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QUATERNARY DEPOSITS IN CAVES AND SHELTERS IN THE CENTRAL MEDITERRANEAN AREA OF SPAIN. SEDIMENTOCLIMATIC AND GEOARCHAEOLOGICAL IMPLICATIONS

ABSTRACT: A revision on karstic caves which have been studied from a sedimentological point of view and conserve an archaeological or faunistic context is attempted. Results of the most representative sequences are compared, which allows to establish a climatostratigraphic framework of the Middle and Upper Quaternary in the region of Valencia, Spain.

KEY WORDS: Western mediterranean – Karstic caves and shelters – Quaternary deposits – Paleoenvironment – Middle and Upper Paleolithic industries – Geoarcheology

INTRODUCTION

Karstic caves are sedimentary environments often containing thick deposits with quite unaltered sequences. The features of the materials which filled these spaces over the time depend on the climatic environment where they had formed and the agents which transported them. Therefore, the study of detritic and lithochemical sediments provides not only paleoenvironmental data, but also information about relevant geomorphic changes affecting the surrounding landscape.

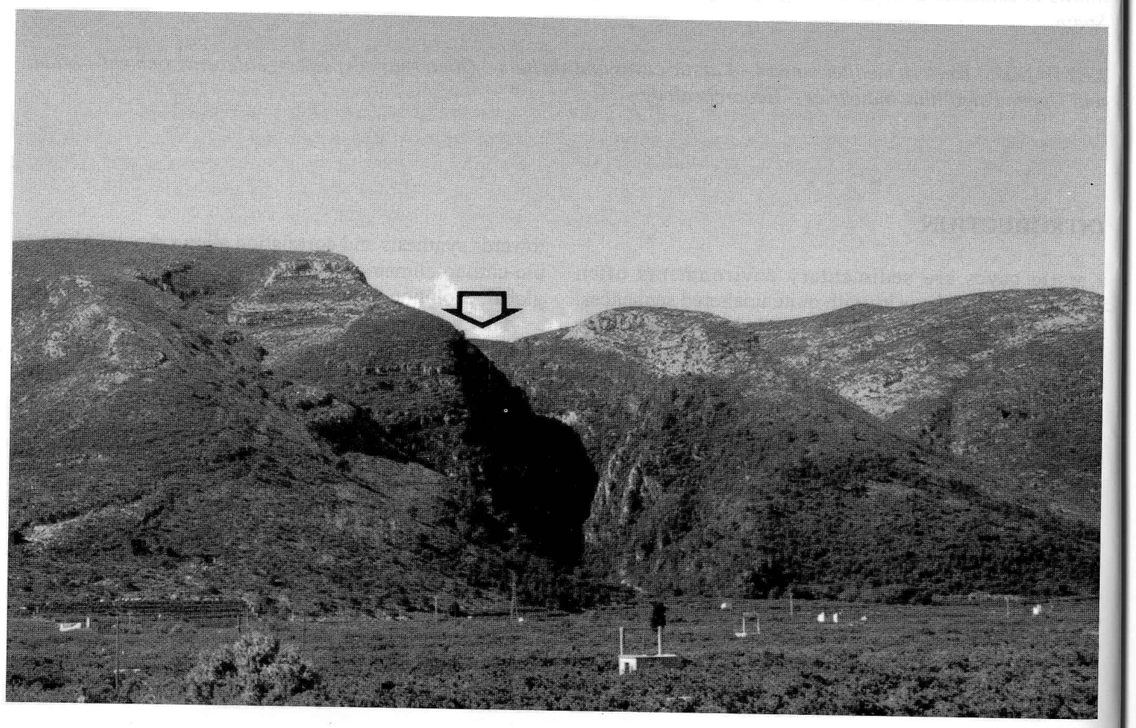
By combining this information with chronological and cultural data, we are able to establish a series of successive sedimentoclimatic phases linked to a specific time-frame comprising the appearance of several human groups. This continental sequence can be used together with other chronostratigraphical records and compared to results of marine research (Atlantic, Pacific, Mediterranean – Emiliani 1955, Shackleton, Opdyke 1973). This effort towards synthesis and correlation allows the definition of bio-chrono-climato-stratigraphical scales determining the global evolution of the Quaternary.

This work is the result of a wide geoarchaeological study, carried out in the past ten years, of the most relevant sites in the region of Valencia, occupied by Middle and Upper Paleolithic human groups. This research has allowed the reconstruction of the Pleistocene sequence in this geographical area which can be regarded as one of the most complete in the Western Mediterranean area.

The working procedure has been based on the sedimentological analysis of selected deposits in caves and shelters and the geomorphological study of the landscape where the archaeological sites were located, paying special attention to morphogenetic changes which took place along the Pleistocene climatic phases. Geochronological data and the lithic implements study provide an ultimate time-frame definition.

FIGURE 1. Geographical location of Paleolithic sites.

FIGURE 2. A general view of the location around Bolomor Cave. The archaeological site opens on the right side of the central ravine.



