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The Sopeña Rockshelter, a New Site in Asturias (Spain) bearing evidence on the Middle and Early Upper Palaeolithic in Northern Iberia

El abrigo de Sopeña, un nuevo yacimiento en Asturias (España) con depósitos de Paleolítico Medio y Superior Inicial en el Norte de la Península Ibérica

KEY WORDS: Middle Paleolithic, Early Upper Paleolithic, Gravettian, Auriñaciense, Mousterian, northern Spain, Cantabrian Mountains.
PALABRAS CLAVES: Paleolítico Medio, Paleolítico Superior Inicial, Gravetiense, Auriñaciense, Musteriense, norte de España, montañas Cantábricas.
GAKO-HITZAK: Erdi Paleolitoa, Hasierako Goi Paleolitoa, Gravettiarra, Aurignaciarra, Mousteriarra, Espainiako iparraldea, Kantauriar mendikatea.

Ana C. PINTO-LLONA[1], Geoffrey CLARK[2], Panagiotis KARKANAS[3], Bonnie BLACKWELL[4], Anne R. SKINNER[4], Peter ANDREWS[5], Kaye REED[6], Alexandra MILLER[2], Rosario MACÍAS-ROSADO[1] and Jarno VAKIPARTA[7]

ABSTRACT

Iberia has become a major focus of modern human origins research because the early dates for the Aurignacian in some sites in northern Spain seem to preclude an 'Aurignacian invasion' from east to west. Neanderthals associated with Mousterian industries occur late in time. The occurrence of Neanderthal-modern hybrids dated to around 24 ka, and the possibility of *in situ* transition between the Middle and Upper Paleolithic along the north Spanish coast, also raise important questions. To approach these questions requires excavations with modern methods of sites containing relevant archaeological records, *in situ* stratigraphic deposits, and reliable dating. Here we offer a preliminary report on the Sopeña site, a rockshelter containing well stratified late Middle and Early Upper Palaeolithic deposits. We describe the sedimentology for the archaeological layers, dates obtained so far, and lithic and faunal materials including the micromammal taphonomy from a deep test pit along the east wall.

RESUMEN

Iberia se ha convertido en foco importante en la investigacion de los orígenes de los humanos modernos debido a las fechas tan tempranas ofrecidas para el Auriñaciense en lagunos yacimientos en el norte de España, que parecen negar una 'invasion auriñaciense' de este a oeste. Hay neandertales, asociados con industrias Musterienses en fechas muy tardías. La presencia de híbridos de Neandertal y hombre modernos datada alrededor de 24 Ka y la posibilidad de una transición *in situ* entre el Paleolítico Medio y el Superior a lo largo de la costa del norte de la península tambien sugieren importantes cuestiones. Para acercarnos a ellas son necesarias excavaciones con métodos modernos en sitios que contengan los depósitos arqueológicos relevantes, estratigrafía *in situ* y dataciones fiables. Aquí ofrecemos un informe preliminar sobre el yacimiento de Sopeña, un abrigo rocoso que contiene depositos bien estratificados del Paleolítico Medio y Superior. Describimos la sedimentología de los niveles arqueológicos, fechas obtenidas hasta ahora y análisis de materiales líticos y de fauna, incluyendo la tafonamía de microvertebrados, todo ello en un sondeo realizado a lo largo de la pared este.

LABURPENA

Iberia gizaki modernoen jatorria ikertzeko gune garrantzitsua bihurtu da, Espainiako iparraldeko aztarnategi batzuetan Aurignaciarrerako emandako oso data goiztiarren ondorioz, bai baitirudi ekialdetik mendebalderako "aurignaciar inbasioa" ezezten dutela. Mousteriar industriei lotutako neanderthalak daude oso beranduko datetan. Neanderthalen eta gizaki modernoen arteko hibridoen presentzia orain dela 24 Ka urte inguru datatu izanak eta penintsulako iparraldeko kostaldean Erdi Paleolitotik Goi Paleolitorako trantsizioa in situ gertatu ahal izanak ere gai garrantzitsuak iradokitzen dituzte. Gai horietara hurbiltzeko, indusketak egin behar dira metodo modernoak erabiliz metaketa arkeologiko garrantzitsuak, estratigrafia *in situ* eta datazio fidagarriak dituzten lekuetan. Hemen, Sopeñako aztarnategiari buruzko atariko txosten bat aurkezten dugu; inguru hori babesgune harritsu bat da, Erdi Paleolitoko eta Goi Paleolitoko metaketa ongi geruzatuak dauzkana. Honako hauek deskribatzen ditugu: maila arkeologikoen sedimentologia, orain arte lortutako datak, eta material litikoen eta faunaren azterketa, mikroornogabeen tafonamia barne; hori guztia, ekialdeko horman egindako zundaketa baten bidez.

[1] Instituto de Historia CCHS CSIC, c/ Albasanz 26-28, Madrid 28037, Spain, acpinto@las.es
[2] Department of Anthropology, Arizona State University, Tempe AZ 85287-2402 USA
[3] Ephoreia of Palaeoanthropology-Speleology of Southern Greece, Ardittou 34b, 11636 Athens, Greece
[4] Department of Chemistry, Williams College, Williamston, Massachusets, 01267 US
[5] Natural History Museum, Cromwell Road, London SW7 5BD, UK
[6] Institute of Human Origins, Arizona State University, Tempe AZ 85287-2402 US
[7] Department of Philosophy, History, Culture and Art Studies, Archaeology, P.O. Box 59, 00014 University of Helsinki, Finland

1.- INTRODUCTION

The inferred behavioural changes at the Middle-Upper Paleolithic transition in Europe (about 45-35 ka) include the appearance and later proliferation in the archaeological record of complex, multicomponent bone and antler tools, personal ornaments, portable and parietal art, and blade technologies (e.g., MELLARS 1989, 2006). These changes in the character of the archaeology over the transition interval have been interpreted in five partly or wholly different ways. Some authors argue that the Upper Paleolithic markers occur as a 'package' and represent the entry and spread throughout Europe of anatomically and behaviourally modern *Homo sapiens* populations that influenced existing Neanderthal technologies by acculturation (e.g., MELLARS 1989, 1996; Harrold 1989; Kozlowski and Otte 2000). Others contend that early Upper Paleolithic material culture was the product of independent and convergent evolution by existing local populations, and that the Early Upper Paleolithic (EUP) constitutes a spatial and temporal mosaic in those areas where it is documented archaeologically (e.g., RIGAUD 1989; CLARK and LINDLY 1989a, 1989b; CLARK 1997, 2002, 2007; OTTE 1990; STRAUS 1995, 1997, 2005). A third view holds that the Aurignacian was the product of newly arrived *Homo sapiens* (as above), but that these newcomers were copying Upper Paleolithic transitional industries (e.g., the Châtelperronian) developed earlier and independently by Neanderthals (ZILHÃO 2011; ZILHÃO and D'ERRICO 1999; D'ERRICO *et al*. 1998), and conversely, that Neanderthals themselves made the early Aurignacian at El Castillo (Spain) (CABRERA *et al*. 2001) and Vindija (Croatia) (KARAVANIĆ 1995). Karavanić and Smith (1998; SMITH *et al.* 2005) also suggested that direct evidence for object exchanges between Mousterian and Aurignacian populations occurred at Vindija. The contested issues thus include:

