

A Palaeoenvironmental Study in Semi-arid Southeastern Spain: the Palynological and Sedimentological Sequence at Perneras Cave (Lorca, Murcia)

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Results are presented of palynological and sedimentological research at the Palaeolithic site of Perneras Cave (coastal Murcia, southeastern Spain). Sedimentological features point to a warm, somewhat humid phase corresponding with the lowermost part of the Mousterian sequence, which was followed by a climatic deterioration which lasted throughout the later Mousterian and Upper Palaeolithic. The palynological study described here barely allows palaeoclimatological inferences to be drawn, but it does highlight interesting paleobotanical data, namely, the presence of Ibero-Maghrebian and Mediterranean elements, which suggest that the site was an important refuge for thermophilous taxa. The reliability of the interpretation of the pollen assemblages is assessed in terms of the incorporation, preservation and distribution of pollen grains into the profile.

Keywords: SOUTHEASTERN SPAIN, PALAEOECOLOGY, PALYNOLOGY, SEDIMENTOLOGY, MOUSTERIAN, UPPER PALAEOOLITHIC.

Introduction

In contrast with other regions of the Iberian Peninsula, palaeoenvironmental information is scarce in semi-arid southeastern Spain. Collaborative research into Quaternary palynology and sedimentology has been undertaken further north (Butzer & Freeman, 1968; Fumanal & Dupré, 1983; Dupré, Fumanal & La Roca, 1985; Dupré *et al.*, 1988; Julià, Parra & Esteban, 1987; Carrión, 1992*b*) and, to a lesser extent, in eastern Andalusia (Carrión, 1992*a*).

Palynology at archaeological sites has often been questioned, perhaps because of interpretative difficulties. However, the value of pollen as a potential source of evidence about the past environment in such deposits should not be discounted, especially in arid and semi-arid situations. As pointed out by several authorities (Bryant & Holloway, 1983; Dimbleby, 1985), the challenge lies in distinguishing between cultural activities and palaeoenvironment as well as

between palaeovegetation (direct reconstruction) and palaeoclimate (inferential).

This paper presents results of sedimentological and palynological research at the site of Perneras Cave (Murcia, southeastern Spain). The purpose of the study is chiefly palaeoenvironmental, but it also takes into account aspects of the cave stratigraphy. How far pollen and sedimentary materials recovered from archaeological excavations enable us to determine past conditions depends on the actual results obtained: the extent and reliability of interpretations based on such materials cannot be deduced *a priori*. This article tries to stimulate a critical appraisal of the aims of such interdisciplinary palaeoenvironmental research and is as much a discussion as a research report.

Geographical Location, Climate and Present Vegetation

Perneras Cave is south-facing at a height of 105 m above sea level on a ridge of Los Ceperos, a range of

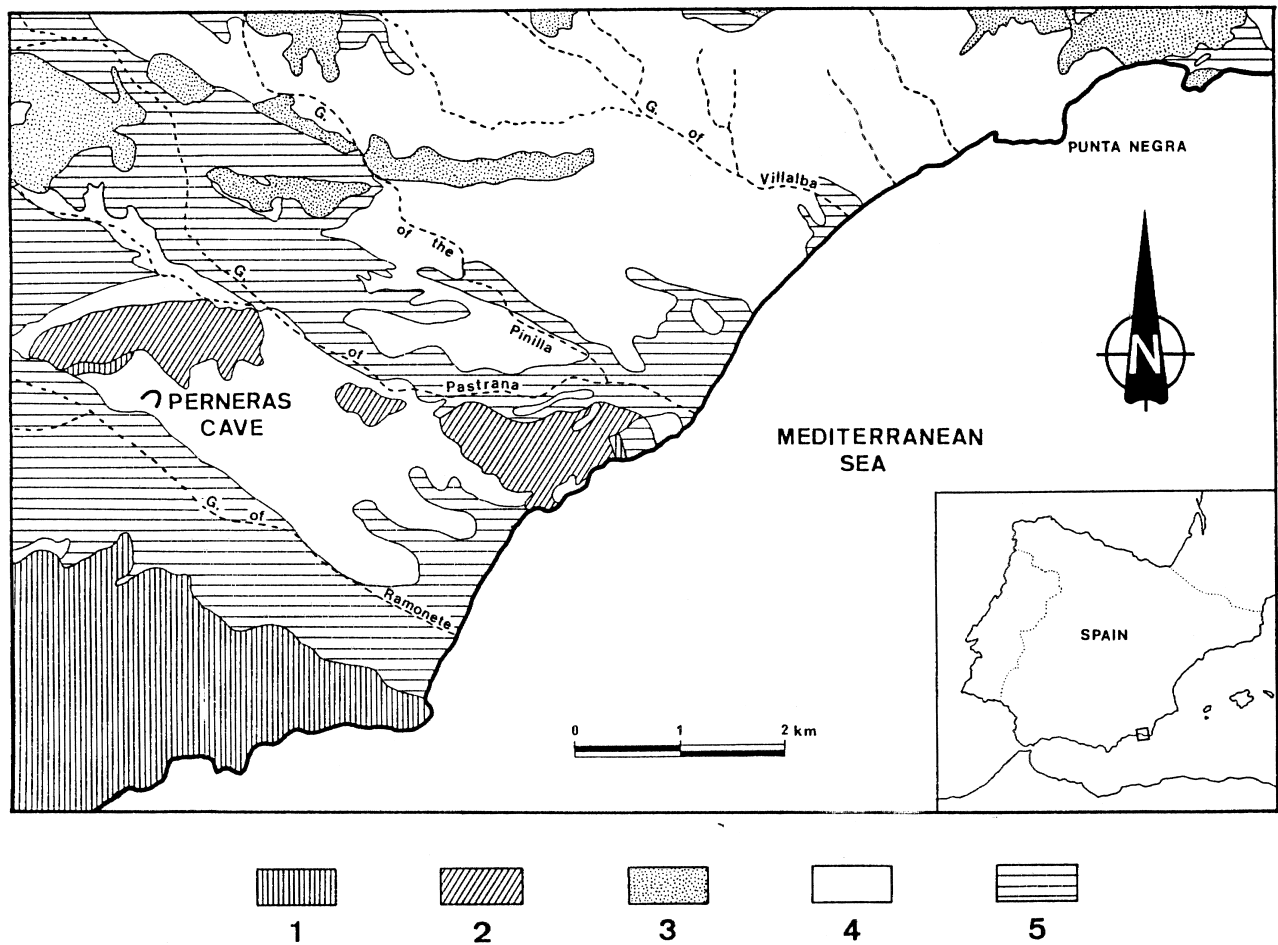


Figure 1. The location of Perneras cave and the geology of the surrounding area. 1: Cambrian-Permian micaschists and quartzites. 2: Triassic dolomites and limestones. 3: Triassic quartzites, limestones and schists. 4: Miocene sandstones and sands. 5: Quaternary alluvial-colluvial.