ARCHAEOLOGICAL SITES AND THEIR GEOGRAPHICAL ENVIRONMENT

The region of Valencia is a coastal territory (400 km) located in the east of the Iberian Peninsula, by the Mediterranean Sea. It comprises several calcareous mountain landscapes of regular height (up to 1,500 m). Its basic structure is made up of several Alpine ranges, aligned NW-SE (Iberian System) in the north and SW-NE (Betic System) in the south, around which several plateaus and tectonic valleys lie. The littoral area is formed by low, narrow plains associated with beach-barrier systems, except for the sectors where ranges exert direct influence on the coast (central sector), thus creating high and medium cliffs under strong tectonic control. Given the calcareous nature of the area, karstic landscape is very important, as shown by the existence of many caves periodically occupied by Paleolithic human groups.

Paleolithic sequence is richly and widely represented in the region of Valencia *(Figure 1)*. It has often been used as necessary material for reference and comparison in the study of other European areas, specially in the Iberian Peninsula (Portugal and Andalucía).

For this work, we have basically chosen deposits featuring long, relevant sedimentary series suitable for correlation with each other. Besides, all the selected material belongs to sites presently under excavation; other

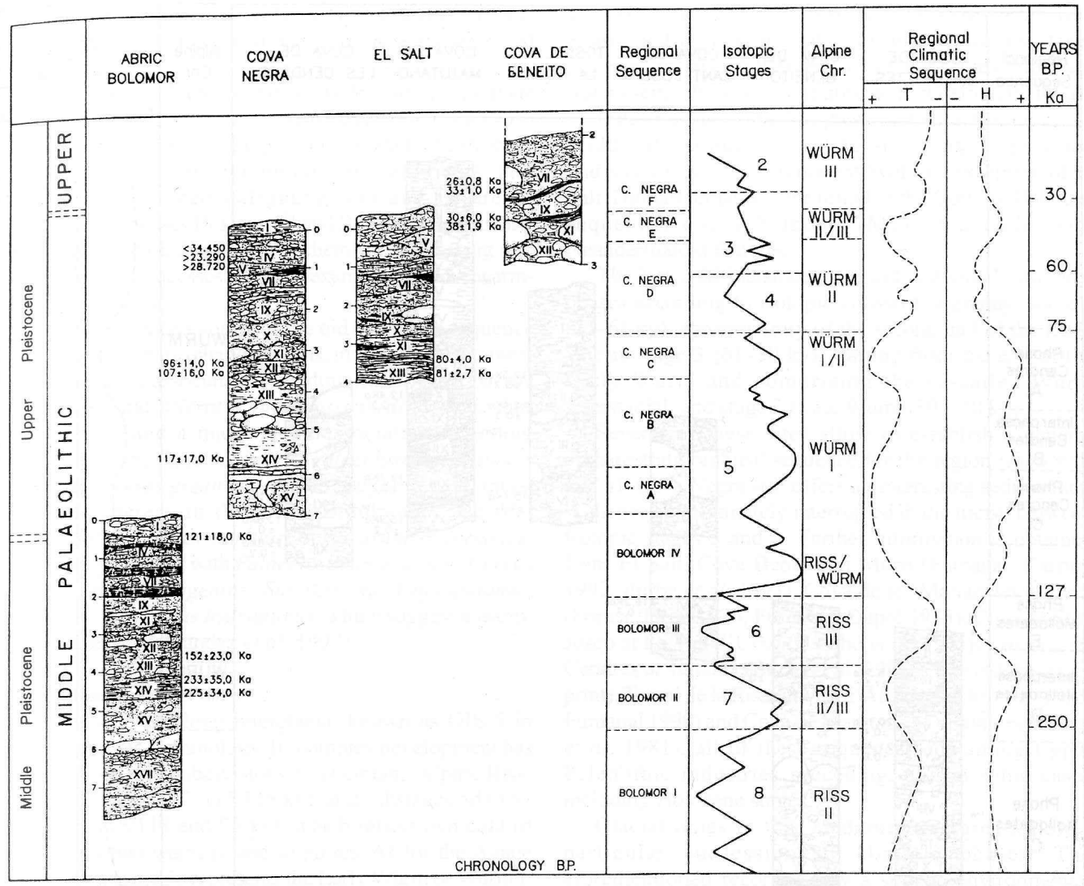


FIGURE 3. Climatostratigraphic sequence of Middle Paleolithic sites.

relevant records from sites no longer under study have been dismissed.

The interpretation of the Middle-Upper Paleolithic, being the main objective of this work, has been carried out upon Cova de Bolomor (mainly on its sedimentological data), Cova Negra and El Salt sites. Cova Beneito has been used for the opening stages of Upper Pleistocene. Records from Malladetes, Sant Josep, Tossal de la Roca, Cova de les Cendres and Cova Matutano have been added later.