(1) how to define the MP-UP transition archaeologically (CLARK 1999; STRAUS 2003; ZILHÃO 2006, MAROTO *et al.* 2012),

(2) when, where and how the MP-UP transition might have occurred (e.g., BAR-YOSEF 2007; RIEL-SALVATORE AND CLARK 2007; KLEIN 2009),

(3) whether the MP-UP transition was a 'sea change' or, as Straus first suggested (1992), a temporal and spatial mosaic with different adaptations on either side of the transition interval (e.g., CLARK 2002, 2007),

(4) what behavioural and/or cognitive changes (if any) accompanied the observed phenomena (e.g., GIBSON 2007; WYNN and COOLIDGE 2007; BICKERTON 2007), and

(5) whether Neanderthals, modern humans, or both were involved (e.g., D'ERRICO *et al.* 1998; ZILHÃO 2011; SHEA 2003.

Within Europe, the human fossil record for this time range is sparse in the extreme, but, in contrast to the situation in the Levant (SHEA 2003), available evidence suggests that European Mousterian industries were exclusively made by Neanderthals (e.g., CHURCHILL and SMITH 2000; BOLUS and CONARD 2001). Most transitional industries (e.g., Châtelperronian, Szeletian, Uluzzian) appear technologically rooted in the local Middle Paleolithic, and so are also assigned to Neanderthals. Although it seems certain that modern humans were established in Europe by about 32 ka (ZILHÃO 2011), they could have been present there as early as about 40 ka (MELLARS 2005), but the few human fossils dated to 45-35 ka do not permit general correlations of particular archaeological industries with particular hominin types.

2. THE TRANSITION IN IBERIA

The Iberian Peninsula poses a particularly puzzling case regarding the dating for the Middle-Upper Paleolithic transition. Very early dates (~ 40 ka) for the Aurignacian in northern Spain (e.g., BISCHOFF *et al.* 1989; CABRERA and BISCHOFF 1989; STRAUS 1992, 1997; BISCHOFF *et al.* 1994; FORTEA PÉREZ 1995, 1996, 1999) are juxtaposed with very late dates for Mousterian sites in southern Spain (HUBLIN *et al.* 1995, 1996; CAMPS 2006). While some suggest that an abrupt replacement occurred in the north at l'Arbreda in Catalunya (e.g., BISCHOFF *et al.* 1989), others suggest that the EUP was mostly a local, *in situ* development (CLARK 1997), and still others propose that the EUP originated in the eastern Mediterranean and spread across Europe from east to west in a progressive wave (e.g., Otte and Keeley 1990, *cf.* CLARK and LINDLY 1991). The debate on the transition in northern Spain turns on a handful of sites, some of them originally excavated in the early part of the last century (e.g., Abric Romaní, l'Arbreda, El Castillo), and where significant finds were lost during the Spanish Civil War (e.g., human remains from Abric Romaní, El Castillo1), or recovery methods were inadequate or biased, and publication was insufficient. Recent work explores the remaining sequence at El Castillo (CABRERA *et al.* 2001, 2006) and witness sections at Abric Romaní (BISCHOFF *et al.* 1994) and l'Arbreda (BISCHOFF *et al.* 1989) have been dated. Transitional deposits may exist in new sites currently being investigated and analyzed with modern techniques (e.g., EL MIRÓN, STRAUS and GONZÁLEZ MORALES 2003), Labeko Koba (ARRIZABALAGA, 2000), La Viña (FORTEA, 1996) and La Guelga (MAROTO *et al.* 2012).

Dating and calibration issues complicate efforts to make sense of the transition interval (VAN ANDEL 1998; VAN ANDEL and DAVIES 2003; VAN DER PLITCHT 1999). For samples older than about 35 ka, where the ^{14}C activity has dropped to ≤ 1% of its original quantum, samples become much more likely to have been contaminated by modern or ancient ^{14}C that could represent as large or a larger portion of total ^{14}C activity than was present originally Thus, the potential for inaccurate determinations becomes very high (SCHWARCZ 1997). Recent problems between ^{14}C ages and known stratigraphy in some transitional sites has led some to suggest that many ^{14}C ages in the 32-40 ka range may be inaccurate (e.g., CONARD and BOLUS 2003) and, when calibrated, possibly as much as 5 ka *older* than the original determinations (ZILHÃO 2011). Also, ^{14}C dates older than 40 ky BP appear to average 1.5-3.0 ky *younger* than more accurate $^{230}Th/^{234}U$ or ESR determinations (e.g., Bischoff *et al.* 1994; Blackwell *et al.* 2008). These problems will hopefully be largely overcome with research now underway to produce high resolution calibration curves extending back to 50 ka (e.g., Hughen *et al.* 2004; Bard *et al.* 2004; see papers in Bronk Ramsey and Higham 2007).

Châtelperronian occupations have been reported at Cueva Morín Level 10 (GONZÁLEZ ECHEGARAY and FREEMAN 1971, 1973), El Pendo Level VIII (GONZÁLEZ ECHEGARAY 1980) and possibly at El Castillo Magdalenian β (CABRERA *et al.* 2001) in Cantabria and other sites in northern Spain. In a long and comprehensive evaluation of Middle-Upper Paleolithic ^{14}C dates and their stratigraphic contexts from the Iberian Peninsula, Zilhão (2006) argues for a general sequence with Mousterian, Châtelperronian, Proto-Aurignacian, and finally Aurignacian for those few north Spanish sites (e.g., Labeko Koba, Morín) whose dates and contexts he considers reliable. Zilhão (2006) thinks that no good evidence for the Châtelperronian exists in Asturias. Several authors who disagree with Zilhão's chronological and contextual interpretations (e.g., MARTÍNEZ-MORENO *et al.* 2010) contest this assessment, and above all, its dating implications. Zilhão's (2006: 64) scepticism about transitional Middle-Upper Paleolithic chronologies arises from the fact that, in Greenland ice cores, the time interval before and after Heinrich Event 4, dated at about 40 ka, shows significant climatic instability that often results in palimpsest formation due to more frequent geological disturbances, particularly erosional events and depositional hiatuses in Iberian caves and rockshelters. Thus, ^{14}C dates in the transition interval should be subjected to particularly close critical scrutiny (ZILHÃO 2006: 64). North of the Ebro Valley, from Asturias in the west to Catalunya in the east, and in those sites that pass his taphonomic 'test', Zilhão (2006: 66) finds that (1) a well-defined Proto-Aurignacian can be detected above the latest Mousterian levels (and above the Châtelperronian in those few sites where he believes it can be documented), (2) the Proto-Aurignacian and Châtelperronian, when reliably dated, are contemporaneous and date to about 42 ka cal BP; and (3) this chronological horizon marks the latest persistence of technocomplexes associated with Neanderthals in these regions.

