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# 2. LITHOSTRATIGRAPHIES AND SEDIMENTS

## 2.1 INTRODUCTION

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

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geology has been reported by El Gout/Khattach/Houari 2009 (a work which contains a summary description from the unpublished Beni Snassen fieldwork of Tayub Naciri in the late 1980s and early 1990s).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

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

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

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

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

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

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

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

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

> *tionné. Ces travertins se sont karstifiés pendant et après leur mis en place, à une période relativement récente du Quaternaire.*
>
> [The *Grotte des Pigeons* is formed in travertines, the insertion of which in the valley of the Oued Zegzel post-dates the main formation phase of the current relief. Karstification, taking advantage of a faulted zone, [was] responsible for major water flow and for the formation of the concreted massif. These travertines were karstified during and after their emplacement, at a relatively recent stage in the Quaternary.]

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

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

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

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

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

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

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

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

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[25] Probably including true spring travertines.

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

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

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

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

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

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

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

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

## 2.2 EARLIER EXCAVATIONS

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

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

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

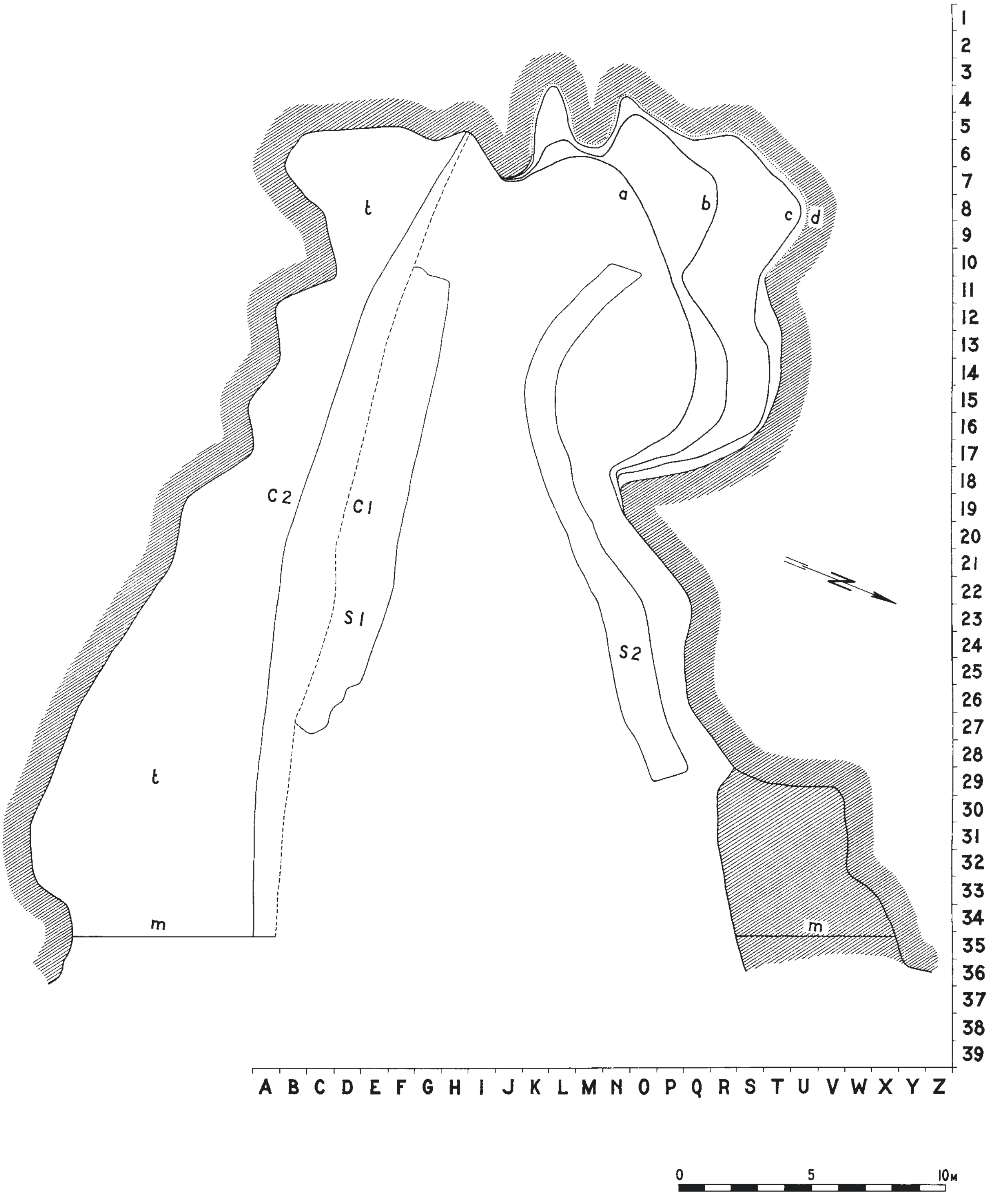

**Fig. 2.4** Site plan: **a-d** successive profiles of the back cave wall, appearing as the [1950s] excavations proceeded. – **m** protective walling. – **S1, S2** Ruhlmann trenches. – **t** reference section [untouched sequence from the top of the 'grey [ashy]' series]. – **C1** edge of S1 in 1948.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

### Ruhlmann 1944-47

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

Ruhlmann made a first attempt to explain the origin of the 'grey [ashy]' series (the grey-shaded entries in **tab. 2.1**), suggesting (1945a, 20-21):

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

Note that Ruhlmann used the term "*brèche*" [breccia] in the correct geological sense (angular stone clasts), with no implication of cementation (there is not even any point-to-point cementation in these units within the main cave, save weak diagenetic zones at the very base on occasion).

On the finding of a few Iberomaurusian lithics in the superficial interval of the 'yellow [loamy]' series towards the centre of his trench, Ruhlmann initially believed them merely to represent 'infiltration' from and through the lowest stony unit of the 'grey [ashy]' series.

Ruhlmann (1947) cut his second trench near the northern wall of the cave, eventually curving somewhat inwards and reaching a total length of some 21 m (described by Roche (1953b) as 30 m long); Roche later (1963) labelled this trench "*Sondage 2*" (or simply "S2") and this feature will here be called 'Ruhlmann (north trench)' where it is necessary to avoid any confusion.

Ruhlmann recorded the following stratigraphy, principally from the middle to outer portion of the north trench, synthesised here as **table 2.2** from his own schematics and descriptive notes.

Ruhlmann took the 'grey [ashy]' series stratigraphy (the grey-shaded entries in **tab. 2.2**) he exposed in the outer end of this north trench (thus c. 14 m laterally from the outer end of the south trench) to be more or less the same as that previously encountered, namely a triple occurrence of the pattern: stony level under ashy archaeological level (with the detail that the basal stony layer was always very thin on this side of the cave). However, presumably judging mostly from the artificial horizontality of the (military) surface, he did note that the layers stood higher towards the north cave wall, with something of a concave-up morphology (*cuvette* [trough]) presumed to occupy a line southwards, closer to the central longitudinal axis of the cave.

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

**Tab. 2.1** Ruhlmann (south trench) stratigraphy.

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

**Tab. 2.2** Ruhlmann (north trench) stratigraphy.

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

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

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

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

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

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

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

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

### Roche 1951-55

Roche took up the excavations at Taforalt only four years later but, largely due to the depth and usual lack of stepping (which must have produced terrifyingly vertiginous sides), the Ruhlmann trenches had suffered considerable collapse (see **Chapter 1**). Roche's plan of the site (published only in 1963, as his fig. 4) is re-

produced here as **figure 2.4**. The degree of collapse on the south side can be appreciated by the difference (now a sloping face) between the lines labelled C1 and C2. Indeed, Ruhlmann's north section of S2 (north trench) had also collapsed, in the outermost part of the cave leaving only the basal 'grey earth' unit between the trench and the cave wall. The tendency towards collapse of the ashy sediments also affected the inner end of the north trench, a matter to which we shall return below.
Roche (1952, 647) set out the stratigraphy as follows:

*1) Sol superficiel : 0m 10.*

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

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

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

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

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

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

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

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

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

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

[1) Superficial soil: 0.1 m.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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[30] Rabat archive, unpublished typescript.

[31] Rabat archive, unpublished plan.

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

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

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

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

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

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

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

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

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

**Tab. 2.3** Roche 1950s stratigraphy.

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

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

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

Roche again noted the difficulties of excavating in such materials:

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

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

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

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

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

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

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

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

There are also cumulative typological graphs, labelled with the left-hand entries in **table 2.4**, including further lines labelled "C52" [*Niveau C* dug in 1952] and "$N_1$ch" ['*chocolat*' in *Nécropole 1*]. Indeed, in the archive, there are several other datasets (although all with less numerical detail), such as the mammal fauna, excavated in the *A-C* system and then later re-assigned in this same manner.

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

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

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

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

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

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

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

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

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

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

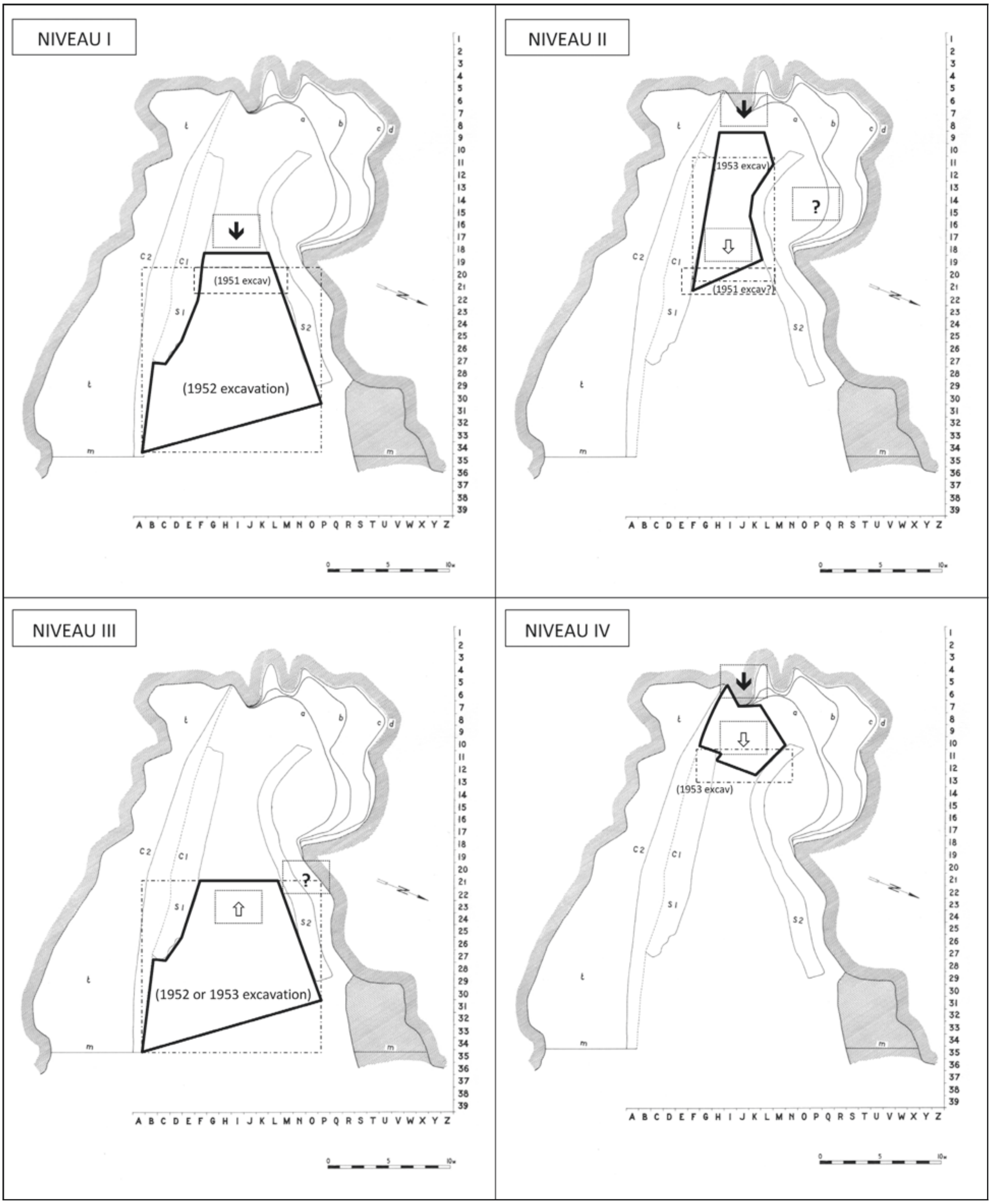

**Fig. 2.5** **a-c** Estimated/approximate plan extent of Roche's *Niveaux*. – (After site plan, Roche 1963, fig. 4 and text).

