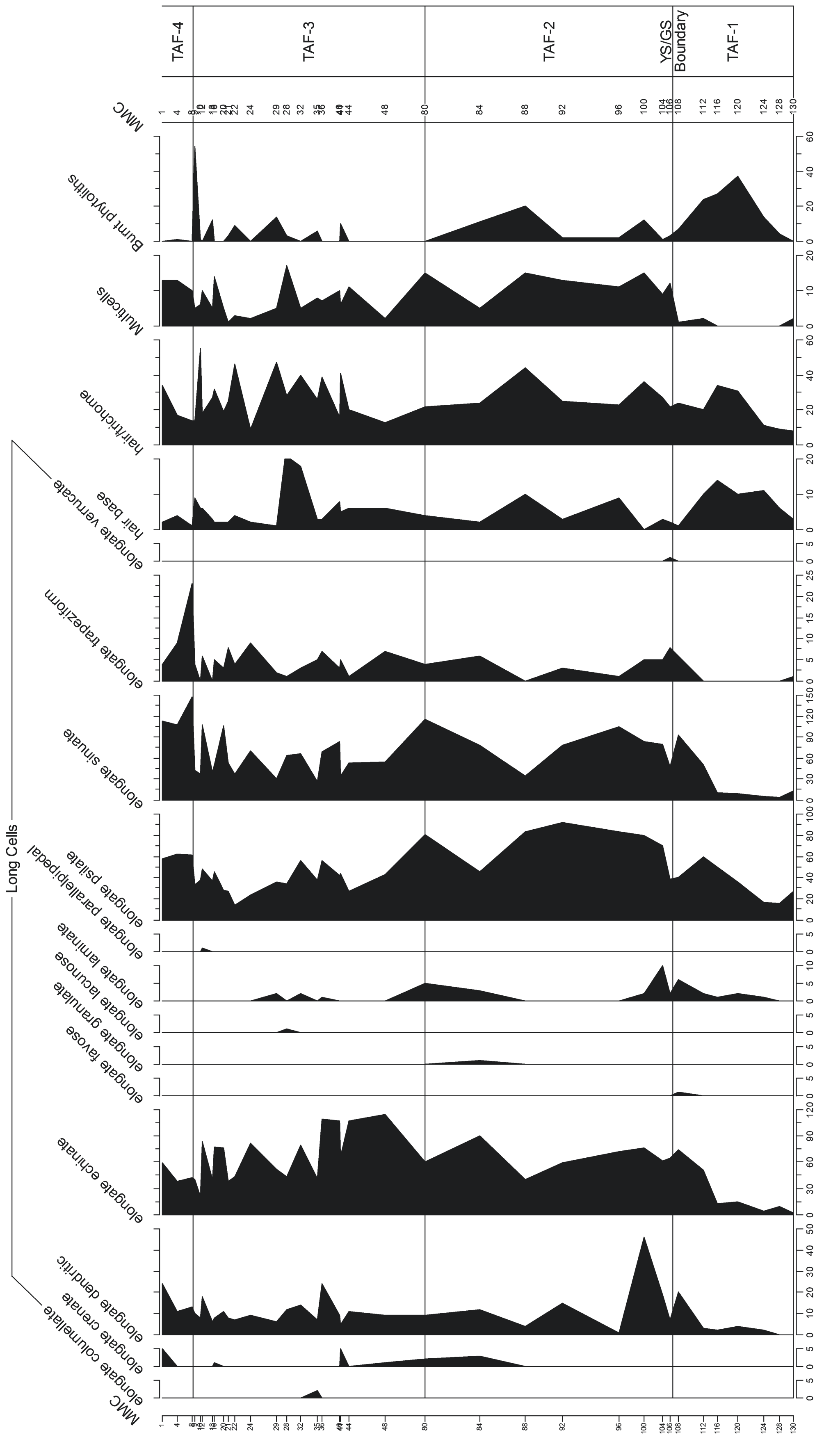


Appendix 7.1 **a-c** Complete phytolith diagram showing morphotypes expressed as counts.