3. SOPEÑA AND ITS REGIONAL SETTING

Sopeña is a rockshelter located at 42º28′60″N, 6º2′60″W in the village of Avin in the Concejo de Onis in Asturias (northern Spain) in the Picos de Europa mountain chain (Figure 1). It is not far from the palaeolithic sites of El Castillo (CABRERA 1984; CABRERA *et al.* 1989, 2000, 2001) and El Sidrón, where many Neanderthal remains have been found (LALUEZA-FOX *et al.* 2011). The Picos de Europa are formed by a massive uplift of Carboniferous limestone rich in karstic features in eastern Asturias. The Sopeña rockshelter opens at an elevation of about 450 m above sea level, 250 m above the River Güeña and at some 100 m above its small tributary, La Güesal, which runs beneath the rockshelter (Figure 2). Of modest dimensions, Sopeña opens to the southwest, and affords an unobstructed view of the adjacent valleys to the west. Today, the rockshelter is relatively dry and lacks running water. Figure 3 shows the rockshelter from the north, and Figure 4 from the west.

Fig. 1. Location of Sopeña in northern Spain. Number 1 indicates the nearby city of Santander; 2 is the location of Sopeña and 3 signals the location of El Sidrón.

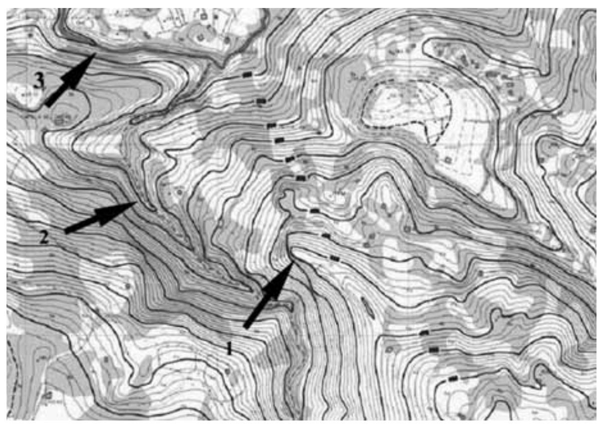


Fig. 2. Local topography. Arrow 1 points to the opening of the shelter, to the SW. Arrow 2 points to La Guesal stream running towards the NNE and 3 to the main river Gueña, running E to W.

Fig. 3. A view of Sopeña from the north. The shelter opens under a rocky outcrop above the valley of the Gueña river..

Fig. 4. A view of Sopeña from the west. The opening of the cave is to the left overlooking the mass of trees. There are other cave openings nearby, some very small and one larger one (Soterraña) south of Sopeña and lower near the Guesal stream, to the low right corner of the photo This is currently used as cattle barn. Some UP and MP materials have been also recovered there.

In 2002, a 2 x 1 m test excavation was dug along the back (east) wall of the rockshelter; it uncovered a section about 3 m below datum without encountering bedrock (Figure 5). Ground penetrating radar indicates that as much as 7 m of deposits lie below Level XV. Sixteen archaeological levels were exposed which are generally horizontal and exhibit well-defined differences in color and texture, and in the kinds and densities of *éboulis*. Figure 6 shows the stratigraphic sequences in the south (6a) and west (6b) walls. Both lithics and fauna are abundant in all levels. Faunal remains are exceptionally common and well preserved, outnumbering the lithics by about 3:1. On the basis of supposedly diagnostic bone and stone artifact types and some radiometric dates detailed below, the sequence documents the late Middle and early Upper Paleolithic. At this early stage in the investigation, no obvious erosional episodes are evident. There is a good possibility that the Middle to Upper Palaeolithic transition may be present at the site, given the very close dates between layers, as detailed below; so far, no Chatelperronian has been identified in the only excavated area, a 2x1 meters test excavation (PINTO LLONA *et al.* 2006a, 2006b, 2009).

Here, we present a preliminary report on the sedimentary micromorphology, the dates available for some levels, the fauna, and the lithic materials recovered in the 2002 test excavation. We believe that Sopeña holds exceptional promise for addressing some of the questions about the nature of the Middle-Upper Paleolithic transition noted above.

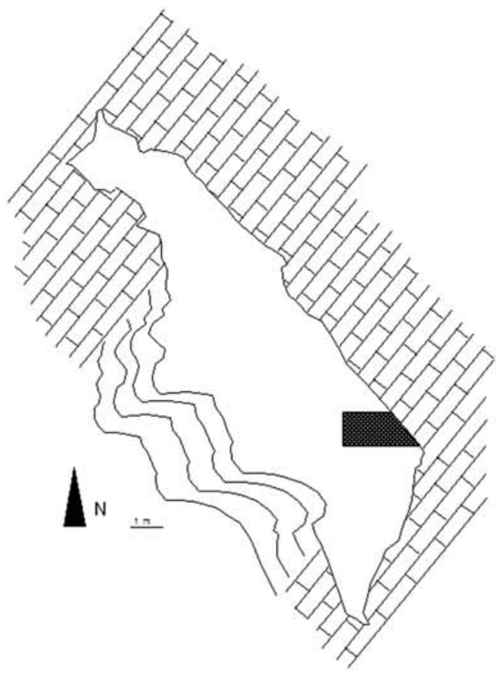


Fig. 5. Plan map of Sopeña. The scale is of one metre. Curvy lines indicate large fallen blocks covered in layers of thick flowstone, making the interior a very sheltered space. In black, the test excavation carried out in 2002.