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

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

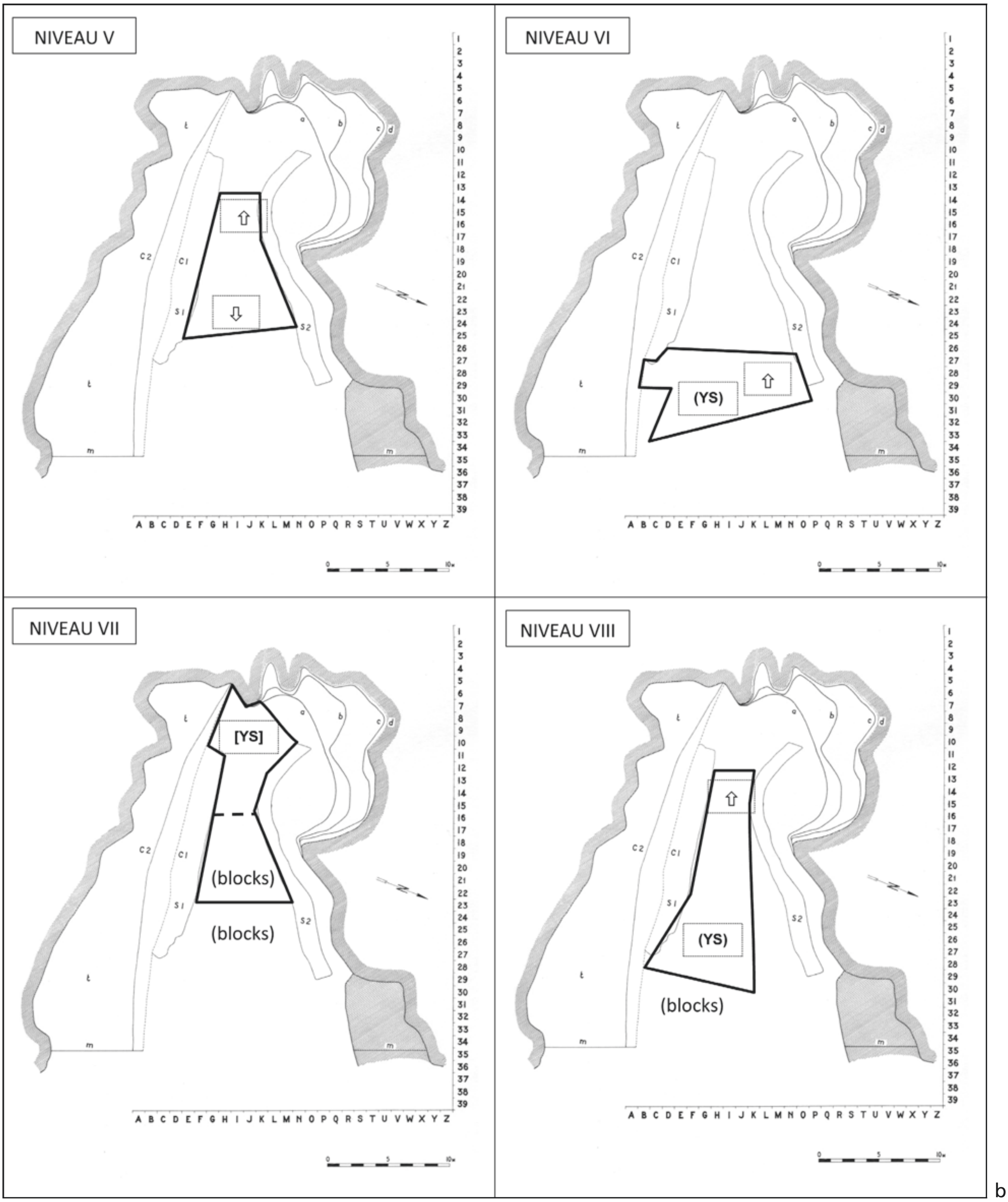

**Fig. 2.5** (continued)

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

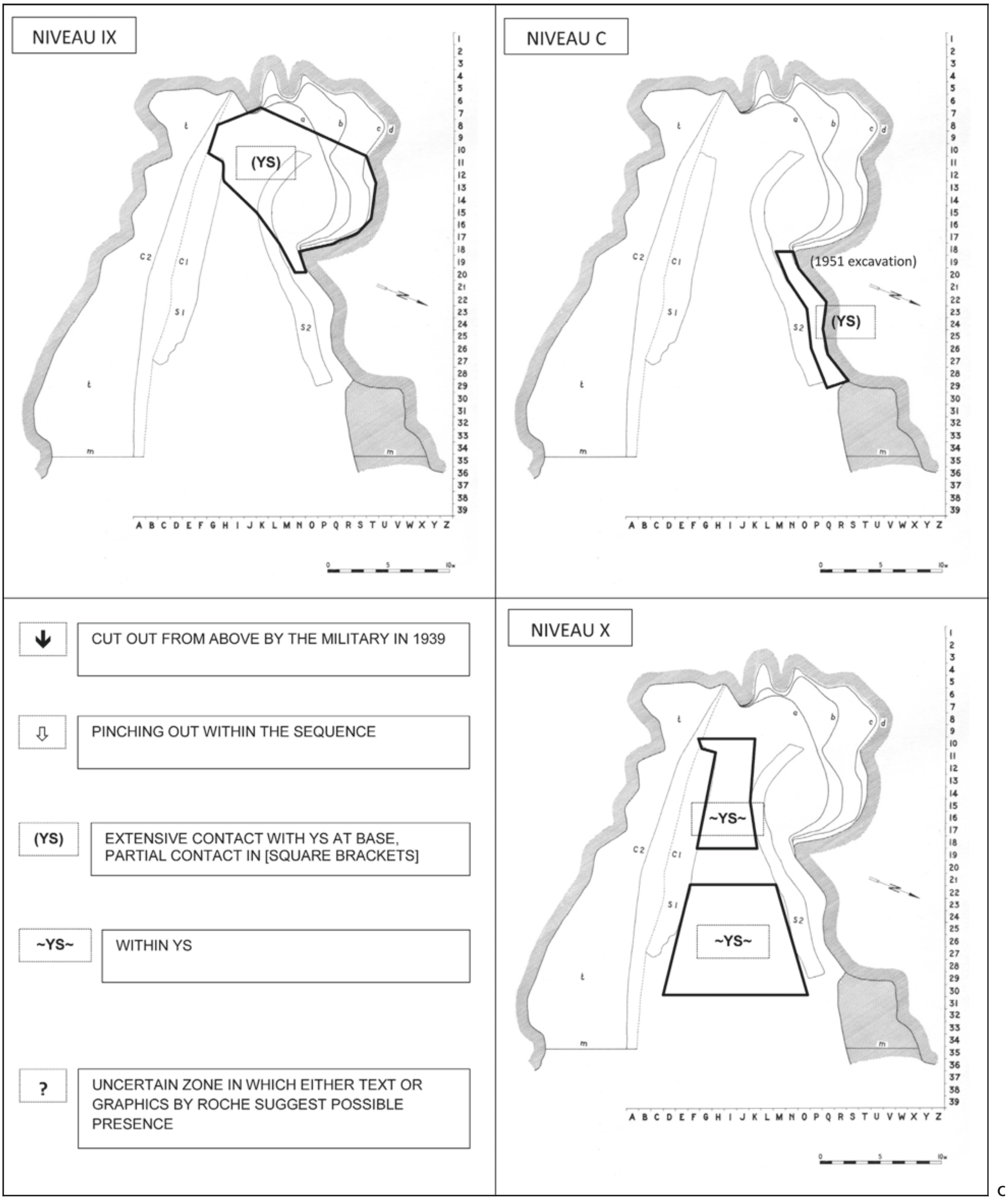

**Fig. 2.5** (continued)

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

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

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

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[38] Roche organised a radiocarbon date on charcoals but the taphonomy of such small and mobile objects requires extreme caution at the sampling point within this type of deposit. Thus, Roche later reported (1959, 729) that the determination (Lamont 399E) was made on 100 g of charcoal grouped (presumably after sieving) from a 0.5 m thick volume over an area of 4 m$^2$ in *Nécropole I*. The stratigraphic reliability of such samples must be doubtful. Furthermore, it is unlikely that the pretreatment procedures of the 1950s could have dealt adequately with the fact that this area had been capped by a strongly organic deposit, probably including Holocene material (Jodin 1954).

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

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

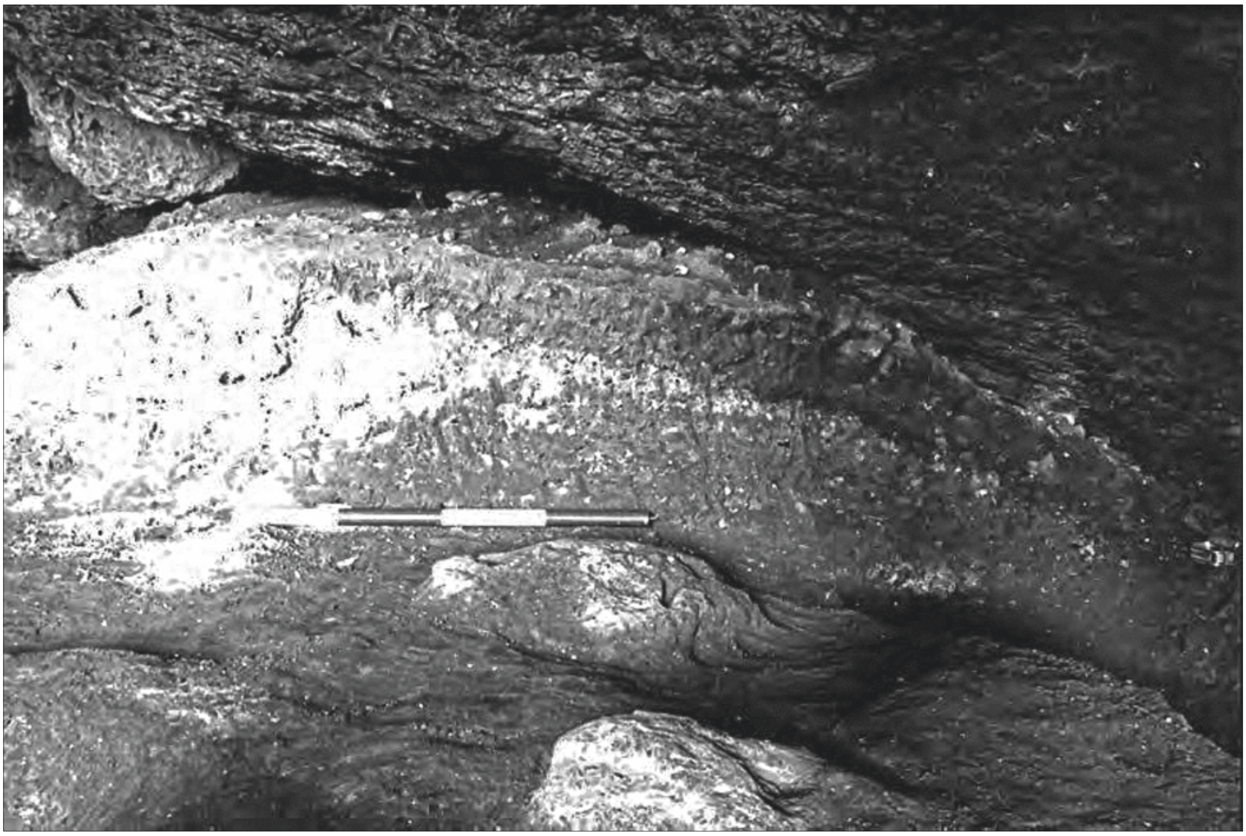

**Fig. 2.7** 1955, W end (S-N section) in *Nécropole I*. – Scale ?40 cm.

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

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

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

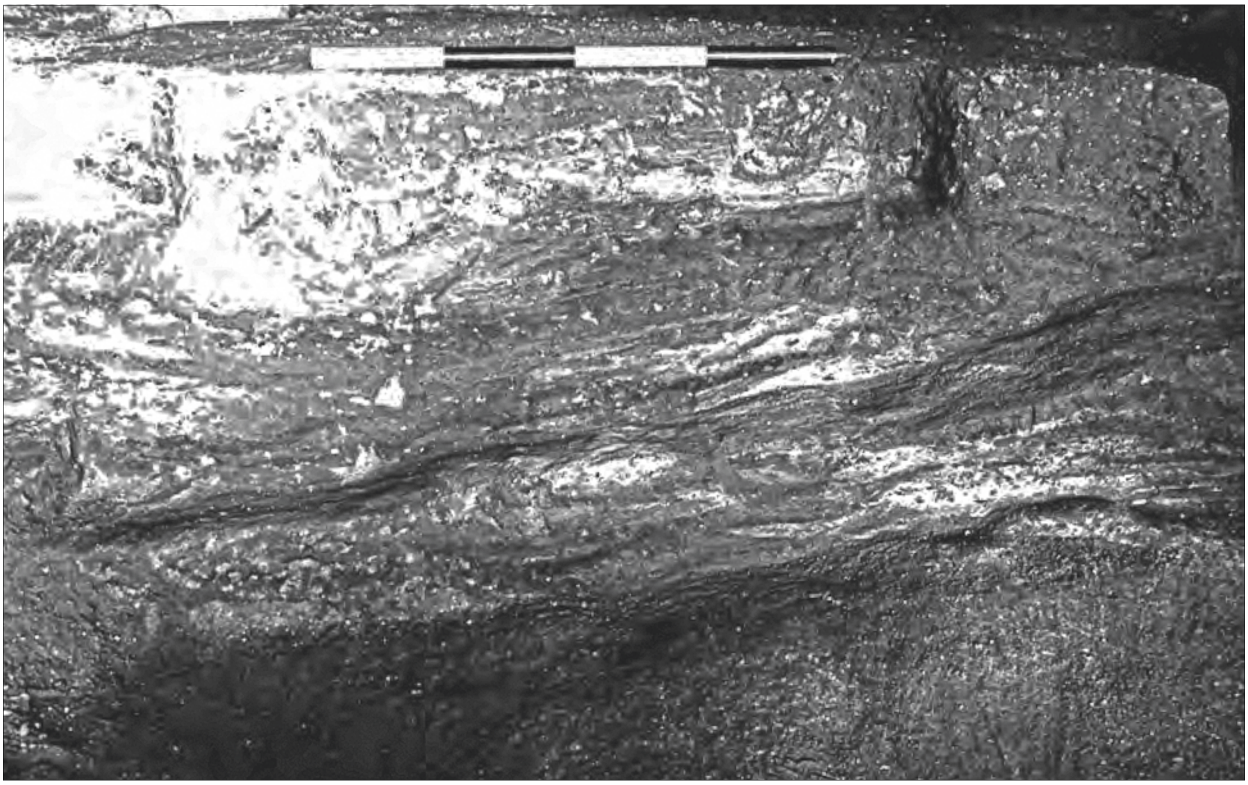

**Fig. 2.8** 1955, S-N section (ultra-violet light) in *Nécropole II*. – Scale ?40 cm.

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

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

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

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

### Roche 1969-76

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

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

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

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

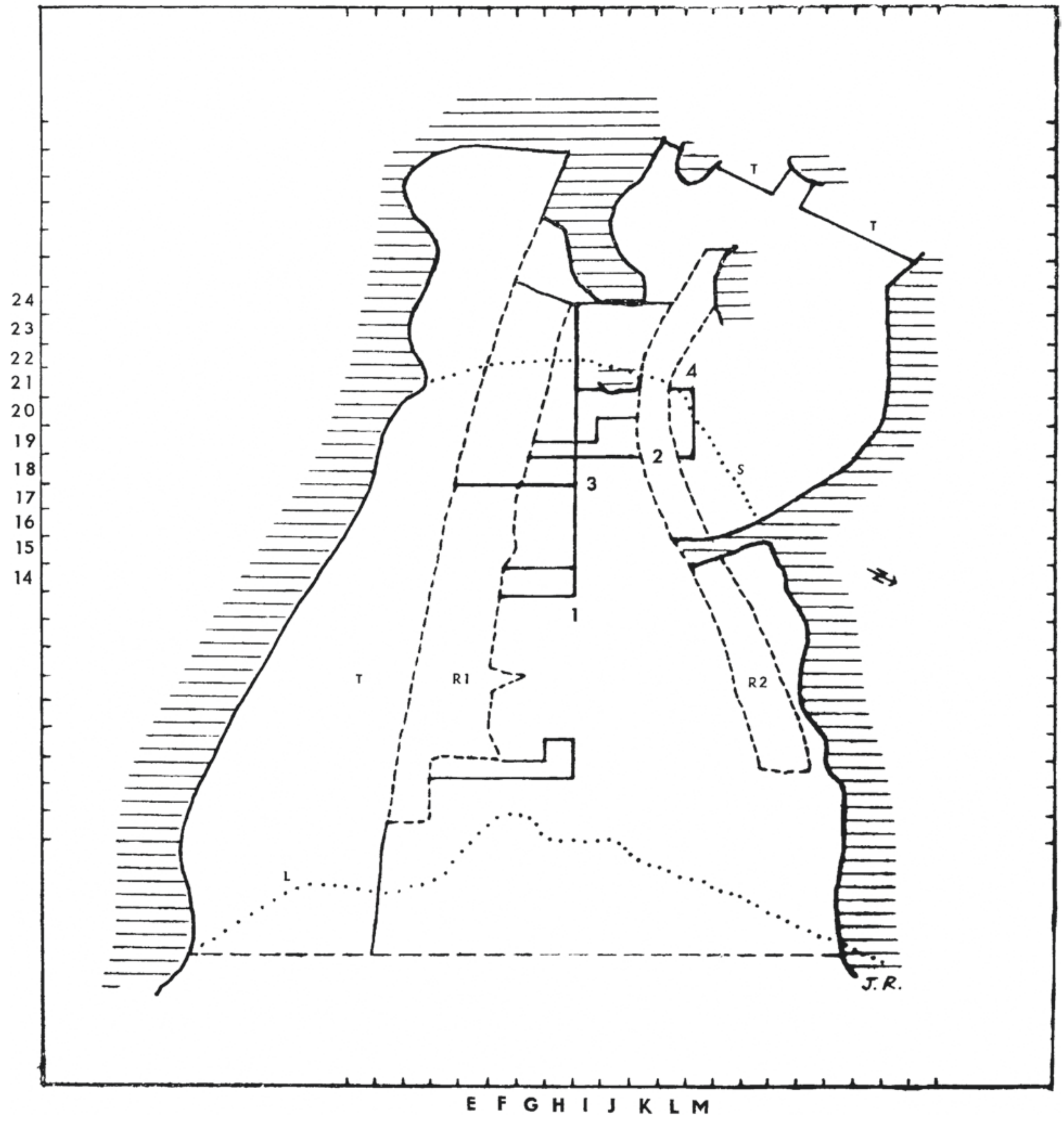

**Fig. 2.9** Roche site plan of 1970s YS sections.

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

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

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

current excavations (see **fig. 2.14** below). Roche showed a number of blackish 'charcoal trains', sometimes with some greyer ashes, as bifurcating and/or merging in this sequence, over 0.95 m thick in total, whilst a slightly more straightforward sequence, with relatively thin archaeological levels lying within a generally well-stratified (laminated) set of dominantly natural deposits, has been recognised during the present campaign.