CHRONOSTRATIGRAPHIC SEQUENCES OF THE REGION OF VALENCIA

Lower-Middle Quaternary

Only a few deposits from these periods have been preserved in caves and shelters in the region of Valencia, and they provide quite irregular information. The main problem is the obtention of a reliable relative or absolute chronological frame to which the first Quaternary sedimentary series may be referred.

Some caves, like Molí Mató, Casablanca, Vilamarxant, Cova del Corb, Pla de les Llomes, Tossal de la Font, Muntanyeta dels Sants, Segària, etc., mostly studied by I. Sarrión (1980), include brechified sediments containing faunal remains from Pleistocene mastological associations. Other examples give a more complete, chronologically determined stratigraphy, like Cova de Cirat at Montán (Garay *et al.* 1994). Despite its exploitation as a quarry over this century, its 8 m thick filling is well represented in remains attached to the walls and unaffected by extraction works. A sequence comprising Lower and Middle Pleistocene, established upon Th/U dating, suggests very active morphogenetic processes. The study of this site proves that the running of the ravine where the conduct is located changed abruptly: the cave received fluvial materials transported by Cirat Gully in a torrential regime over long time intervals of the Early Quaternary. This

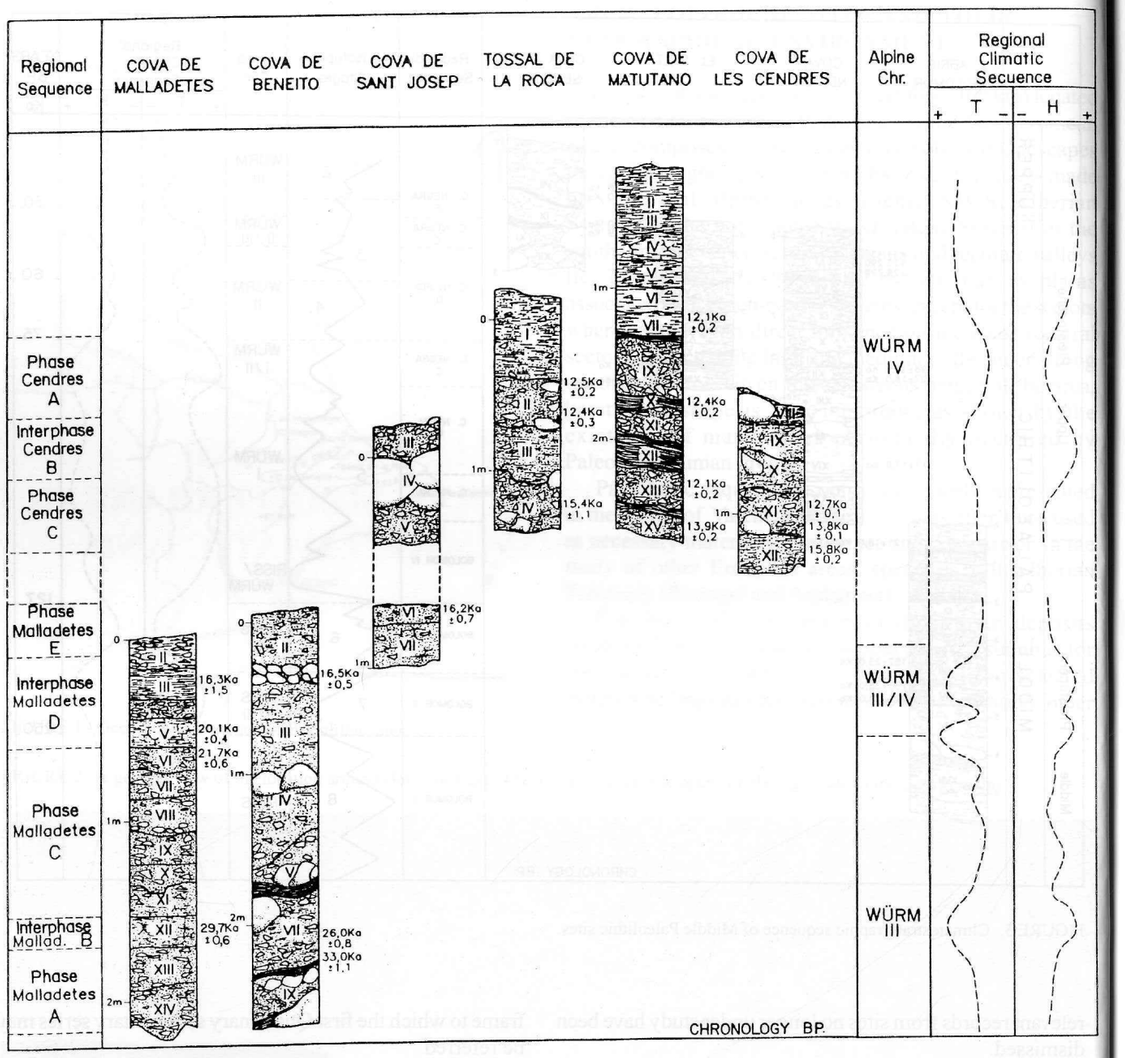


FIGURE 4. Climatostratigraphic sequence of Upper Paleolithic sites.

situation changed around 200,000 BP, when the channel bed probably reached its present disposition at a lower level, thus leaving hypogean terraces at a higher level and disconnected from the present riverine network.