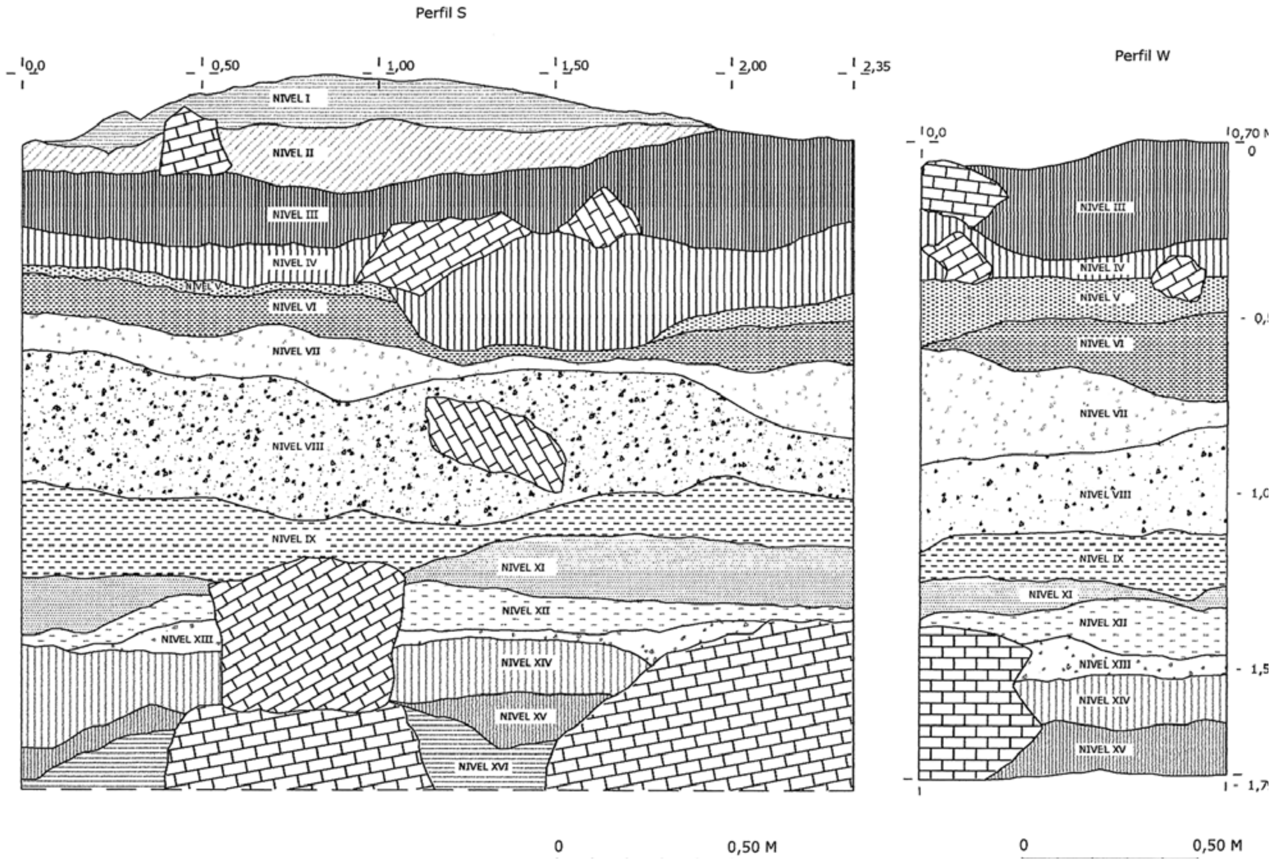


Fig. 6. Stratigraphic profile of the sondage 2002, left south wall, right west wall2. Levels are numbered from the top down. Levels XVI to XII are Middle Palaeolithic, and levels XI to I are Early Upper Palaeolithic. The upper levels are Gravettian.

At Sopeña, the research objectives are:

(1) to improve our understanding of behavioural shifts between the Middle and the Upper Paleolithic that can shed light on our understanding about the extinction of Neanderthals and the emergence of modern human behaviour by analyzing the rich faunal and archaeological records preserved at the site;

(2) to try to determine whether or not these shifts were a strictly local development, as has been argued by Cabrera and others;

(3) to refine the much debated chronology of the Middle-Upper Paleolithic transition in northern Spain, should any archaeological deposits corresponding to it be identified at the site.

4. STRATIGRAPHY AND MICROMORPHOLOGY AT SOPEÑA

4.1 Methodology

Field observations were supplemented with micromorphological sampling and analysis, the study of undisturbed sediments and soils in thin section (COURTY *et al.* 1989). Seven intact samples were collected from the profiles of the test trench inside the rockshelter. The samples were jacketed with Plaster of Paris before removing them so as to secure their integrity. After being dried in the oven for several days at 50°C, they were impregnated with polyester resin diluted with styrene. After being cured, they were cut into thin slices with a rock saw and sent to Quality Thin Sections, Arizona, USA, to prepare 7 x 5 cm thin sections. In addition, a reference sample was collected from the soils on the hill above the rockshelter, as well as a sample from some coarse grained rocks from the limestone terrain in front of the rockshelter. Overall, 19 thin sections were prepared and studied under binocular and petrographic microscopes with magnifications ranging from X4 to X40 and X12 to X500 respectively. Descriptive terminology of thin sections follows that of Courty *et al.* (1989) and Bullock *et al.* (1985) as modified by Stoops (2003).

4.2 Descriptions and interpretations

The rockshelter contains sediment from several sources, fine grained sediment probably blown or washed into the cave, *éboulis* falling from the cave roof and materials carried in and produced by fauna inhabiting the cave. Humans contributed significantly producing relatively large amounts of burnt remains. Fine grained material washed in primarily from the southern edge of the cave. The collapsed limestone blocks at the rockshelter entrance dip towards the back, making a basin-like feature where the sediment accumulated.