hills overlooking the alluvial plains of two ephemeral streams, Ramblas Ramonete and Pastrana. The site is at N 37°32'8" and W 1°25'48", which is 15 km east of the town of Mazarrón (Murcia) and some 3-5 km from the Mediterranean sea (Figure 1). The local geology is predominantly Triassic dolomites and limestones followed by Neogene rocks, mainly conglomerates, breccias and sandstones.

The climate is markedly Mediterranean, with mild winters, infrequent frosts and equinoctial rainfall. Seasonality is reduced by the influence of the sea although there is a distinct dry summer season (4 months). Nearby meteorological stations on the coast indicate mean annual temperatures ranging from 17.8–19.1°C, and rainfall ranging from 151–213 mm during the year.

Today the area around the cave is dominated by elements typical of the thermo-Mediterranean semi-arid *Mayteno-Periplocetum angustifoliae* and *Chamaeropo-Rhamnetum lycioidis* associations (Rivas-Martínez, 1987), although human pressures have confined the natural vegetation. On the abundant saline soils, several species of chenopods, sagebrush,

Thymelaea, *Limonium* and *Lycium* occur frequently. Botanically, the area is exceptional within Europe because of the presence of elements typical of the Ibero-Mahgrebian flora (*Tetraclinis articulata*, *Periploca angustifolia*, *Maytenus europaeus*, *Calicotome intermedia*, *Ziziphus lotus*, *Anabasis articulata*, *Salsola genistoides*, *Withania frutescens*, *Sideritis pusilla*), suggesting a late Tertiary migration (Rivas-Martínez, 1987).

Cultural Sequence

Archaeological research at Perneras Cave began with excavation by L. Siret in the last century. His stratigraphical scheme was considered for decades to be the main reference for the southeastern Spanish Quaternary succession (Siret, 1893). Paradoxically, the location of the cave was lost and it remained unknown until 1979, when it was rediscovered and excavated anew by Montes (1985, 1988, 1989) (Figure 2).

The industrial sequence comprises Mousterian (beds XI–IV in Figures 3–5; biozone A in Figures 6 & 7) and

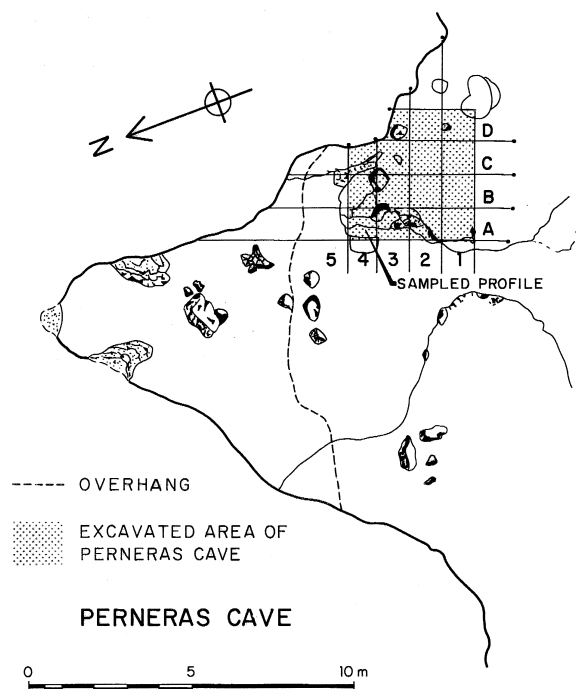


Figure 2. Section of the cave with position of the sampled profile (modified from Montes, 1989).

Upper Palaeolithic toolkits (beds III–II in Figures 3–5; biozone B in Figures 6 & 7). The Mousterian displays a typological composition somewhat similar to the Charentian Quina type of the French Dordogne. There are few tools at the bottom, but they become quite abundant in the upper levels. Overlying the strata containing the Mousterian, there is a Final Aurignacian industry, no doubt following a hiatus in the sequence. Some aspects of the latest Upper Palaeolithic such as notched pieces and denticulates and an abundance of backed bladelets and burins (Montes, 1989) are indicative of Magdalenian to early or “microlaminar” Epipalaeolithic, but it is difficult to classify this level definitively. The nature of the sediment studied did not allow absolute datings.

The Stratigraphic Record

The fill of the cave lies mainly upon a stalagmitic floor which extends out to the exterior area. Over it, detritic deposits contain remains of Mousterian and Upper Palaeolithic industries. The stratigraphic sequence, with a total depth of 2.90 m, allows identification of 11 levels (Figure 3), which, from base to top, appear as follows:

Level XI. The oldest, is a lithochemical deposit of sedimentary origin containing rounded, mostly volcanic (basalt) boulders. Its thickness is some 15–20 cm.

Level X. A layer of 30 cm deposited in abrupt contact. All the materials here are highly encrusted to the point that block sized elements are composed mainly of carbonate-indurated clays and rubbles which are mostly remains of the previous crust from level XI. Gravels are sub-rounded and have a carbonate film on all their sides. There are also abundant concretions of calcium carbonate in nodular form. The fine fraction is a silty sand and corresponds to a fanglomeratic transport. The surface of this level looks irregular and presents erosional notches and cutbacks.

Level IX. This is in erosive contact. Coarse fractions increase both their size and amount, and flattened morphologies appear for the first time. The gravel-sized material has sharp edges, as do the boulders. There is a general massive structure to the deposits, with a variable thickness of between 25–50 cm.

Level VIII. A layer of some 8–10 cm thick over a net contact. This layer has a clear dip towards the inside of the cave and includes some blocks accompanied by small flattened rubble with an angular and little evolved aspect. Ophites and quartz are present.

Level VII. With a thickness of 40–60 cm, the bottom of the deposits “fits” the inclined geometry of level VIII. Boulders and gravels are of basalt, ophite, quartz and remains of carbonated crusts, with sub-angular and flattened morphology. Grain size is sandy and general structure massive.