The relationship between the filling of these Pleistocene stages and human industry *(Figure 1)* is still more peculiar. The most important example so far is Cova de Bolomor *(Figure 2)* at Tavernes de la Valldigna (Fumanal 1993, Fernández *et al.* 1994). The chronostratigraphy of this archaeological site comprises much of Middle Pleistocene and the transit to Upper Pleistocene, including a Lower Paleolithic flake assemblage whose upper unit may well be regarded as Early Mousterian. Sedimentological results establish four climatic phases *(Figure 3)* named Bolomor-I to IV. They begin with a cool, moist climatic cycle (B-I) followed by an interstadial period associated with the Riss II/III transit in the Alpine chronology. A sudden climatic degradation (B-III) corresponds to Isotopic Stage 6 or the Alpine Riss III stage. The last, warm and moist phase Bolomor-IV reflects the mild climate of the Eemian interglacial (Isotopic Stage 5/Riss-Würm).

In these Valencian sites, Middle Pleistocene morphogenetic features suggest a varying climate which favoured specific processes. On the one hand, physical weathering is frequent, although apparently not very intense, under cold environmental conditions. During a clear thermal minimum in the phase Bolomor-III, abundant frost slabs were accumulated by the frost/thaw alternance

at the base of the shelter entrance. These seem to reflect the conditions prevailing at the end of the Riss glacial period (Riss III).

On the other hand, warm episodes often reactivate hydric fluxes which in turn create quite thick rainwash deposits, whose tops appear presently eroded. The strongly carbonated waters cemented the sediments and occassionally formed stalagmitic soils and calcareous breccias. The phases Bolomor-II and Bolomor-IV, showing thin, well-classified sediments, chemical weathering and soil formation processes are good examples of those warm-moist conditions.

Associated fauna confirms the old age of the sequence and reflects climatic changes. Thus, in the phase Bolomor-I, a microfauna association including *Allocricetus bursae Pyrenaicus* and *Microtus breccensis mediterraneus* has been found, and a macrofauna association including *Hemitragus* sp., *Equus caballus, Palaeoloxodon antiquus* and *Megaloceros giganteus*, which suggest a cold, moist climate, whereas in the phase Bolomor-IV we find associations of *Sorex minutus, Sorex araneus coronatus* and *Sorex* sp., along with *Palaeoloxodon antiquus, Cervus elaphus, Bos primigenius, Sus scropha, Hippopotamus amphibius* and *Equus hydruntinus*, which suggest a warm, moist climate (Fernández *et al.* 1997).

Upper Pleistocene

It begins with the long interglacial known as OIS 5 in marine isotopic terminology. Its complex development has been divided into subdivisions 5e (Eemian, Alpine Riss/Würm, between 127–115/118 ky), and substages 5d to 5a (between 115/118 and 75 ky), which reflect two cold (d and b) and two warm (c and a) pulses. As for the Alpine chronology, stage 5c represents the Early Würm or Würm I.

In the region of Valencia, these early stages of Upper Pleistocene are presently represented by some segments of the stratigraphic record of three archaeological sites *(Figure 3):* the last sedimentary units of Cova de Bolomor (phase Bolomor-IV), the first deposits of Cova Negra at Xàtiva (Villaverde 1984, Fumanal 1986), phases Cova Negra-A, B and C, and sedimentary unit Salt-E from El Salt site in the Alcoi valleys (Galván 1992, Fumanal 1994). However, the state of research in these sites would require a more elaborate interpretation of the inner evolution of this important transit period between two glacial stages. For this work, among all disciplines allowing paleoclimatic reconstruction, the results of sedimentological study will be basically used.

The morphogenesis prevailing over this long interstage outlines the importance of the limestone cycle processes (disolution-precipitation of $CaCO_3$), consisting of either the construction of stalagmite floors or brecciae, or the development of travertine structures. Many of the levels accumulated along this thermical optimum have this lithochemical nature (levels VI, IV, III and II in Cova de Bolomor; level XV in the ultimate classification of Cova Negra; levels XIII and XII in El Salt). Some soil formation, not very intense in these karstic environments but well established by micromorphological analysis, also takes place, as in level XII from Cova Negra. Last, rainwash waters settle thick levels of thin, well classified material.

Industries associated to these moments belong to the Middle Paleolithic, including abundant scrapers and scarcely a Levallois component, with the exception of El Salt. Human remains were found in the Cova de Bolomor sequence: one left molar (M1) of a child with Neanderthaloid features.

The last cold Pleistocene period is divided into three phases according to isotopic chronostratigraphy: stage 4 (75–61 ky), contemporary of the second half of the Early Würm, stage 3 (61–30 ky), starting from the end of the Early Würm and comprising the so-called Würm Interstadial, and stage 2 (Late Würm, 30 – 10 ky).