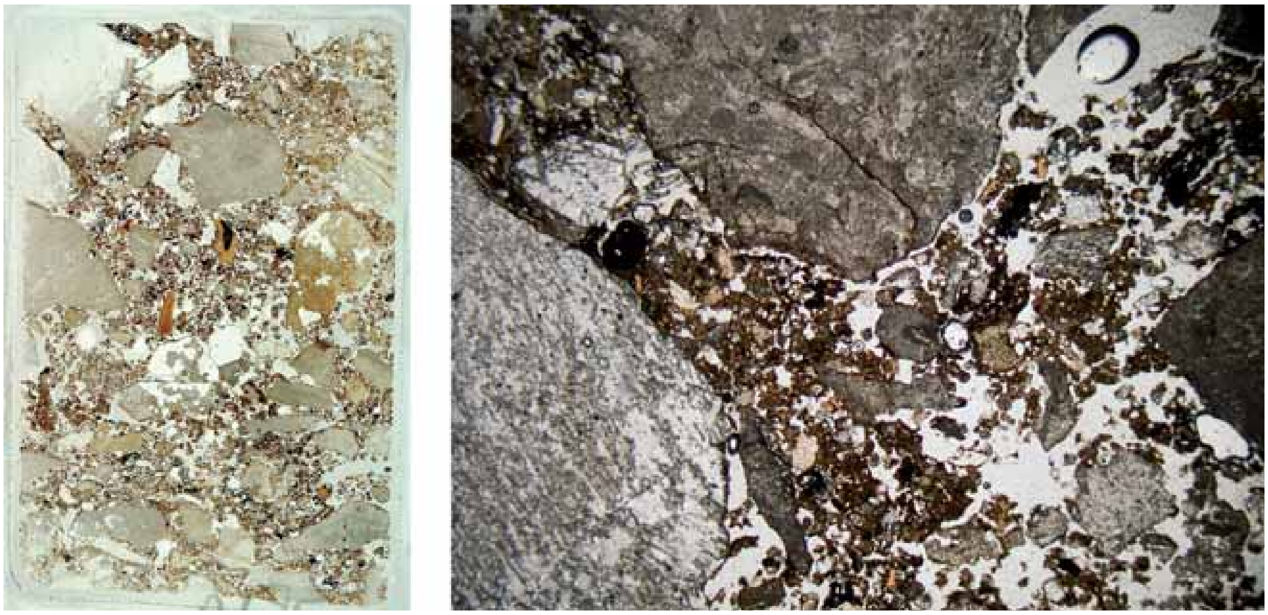


Fig. 7. Level I, a, macrophotograph of thin section SP1a. Angular roof spall and fine matrix in between Yellowins burnt bone and black charcoal fragments are visible. Height of view 7.5 cm. b, Level I: microphotograph of thin section SP1a with moderately disturned fine matrix in between limestone roof spall. Plane Polarized Light (PPL). Width of view 11 mm.

Level I occurs only on the southern profile. This level is a light grey-brown matrix-supported gravel, with areas where it is locally clast-supported. Clasts are mainly fine pebbles, but a few cobbles also occur. The clasts show crude horizontal bedding. The limestone *éboulis* are mostly angular, but have experienced some incipient rounding due to weathering. This level contains mainly limestone *éboulis*, but with high concentrations of bone, lithics, and probably, dispersed burnt remains which most likely gives this layer the gray tint. Level I grades into Level II over a zone averaging 1-2 cm in thickness.

Under the microscope Level I (thin section SP1) comprises angular and unsorted limestone and travertine fragments without any obvious structure embedded in a loose sandy clay silt matrix with complex microstructure (Figure 7a). Some areas in the groundmass around the gravel still retain a compact porphyric coarse/fine related distribution, but the rest is disturbed rather percolated from above material (Figure 7b). The matrix contains clay, calcitic sand and silt, quartz clasts, very abundant bone fragments of all sizes, which have suffered different degrees of burning but have not been calcined -, and charcoal shreds. Some bone fragments are rounded and amorphous, implying chemical alteration possibly due to digestion. In summary, Level I has hearth debris mixed with *éboulis*. The combustion debris looks more or less *in situ*, but they also shifted into the porous gravel where they lost their distinctiveness.

Level II resembles Level I, except that is more strongly clast-supported and lacks burnt remains. Hence, it has a browner color. The contact with the underlying Level III is gradual ranging over 3 to 6 cm. Under the microscope (thin section SP1b), the pores of the gravel contain percolated fine sand and sandy clay silt aggregates with a very loose, spongy microstructure (Figure 8a). Some elongated particles show vertical orientations (Figure 8b). Some bone is still present, but the majority is not burnt. Occasionally, some fine amorphous charred plant fragments are observed. Level II formed due to *éboulis* accumulation. The formation of *éboulis* has been attributed to freeze-thaw action but not all researchers agree on this (see discussion in Woodward and Goldberg 2001 and references therein). Nevertheless, other more secure cryogenic features were identified in the underlying layers (see below) so it might be assumed that the *éboulis* is of cryogenic origin and probably marks a change to colder conditions already from layer III (see below), perhaps approaching the last glacial maximum. The majority of the anthropogenic input of this layer should have been shifted from above.

Level III has black, white, gray, and red or dark brown sublevels, suggesting *in situ* combustion features. Its thickness increases towards the rockshelter centre and thins to the back. In the southern profile, its base is marked by a pink-violet halo on top of Level IV, probably related to post-depositional chemical alteration of the burnt substrate (KARKANAS *et al.* 2002). With many clasts, the layer is almost clast-supported in some areas, but still abounds with burnt remains. Although its grain size resembles that in Level II, it is somewhat coarser having more medium sized pebbles (3-5 cm). Also, a few clusters of large decimetre-sized clasts that might be related to hearth constructions, but it is not clear from the profile observations. The contact with the underlying Level IV is locally very sharp, but in other areas is only abrupt to clear ranging over 3 to 5 cm (terminology of boundary sharpness follows COURTY *et al.* 1989). In the latter areas (e.g., west profile) the level forms a basin which may be due to erosion or subsidence.

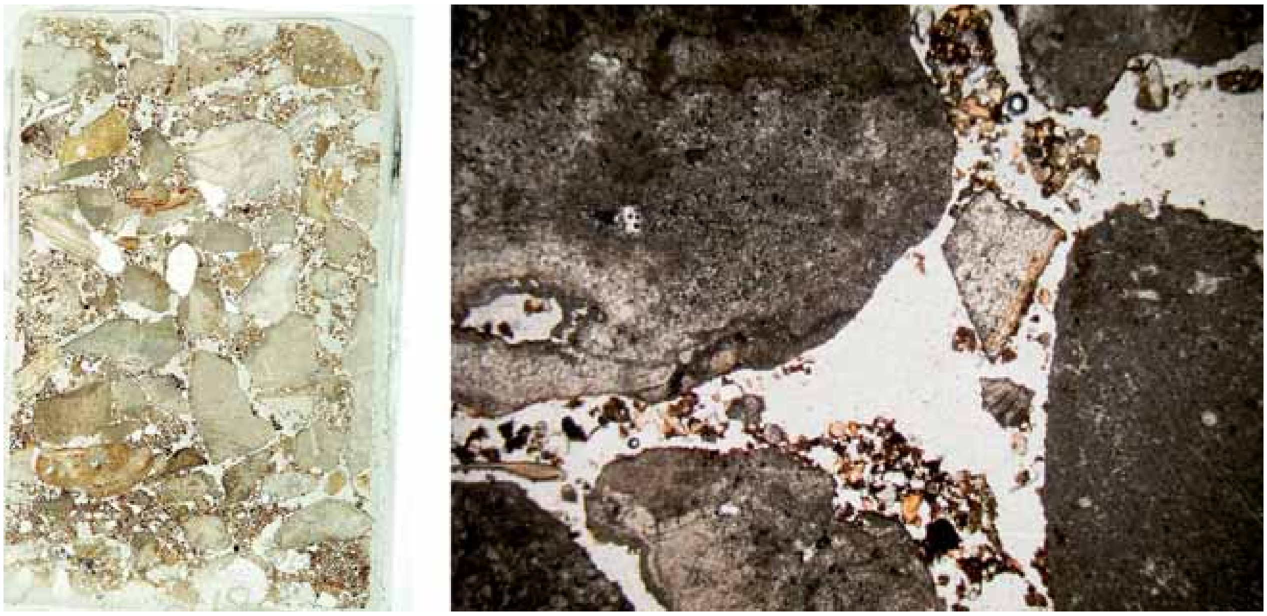


Fig. 8. Level II, a macrophotograph of thin section SP1b showing clast-supported roof spall. Height of view =7.5 cm. b, Level II: microphotograph of fine material in between limestone fragments. Note the vertical orientation of some coarser clasts. PPL; width of view 11 mm.