The question therefore arises as to what Roche meant by "*un Epipaléolithique ancien*" [an Early LSA], remembering that his most obvious contribution up to this point had been in the detailed analysis of the lithic industries of the 'grey [ashy]' series (as well as in the analyses of MSA lithics from deeper in the stratigraphy). However, we now hit a complete blank – there is no published (or archival) description of this material, not even a passing comment. In fact, in addition to these stratigraphic details, the 1976 publications concentrated exclusively upon the matter of radiocarbon dates. There must be a strong suspicion that it was the numerical values of these dates[42] which allowed the development of an 'easy assumption' that the LSA/MSA boundary fell at the *Niveaux 17/18* level. The assumption is definitely incorrect in the centre of Roche's 'type section' (Sector 3 in the system used during the current campaign), where the LSA/MSA transition actually occurs, without any doubt, after a thickness of only c. 0.45 m of the 'yellow [loamy]' series, at approximately the base of Roche *Niveau 13*; all the beds (and the boundary in question) are dipping outwards to the east, with at least a slight local thickening in most of the component subunits in that direction but, commensurately, an increasing thinning westwards, into the cave.

It was noted above that other 'yellow [loamy]' series (and below) section drawings survive in the archives (with plan alignments as shown in **fig. 2.9**). In Roche Section 4, the labelled *Niveaux 10-17* set were laterally interrupted by very large amorphous zones (in the complete thickness of over 1 m and in a width of 1-1.5 m), showing an unexplained ornamentation (not stone blocks but possibly large burrows or perhaps strong carbonate cementation, the latter being the most likely, judging from the study of the surviving deposits in this area); whatever the cause, there is no plausible stratigraphic continuity across these zones (we have recovered no LSA material at all in this area, the current Sector 1). Similarly, in Roche Section 1, the stratigraphy was completely cut by very large limestone blocks (of dimensions well over 1 m), immediately west of the published section H/I 18-17. And again, Roche Section 2 (isolated at each end by the Ruhlmann trenches) showed a complex laminated set, interrupted in the centre by what is now interpreted as a large drip-pocket (cementation, down-warping, etc.); the current excavations here (Sector 6) have recovered LSA material only in the top 0.35 m (at most), whilst the Roche drawing showed the 'Aterian/Epipalaeolithic' boundary (explicitly as a red line) almost a metre lower.

By 1975 (Hassar-Benslimane 1976), Roche appears to have been working only at increasing depth in the MSA levels.

### Raynal 1977-82

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

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

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

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

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

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

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

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

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

### Courty 1980s

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

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

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

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

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

## 2.3 THE CURRENT CAMPAIGN

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

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

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

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

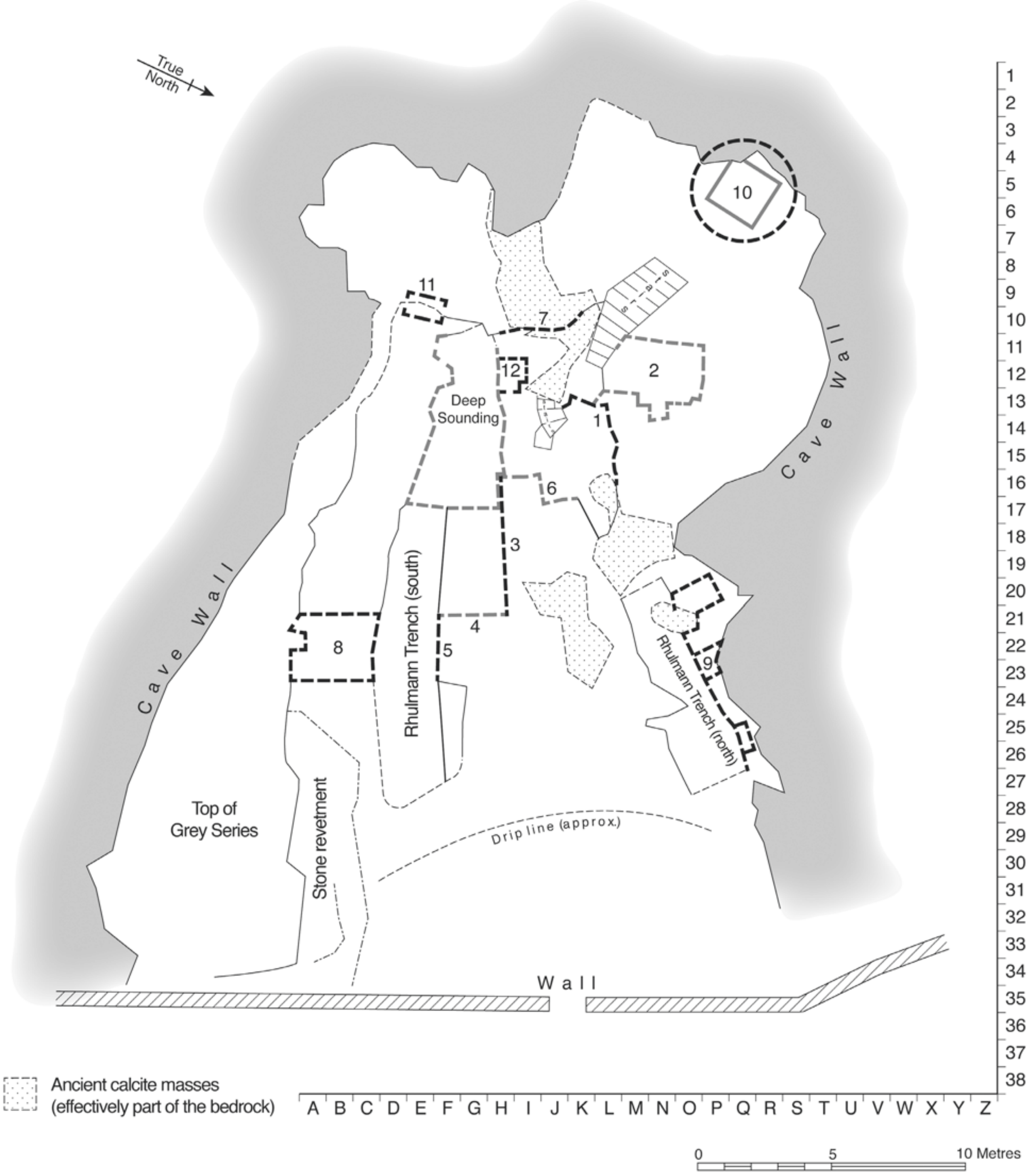

**Fig. 2.10** Site plan, current campaign, showing sectors.

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

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

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

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

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

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

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

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

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

## 2.4 LITHOSTRATIGRAPHIES

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

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

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

### Sectors 1 & 2

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

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

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

### Sector 8

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

### Sectors 3, 4 & 5

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

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

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

### Sector 9

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

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

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

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

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

### Sector 10

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

### Other Traces

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

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

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

## 2.5 DEPOSITION RATES

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

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

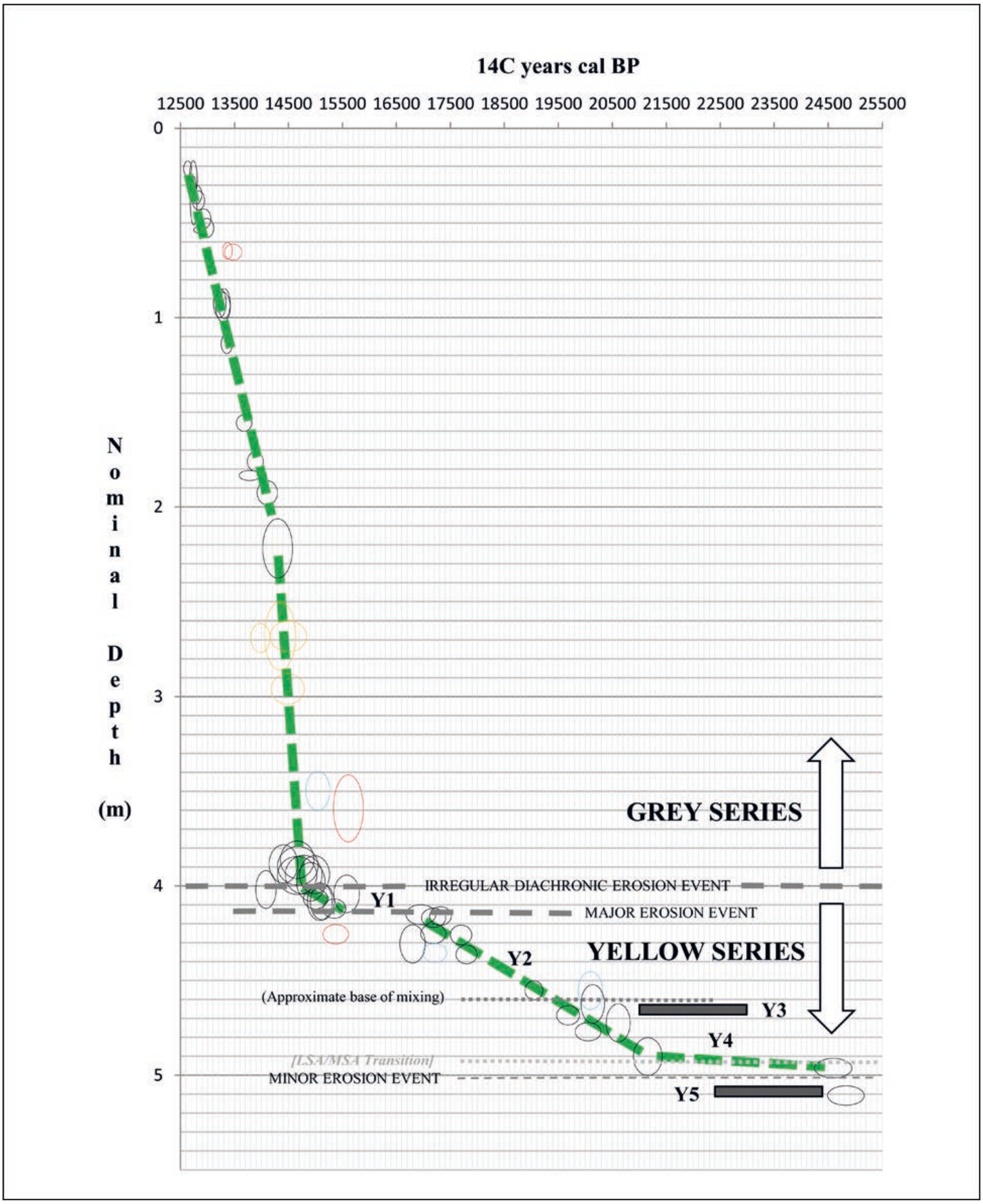

**Fig. 2.17** Sector 8 deposition diagram.

A basic 'deposition diagram' (fig. 2.17) has been constructed with 'nominal depths' (and the main discontinuities contributing to the understanding of the lithostratigraphy) on the vertical axis but unmodelled $^{14}$C years cal BP on the horizontal axis (incorporating the 2-sigma range). The advantage of this approach is that real sedimentological/lithostratigraphic information can be included and the overall presentation allows the reader to examine some of the professional judgements underlying the conclusions which can be drawn. The main disadvantage of this diagram is that the manner of portraying individual dated objects (by ovals, in order to avoid the visual confusion that would result from the use of rectangles or crosses) obscures the fact that the radiocarbon determinations (probability densities) are usually significantly asymmetrical. Whilst the estimation of sedimentation rates could be undertaken mathematically (within selected relevant sections of the diagram), the present author feels that the 'best fit by eye' method used here (the dashed green line sections) is adequate for present purposes.

This diagram (**fig. 2.17**) will be used below in this chapter as a basis for the discussion of sedimentation rates. The same dataset will be subjected to Bayesian modelling in **Chapter 4**, where there will also be a combined discussion of the various factors bearing upon the understanding the temporal characteristics of this sequence.

## 2.6 LITHOGENESIS

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

### Geogenic Sedimentation

The exterior Quaternary deposits in the immediate vicinity have not been studied in any detail. Laouina (1990) has produced the most useful compendium covering the whole region and certain salient points from his work are summarised here. He noted (p. 218) the absence of periglacial or nival forms, even at higher altitudes and further to the south (more continental conditions) in any of the Pleistocene deposits he studied; he also suggested that the common survival of ancient carbonate crusts (a repetitive motif in most of the sedimentary cycles studied, of various ages) indicated a lack of truly wet Quaternary (including Holocene) periods in this area. He reported (pp. 374-375. 407) that the red soils caught in surface micro-karst contained material originating from the local bedrock, dominantly a strongly clayey silt, usually with only a small (< 10 %) fine sand component, becoming increasingly clayey deeper into solution hollows (clays derived from the bedrock); sand content could reach c. 13 % at the very top of red soils (*terra rossa*) but, in any case, the profiles remained poorly sorted. However, he did note dolomite rhomb sand as a weathering product in some pockets. Laouina recorded deposits – especially the matrix of stony deposits in mountainous and foothill slopes (pp. 414-415) or in otherwise clearly fluvial deposits (pp. 416-419) – with coarser silts (low in clay and sand, some coarse-tail, others fine-tail skewed) but he assumed they were colluvial or fluvial, derived from local soils and did not consider an aeolian origin. He did mention (in a recent terrace of the Moulouya) an aeolian bed (p. 440), with mica quartz and very little carbonate, but this was a sand.

Within the cave, the Yellow Series is typically composed of quite laterally persistent units, always with a strong mode in the fine sand grades and a finer 'tail' (mostly silts but with some clays), poorly sorted overall. In more protected areas and, especially, deeper into the cave, nearly all these sediments are finely structured (laminated or wide thin-lenticular bedding) and, even eastwards, show a marked oblique dip to the 'south-east' (thus, outwards and southwards across the cave). Such structure is the result of intermittent wash, at various energies but never strong enough to show clear current structures (for instance, there are no cut-