b

Appendix 7.1 (continued)



c

Appendix 7.1 (continued)

Sample	acicular	angle	bilobe	bulliform	carinate	conical	cork	cubic
MMC1	8	0	0	12	0	10	3	4
MMC4	0	0	3	1	0	7	11	0
MMC8	0	0	7	0	0	8	10	0
MMC9	0	0	2	45	0	65	48	17
MMC10	0	0	2	10	0	54	33	8
MMC12	0	0	1	3	0	11	24	1
MMC13	0	0	1	18	0	53	40	17
MMC16	0	0	1	0	0	11	10	0
MMC20	0	0	2	0	0	11	1	6
MMC21	3	0	0	8	0	48	24	8
MMC22	0	0	0	13	0	39	27	15
MMC24	0	0	2	2	0	8	11	0
MMC29	0	0	2	14	0	50	25	11
MMC28	1	1	12	2	0	19	6	0
MMC32	0	0	2	1	0	11	27	0
MMC35	0	0	4	29	0	75	22	17
MMC36	1	0	6	1	0	18	16	0
MMC40	0	0	6	2	0	9	25	0
MMC41	0	0	0	10	0	77	11	9
MMC44	0	0	7	2	0	24	41	0
MMC48	0	0	9	3	0	26	21	0
MMC52	0	0	4	0	0	22	16	0
MMC56	0	0	3	3	0	27	22	1
MMC57	0	0	1	21	0	40	4	14
MMC80	0	0	0	1	0	10	31	0
MMC84	0	0	4	2	0	36	50	0
MMC88	0	0	0	4	0	16	31	0
MMC92	0	0	1	1	0	7	5	1
MMC96	0	0	3	2	0	13	12	0
MMC100	0	0	2	0	0	12	18	5
MMC104	0	0	2	0	0	26	17	2
MMC106	0	0	1	2	0	61	15	7
MMC108	0	0	0	3	0	46	18	6
MMC112	0	0	0	19	0	22	31	11
MMC116	0	0	1	48	0	47	8	24
MMC120	0	0	0	75	0	52	19	13
MMC124	6	0	0	64	0	52	43	28
MMC128	0	0	0	87	0	43	77	20
MMC130	3	0	0	16	5	3	16	0
Total	**22**	**1**	**91**	**524**	**5**	**1169**	**869**	**245**

Appendix 7.2 Raw phytolith data.

Sample	cuneiform	fusiform	globular echinate	globular granulate	jigsaw piece	lanceolate	oval	papillae
MMC1	1	0	3	13	0	0	0	11
MMC4	0	0	1	8	3	0	12	12
MMC8	0	0	4	18	2	5	13	23
MMC9	0	0	2	8	0	0	26	51
MMC10	0	0	2	3	2	0	23	64
MMC12	0	0	4	43	5	7	5	49
MMC13	3	0	3	6	0	4	37	60
MMC16	0	0	12	49	1	3	9	48
MMC20	0	0	3	27	0	5	17	43
MMC21	0	0	3	57	0	4	16	45
MMC22	0	0	3	66	0	0	30	43
MMC24	0	0	12	58	1	10	13	43
MMC29	0	0	2	26	0	0	27	78
MMC28	0	0	0	42	0	5	28	65
MMC32	0	0	1	11	3	0	28	86
MMC35	0	0	3	18	0	0	19	62
MMC36	0	0	2	21	0	0	15	51
MMC40	0	0	2	12	1	10	28	68
MMC41	1	0	3	12	0	4	14	61
MMC44	0	0	2	19	2	1	33	41
MMC48	0	0	1	26	0	6	15	37
MMC52	0	0	4	53	6	4	30	58
MMC56	0	0	1	30	3	6	23	54
MMC57	2	0	4	16	0	1	12	43
MMC80	0	0	0	6	5	6	35	54
MMC84	0	0	2	11	0	9	29	64
MMC88	0	0	1	5	0	1	39	52
MMC92	0	0	0	3	6	6	16	41
MMC96	0	0	1	5	1	1	24	54
MMC100	0	0	1	5	6	0	36	28
MMC104	3	0	1	12	1	0	21	47
MMC106	0	0	7	13	0	0	12	52
MMC108	1	1	2	8	8	0	22	23
MMC112	3	0	4	4	0	16	29	54
MMC116	25	0	0	1	0	0	47	47
MMC120	18	0	3	6	0	1	34	82
MMC124	15	0	1	2	0	7	27	89
MMC128	6	0	0	4	0	5	18	96
MMC130	0	0	15	163	0	0	7	8
Total	**78**	**1**	**115**	**890**	**56**	**127**	**869**	**1987**