The contact between Levels II and III in the studied thin sections (thin section SP1c) is microscopically sharp (Figure 9a). The sediment in thin section SP1c consists of spongy to granular burnt remains containing black amorphous aggregates of charcoal, but also charcoal pieces with plant cellular structure (Figure 9b). There is an abundance of bone with different degrees of burning and sizes down to a few microns (Figure 9b). Quartz grains and few brown decalcified soil aggregates also occur. No ash was identified, while the only calcareous material was 10% gravel-sized limestone *éboulis*.

In summary, Level III has *in situ* hearth remains. The calcitic ash has presumably dissolved away by the action of acidic pore water that might have reacted with organic matter such as guano (SHACHAK-GROSS *et al.* 2004). Mostly, the charred material does not resemble wood charcoal, but some grassy plant fibre. Alternatively, they may be wood charcoal that has been post-depositionally altered by humic acids. Level III also marks a change to more intense *éboulis* production than layers below suggesting probably a change to colder climatic conditions than below.

Level IV is a light brown clay-rich sediment with a granular structure that contains more gravel towards the rear wall of the rockshelter. On the southern profile a small channel-like feature has a clast-supported gravel with angular fine pebbles. This feature is called here Level IVa. The lower contact is abrupt to clear ranging over 3 to 5 cm. In places (e.g., southern profile), Level IV directly overlies Level VI. Some mixing in the materials within the underlying Levels V and VI is observed. Microscopically the contact between Levels III and IV is distinct and sharp (Figure 9c). Nevertheless, some fragments from Level IV are incorporated as rip-up clasts inside the burnt remains of Level III. The groundmass of the matrix-supported gravel is a dense massive sandy clay silt with porphyric coarse/fine related distribution and a few vughs or vesicles with bridge coatings (menisci). There are some faint indications for incipient development of platy microstructure probably due to freeze-thaw activity (Figure 9d) (VAN VLIET-LANOË, 2010). In particular, Level IVa (thin section SP3a) is a crudely sorted, subrounded gravel that is almost clast-supported having grains with dusty compound coatings made from silt, clay, and calcite. The matrix is finely granular locally with a spherical or even lenticular microstructure. Some dispersed charcoal pieces and a large amount of bone mostly non-burnt occurs, some of which have vertical orientations. Level IV contains sediment probably deposited by debris flows altered by weak cryoturbation. Level IVa was formed by channelized running water.

Level V appears to be a thin combustion feature with black, gray, and white sublevels that locally seem to be *in situ* features. This level appears only in the western profile. Erosional processes related to Level IV's deposition removed it from the southern and northern profiles. Since the lower contact is sharp, the fire was built on the erosional surface atop Level VI. In the western profile, its lower contact with Level VI appears to have been baked, suggesting an intact combustion feature sits on the surface of Level VI. Under the microscope, the sediment is coarse unsorted matrix-supported gravel. The clay-rich matrix is rich in charcoal fragments and burnt bone (Figure 9e). The groundmass has a spongy to granular microstructure. Level V contains mainly hearth debris, probably disturbed by slopewash and humans and to which roofspalling has added *éboulis*. Freeze-thaw action may have affected this unit.

Level VI has a light to medium brown colour. It contains clay in its matrix, and pebbles averaging 5-7 cm in diameter, but some bigger ones present. The contact with Level

VII below is clear ranging over 3 to 6 cm but elsewhere is very sharp. The very sharp contact occurs in places where the contact forms a basin. Both features hint that erosional processes have removed parts of Level VII. Microscopically the boundary with the underlying clay-rich Level VI is also sharp (Figure 9f). The sediment has a well- developed fine lenticular microstructure produced by freeze-thaw action (VAN VLIET-LANOË, 2010). The layer lacks much anthropogenic input. Fine material probably derived from the erosion on the hills above the rockshelter. Levels VI to IV have evidence for water flow, causing crudely sorted gravel and clay-rich sediment to accumulate and more erosional features, suggesting a more humid climate.

Level VII is dark brown to very dark grey level contains many clasts and with a sharp contact with the underlying level. Some clasts that cluster might be related to hearth construction. In the field, however, no clear signs of *in situ* burning features are apparent. Towards the back of the rockshelter, Level VII truncates features in Level VIII. Both Levels VII and VIII seem to have been disturbed by