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

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

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

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

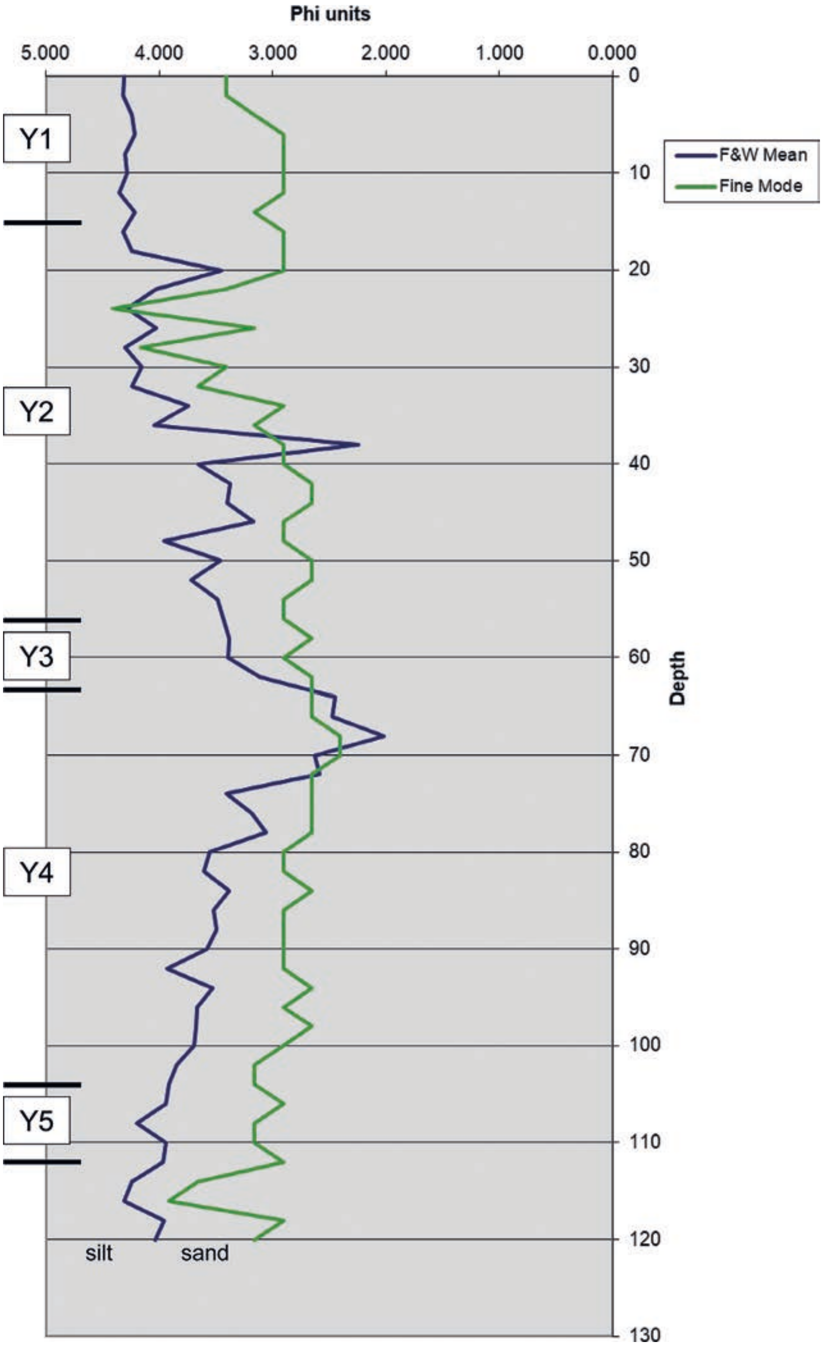

**Fig. 2.20** Sector 8 Yellow Series Particle Size (decarbonated): Central Tendencies.

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

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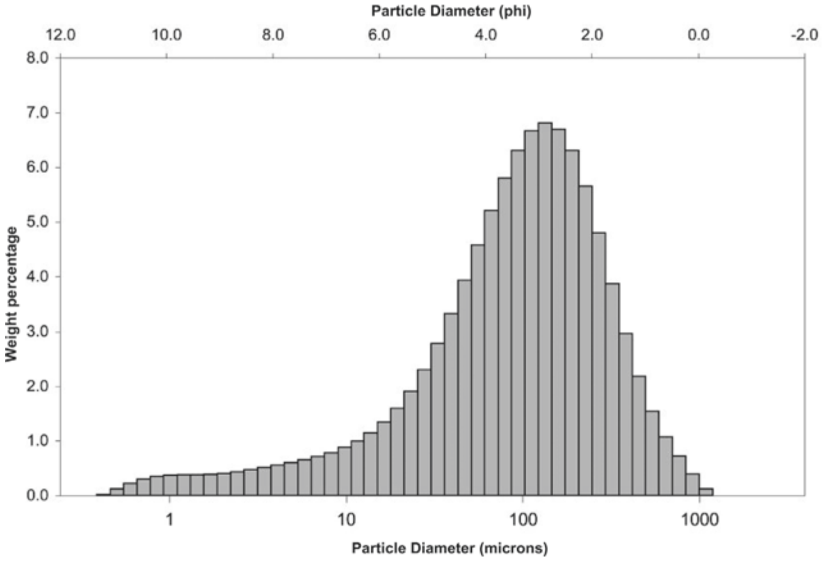
[51] Particle size range (0.388 to 4000 microns, 11.36 to -2 phi): after HCl-treatment, measured with Mastersizer 2000 particle size analyser and Hydro 2000 MU sample dispersion unit. Reported carbonate content is the HCl-soluble portion. Analysis using Gradistat v.6 2008 (developed by Dr. Simon J. Blott,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

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

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



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

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

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

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

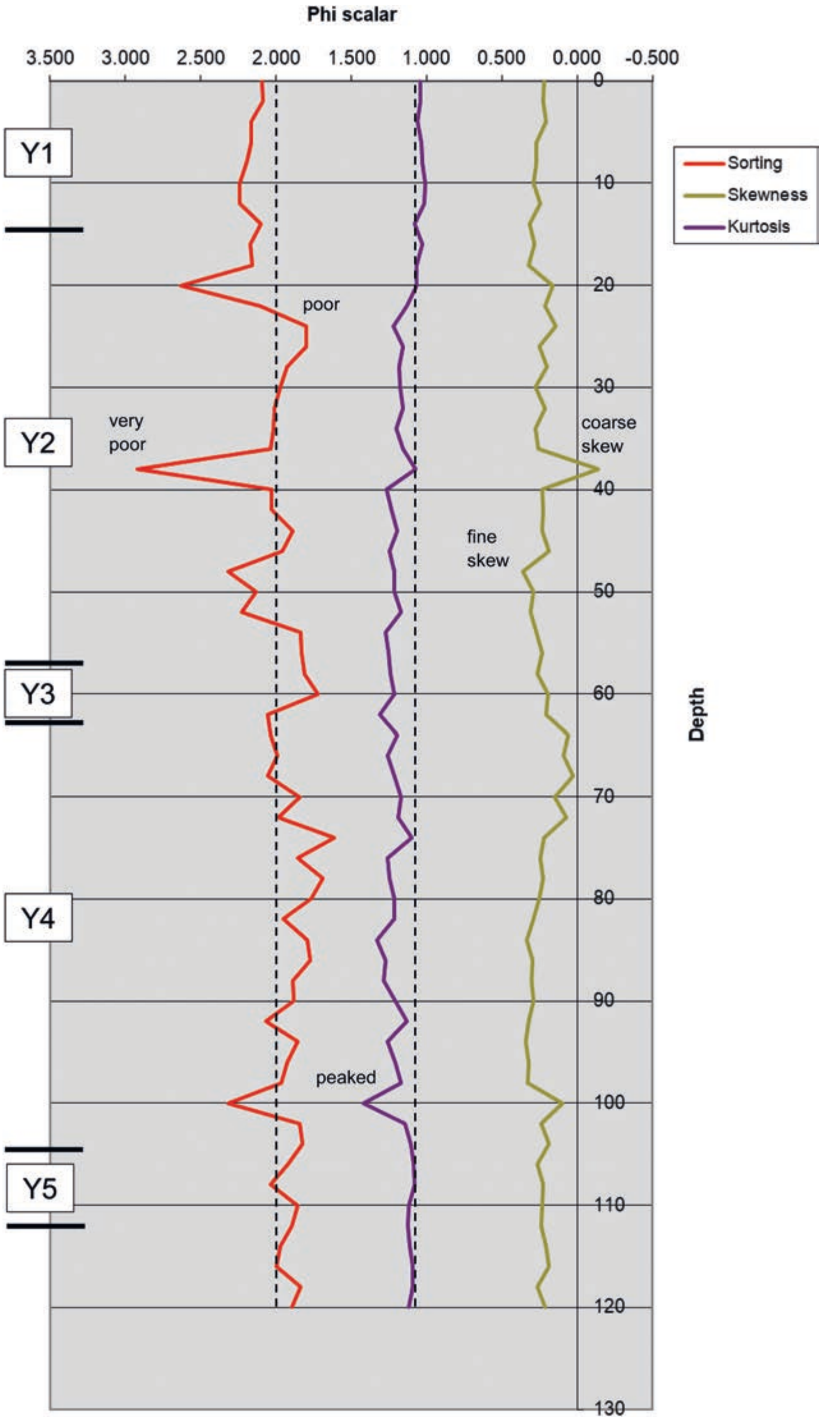


**Fig. 2.22** Sector 8 Yellow Series Particle Size (decarbonated): Folk/Ward (1957) Logarithmic Distribution Statistics.

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

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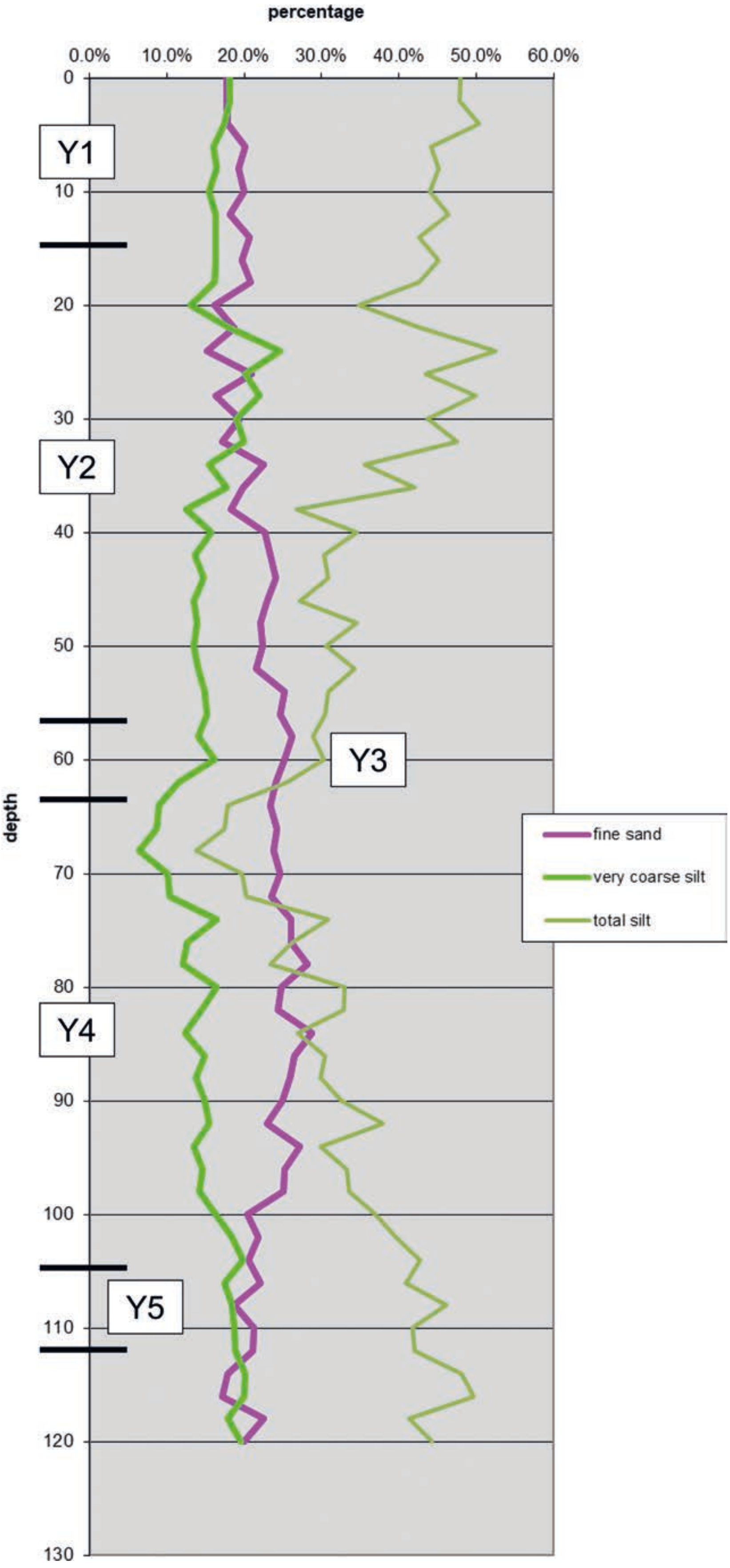
[53] Courty (1989, fig. 11.3) had already noted this structure.

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



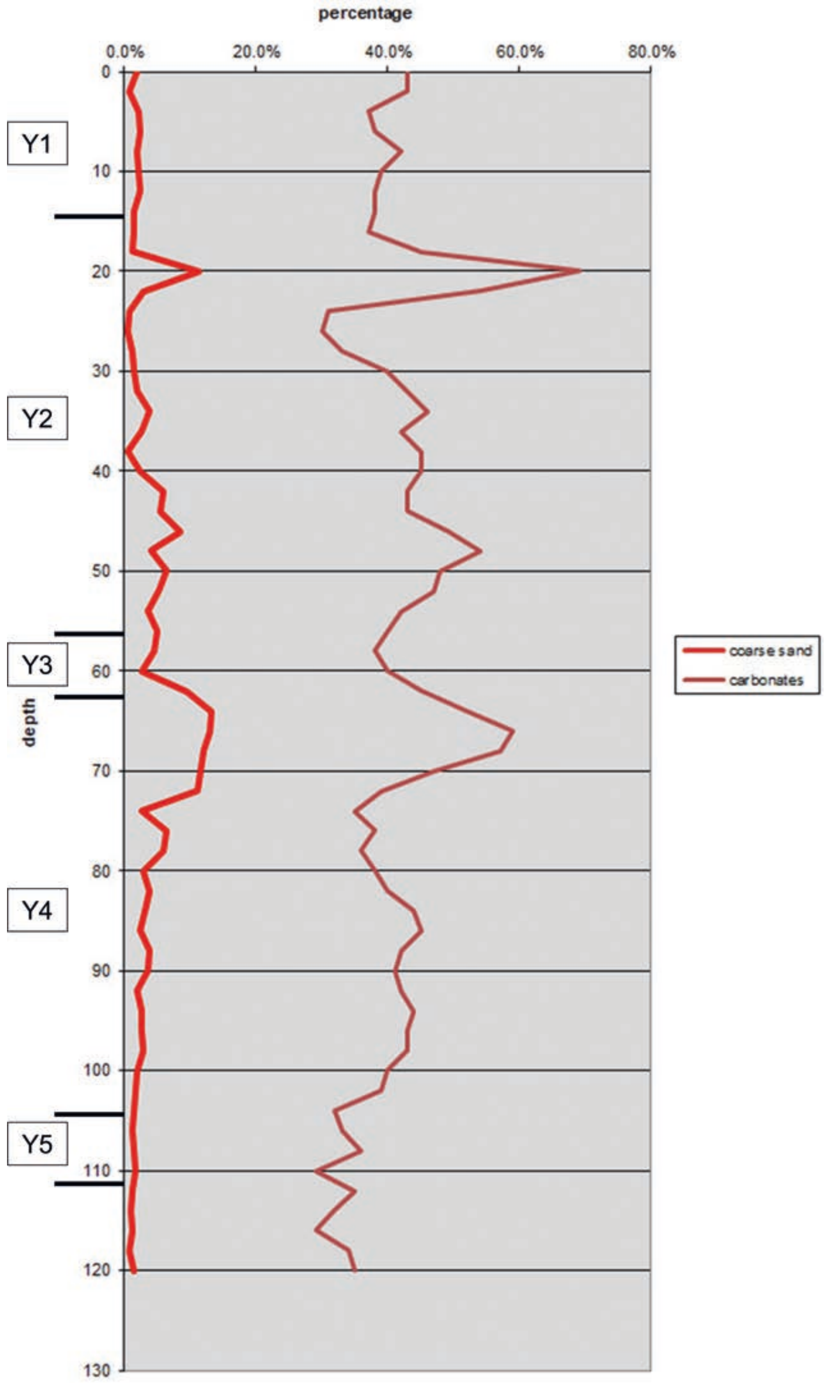


**Fig. 2.24** Sector 8 Yellow Series Particle Size: Coarse Sand (decarbonated) (0-1 phi, 1000-500 micron) and carbonates.

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

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

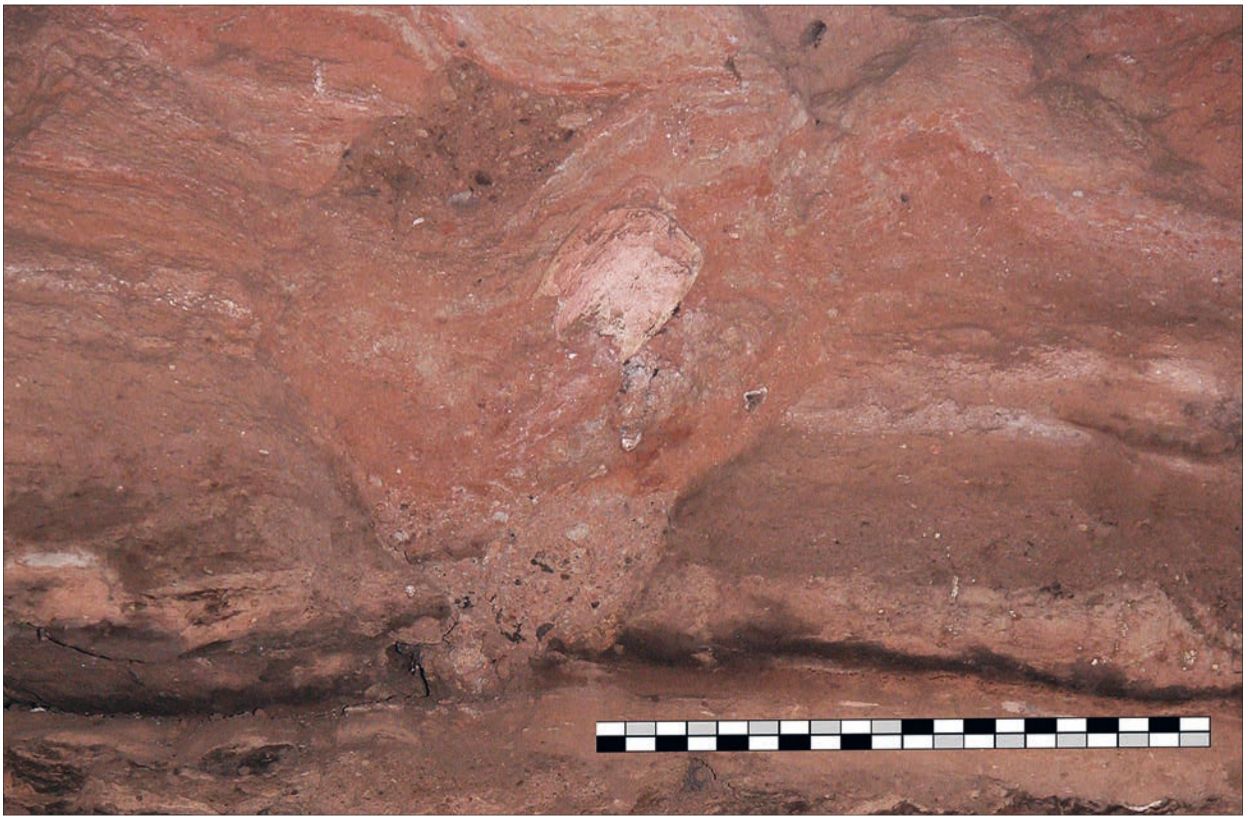


**Fig. 2.26** Plastic deformation and drip structure in Sector 6, probably stratigraphically equivalent to the phenomena in the upper part of S8-Y2, N-S section. – Scale 20 cm.