Appendix 7.2 (continued)

Sample	parallelipedal	platey	polylobe	rectangular	reniform	rondel	saddle	scutiform
MMC1	0	0	3	0	0	89	2	0
MMC4	0	0	4	0	0	135	9	4
MMC8	0	0	0	0	0	76	0	9
MMC9	4	0	3	35	0	33	9	0
MMC10	0	0	2	25	0	45	2	0
MMC12	0	0	9	0	0	86	0	0
MMC13	5	0	0	33	2	38	3	0
MMC16	0	0	3	0	0	102	0	0
MMC20	0	0	5	20	0	82	0	0
MMC21	3	0	1	26	0	68	2	0
MMC22	9	0	0	37	0	38	9	0
MMC24	0	0	1	6	0	96	0	0
MMC29	0	0	2	30	0	64	4	0
MMC28	0	6	4	0	0	81	5	0
MMC32	0	0	4	9	0	63	7	0
MMC35	5	0	0	44	0	19	3	0
MMC36	0	0	2	5	0	70	3	0
MMC40	0	0	3	23	0	60	7	0
MMC41	2	0	2	34	0	32	0	0
MMC44	0	0	4	19	0	50	2	0
MMC48	0	0	1	14	0	59	3	0
MMC52	0	1	1	10	0	50	2	0
MMC56	0	1	6	24	0	47	4	0
MMC57	11	0	0	35	0	35	0	0
MMC80	0	0	1	26	0	28	0	0
MMC84	0	0	1	7	0	47	3	0
MMC88	0	6	2	0	0	39	2	1
MMC92	0	0	6	0	0	78	9	0
MMC96	0	0	5	0	0	42	13	0
MMC100	0	0	0	0	0	59	2	0
MMC104	0	2	1	3	0	88	2	0
MMC106	2	0	2	29	0	36	8	0
MMC108	2	12	3	0	0	91	4	1
MMC112	1	0	0	24	0	19	12	2
MMC116	3	0	0	22	3	12	0	7
MMC120	3	0	0	29	1	13	5	0
MMC124	5	0	0	34	0	11	2	0
MMC128	4	0	0	35	0	8	3	0
MMC130	0	0	0	0	1	16	4	0
Total	**59**	**28**	**81**	**638**	**7**	**2105**	**145**	**24**

Appendix 7.2 (continued)