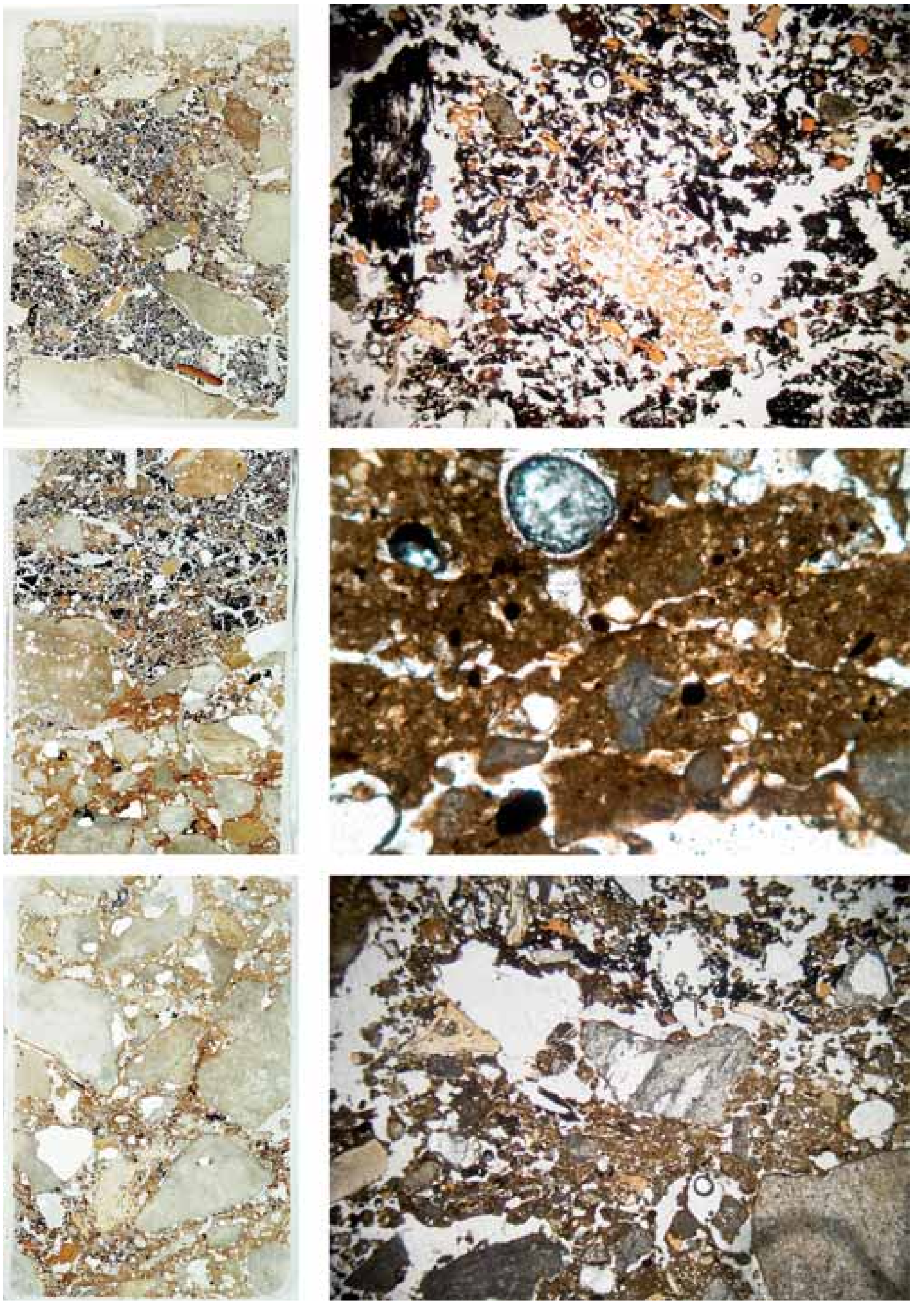


Fig. 9. Levels II to IV, a, macrophotograph of thin section SP1c showing burnt remains sharply overlain by layer II on the top of the thin section. Height of view 7.5 cm. b, Microphotograph of thin section SP1c showing black charred plant material and burnt bone (orange yellow). PPL; width of view 11 mm. c, Macrophotograph of thin section SP2 showing the sharp contact between layer III (burnt remains) and the clayey gravel layer IV. Rounded and elongated vesicles are visible. Height of view 7.5cm. d, Microphotograph of SP2 showing planar fractures probably related to freeze-thaw activity. PPL; width of view 2.7 mm. e, Macrophotograph of thin section SP3b. Limestone roof spall with some dispersed burnt remains towards the lower part. The contact of these remains and the underlying clayey sediment located in the lowermost part is shown better in Figure 10. Height of view = 7.5 cm. f, Microphotograph of SP3b showing the sharp contact between layers V and VI in the middle of the photo. Layer V has some black charcoal fragments and orange burnt bone. The lenticular structure of layer VI is visible below. Width of view 11 mm.

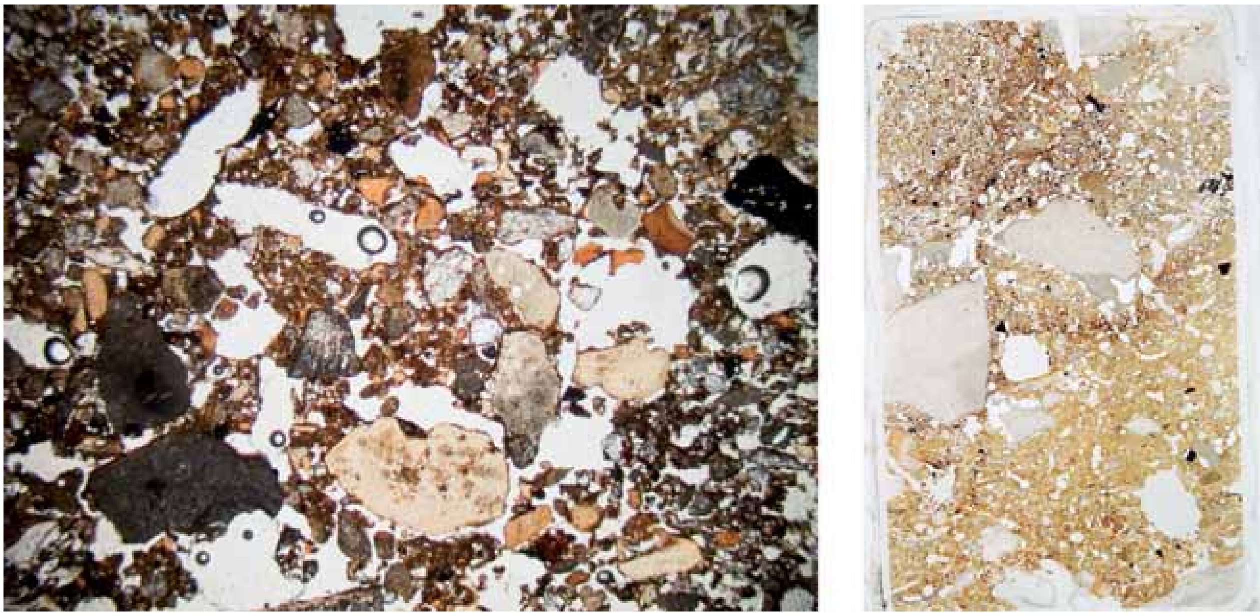


Fig. 10. Levels VII and VIII, a, Microphotograph of thin section SP3c showing a complex pore structure with elongated and rounded vesicles, channels and chambers. Also shown are beige rounded coprolite fragments and orange and yellowish angular and rounded bone and a black charcoal in the middle-upper right of the photo. PPL; width of view 11 mm. b, Macrophoto of SP3c showing some dispersed burnt remains on the top and a prominent reddish burnt horizon in the middle resting upon clayey sediment of layer VIII. Height of view 7.5 cm.

cryoturbation. Under the microscope the sediment of Level VII consists of sandy aggregates that look quite well sorted. The sand-sized grains consist of rounded bone fragments or clay silt rounded welded aggregates. They have also large irregular vughs with smooth walls, vesicles, and dusty clay coatings (Figure 11). Also, many angular to subrounded fragments of dusty apatite have quartz inclusions and many charcoal fragments but few burnt bone (Figure 10a). These may be hyaena coprolites (KARKANAS and GOLDBERG 2010b). All these rest upon gray dusty calcitic aggregates that resemble a sublayer of welded wood ash crystals with a spongy to vesicular microstructure. The lower part of this level consist of a reddish surface formed above the contact with the underlying Level VIII (Figure 10b).

The base of Level VII houses an *in situ* combustion feature. Above, slopewash has strongly reworked the sediment, which may indicate a gradual change to milder climatic conditions relatively to the layers below. However, the high amount of vesicles can be also attributed to thawing (VAN VLIET LANOË 2010). It contains a large concentration of carnivore coprolites.

