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.)

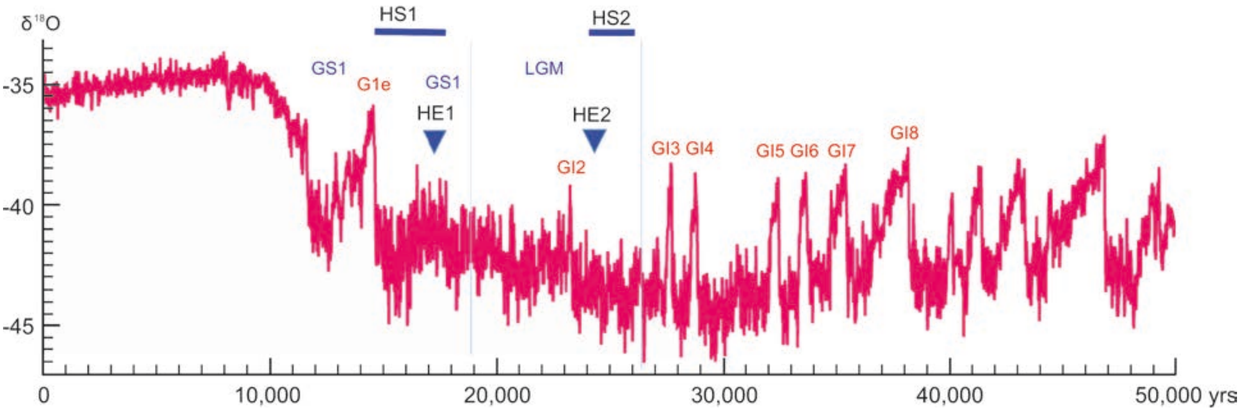

Fig. 18.1 NGrip Greenland Ice Core curve indicating GI (Interstadials) and relevant GS (Stadials). The vertical axis is a proxy for temperature variation as reconstructed from the Ice Core. HS1 and HS2 refer to Heinrich Stadials 1 and 2 (cold events recorded in the oceanic cores but with no precise equivalents 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) condi-

tions, 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.

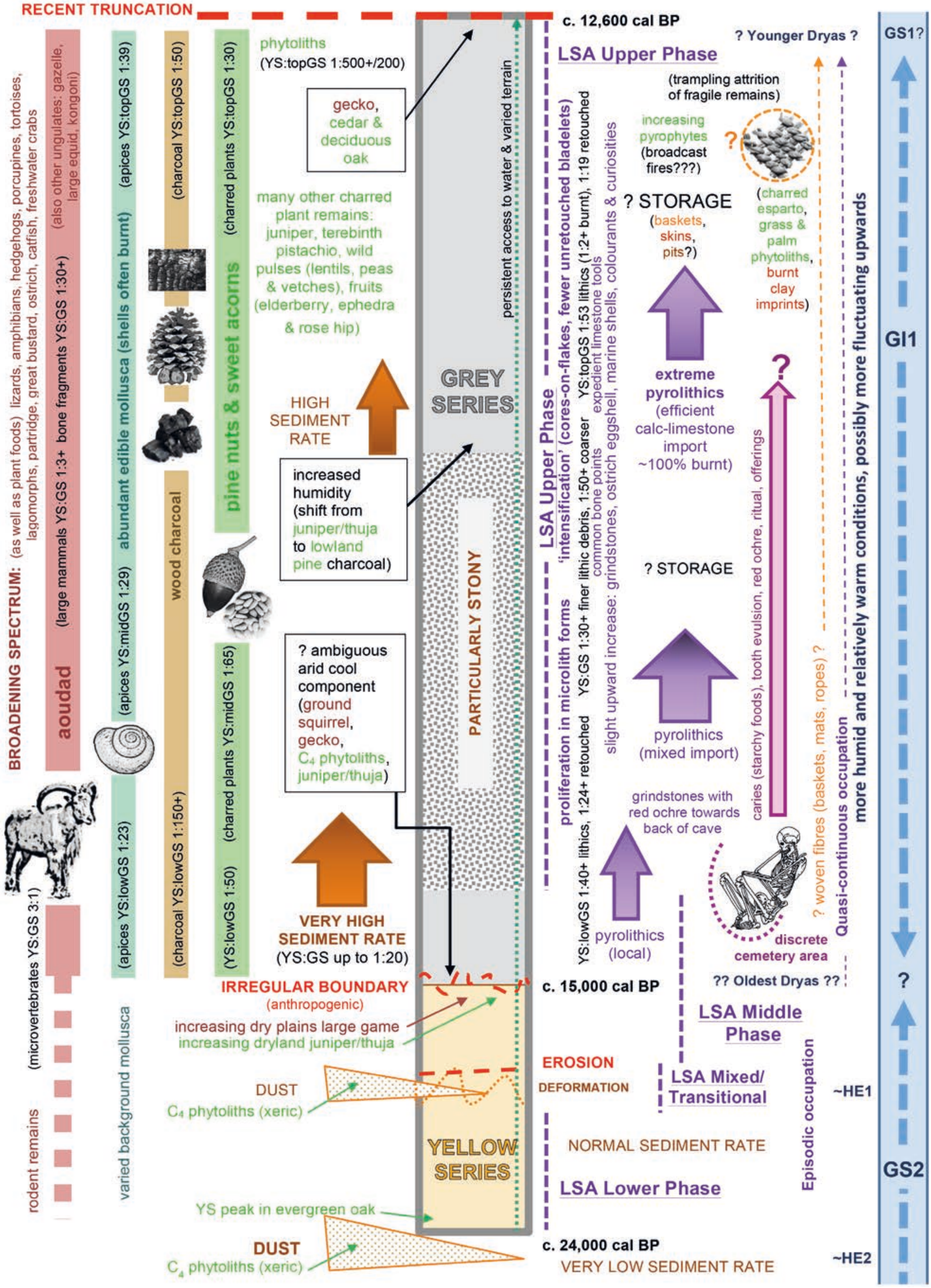

Fig. 18.2 Summary of main subsistence and other behavioural evidence from Taforalt, against the environmental background.

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.