Several of these sites allow to establish a general climatostratigraphical sequence for the region *(Figures 3 and 4)*. Cova Negra still offers an interesting sedimentary sequence approximately interrupted in the transit between isotopic stages 3 and 2. Further information is obtained from El Salt, Cova Beneito at Muro (Fumanal, Carrión 1992, Iturbe *et al.* 1993), Cova de les Malladetes at Barx (Fortea, Jordá 1976, Fumanal, Dupré 1983), Cova de Sant Josep at La Vall d'Uixò (Casabó *et al.* 1995), Cova de les Cendres at Teulada (Badal *et al.* 1991, Villaverde *et al.*, in print), Tossal de la Roca at Vall d'Alcalà (Cacho *et al.* 1983, Fumanal 1990) and Cova de Matutano at Vilafamés (Olaria *et al.* 1981), all of these sequences containing Upper Paleolithic industries preceding, and in some cases including Holocene stages.

Glacial times in this Mediterranean area follow a particular succession of climatic phases. The aforementioned records show a sudden environmental degradation: a temperature decrease and a gradual aridification all through the transitional stages into the last third of the Upper Pleistocene. At Cova Negra, that cold-moist phase (including gelifraction processes, active rainwash and karstic activity), later becoming cold-arid (with occasional aeolian activity), is reflected in the sedimentary unit of Cova Negra-D. The only analogues found so far are sedimentary units D and C from the El Salt site.

This severe stage is followed by a warm and morphogenetically stable interstadial so far recognisable in three sites: Cova Negra, Interphase E (reflected in level IV), El Salt, unit B (level V), Cova Beneito, levels XII–XI. Environmental characteristics favour alteration and smooth soil formation processes (Cova Negra), rainwash and the formation of travertine levels (El Salt). As for the chronology, we are in the second half of the isotopic stage 3, Würm interstadial, Alpine Würm II/III, absolute dates being between 43,000 and 34,000 BP.

This mild interval, over which the forest advances (Carrión 1992, 1997), comes to a sudden end, after which climatic conditions become aggressive enough as to favour physical weathering again. This cold phase is somehow

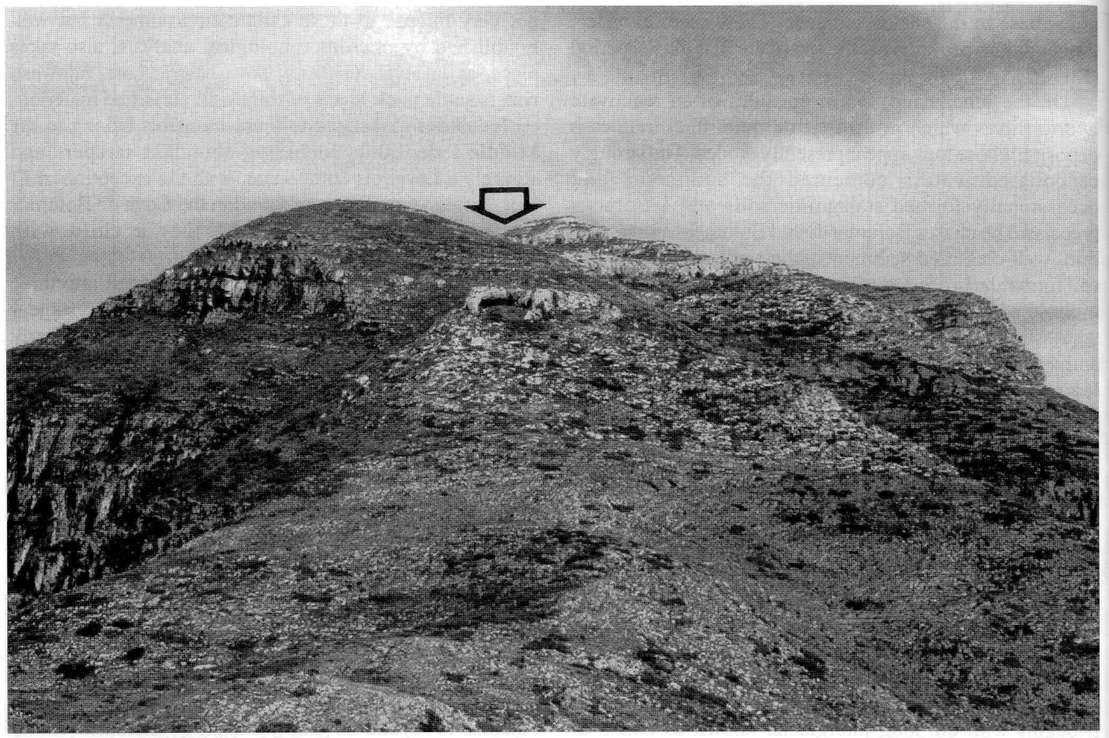
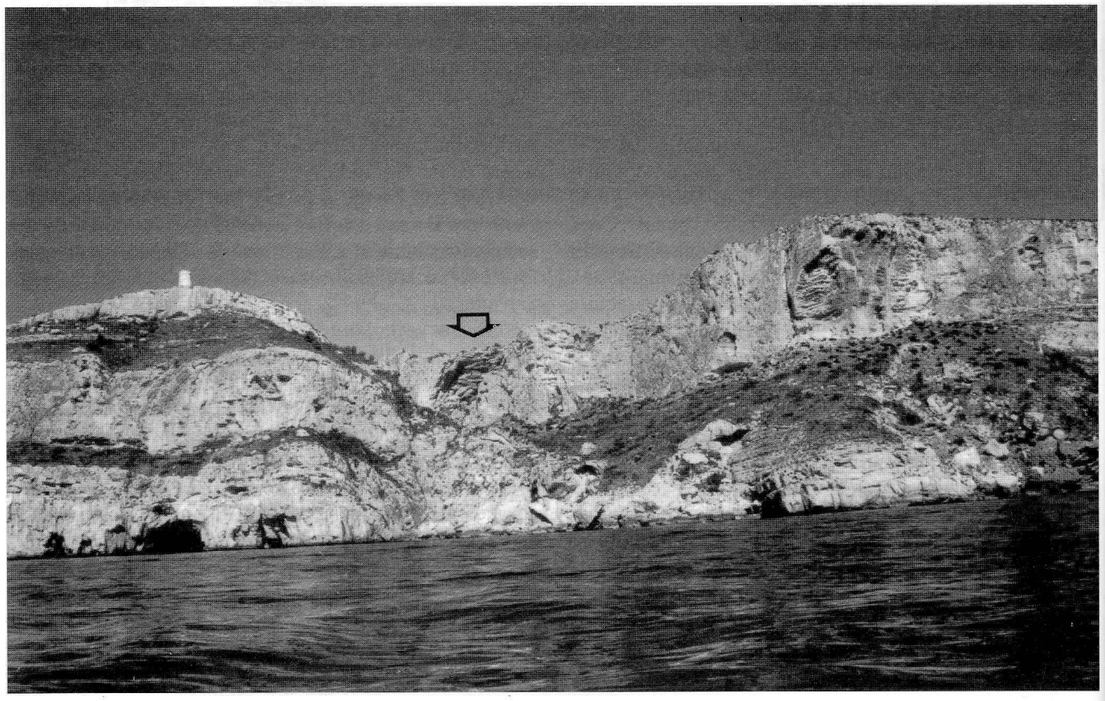