Level VI. This deposit has an abundant, good-sized coarse fraction, with significant numbers of slabs (the maximum number in the profile). It shows a varied lithology with ophites, basalts, quartzites which appear to be covered by a clayey film. The deposit is encrusted by carbonates. There is a sandy matrix. The deposit is 40–50 cm thick.

Level V. This has a depth of 20 cm, and is made up of boulders and sub-angular gravels, with a clayey film covering their surfaces. No flattened elements appear. The structure is massive and has a sandy matrix enriched by pelitic-sized material.

Level IV. This layer is between 30–35 cm thick. As with level V, it also contains abundant material larger than 2 cm, with a high proportion of basalt and ophite boulders. It has a massive structure and a sandy matrix. A stalagmite layer (about 1 cm thick) extends over the surface of this level, indicating a cessation in detritic supply.

Level III. This layer is made up of coarse fractions of sharp-edged materials which include small slabs. Ophites, quartzites and basalts are abundant. The matrix is made of clay aggregates which show traces of bioturbation. The layer lies in conformable contact on the previous level.

Level II. Has a significant coarse fraction, enveloped in a sandy-clay fine material. Aggregates can be identified

Perneras Cave

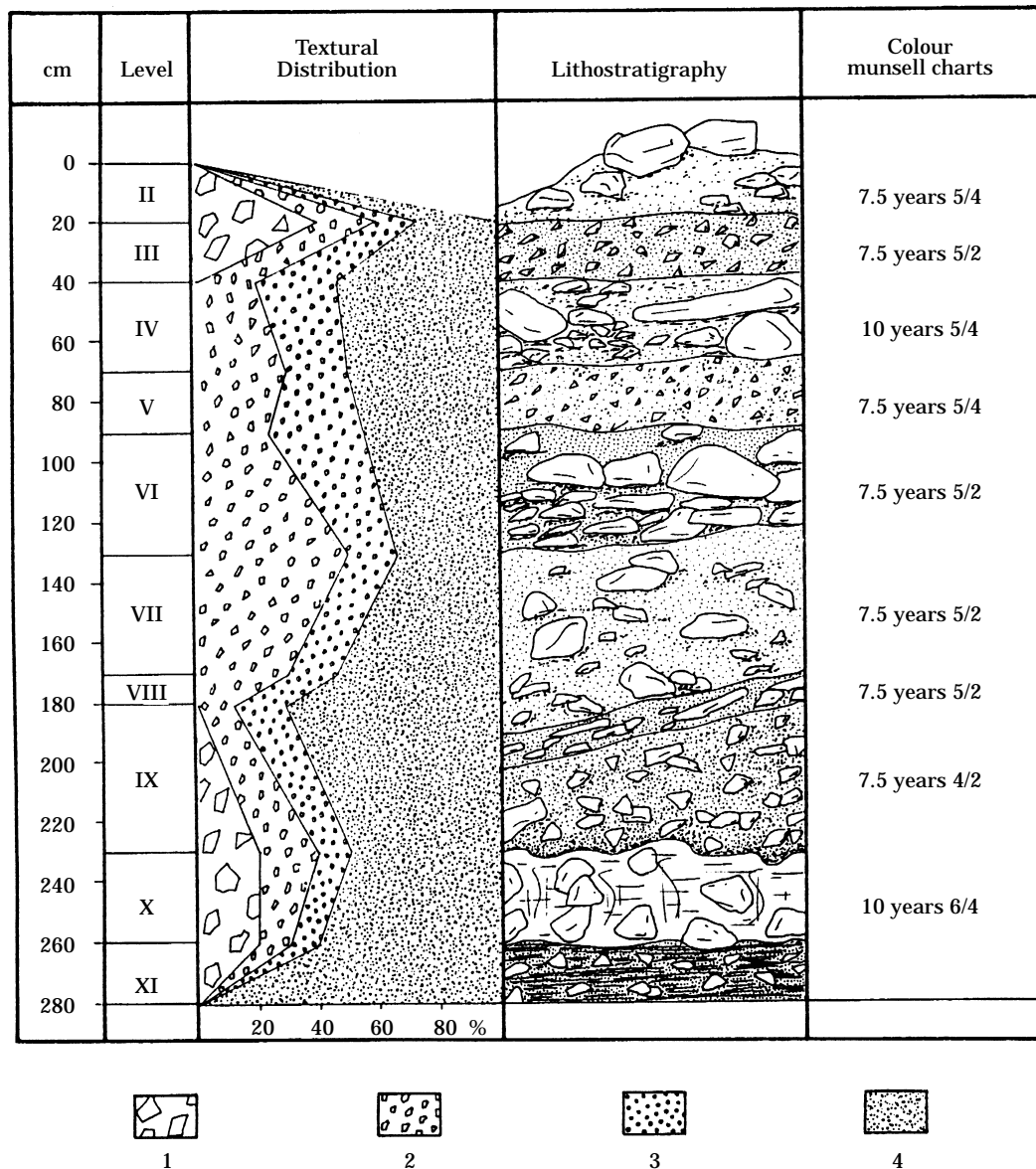


Figure 3. Lithostratigraphical profile and global textural distribution. 1: >10 cm. 2: 2–10 cm. 3: 2 mm–2 cm. 4: <2 mm.

with bioturbation structures. The thickness of this level is 20–30 cm and its top displays notable irregularities. This deposit is sporadically covered by a thin layer of present day sediments that correspond to level I. This deposit has not been analysed because of the uncertainty of its origin.

Sedimentological features

The following comments summarize the principal sedimentological features:

(a) *The coarse fraction.* This is predominant in the middle-upper part of the profile, that is, from level

IX to II (Figure 3). At the bottom (levels XI and X) the content of boulders and gravels decreases and it includes encrusted clay blocks which distort the graphic expression of coarse material. The morphology of the coarse fraction varies gradually throughout the sequence: it is sub-rounded in level X, changing to sub-angular in level IX and angular in upper levels (Figure 4). There are minor variations in levels V and III. With the exception of level X we find possible frost slabs in nearly all the other levels, especially in level VI (Figure 5). The lithologies are the same throughout and include volcanic/metamorphic materials which mainly come from physical weathering of the cave's ceiling and walls.