Sample	square	stellate	stomata	tracheid	trapezoid	unciform	unidenti-fied 1	elongate columellate
MMC1	0	0	6	0	31	0	9	0
MMC4	8	0	3	0	26	0	0	0
MMC8	14	0	0	0	18	0	0	0
MMC9	28	0	1	0	29	0	0	0
MMC10	29	0	1	0	52	0	0	0
MMC12	10	0	1	0	30	0	0	0
MMC13	38	0	0	0	21	0	0	0
MMC16	11	0	1	0	20	0	0	0
MMC20	8	0	4	0	30	0	0	0
MMC21	18	0	0	0	32	0	0	0
MMC22	30	0	0	0	24	0	0	0
MMC24	9	0	4	0	38	0	1	0
MMC29	22	0	1	0	22	0	0	0
MMC28	15	0	2	0	15	0	0	0
MMC32	24	0	8	0	21	0	0	0
MMC35	20	0	2	0	45	0	0	2
MMC36	10	0	3	0	29	0	0	0
MMC40	0	0	1	0	28	0	0	0
MMC41	12	0	3	0	31	0	0	0
MMC44	11	0	3	0	36	0	0	0
MMC48	6	0	3	0	58	0	0	0
MMC52	12	0	2	0	33	0	0	0
MMC56	17	0	2	0	58	0	2	0
MMC57	12	0	2	0	65	0	0	0
MMC80	12	0	10	0	40	0	0	0
MMC84	5	0	1	0	60	0	0	0
MMC88	51	0	9	0	27	0	8	0
MMC92	16	0	9	0	25	0	8	0
MMC96	20	0	5	0	41	0	3	0
MMC100	19	0	5	0	35	0	0	0
MMC104	16	0	7	0	54	0	2	0
MMC106	14	0	4	0	87	0	0	0
MMC108	33	0	3	0	53	0	5	0
MMC112	30	0	2	0	33	0	0	0
MMC116	34	0	3	0	62	0	2	0
MMC120	37	0	1	0	29	0	0	0
MMC124	29	0	0	0	57	0	0	0
MMC128	39	0	0	0	42	0	0	0
MMC130	0	1	19	1	16	1	174	0
Total	719	1	131	1	1453	1	214	2

Appendix 7.2 (continued)

Sample	elongate crenate	elongate dendritic	elongate echinate	elongate favose	elongate granulate	elongate lacunose	elongate laminate	elongate parallelpipedal
MMC1	5	24	59	0	0	0	0	0
MMC4	0	11	38	0	0	0	0	0
MMC8	0	13	42	0	0	0	0	0
MMC9	0	10	40	0	0	0	0	0
MMC10	0	8	21	0	0	0	0	0
MMC12	0	18	84	0	0	0	0	1
MMC13	0	6	40	0	0	0	0	0
MMC16	1	8	77	0	0	0	0	0
MMC20	0	11	76	0	0	0	0	0
MMC21	0	8	38	0	0	0	0	0
MMC22	0	7	44	0	0	0	0	0
MMC24	0	9	82	0	0	0	0	0
MMC29	0	6	52	0	0	0	2	0
MMC28	0	12	44	0	0	1	0	0
MMC32	0	14	80	0	0	0	2	0
MMC35	0	7	41	0	0	0	0	0
MMC36	0	24	109	0	0	0	1	0
MMC40	0	9	107	0	0	0	0	0
MMC41	5	5	67	0	0	0	0	0
MMC44	0	11	107	0	0	0	0	0
MMC48	1	9	115	0	0	0	0	0
MMC52	2	10	36	0	0	0	3	0
MMC56	0	5	62	0	0	0	5	0
MMC57	0	6	114	0	0	0	0	0
MMC80	2	9	61	0	0	0	5	0
MMC84	3	12	90	0	1	0	3	0
MMC88	0	4	40	0	0	0	0	0
MMC92	0	15	59	0	0	0	0	0
MMC96	0	1	72	0	0	0	0	0
MMC100	0	46	76	0	0	0	2	0
MMC104	0	19	62	0	0	0	10	0
MMC106	0	7	65	0	0	0	2	0
MMC108	0	20	74	1	0	0	6	0
MMC112	0	3	51	0	0	0	2	0
MMC116	0	2	13	0	0	0	1	0
MMC120	0	4	15	0	0	0	2	0
MMC124	0	2	4	0	0	0	1	0
MMC128	0	0	10	0	0	0	0	0
MMC130	0	0	2	0	0	0	0	0
Total	**19**	**395**	**2269**	**1**	**1**	**1**	**47**	**1**

Appendix 7.2 (continued)