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

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

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

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

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

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

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

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

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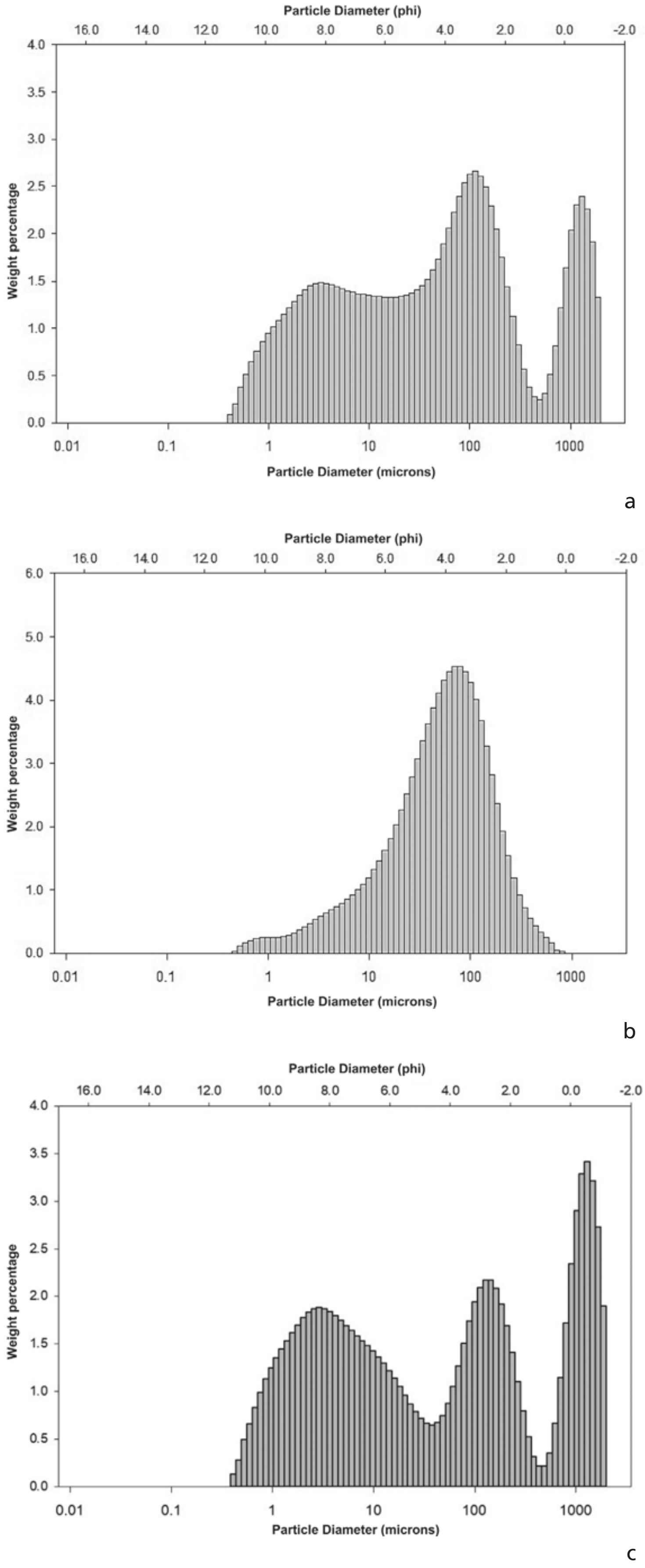
[54] This archaeological material, indeed, all the lithics within the CTX 11-16 interval in S9, belong to a non-Levallois flake industry with large core-tools ('adzes'); pending full analysis, this material is referred to as "intermediate" given its consistent stratigraphic position lying between classic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

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



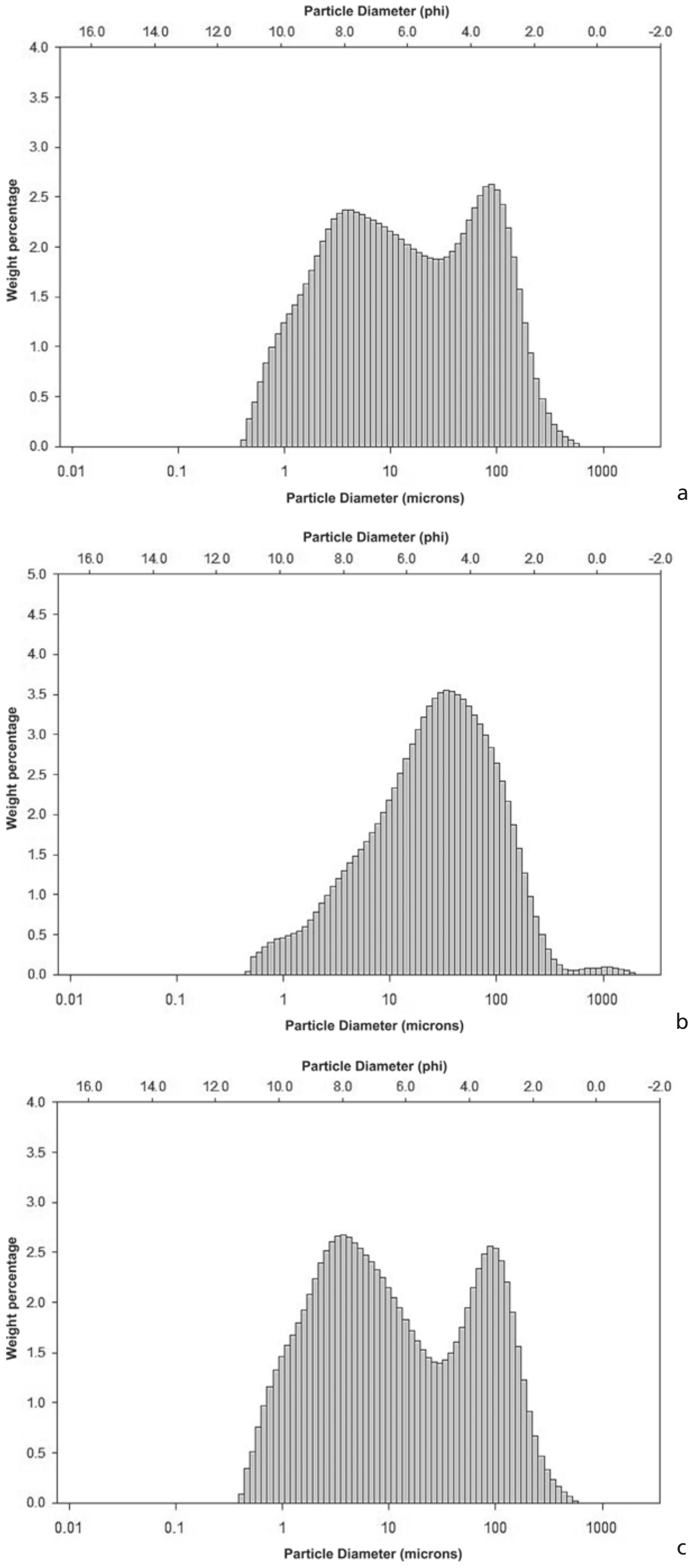


**Fig. 2.32** Sector 9(E) Yellow Series Particle Size: distribution in CTX 13. – **a** whole sediment; **b** non-carbonate; **c** carbonate.

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

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

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

## Anthropogenic Sedimentation and Effects

### General Characteristics

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

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

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

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

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

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

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

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

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

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

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

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

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

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

### Carbonate Stone and Pyrolithic Processes

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

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

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

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

would have resulted a need to for additional import of c. 130 m³ or 340 tonnes of dolostone (over some 2,200 years, thus just over 150 kilos a year at a steady 'average' rate). The LSA occupants would hardly have gone to such pains without very good reasons[58].

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

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

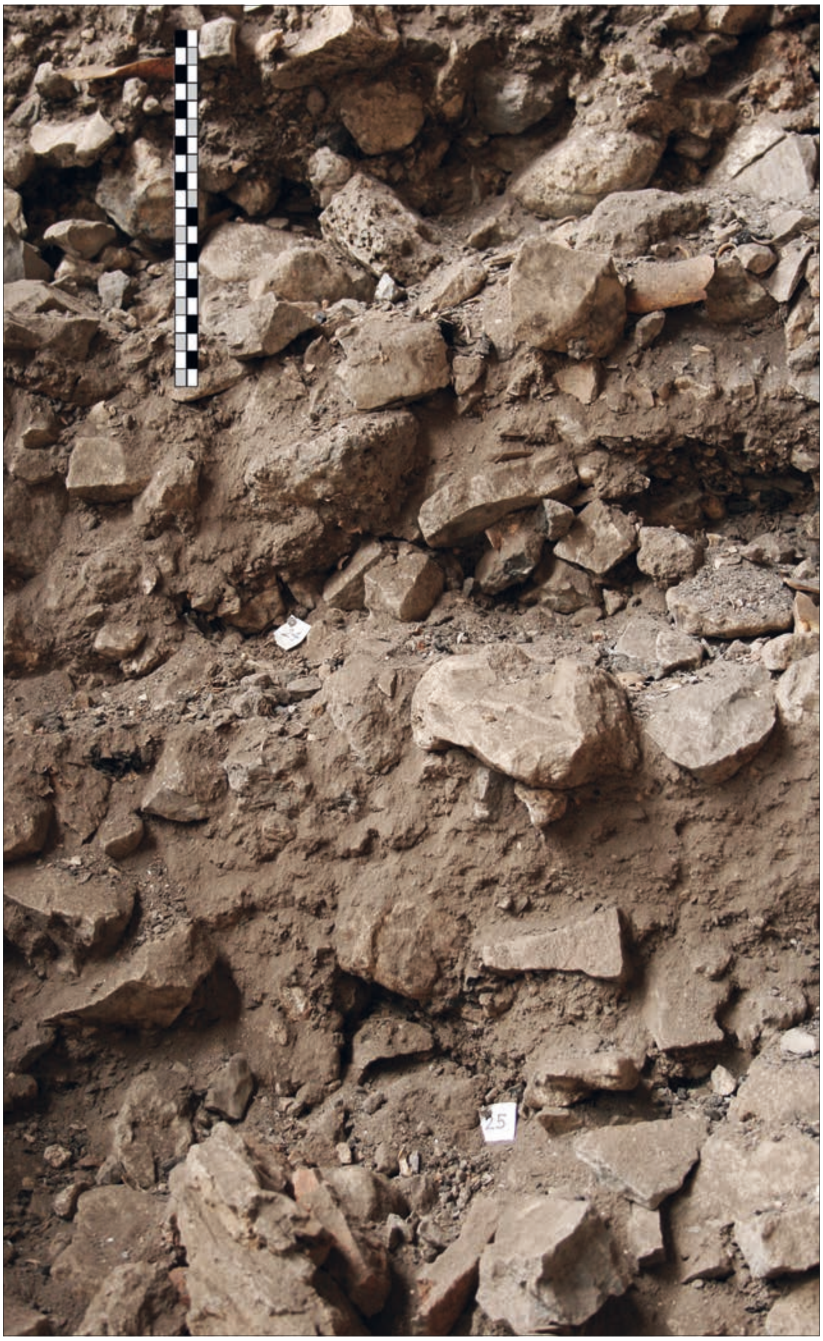
**Fig. 2.40** Sector 8, Units L20 to L21, localised wash, E-W section. – Scale 10 cm.

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

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

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

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



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

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

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

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

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

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

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

**Tab. 2.5** Thermal properties of limestones and dolostones.

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

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

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

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

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

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

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

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

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

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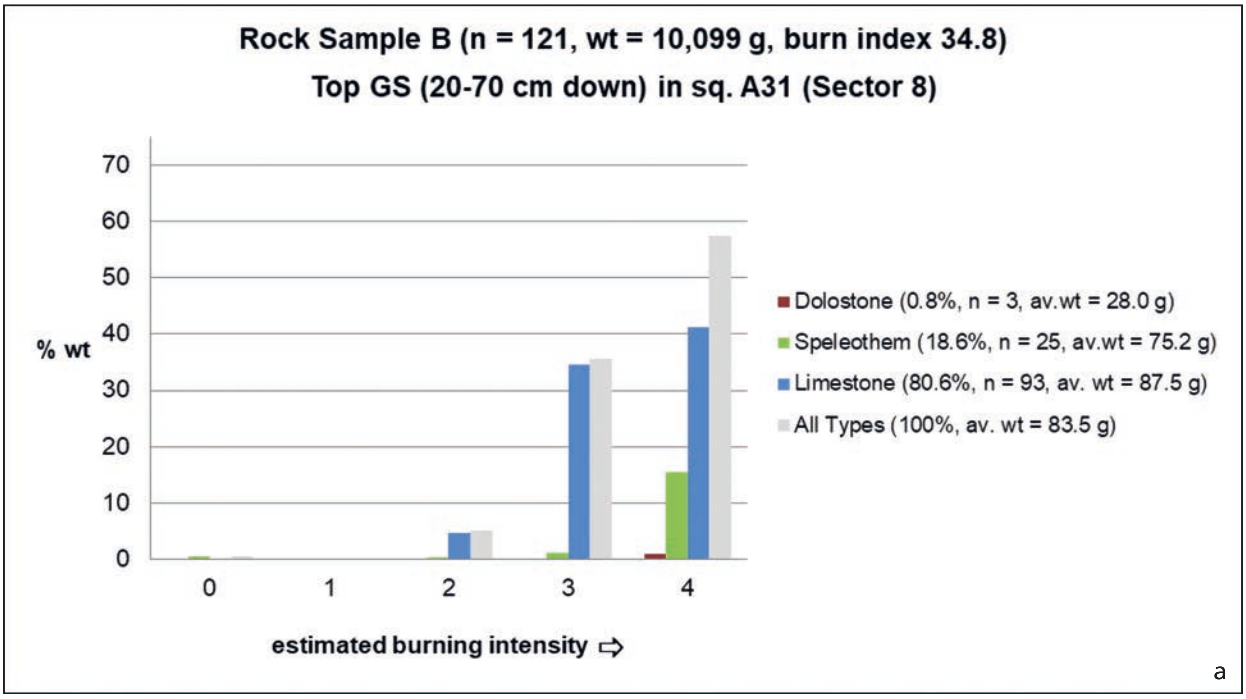
[61] Another estimate of size, 'equivalent square aperture passed', was also recorded; this parameter was used in selection of stones for all samples only in the interval 10-64 mm but has not been used further in the results reported here.