FIGURE 5. Malladetes Cave on the western slope of the Monduver Mountain.

FIGURE 6. Cendres Cave, located at the top of the Moraira sea-cliffs.



indeterminate, but may reflect already the final interval of isotopic stage 3 and/or the beginning of stage 2. This phase is documented in Cova Negra-F (levels III, II and I), and levels X–IX at Cova Beneito. Both caves record it as a distinctly dry and cold period that includes frequent gelifraction processes.

The most interesting aspect of this stratigraphic succession is the existence of Mousterian assemblages until the end of stage 3 that, in other Peninsular areas, includes already the initial Upper Paleolithic industries. Thus, the Mousterian technocomplex associated with Cova Negra levels III–I and Cova Beneito levels X–IX must be correlated with cold intervals recorded between the Les Cottes and Arcy phases, later than datations obtained for the La Arbreda or El Castillo Early Aurignacian phase (Bischoff *et al.* 1989, Cabrera, Bischoff 1989). This situation is clearly parallel to that of several sites in the south of the Peninsula, such as Boquete de Zafarraya (Hublin *et al.* 1995) and Carihuela (Vega *et al.* 1988, Vegas, Carrión 1993) in Andalucía and Caldirao, Columbeira and other sites in Portugal (Zilhâo 1995), which confirms this process of industrial stability, apparently linked to a long-lasting Neanderthal population. This proves the process of appearance of anatomically modern men in South-Western Europe to be very complex.

Some elements of the fauna associated with the final stages of the Middle Paleolithic persisted longer than they did in other northern areas, possibly indicating milder climatic conditions in the Spanish Mediterranean area. It is the case of *Hemitragus* sp., present in Bolomor from the beginning of the sequence and in Cova Negra until level I, an interval correlated with the onset of the Last Glacial Stage (Late Würm). The same stratigraphic position concerns *Dama* sp., also present in the upper levels of this site (Martínez Valle 1995).