Sample	elongate psilate	elongate sinuate	elongate trapeziform	elongate verrucate	hair base	hair/ trichome	Multicells	TOTAL
MMC1	58	113	4	0	2	34	13	509
MMC4	62	108	9	0	4	17	13	509
MMC8	61	147	23	0	1	14	10	518
MMC9	33	43	4	0	9	14	5	564
MMC10	38	37	0	0	6	55	6	528
MMC12	48	108	6	0	6	18	10	588
MMC13	37	40	0	0	3	27	5	540
MMC16	46	51	5	0	2	32	14	517
MMC20	28	106	3	0	2	19	5	514
MMC21	27	53	8	0	2	25	1	525
MMC22	14	37	4	0	4	46	3	542
MMC24	24	70	9	0	2	9	2	522
MMC29	36	31	2	0	1	47	5	562
MMC28	34	64	1	0	21	28	17	529
MMC32	56	67	3	0	18	40	5	591
MMC35	38	27	5	0	3	26	8	544
MMC36	56	69	7	0	3	39	7	567
MMC40	42	84	3	0	8	16	10	564
MMC41	44	35	5	0	5	41	6	531
MMC44	27	53	1	0	6	20	11	533
MMC48	43	55	7	0	6	13	2	539
MMC52	62	62	13	0	10	18	9	533
MMC56	63	82	7	0	9	36	13	616
MMC57	41	25	8	0	3	20	12	547
MMC80	81	116	4	0	4	22	15	584
MMC84	46	78	6	0	2	24	5	601
MMC88	83	35	0	0	10	44	15	525
MMC92	92	78	3	0	3	25	13	526
MMC96	83	105	1	0	9	23	11	550
MMC100	80	84	5	0	0	36	15	577
MMC104	70	80	5	0	3	27	9	592
MMC106	39	48	8	1	2	22	12	558
MMC108	40	93	6	0	1	24	1	611
MMC112	60	51	0	0	10	20	2	515
MMC116	50	10	0	0	14	34	0	520
MMC120	36	9	0	0	10	31	0	528
MMC124	17	5	0	0	11	11	0	517
MMC128	16	4	0	0	6	9	0	532
MMC130	27	13	1	0	3	8	2	522
Total	**1838**	**2376**	**176**	**1**	**224**	**1014**	**292**	**21290**

Appendix 7.2 (continued)

Sample	Unidentified phytoliths	Silica aggregate	Burnt phytoliths	Biogenic Silica	Diatoms	Pollen	% dendritics	% multi-cells
MMC1	27	0	0	0	0	14	4.72	2.55
MMC4	38	0	1	0	0	3	2.16	2.55
MMC8	35	0	0	0	0	4	2.51	1.93
MMC9	4	0	54	3	0	0	1.77	0.89
MMC10	12	0	1	4	0	0	1.52	1.14
MMC12	44	0	0	0	0	0	3.06	1.70
MMC13	4	0	12	3	0	0	1.11	0.93
MMC16	23	0	0	0	0	4	1.55	2.71
MMC20	37	0	0	0	0	5	2.14	0.97
MMC21	9	0	3	1	0	0	1.52	0.19
MMC22	10	0	9	0	0	0	1.29	0.55
MMC24	28	0	0	0	0	2	1.72	0.38
MMC29	7	0	14	1	0	0	1.07	0.89
MMC28	45	0	3	0	0	0	2.27	3.21
MMC32	48	0	0	0	0	0	2.37	0.85
MMC35	15	0	6	11	0	0	1.29	1.47
MMC36	40	0	0	4	0	2	4.23	1.23
MMC40	46	0	0	0	0	1	1.60	1.77
MMC41	7	0	10	2	0	0	0.94	1.13
MMC44	25	0	0	0	0	0	2.06	2.06
MMC48	34	0	0	0	0	0	1.67	0.37
MMC52	30	0	1	0	0	3	1.88	1.69
MMC56	26	0	0	0	0	6	0.81	2.11
MMC57	10	0	8	3	0	0	1.10	2.19
MMC80	9	0	0	0	0	0	1.54	2.57
MMC84	7	0	11	0	0	0	2.00	0.83
MMC88	13	0	20	0	0	0	0.76	2.86
MMC92	3	0	2	0	0	0	2.85	2.47
MMC96	11	0	2	0	0	0	0.18	2.00
MMC100	18	3	12	5	6	0	7.97	2.60
MMC104	16	0	1	2	0	0	3.21	1.52
MMC106	9	0	3	4	0	0	1.25	2.15
MMC108	15	2	7	1	0	0	3.27	0.16
MMC112	46	0	24	9	3	4	0.58	0.39
MMC116	19	0	27	1	0	0	0.38	0.00
MMC120	21	4	37	5	0	0	0.76	0.00
MMC124	23	1	14	9	0	0	0.39	0.00
MMC128	12	0	4	26	0	0	0.00	0.00
MMC130	51	0	0	8	0	34	0.00	0.38
Total	877	10	286	102	9	82		