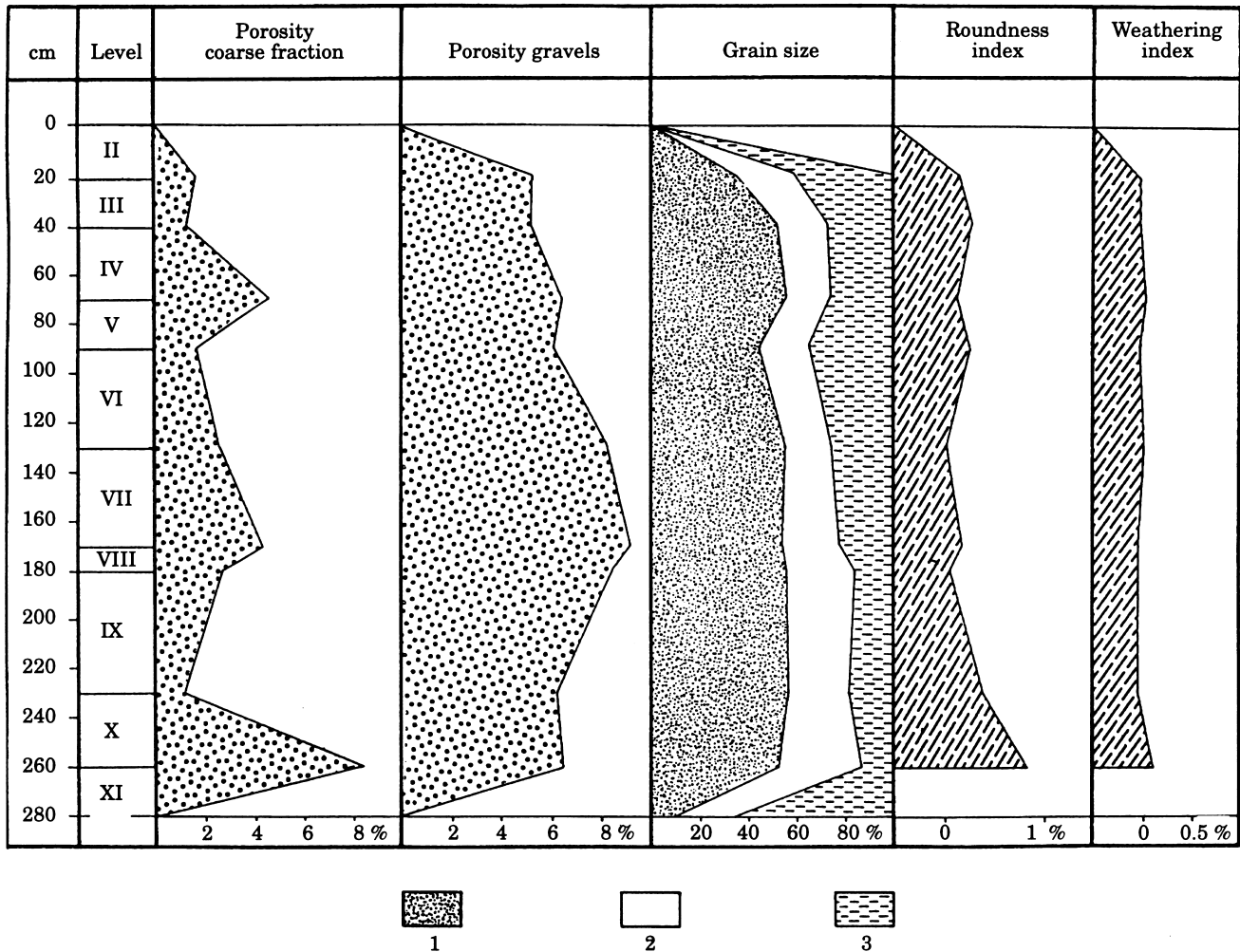


Figure 4. Porosity/roundness/weathering indices. Grain size fine fraction: 1: sand. 2: silt. 3: clay.

It should be noted that the basal level XI is a stalagmitic floor of sedimentary origin.

Materials are either autochthonous, or come from the immediate surroundings. Gravels occasionally present a mixed population (angular and sub-rounded) thus showing a sporadic external influence (noticeable in levels X, V and IV). The indices of internal alteration (porosity) are high in level X and, to a lesser degree, in levels VII and IV (Figure 4).

(b) *The fine fraction.* The textural composition of the fine fraction (Figure 4) suggests differences in the modes of transport, as well as in the origin of the materials. Grain size curves and frequency histograms are grouped in three families. The first is formed by a single level, X. The second is made up by levels IX, VIII, VII, VI, IV and III. The third one is formed by levels V and II. The first two groups, with a predominance of poorly-sorted sandy material, relate primarily to the internal channels of the shelter (cracks and tunnels). The third group is very similar to the sedi-

ments of the current slope cover, but with a greater proportion of clay. In the first two groups, transport appears to have been due to a relatively abundant and fairly energetic water supply. For the third group (levels V and II), the transport may have been caused by a less intense supply of water, which was more evenly distributed throughout the year. The carbonate contents in these levels suggest some loss from these levels, to produce carbonate-enriched lower levels, which is the usual case when the presence of water has been high and continuous.

(c) *Profile structures.* There are only two abrupt contacts: One between level XI (lower stalagmitic pavement) and level X, the other between levels X and IX. The rest are normal or with net contacts which mean that these changes correspond to clear interruptions, or hiatuses in depositional rhythm. Bioturbated structures are observed in levels III and II. Important widespread carbonation appears in both levels X and VI. The first appears to have its source in an upper eroded horizon,