From this moment on, the climatostratigraphic sequence of the region of Valencia has many analogues *(Figure 4)*. The sedimentopollinical study of profiles Z-I and Z-II from Cova de Malladetes *(Figure 5)* has provided a key reference for the paleoenvironmental reconstruction of the following thousands of years. This series comprises almost the entire last glacial phase (Alpine Würm III, Würm IV or Late Würm, isotopic stage 2). This time interval seems to be rather severe, as frequent mechanical weathering processes accumulated small frost slab deposits under the ceiling and walls of the shelter. This pattern is reflected in the phases Malladetes-A (lower segment, levels XIV and XIII of profile Z-II) and Malladetes-C (middle segment, levels XI to VI of Z-II), and is reversed twice in phases Malladetes-B (level XII) and Malladetes-D (levels V to III), thus suggesting warm, biostatic environmental conditions.

The sequence of Paleolithic industries corresponding to the above chronostratigraphic phases contains several Aurignacian levels at the base, poor in lithic contents and showing a considerably low density of remains given their thickness, but containing a clearly defined bone industry (levels XIV–XI), dated to 29,690±660 years BP and apparently matching quite well the dates assigned to the Kesselt's warm phase (Leroi-Gourham 1997); some Gravettian levels, with a clear typological definition based upon pointed backed pieces (levels X–VIII); and, last, a long Solutrean sequence starting in Lower Solutrean and, with some hiatuses (level IV, a frost slab bed with no archaeological record, apparently belongs to the Upper Solutrean, which is well recorded at the Cova de Parpalló site, scarcely two kilometres away from Malladetes), ending up in a developed final Solutrean of the Iberian facies, dated to around 16,500 years BP (Fortea, Jordá 1976).

Records from Cova Beneito are not very remote. The interglacial phase defined at the base of its sedimentation (levels XII–XI), showing a Mousterian occupation lasting until the following level, is followed by a distinctly cold sedimentary segment (levels IX–V). This severe interval corresponds to phase Malladetes-A. The next interphase (Malladetes-B) could be represented in the erosive episode at the top of level V in Cova Beneito. A subsequent cold event is recognised in the regional sequence as phase Malladetes-C. The Beneito level IV (cold/cool features) begins at the base of this new stage, contemporary with levels XI, X and IX of the Malladetes record. Within the same globally indicative phase, a slight turn towards warmer conditions (reflected in Malladetes level VIII) seems to appear, again in the form of erosive processes at the top of level Beneito IV.

The upper part of both sequencies is poorly defined in Cova Beneito due to a sudden sedimentary change caused by a collapse of the ceiling. Nevertheless, alternances detected through the sedimentological sequence appear to be quite well defined by absolute datations: A Solutrean-Gravettian industry from this site has an associated date of 16,300 years BP, and the warm-cool-warm oscillation (Interphase Malladetes-D, around 20,000 and 16,500 years BP) shows a partial correspondence at the end of these series. A basal occupation of the Cova de Sant Josep, presently under investigation (levels VII and VI) is probably close to these episodes, in respect to its depositional context, chronological data and industrial remains, considered to be Solutrean-Gravettian (Casabó *et al.* 1995).

It is worth mentioning that the characteristics of Malladetes-D (a mild and moist phase) may mean an erosive stage in other caves. That would explain the interruption or the lack of industrial and sedimentary continuity in some sequencies. It is clear that environmental conditions deteriorated after this interphase, thus reactivating the formation of deposits through mechanical weathering, still within the Solutrean-Gravettian conditions.

Study of the Beneito industry seems to confirm this general correspondence with Malladetes, as, in levels IX to V, we find an Aurignacian complex *s.l.*, difficult to define upon the scarce material found, followed in level IV by a developed Aurignacian not recorded at Malladetes, but likely corresponding to level XI (the absence of this Aurignacian facies may be explained by the erosive contact between Malladetes levels X and XI), and a Gravettian (top

of level IV) whose structure is similar to that of Malladetes levels X–VIII. The aforementioned erosive processes at the top of Beneito level IV may explain the absence of the Early Solutrean at the site (see Villaverde, Aura, in print, versus Iturbe *et al.* 1994). The subsequent sequence seems to correlate well with the Developed and Late Solutrean from Parpalló and Malladetes. Anyway, establishing a characterization of stages well documented at two sites only, and showing interruptions in the recorded industrial series, must be undertaken cautiously. The presence of cold sedimentological characteristics in Malladetes level IV may render a more detailed definition of the interphase Malladetes-D.

From the phase Malladetes-E on, still greater limitations appear. None of the local sites has provided the levels of the Early Magdalenian present in the Parpalló sequence (Aura 1995). This phenomenon takes place not only in Valencia, but also in the south-east and south of the Peninsula (Cortes *et al.* 1996). As the succession of the Developed Solutrean and the Early Mediterranean Magdalenian is only recorded in Parpalló (Aura, Villaverde 1995, Villaverde, Martínez 1995), it is very difficult to link the data and climatic phases with those of sites containing Paleolithic industries assigned to the Middle and Upper Magdalenian. It must be remembered that, in Parpalló, this Early Magdalenian sediment is two metres thick and incorporates a lithic and bone industry clearly different from the Developed Solutrean and Middle and Upper Magdalenian, as defined in the Cova de les Cendres, Tossal de la Roca and Matutano sites. All these industries have a high percentage of blades, whereas the Early Magdalenian from Parpalló is not laminar and has a strongly different industrial composition with abundant flakes (Aura 1995).