Appendix 7.2 (continued)

Sample	% short cells	% long cells	C4 %	C3 %	D/P	Iph (%)	Ic (%)	Fs (%)
MMC1	38.70334	34.38114	0.392927	33.79175	0.093567	40	95.37037	6.896552
MMC4	48.52652	35.16699	2.357564	43.222	0.040724	56.25	91.01124	0.431034
MMC8	39.96139	44.59459	1.351351	33.97683	0.127168	0	94.0678	0
MMC9	71.98582	14.1844	1.950355	68.08511	0.028818	64.28571	93.69369	11.39241
MMC10	67.61364	14.20455	0.757576	65.34091	0.015823	33.33333	96.84211	2.86533
MMC12	49.14966	27.55102	0.170068	39.96599	0.221698	0	91.86992	1.271186
MMC13	70.74074	14.25926	0.740741	68.33333	0.027027	75	98.22222	4.825737
MMC16	54.35203	19.72921	0.193424	41.97292	0.293269	0	97.08029	0
MMC20	51.36187	26.6537	0.389105	44.35798	0.131004	0	95.36424	0
MMC21	69.14286	16.7619	0.380952	57.90476	0.212766	66.66667	98.42105	2.614379
MMC22	70.66421	10.1476	1.660517	56.27306	0.240418	100	95.65217	4.140127
MMC24	60.34483	19.7318	0.383142	45.4023	0.307018	0	97.77778	0.83682
MMC29	67.61566	12.27758	1.067616	61.3879	0.08589	50	96.22642	3.988604
MMC28	58.03403	18.71456	3.213611	45.74669	0.166008	23.80952	87.19512	0.772201
MMC32	51.77665	21.3198	1.522843	46.3621	0.046875	53.84615	91.21622	0.353357
MMC35	71.13971	12.86765	1.286765	65.625	0.061404	42.85714	96.60194	7.967033
MMC36	44.44444	23.28042	1.587302	38.44797	0.109005	27.27273	91.47287	0.440529
MMC40	50.53191	22.87234	2.304965	45.39007	0.057377	43.75	88.23529	0.743494
MMC41	59.88701	15.81921	0	56.49718	0.051903	0	98.9011	3.333333
MMC44	55.72233	15.197	1.688555	49.15572	0.091304	15.38462	91.33333	0.738007
MMC48	53.43228	19.48052	2.226345	45.64007	0.113924	23.07692	90.22556	1.162791
MMC52	57.78612	25.70356	1.125704	44.27767	0.252212	28.57143	94.65649	0
MMC56	54.22078	24.67532	1.136364	46.75325	0.113553	30.76923	91.44737	1.016949
MMC57	58.13528	13.52834	0.182815	53.93053	0.068493	0	99.375	7.094595
MMC80	45.37671	34.41781	0	41.78082	0.028169	0	99.10714	0.409836
MMC84	55.07488	21.63062	1.164725	51.5807	0.048689	37.5	93.93939	0.630915
MMC88	56	22.47619	0.380952	50.09524	0.025641	50	97.31544	1.509434
MMC92	45.24715	32.88973	1.901141	38.40304	0.014493	56.25	88.0597	0.471698
MMC96	44.54545	34.36364	2.909091	38.90909	0.027523	61.90476	82.5	0.869565
MMC100	40.38128	29.28943	0.693241	36.74177	0.030303	50	97.03704	0
MMC104	51.85811	26.18243	0.675676	46.95946	0.049057	40	96.89441	0
MMC106	63.08244	17.2043	1.612903	57.16846	0.063898	72.72727	93.60465	0.609756
MMC108	56.46481	22.74959	0.654664	49.59083	0.034602	57.14286	96.61836	0.977199
MMC112	61.35922	21.5534	2.330097	57.08738	0.029091	100	91.89189	6.20915
MMC116	76.15385	11.53846	0.192308	74.80769	0.002618	0	99.47368	12.30769
MMC120	79.73485	8.522727	0.94697	76.89394	0.022959	100	97.31183	18.24818
MMC124	90.1354	4.255319	0.386847	90.32882	0.007042	100	98.93617	13.64606
MMC128	91.54135	3.759398	0.56391	90.22556	0.009852	100	98.23529	18.01242
MMC130	89.27203	7.854406	0.766284	18.00766	2.197531	100	86.66667	16.49485