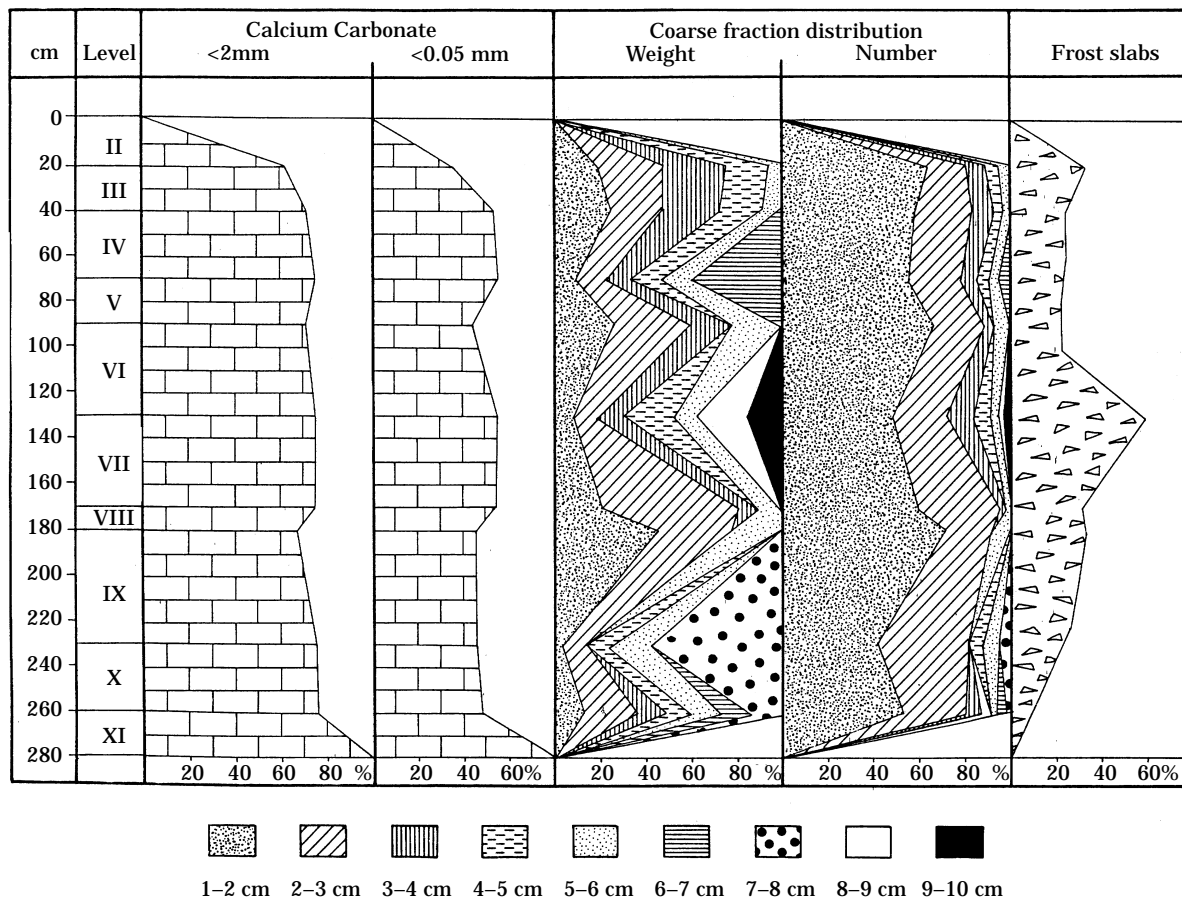


Figure 5. Calcium carbonate content, size distribution and percentage of frost slabs in coarse fractions.

as is indicated by the irregular topography of its surface, while the second appears to have inherited its carbonates from level VI.

A comment about palaeoclimatic conditions

The sedimentologic results identify three depositional episodes that reflect distinct environmental phases:

(1) Represented by level XI. A stalagmitic floor with laminae, stromatolites and algae hangings which formed under conditions of laminar circulation of water and vegetation colonization. Archaeologically sterile, it is difficult to connect it chronologically with later detritic sediments.

(2) Represented by level X. This level formed under mild temperate-humid climatic conditions, which are evident in the existence of aggregates in fines, the absence of angular rubbles, the high porosity, alteration, rounding, etc., in the profile. The whole level appears to be gently enriched in carbonates derived from higher horizons, which have been eroded later. These features show climatic conditions which might correspond to an interstadial phase of the last cold Quaternary period.

(3) The latest period, represented by levels IX–II, is wider and displays very little internal variation. The climatic conditions, at first, were relatively harsh with respect to level X and clearly deteriorated further by level VI. The sediments are more angular and lack post-depositional alteration, while the average size of clasts becomes progressively larger. These layers appear to belong to advanced periods in the last cold stage of the Pleistocene with the only interruption, of little importance, corresponding to the more temperate and humid level V, which is interbedded in the Würm sequence of the site.

Pollen Analysis

Methodological considerations

From the section shown in Figures 2 and 3, some 43 samples were taken for pollen analysis. The sediments were treated in the laboratory using the modified classical chemical method—HCl, HF, KOH—(Delcourt, Mullenders & Piérard, 1959; Moore, Webb & Collinson, 1991), followed by a concentration in a dense liquid (Girard & Renault-Miskovsky, 1969). Samples 3, 4, 13, 14 and 26–43

proved to contain very few palynomorphs or none at all. Two pollen diagrams have been prepared, the first including all taxa in the pollen sum apart from *Glomus* (Figure 6), and the second consisting of ecologically-selected types and groups (Figure 7). We decided to exclude the abundant *Glomus* spores because their good preservation state was not consistent with the surrounding assemblages. Asteraceae and other ubiquitous herbs with alleged zoophily have been excluded from Figure 7 to highlight fluctuations of the *a priori* major palaeoclimatical markers (*Quercus*, *Olea*, *Phillyrea*, *Pinus*, etc.).

Palynological results

Pollen biozone B is differentiated from zone A mainly by an increase in the percentage of Cichorioideae together with a mean decrease both in *Pinus* and *Artemisia* (Figure 6). Other minor features in pollen-biozone B are greater amounts of *Helianthemum* and Brassicaceae, and an abundance of *Glomus*. In the summary pollen diagram (Figure 7) most curves show small or erratic fluctuations. Increases in Other Asteraceae, Other Herbs and Other Mediterranean Shrubs (See Appendix) also characterize pollen biozone B.

An underlying goal in determining this zonation was to try to differentiate Upper from Middle Palaeolithic contexts, since excavation records suggest that disturbance may well have significantly affected Upper Palaeolithic layers. This possible disturbance makes it difficult to determine the "integrity" of the corresponding pollen spectra, even though the section sampled was chosen because it appeared to be undisturbed.