Until the characteristics of this phase and its precise time dimension can be clearly defined in one of the sequences presently under excavation (dates associated with the first laminar Magdalenian industries suggest a 15–16 ky horizon; whether it is subsequent or partially contemporary of the end of the Early Magdalenian cannot be assessed yet), it may be supposed that climatic phenomena associated with the Angles and Prebölling pulses triggered erosive phases similar to those observed at the top of Sant Josep level VI. Those stages have not been recorded yet in any of the Spanish Mediterranean series (as, for instance, Nerja and Pirulejo in Andalucía, with sequences shifting directly from the Developed Solutrean levels to the Upper Magdalenian) (Aura 1995, Cortés *et al.* 1996).

Other stratigraphic sequences containing Upper and Middle Magdalenian material have been found at Sant Josep, Tossal de la Roca, Matutano and Cova de les Cendres *(Figure 6)*. These industrial stages formed approximately between 15,000 and 11,000 years BP during climatically harsh conditions, temporarily interrupted by one warm moment (Fumanal 1995). This cold pulse (phase Cendres-C) is reflected in Sant Josep (levels V to III), Tossal de la Roca (level IV), Matutano (levels XV to XIII) and Cendres (levels XII–XI). The subsequent interphase Cendres-B is deducted from the Tossal de la Roca level III, Matutano level XII and Cendres level IX–X. A last cold stage (phase Cendres-A) is found in the Tossal de la Roca level II, Matutano XI to VIII and Cendres VIII. Chronologically, this succession ends with the onset of the present interglacial, represented only by the final segments of two sites (Matutano and Tossal de la Roca), which show a distinct climatic amelioration.

Paleontological and antracological data from the Cova de les Cendres series show an arboreal association *Pinus nigra – Juniperus* and the presence of *Microtus arvalis* and *Pirrhocorax graculus,* both having parallels in the Meso- and Supramediterranean levels, but not in the Thermomediterranean level that they presently occupy (Villaverde *et al.* in print). Nevertheless, further investigations are needed to define more precisely the climatic pulses of these stages.

Industries from these stratigraphic sequences have been fundamentally reinterpreted during the past years, especially upon the rich series provided by Parpalló (Aura 1995). Further data have been provided from sites presently under excavation. The current scientific debate is focused on whether to define a separate Middle Magdalenian phase, located approximately between 14,500 and 13,500 years BP, or to include this as a part of the initial Mediterranean Upper Magdalenian (Aura 1995, Villaverde, Martínez Valle 1995, Villaverde *et al.*, in print). Limited as we are by the preliminary character of the results provided so far and the probably functional variability of the studied associations, it is not possible to be too precise about the industrial and chronological dynamics of these stages. We can only confirm the unity of industrial processes since their start around 15,000 – 14,000 years BP, and their clear continuation in the Early Holocene Epipaleolithic industries which constitute a definite Epimagdalenian (Aura 1995).

FINAL COMMENTS

The reconstructed paleoenvironmental phases based on a correlation of the paleoclimatostratigraphy, geological contexts and cultural sequences of the region of Valencia provide the most reliable climatostratigraphical periods at a regional level and, in our opinion, are more accurate than other globally indicative chronological schemes (including oxygen isotope records, the Alpine chronostratigraphic sequence).

Geological absence of certain time intervals not represented in the general chronostratigraphic sequence (e.g. the Early Magdalenian sequence from Cova del Parpalló) can be explained by the frequent (and not always sufficiently taken into account) elimination of a part of the sedimentary deposit due to erosional processes.

It is in these chronologies, and not before, that the possibilities of industrial precision associated with Upper

Paleolithic phases allow us to establish a correlation among several sites.

Despite this fact, the synthesis of the climatostratigraphy of the Early, Middle and particularly Upper Paleolithic records from Valencia may be regarded as one of the most complete in the Mediterranean area and very close in details and phases to data provided by adjacent geographical areas (Cantábrico, Périgord, etc.).

For the purpose of a specific phase determination, a priority has been given to the terminology associated to particular key sites: Bolomor for the Middle Pleistocene, and Cova Negra, Malladetes and Cova de les Cendres for the Upper Pleistocene. These sites occupy a small area, being located less than 50 km away from each other, and are represented by thick sequences comprising long and high resolution time intervals.

This chronostratigraphic framework may be later used for the establishment of a more general and uniformly applicable sequence by incorporating new and/or more closely fixed phases or interphases. As for Cendres, as the base of the deposit has not been reached yet, we have chosen to reverse the order, thus allowing the inclusion of future phases or interphases.

Finally, it must be pointed out that the climatic terminology used for the description of individual phases is relative and refers specifically to the particular studied area (a Mediterranean coastal landscape). Consequently, the classification of stages as „cold" or „warm" is not parallel to that of other latitudes.

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