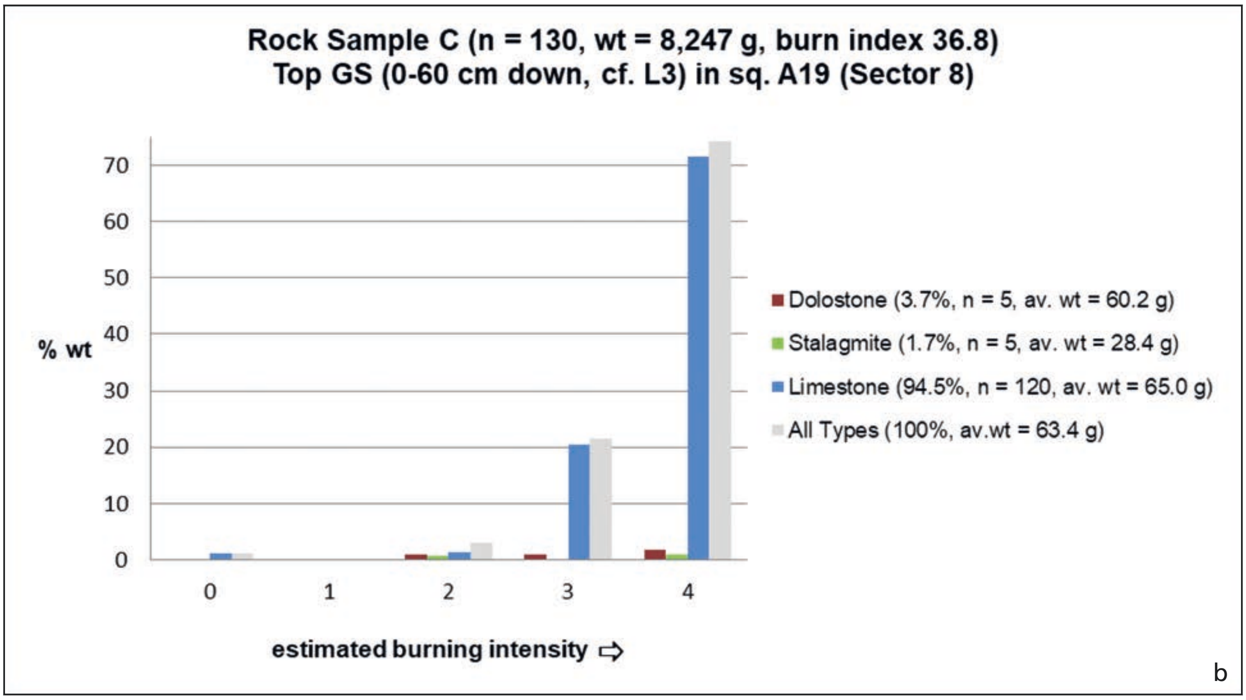
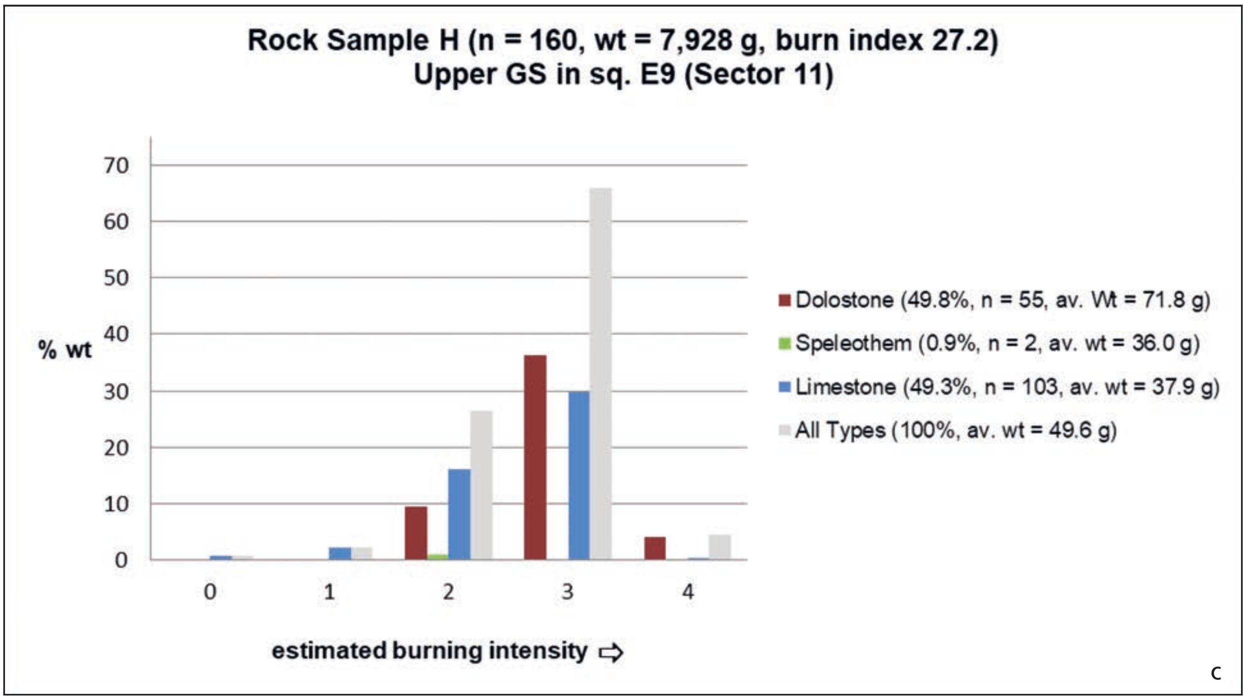


**Fig. 2.44** **a-i** Cave samples of stones (archaeological burning), graphic analysis.

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

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



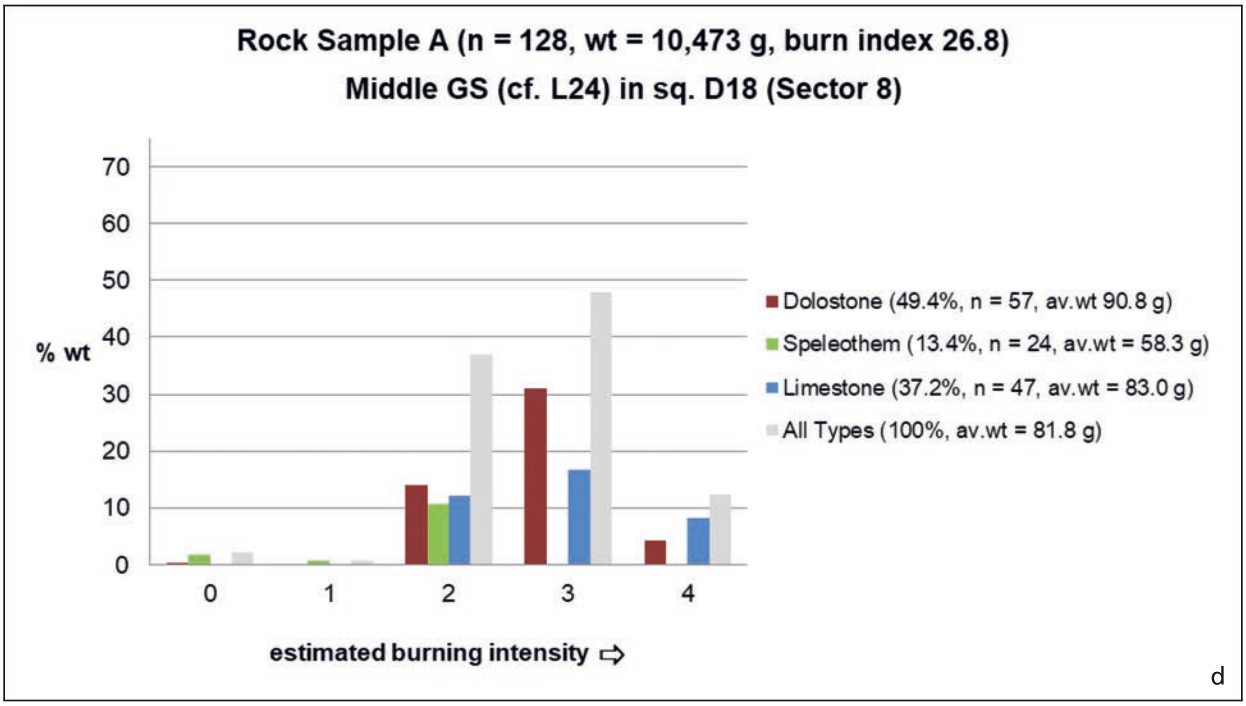
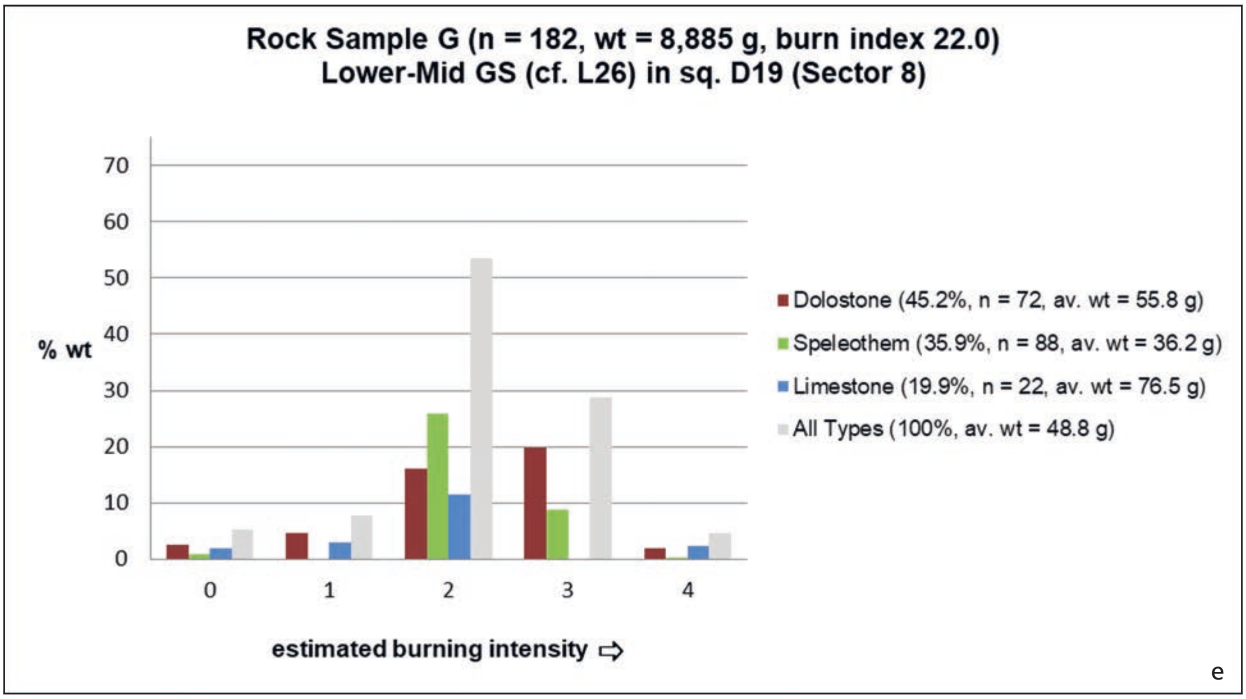


**Fig. 2.44** (continued)

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



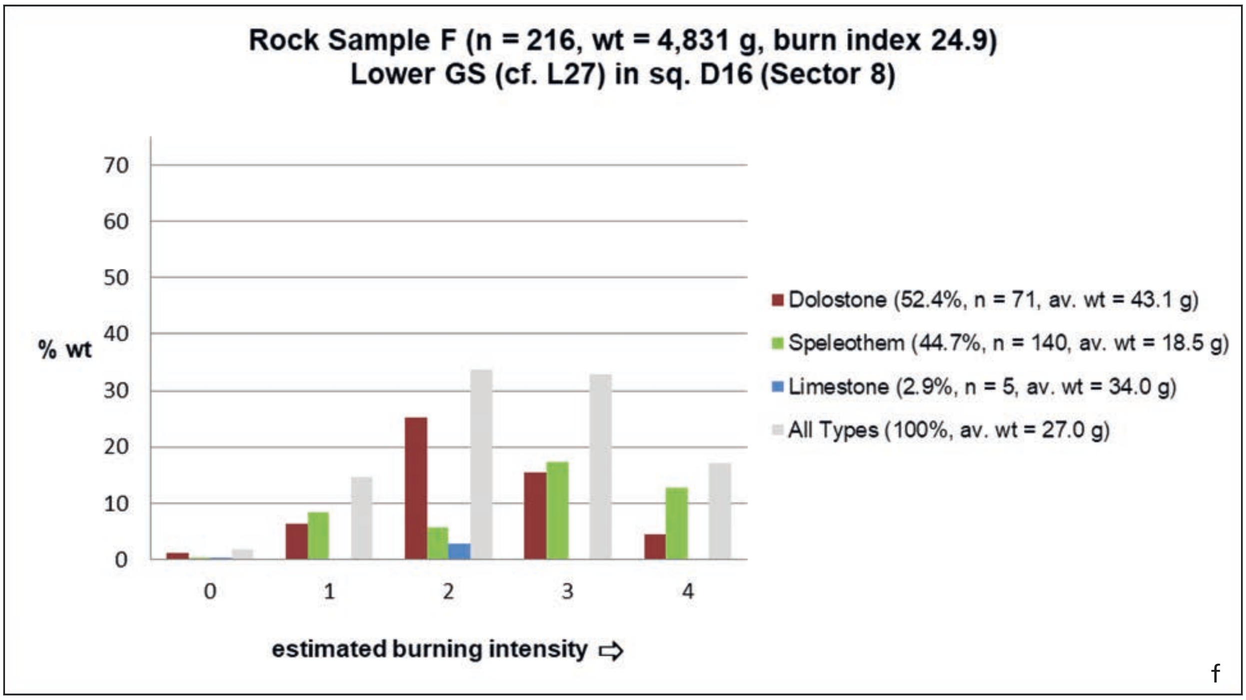
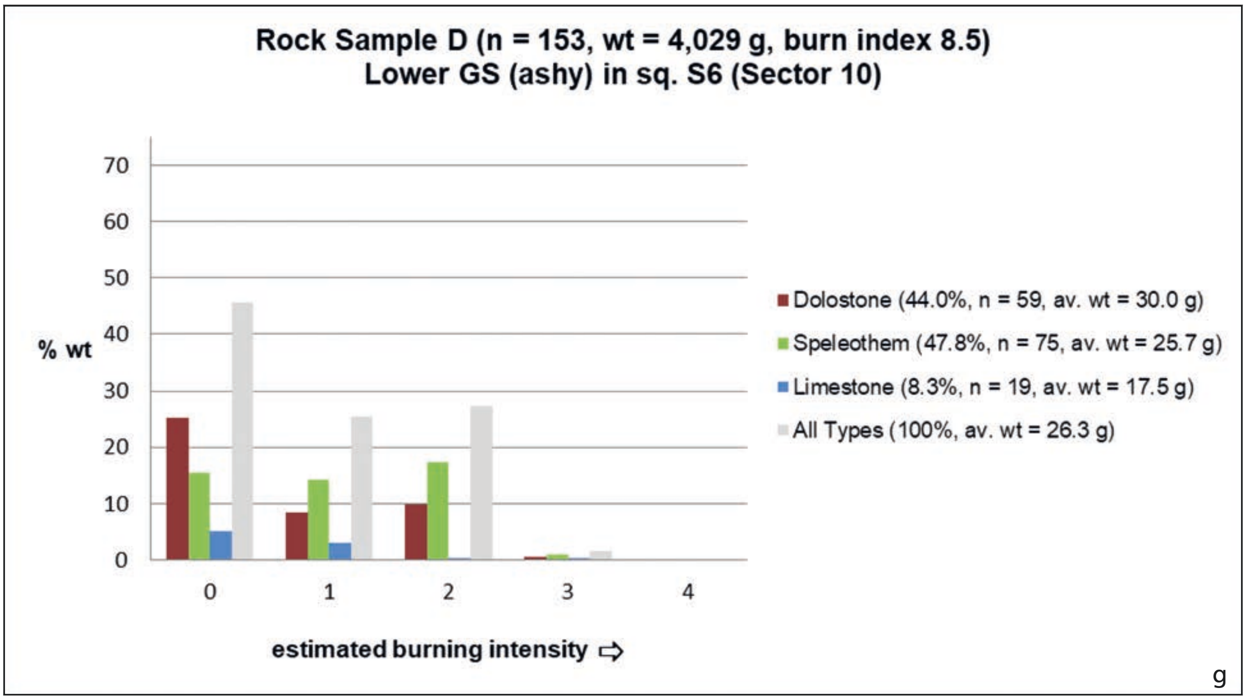