Appendix 7.2 (continued)

Sample	% globular granulate	% globular echinate	Novello/Barboni 2015
MMC1	2.554028	0.589391	12.30769231
MMC4	1.571709	0.196464	4.74137931
MMC8	3.474903	0.772201	6.989247312
MMC9	1.41844	0.35461	2.801120448
MMC10	0.568182	0.378788	2.469135802
MMC12	7.312925	0.680272	7.826086957
MMC13	1.111111	0.555556	1.769911504
MMC16	9.477756	2.321083	3.703703704
MMC20	5.252918	0.583658	4.583333333
MMC21	10.85714	0.571429	2.75862069
MMC22	12.17712	0.553506	2.380952381
MMC24	11.11111	2.298851	3.797468354
MMC29	4.626335	0.355872	1.807228916
MMC28	7.939509	0	4.528301887
MMC32	1.861252	0.169205	5.185185185
MMC35	3.308824	0.551471	2.005730659
MMC36	3.703704	0.352734	10.21276596
MMC40	2.12766	0.35461	3.557312253
MMC41	2.259887	0.564972	1.700680272
MMC44	3.564728	0.375235	4.564315353
MMC48	4.823748	0.185529	3.658536585
MMC52	9.943715	0.750469	4.237288136
MMC56	4.87013	0.162338	1.798561151
MMC57	2.925046	0.731261	2.013422819
MMC80	1.027397	0	4.054054054
MMC84	1.830283	0.332779	4.301075269
MMC88	0.952381	0.190476	1.680672269
MMC92	0.570342	0	6.756756757
MMC96	0.909091	0.181818	0.456621005
MMC100	0.866551	0.17331	18.85245902
MMC104	2.027027	0.168919	6.690140845
MMC106	2.329749	1.25448	2.1875
MMC108	1.309329	0.327332	6.472491909
MMC112	0.776699	0.776699	1.079136691
MMC116	0.192308	0	0.520833333
MMC120	1.136364	0.568182	1.01010101
MMC124	0.386847	0.193424	0.46728972
MMC128	0.75188	0	0
MMC130	31.22605	2.873563	0

Appendix 7.2 (continued)

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Grotte des Pigeons, Taforalt (Morocco), is one of the most famous cave sites in North Africa. We present new findings on the Iberomaurusian hunter-gatherer inhabitants who faced major challenges of a rapidly changing climate.

In this volume we describe archaeological evidence covering the period 23,000 to 12,500 years ago. We examine the nature of environmental and behavioural changes, culminating in a major broadening of the food spectrum at around 15,000 years ago, linked to technological innovation in some aspects but conservatism in others. The cave also came to be used as a substantial human cemetery, enabling us to explore burial practices and recover additional information on diet and life-styles.