The matter of pollen preservation is relevant to the consideration of the taphonomic processes affecting the pollen record. Figure 6 shows percentages of indeterminate pollen grains per sample. Generally speaking, preservation was better and more uniform in the Mousterian sediments (levels IV–VI, zone A), except for the lowermost samples from level VI. Samples from level II contained both well- and poorly-preserved pollen, albeit with some difference in their susceptibility to stain. In level III, pollen was uniformly corroded, sample 7 having the highest percentage of indeterminate palynomorphs. Nevertheless, pollen grains were particularly abundant in this sample 7 and in sample 8. It is also noteworthy that Cichorioideae pollen was badly preserved in levels II and III (Figure 6), suggesting that their relative abundance could be partially or wholly the consequence of differential preservation, although other possibilities such as human introduction (coprolites, unifloral honeys, flowers, etc.) or the local existence of Asteraceae-dominated communities cannot be dismissed.

There is evidence of bioturbation in levels II and III which may have caused some vertical displacement, and possible penetration by later pollen. This would agree with both the nature of the accumulation in the lower part of level III and the existence of a mixture of

pollen in level II. It is possible that badly-preserved pollen are coeval with the stratum, whilst the remaining palynomorphs may be, to some extent, intrusive. This possibility is strengthened by the presence of some darker, brownish grains in samples 7 and 8, an observation which indicates the reworking of older, oxidized material. Such considerations instill caution with regard to chronological attribution of the pollen spectra of zone B. As regards the process causing penetration by later pollen, current interpretative methodology does not allow a clear-cut choice between intrusion, mixing, or downward movement.

It is in this context that the abundance of chlamydospores of the mycorrhizal fungus *Glomus* in pollen biozone B must be considered (Figure 8(d)–(f)). Several factors could be involved: root activity, either *in situ* or from allochthonous sediments; sedimentary mixture; faeces of edaphofauna ingesting spores from elsewhere, etc. Interestingly, the distribution of *Glomus* down the profile is coincident with the hypothetical presence of intrusive pollen and, to a lesser extent, with impoverished assemblages. The Chlamydospores or *Glomus* were well preserved and were present in the palynologically sterile samples 3 and 4, which tends to suggest either that they are resistant to decomposition, or that they were introduced relatively recently. Whatever the case, *Glomus* could well be a marker for the influence of contamination.

It is worth noting that, at Pernerias, the most suitable sediments for pollen analysis are those confined to levels with calcium carbonate deposition. Perhaps the upper beds II and III were affected by greater aeration, whereas crusting in levels IV and VI sealed the horizons so pollen could remain stratigraphically and chemically stable and undamaged. In theory, both preservation and distribution of pollen in subaerial deposits may be influenced by many processes; in practice it is very difficult to identify which processes influenced them. Other sedimentary features are hard to correlate with the palynological information, such as the proportion of coarse material, the bed structure, or the intensity of the processes of chemical alteration. We have been unable to find an explanation to relate the absence of pollen in 22 of the samples to these features.

Judging from the present-day vegetation, the studies on modern pollen rain in Mediterranean contexts (e.g. Pérez-Obiol, 1988; Burjachs, 1990), and by taking the sequence as a whole, it is reasonable to argue that there has been little change in the vegetation over time. The local landscape was characterized by the scarcity of its tree cover, and the presence of an important Mediterranean xerosclerophyllous component, as well as other taxa suggesting marked aridity (*Artemisia*, Chenopodiaceae, *Ephedra*, Labiatae, *Sideritis*, Thymelaeaceae, *Lycium*) (Figure 9). The constant presence of *Plantago* and Poaceae also suggests the continuous presence of open vegetation, or even that human pressure could have affected the cave surroundings, thus favouring

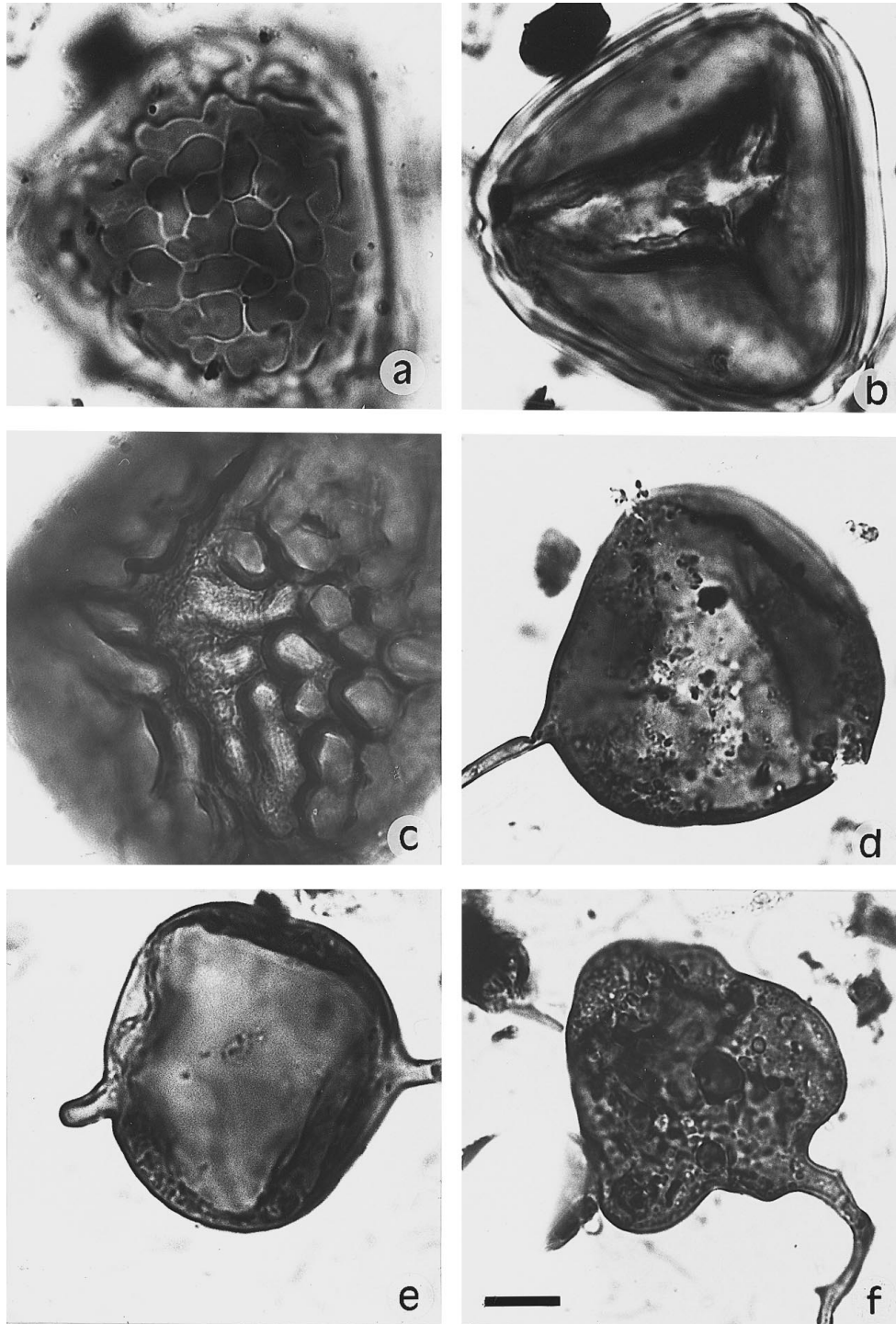


Figure 8. LM micrographs of some pollen types from Perneras Cave. (a, b) *Cosentinia*; (c) *Riccia*; (d, e, f) *Glomus*.