**Fig. 2.44** (continued)

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



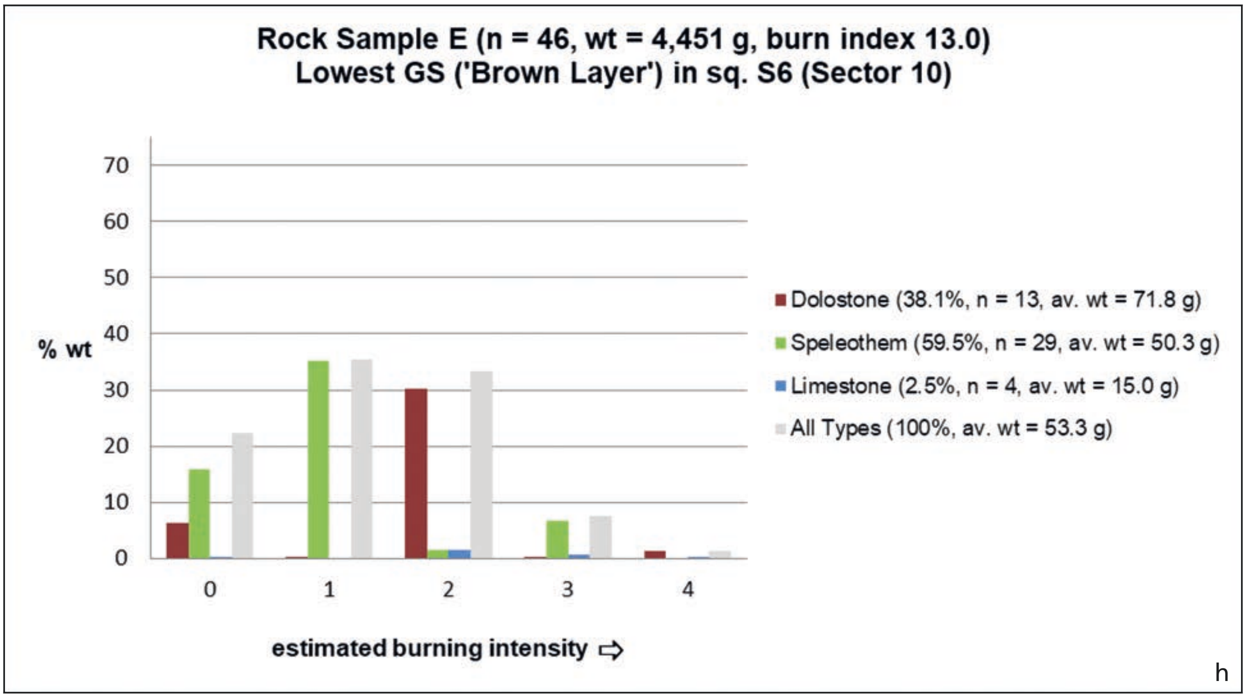


**Fig. 2.44** (continued)

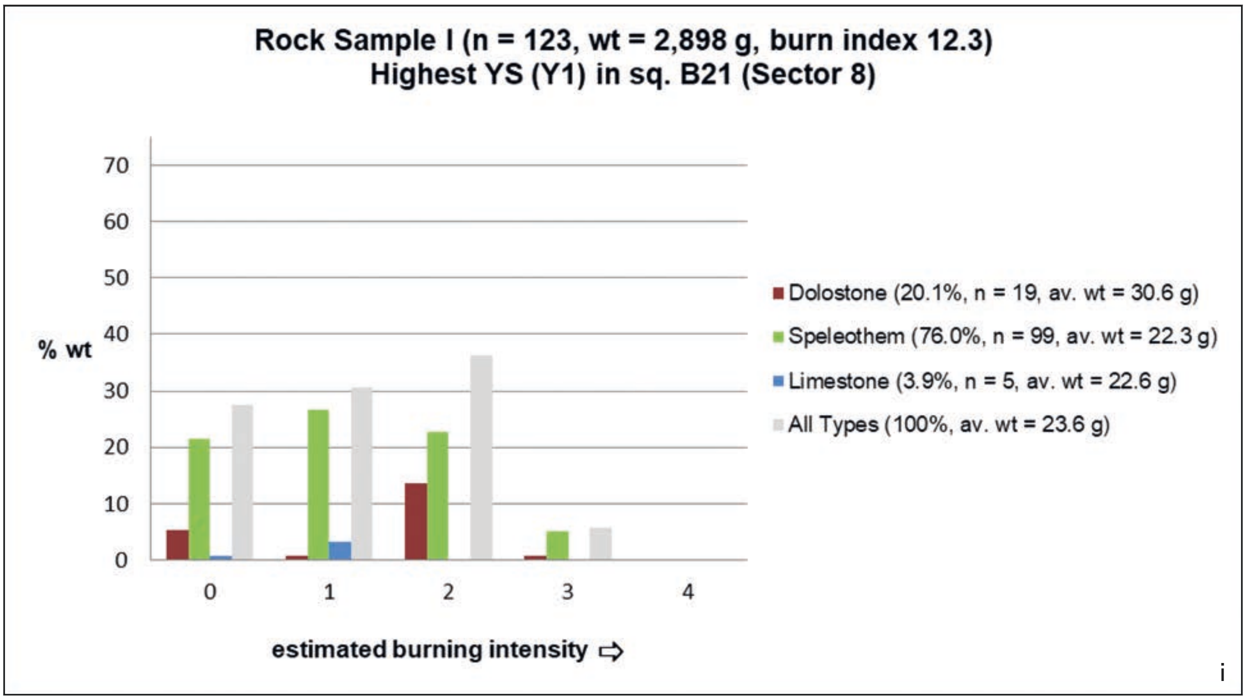


**Fig. 2.44** (continued)

**Fig. 2.45** Small experimental charcoal hearth.

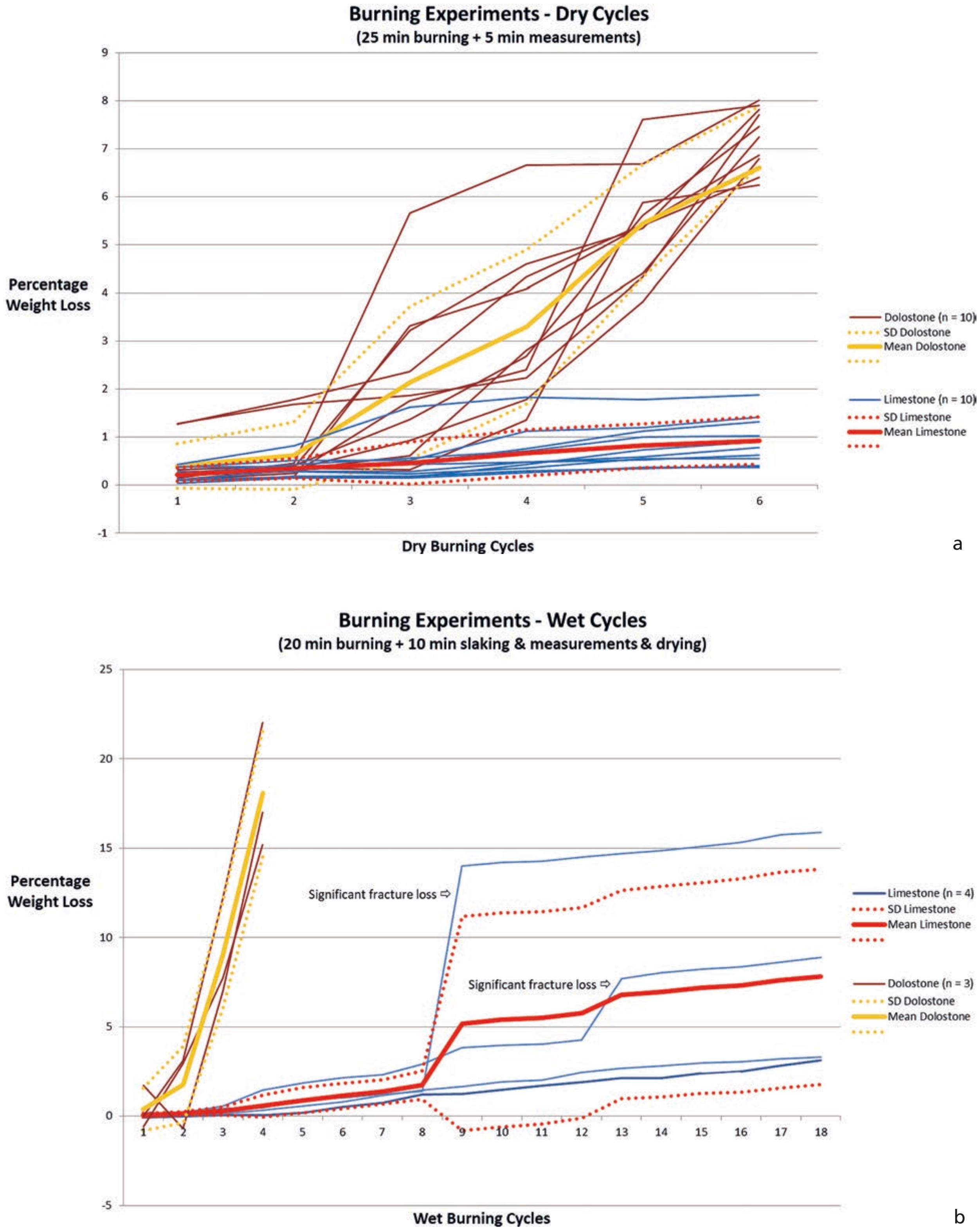


**Fig. 2.46 a-b** Experimental samples of stones (dry & wet burning cycles), graphic analysis.

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

## 2.7 DISCUSSION

### The Yellow Series

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

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

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

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

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

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

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

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

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

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

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

To recapitulate, the raised silt contents at Taforalt in S8-Y4spit3 and the upper part of S8-Y2 (and their respective 'south side' correlates) would therefore suggest that wash input was capturing aeolian dust from the exterior surroundings, mostly via the local karstic system. Prior to pedogenic incorporation, newly deposited aeolian silts are extremely vulnerable to remobilisation by water, so that there is no reason to suspect any great time lapse between the generating cool / dry climate phase and final deposition within the cave. It is likely that the better expression of the earlier phase in Sector 9 actually reflects a more direct route on the 'north side', by very local wash down the back-slope of an entrance talus, where silts may have been concentrated due to the effects of the cliffs above and the ionised air boundary at the cave mouth. In the later phase at Taforalt (supposed 'HE1' correlate), conditions certainly became increasingly damper within the cave, possibly even with transient superficial freezing (which would have increased deformation pressures), although there are no unequivocal signs of ground-ice (either macroscopically or microscopically, cf. **Chapter 3**). The deformation within Unit S8-Y2 is mirrored in the apparently mixed nature of some of its contained materials. Radiocarbon dates from this unit show less coherence and steady ordering than in any other unit (see **Chapter 4**). The lithic artefact collection may be interpreted (see **Chapter 12**) as a physical mixture of two assemblages, although the artefacts likely to belong to the younger of the two seem to be present in sufficient numbers to suggest that the actual cultural (archaeological) change occurred within the upper Y2 timescale itself (rather than at the beginning of Y1 time, after the erosion event capping Y2). In the earlier phase at Taforalt (supposed 'HE2/LGM' correlate), there are no indications of climatic instability, with sedimentation rate either very slow (Sector 8) or faster extremely locally but with no subsequent deformation or significant erosion (Sector 9).

It would therefore appear that, at Taforalt, a relatively 'highland' site, the earliest LSA archaeology appeared more or less directly after – not during – intervals (including the supposed 'HE2/LGM') of significant silt deposition, probably due to aeolian transport in a generally dry, possibly cooler, climate. It is possible from currently available data that LSA industries appeared slightly earlier in relatively 'lowland' (currently coastal) sites (cf. **Chapter 12**). These observations beg the question of the importance of climatic determinism – a question that cannot be answered without a sustained regional analysis of all relevant sites, of early LSA, late MSA and, indeed, 'Intermediate' types. At Taforalt, LSA people were certainly able to cope with the subsequent conditions during the probable 'HE1' and 'YD' correlates.

## The Grey Series

### General Characteristics

Overall, the term 'midden' has often been used for such material as the Grey Series, at Taforalt and at other similar (if usually smaller-scale) sites. However, one wonders whether some extension of this idea, perhaps a term such as 'macro-midden' or even 'hyper-midden', might be more appropriate for this immense composite accumulation. Since the anthropogenic component is so dominant, no direct 'climatic/environmental' signal is recoverable at the macroscopic level from the sediments themselves.

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

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

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

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

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

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

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

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

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

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

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

At Taforalt, a particular micro-excavation technique was therefore devised, involving the removal of c. 2 mm thick spits, using only a small soft brush and a rubber-bulb air blower. Three blocks (15 × 40 × 40 cm; 15 × 40 × 40 cm; 25 × 30 × 30 cm) in Sector 8 Unit L28, another block (15 × 40 × 40 cm) in Unit L25, and a further block (15 × 40 × 40 cm) in Sector 11 from high in the GS sequence (approximately equivalent to L6-L11 in Sector 8) were treated in this way. This work was laborious (0.1185 $m^3$ excavated in approximately 30 hours) and, perhaps not unsurprisingly, no charred composites were encountered. However, *in situ* phytolith packets were observed on two occasions, showing that extremely fragile associations can indeed be recovered (cf. **Chapter 7**). On balance (taking into account, on the one hand, the toll upon sanity and the

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

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

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

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

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

## Pyrolithic Processes

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

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

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

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

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

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

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

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

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

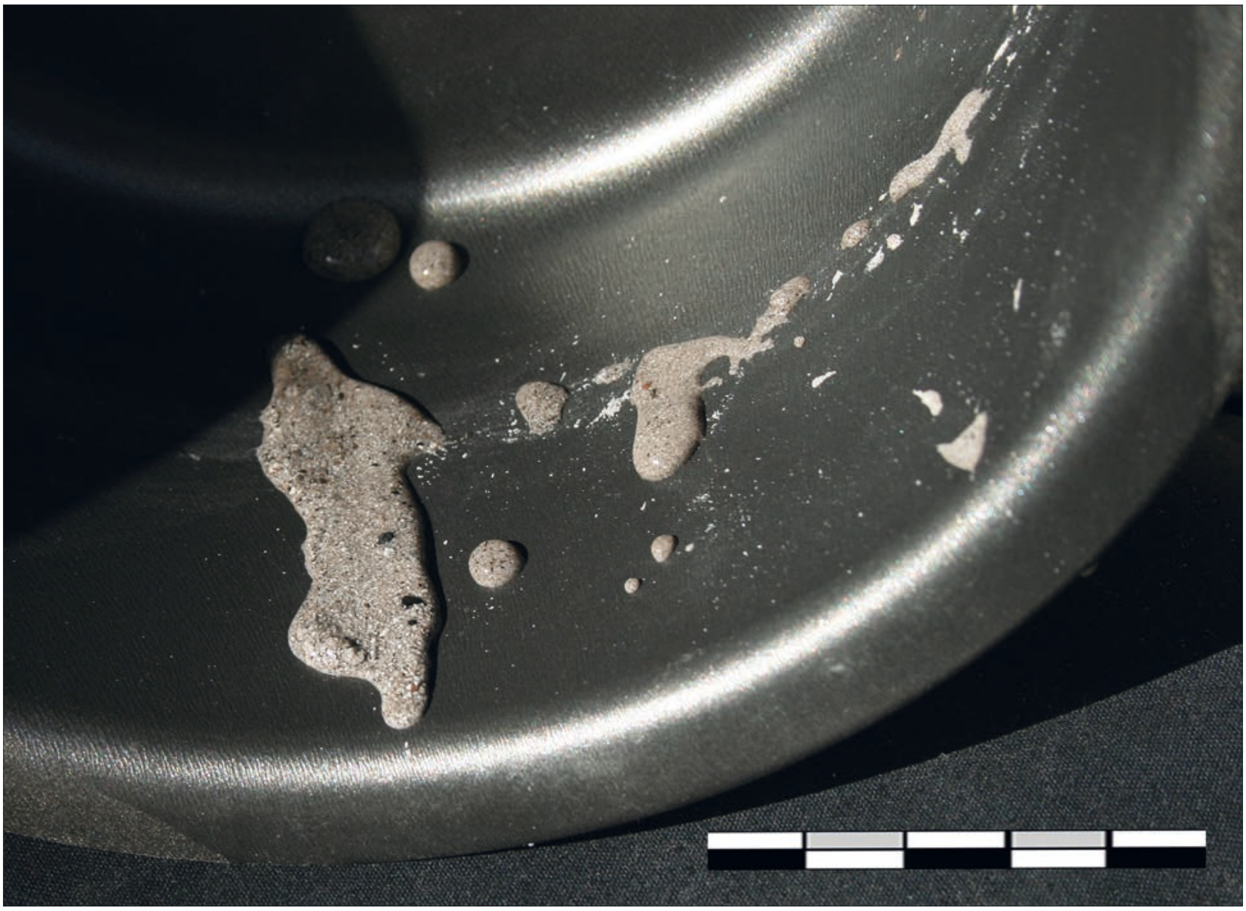


**Fig. 2.55** Coarser particulate residue (after decantation of 'milky' water) from dolostone after a first wet burning cycle. – Scale 5 cm.