the installation of nitrophilous assemblages. Similarly, human pressure could partially explain the abundance of other taxa such as Asteraceae and Brassicaceae, and even the presence of abundant helio-nitrophilous herbs (Geraniaceae, *Paronychia*, *Asphodelus*, *Malva parviflora*, *Reseda*). A similar hypothesis of Palaeolithic

ruderalization has hitherto been put forward by Munuera & Carrión (1991) for the nearby Algarrobo Cave.

Of considerable interest is the relative abundance and nearly constant presence of *Quercus* at Perneras, which lends support to a suggestion that *Quercus*-

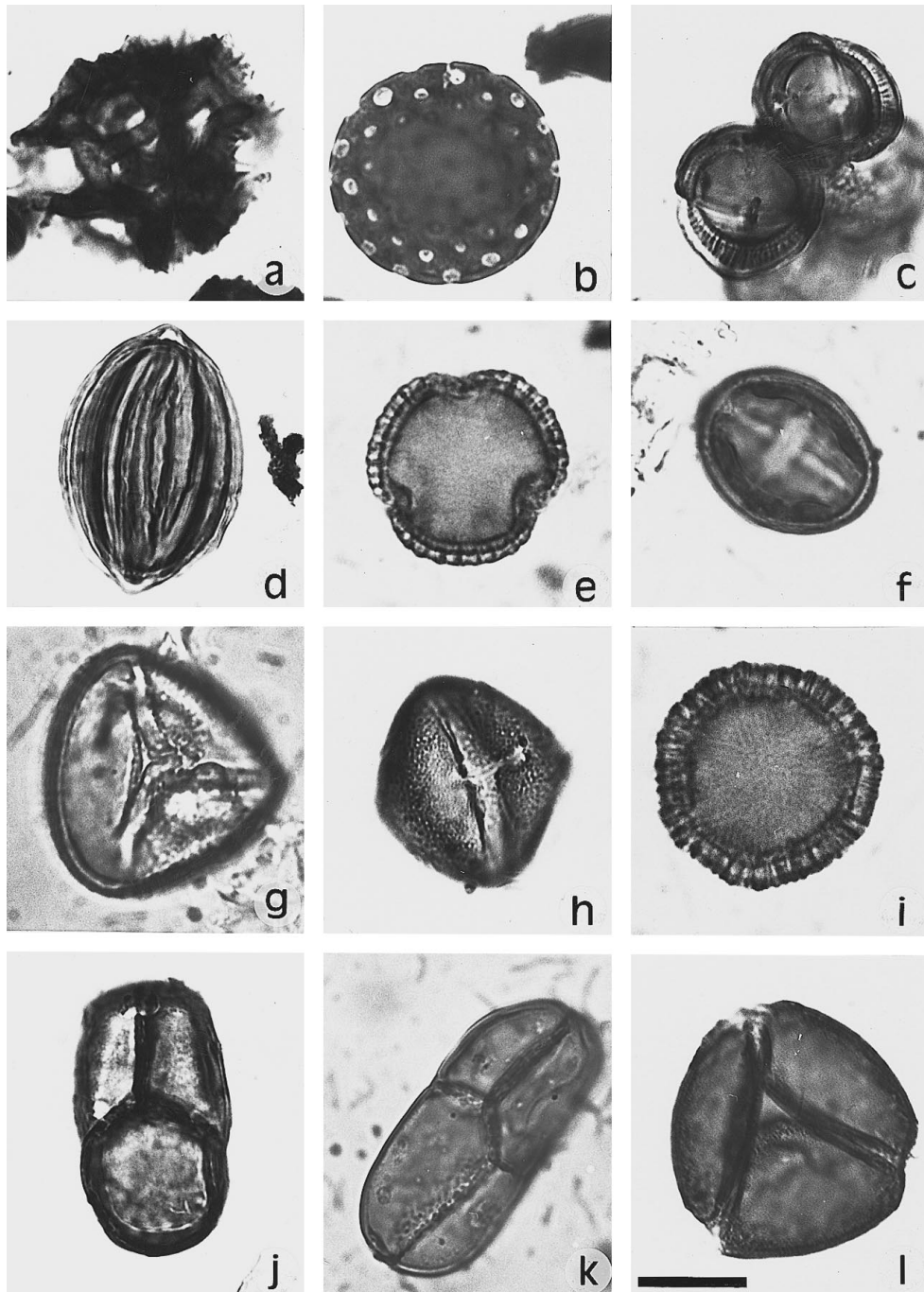


Figure 9. LM micrographs of some pollen types from PERNERAS CAVE. (a) Cichorioideae; (b) Chenopodiaceae; (c) Lump of *Artemisia* pollen; (d) *Ephedra fragilis*; (e) *Olea*; (f) *Osyris*; (g) *Selaginella*; (h) *Lycium*; (i) Thymelaeaceae; (j, k) *Periploca*; (l) *Withania*.

dominated communities, albeit not widespread, were present locally in Mousterian times. Likewise, there are numerous taxa which can be assumed to represent a Mediterranean vegetation similar to that found today near the coast: *Olea*, *Phillyrea*, Cupressaceae, Rhamnaceae, *Pistacia*, *Periploca*, *Osyris*, *Genista*, *Ephedra fragilis*, *Helianthemum*, *Cistus*, Labiatae, *Ruta*, etc.