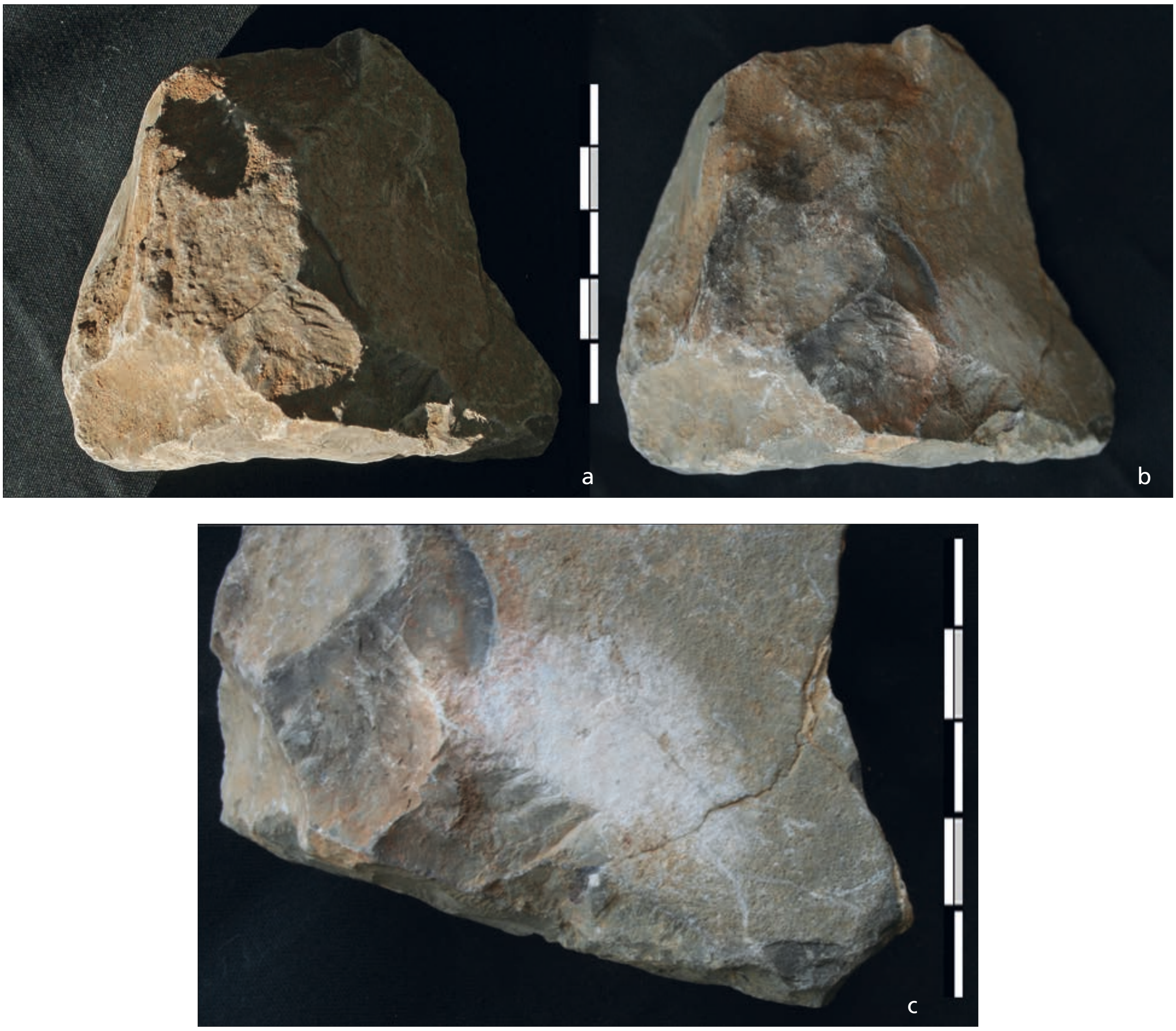


**Fig. 2.56** Experimental limestone: before burning (**a**); after 18 wet burning cycles (**b**, with slightly reoriented detail **c**); only minor effects, including some surface powdering and discoloration. – Scales 5 cm.

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

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

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

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

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

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

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

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

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

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

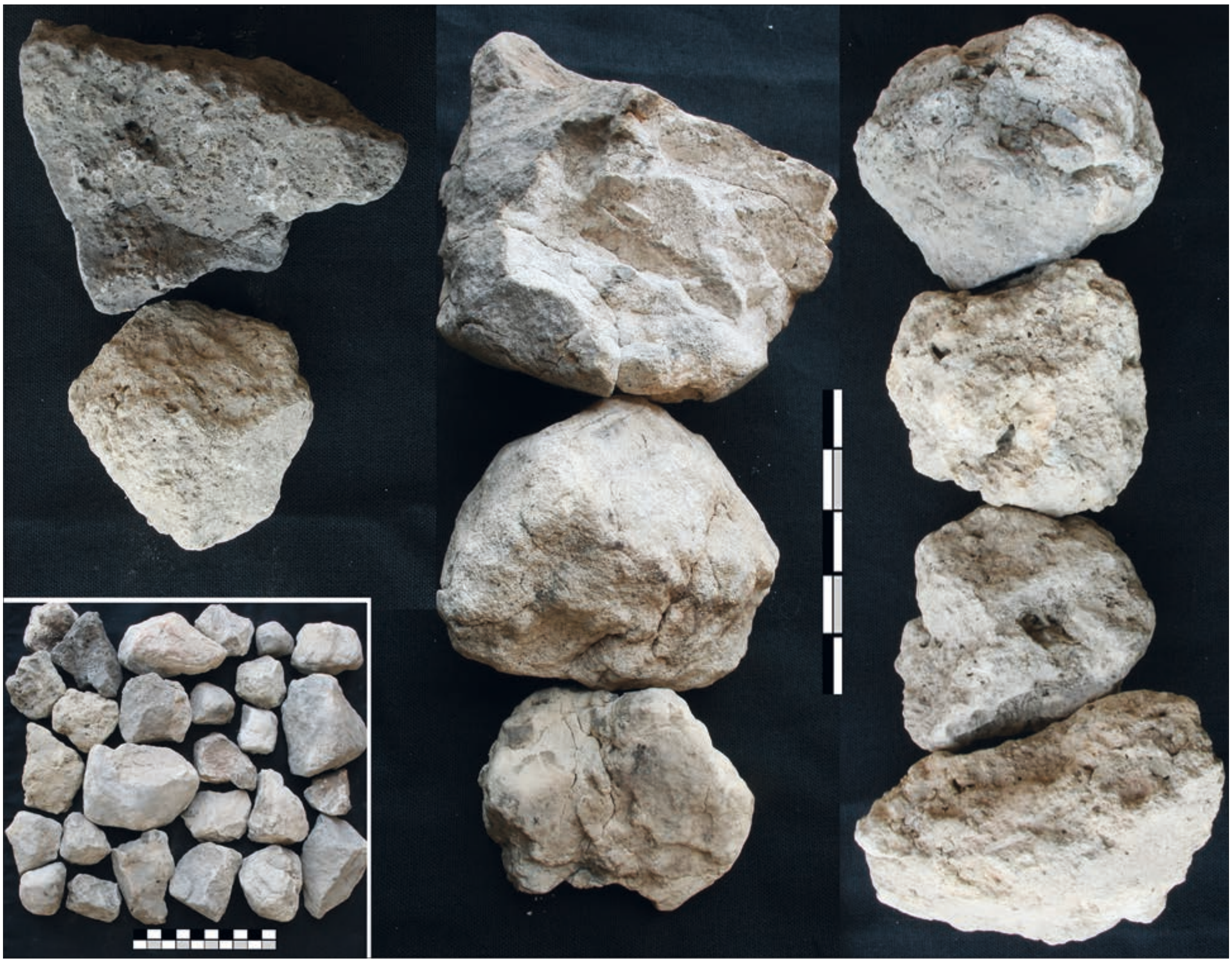

**Fig. 2.58** Archaeological sample of burnt dolostone; most common effects include vugginess and increased porosity, crazing and curvilinear cracking, deep loss of volume, rounding and surface granularity. – Scales in cm units.

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

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

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

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

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

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

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

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

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

### The Special Case of Sector 10

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

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

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

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

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

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

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

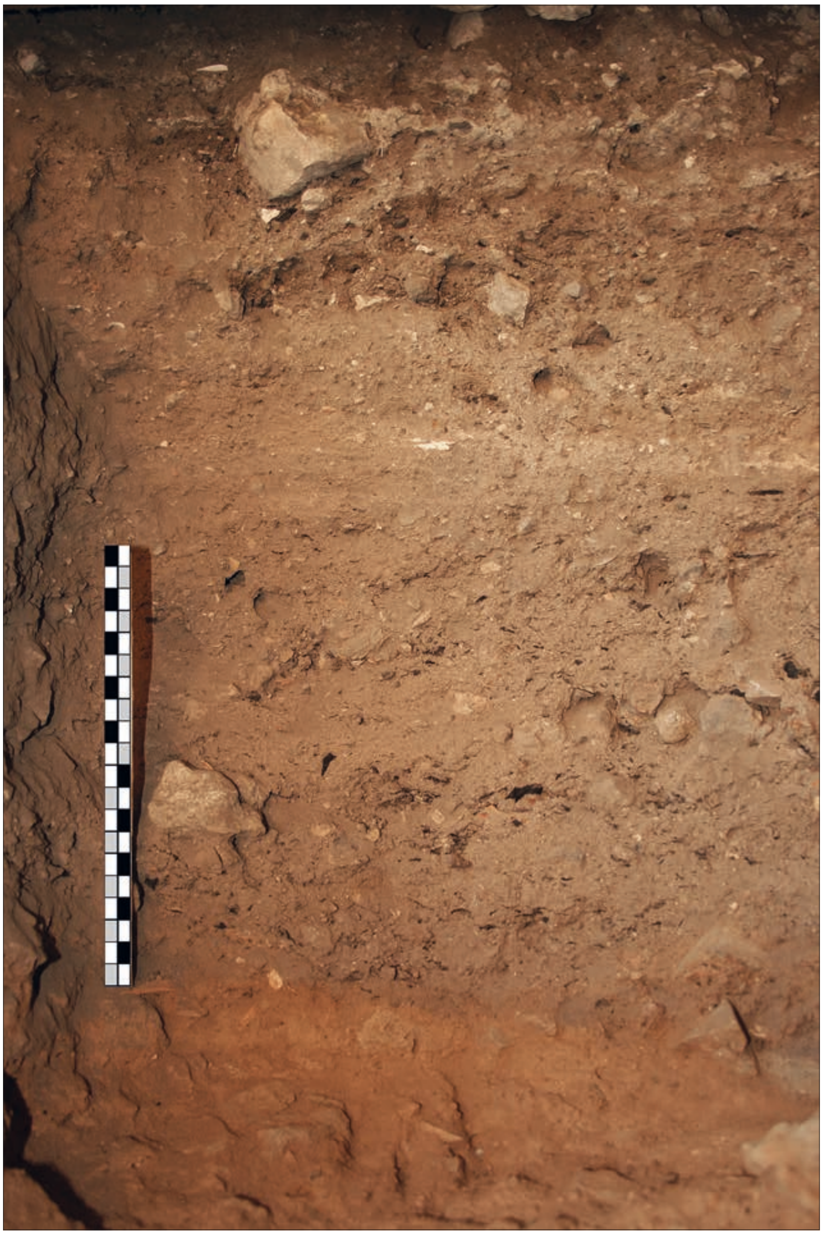
**Fig. 2.60** Yellow Series/Grey Series Boundary in Sector 8, sqC24, E-W section, base of lithics column; slot is 1 m wide.

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

### The Transition between the Yellow Series and the Grey Series

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

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



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

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

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

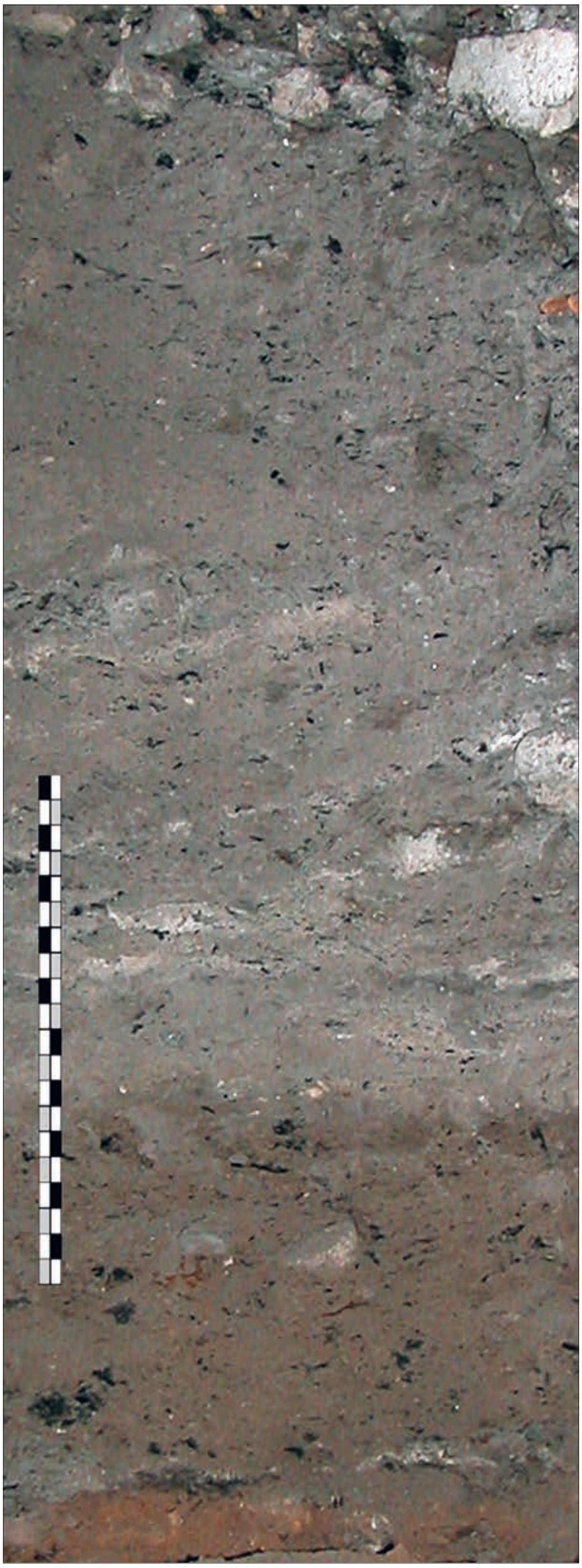


**Fig. 2.62** Sector 8, sqB21, Units G96-6 to Y1, E-W section. – Scale 20 cm.

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

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

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

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

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

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

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

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

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