Reconstructing ancient climate from these assemblages is complicated. Poor understanding of the factors influencing the *Mayteno-Periplocetum* and *Chamaeropo-Rhamnetum* formations is a major handicap. Although bioclimatic factors could be involved, it is also possible that, in part, they could be favoured by degradation of *Pinus*, *Quercus* or *Tetraclinis* forests. Studies in the southern Mediterranean demonstrate

that the passage of forest to scrub groups can increase resistance to anthropozoogenic influence (Barbero *et al.*, 1990). Evidence of such changes is supported by the testimonies of local elderly shepherds, who have witnessed the spread of spiny leaved shrubs such as *Calicotome* on overgrazed areas, and documentary sources which suggest that tree felling for boat building has been intense during historical times (Sánchez-Gómez, 1990). In conclusion, it is hard to establish whether the present range of coastal xeromorphic scrub is due to increasing dryness during the Holocene, whether it is a result of human influence, or whether both factors have intervened. Much more detailed information is needed about the circumstances affecting the patterns of succession of these communities.

The presence of *Periploca* (Figure 9 (j) & (k)) is noteworthy because of its novelty. In the literature consulted by the present authors, there is no mention of *Periploca* pollen being found in Europe, apart from the occurrence of Asclepiadaceae at Almizaraque, Almería (Mariscal, 1992) which may correspond to *Periploca*. Furthermore, the most likely species involved is *P. angustifolia*, the only Iberian taxon of the genus which is well-known to agriculturalists because it indicates places suitable for cultivation of citrus fruit: that is to say, it is a bioclimatic marker for the absence of frost. Other indicators of warm climate found in the samples are *Osyris*, *Olea*, *Pistacia*, *Myrtus*, *Withania*, *Ephedra fragilis*, *Ruta*, *Lycium*, *Thymelaea*, *Selaginella denticulata*, *Cosentinia*, etc. (Figures 8 & 9).

Considerable attention has been devoted recently to the biogeography of Quaternary refugia of trees throughout the European continent. Bennett, Tzedakis & Willis (1991) hold that the Iberian Peninsula seems to have been a less important region for refugia than were the Balkans, the Alps or the mountains of Italy and they argue that the greater aridity, smaller massifs and scarcity of palynological data might be responsible for this. In our opinion, the major limitation is that very few records have been examined, especially from Mediterranean contexts. It seems likely that aridity governed the spread of mesothermophilous elements, although the diversity of landscapes in the Iberian Peninsula must surely have provided suitable areas for their development. Perhaps the conclusions of Bennett, Tzedakis & Willis (1991) would have been different if their approach had investigated more than a mere five organogenic deposits (Padul, Valle de la Nava, Sanguijuelas, Sanabria, Comprida) and had included palynological surveys from caves, rockshelters and palaeosols. Many studies have now been published based on Spanish sites that show the presence of abundant mesothermophilous trees during stages when northern Europe underwent last-glacial conditions: Lezetxiki Cave (Sánchez-Goñi, 1992), Atapuerca Cave (García-Antón & Sainz-Ollero, 1991), Carihuela Cave (Carrión, 1992a), Algarrobo Cave (Munuera & Carrión, 1991), Cova Beneito (Carrión, 1992b), Cova

Malladetes (Dupré, 1988), Pla de l'Estany (Pérez-Obiol, 1988; Burjachs, 1990), Cova de l'Arbreda (Burjachs, 1987), Abric Romani (Burjachs & Julià, 1992), Banyoles (Pérez-Obiol & Julià, 1992), and Lake Llauset (Vilaplana, Montserrat & Schlüchter, 1989), etc.

A broad reading of these studies of the evolution of Iberian forests during the Quaternary suggests that the vegetational complexity of the Peninsula is connected with the existence of refugia (Costa-Tenorio *et al.*, 1990). The presence of north African floristic contribution is significant, at least for southeastern Spain, and it is worth remembering that the Iberian "sub-continent" has afforded a geological link between Africa and Europe since the early Cretaceous.

Conclusions

From the typology of the palaeolithic industry found, the only possible chronological attribution for the Perneras cave deposit reported here is that it belongs in the middle to upper part of the Upper Pleistocene (Montes, 1989). A more detailed date is not possible with the present data. The sedimentary features suggest relatively little variation in depositional conditions, and both the Mousterian and the Upper Palaeolithic beds are poorly differentiated palynologically. Pollen biozone B might reflect, however, a more open landscape than that of the preceding Mousterian pollen biozone A. This possibility would agree with standard interpretation of the presence of considerable aridity during oxygen-isotope stage 2 in the Mediterranean region. Whatever the case, a long Upper Pleistocene sequence is still needed before an accurate chronostratigraphy can be established for the semi-arid region of southeastern Spain. In conclusion, in this work we have been able to present some palaeobotanical novelties and to discuss some palaeovegetational issues, but we have been unable to do more than merely refer to the palaeoclimate. We have not been able to produce a precise geochronological framework for the site.

The data presented here, regardless of local considerations, lend support to the hypothesis that, from a pollen-analytical perspective, Mousterian and Upper Palaeolithic layers can and should be differentiated. While the Mousterian pollen record suggests conditions for chemical and stratigraphical stabilization and, therefore, could be reliable, the Upper Palaeolithic pollen record shows features that indicate pollen deterioration, differential preservation, contamination, downward movement and reworking. Perneras may exemplify many of the limitations and possibilities associated with using cave sediments for palaeoecological interpretation.

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Appendix

The following pollen taxa are included in the groupings of the Figure 7:

OTHER ASTERACEAE: Cichorioideae, Asteroideae, *Centaurea*. OTHER HERBS: Brassicaceae, Geraniaceae, *Paronychia*, Caryophyllaceae, Apiaceae, *Rumex*, Polygonaceae, *Lotus*, *Lathyrus*, Fabaceae undiff., Dipsacaceae, *Allium*, *Asphodelus*, Liliaceae undiff., Campanulaceae, *Malva parviflora*, Polygalaceae, *Reseda*, *Thalictrum*, *Fumaria*, Sanguisorba, *Nuphar*.

OTHER MEDITERRANEAN SHRUBS: Rhamnaceae, *Pistacia*, *Myrtus*, *Erica arborea*, *Buxus*, *Hedera*, *Periploca*, *Osyris*, *Withania*, *Lycium*, *Ephedra fragilis*, *Genista*, *Ononis*, *Cistus*, *Helianthemum*, *Ruta*, Thymelaeaceae, Lamiaceae, *Sideritis*.