Level VIII is a light brown clay-rich gravel with moderate numbers of pebble-sized clasts in the western profile, but with more pebbles towards the back. Some larger clasts occur in scattered locations. The contact with the underlying Level IX is gradual ranging over 5 to 10 cm. In Level VIII (thin sections SP4a, SP4b), the sandy to gravelly clay silt matrix contains high numbers of individual sand-sized grains of bone, limestone, and coprolite. The groundmass is rich in calcite and clay with a speckled birefringence fabric. Thin section SP4b shows more decalcification. The sediment has well developed lenticular to spherical microstructure typically seen in cryogenic features. Towards the base, the cryogenic features seem to be less developed. The bone is rounded with altered surfaces and isotropic rims. Coprolite apatite fragments also occur. The few charcoal pieces are rounded as well and incorporated inside the spherical aggregates (Figure 11). In summary, the Level is affected by intense freeze-thaw action. Most of the bone seems to derive from carnivore coprolites. There is little anthropogenic input.

Level IX resembles Level VIII, but has a darker red colour. Burning and subsequent post-depositional alteration may have produced some pink and red pockets with diffuse contacts (KARKANAS *et al.* 2002). Some darker lenses occur in the northeastern profile. In Level IX (lower part of Figure 11; thin sections SP5a, SP5b, SP5c), the slightly reddish brown sediment becomes more clay-rich than in Layer VIII, but the cryogenic features remain the same. Probably, cryogenesis affected both Levels VIII and IX at the same time. The contact between these two levels is quite sharp at the microscopic scale, considering the cyroturbation. In addition, the matrix near the contact is more decalcified. Compared to Levels VIII, Level IX has higher concentrations of reddish dusty clay coatings. Rounded bone and coprolite fragments reach 30% (Figure 11). Few rounded charcoal fragments occur. Towards its base, Level IX shows some banding, with charcoal and burnt bone. Cryoturbation has affected the lower part less. The base of Level IX has disturbed hearth remains. Strong cryoturbation has affected the layer. Input of carnivore coprolites greatly exceeds the little from anthropogenic sources.

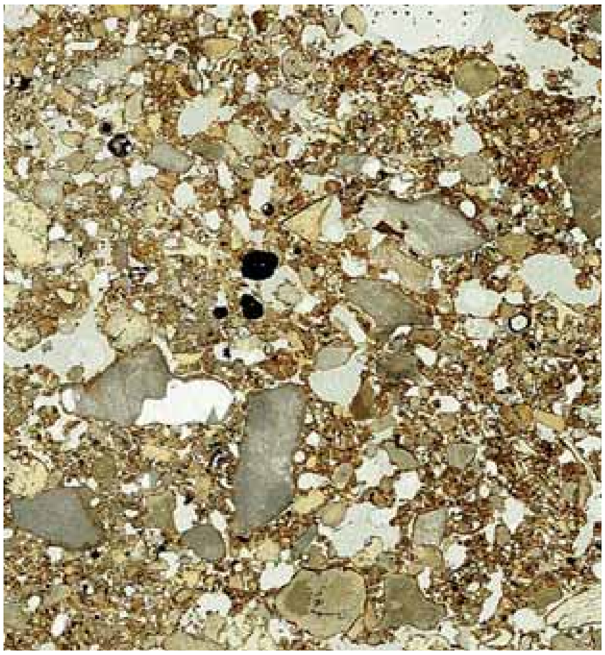


Fig. 11. Levels VIII and IX, Macrophoto (detail) of SP5b showing abundant yellowish rounded bone and corporlite fragments, gray subrounded limestone roof spall and black rounded charcoal. Height of view 2 cm.

Level X represents a beige silty lens separating dark burnt features in Level IX. Micromorphological sampling was not conducted in this level.

Level XI contains mostly silty clay with some fine clasts scattered throughout which become coarser towards the back of the rockshelter. Some tiny charcoal fragments are also dispersed in the unit. The contact with the underlying Level XII is very sharp and distinct. Some parts with higher concentrations of gravel occur near the contact with Level IX producing a kind of mixture of the two levels there and implying erosional processes. The matrix of Level XI (thin section SP6a) is a sandy clay silt with a decalcified groundmass and a stippled-speckled to granostriated microfabric with channel and chamber voids and a few vesicles. Evidence exists for rounded earthworm faeces. The sand-sized grains are all well rounded to subrounded coprolite apatite fragments (Figure 12). The matrix is also characterized by a high concentration of aggregated, decayed and amorphous organic matter. Some bone, mostly rounded and dissolved on the edges occurs, as do limestone *éboulis* with incipient apatite rim alteration. Level XI was mostly deposited naturally, probably by slopewash, and has been quite strongly bioturbated. Chemical alteration of the sediment involved its decalcification and the formation of apatite reaction rims on the large *éboulis* (KARKANAS and GOLDBERG 2010b). The alteration is probably attributed to decayed guano accumulated on an exposed surface (KARKANAS and GOLDBERG 2010a), hence the apatite reaction rims (chemical alteration). The amount of chemically altered organic matter, that appears to be guano, suggests that this unit may have been deposited during a mild climatic interval when little other sedimentation was occurring, which thus allowed the organic matter to accumulate. In addition, the large amounts of rounded coprolites and aggregated material and the presence of vesicles might be attributed to freeze-thaw processes that have post-depositionally affected the layer (VAN VLIET LANOË 2010). Both from field observations and micromorphological analysis, the nature of sedimentation and alteration changes at the top of Level XI. Thus, this marker horizon may be an unconformity.

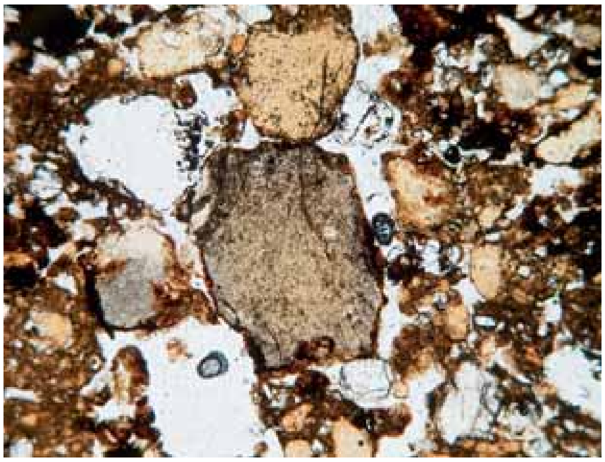


Fig. 12. Level XI, Microphoto of thin section thin section SP6a showing rounded and subrounded bone and coprolite fragments in an organic-rich (dark areas) sandy clayey matrix. PPL. Width of view 2.7mm.

Level XII contains a pale yellow to white clay-rich silt, with a few clasts scattered throughout. The level appears to be crudely laminated. The contact with the underlying Level XIII is mostly gradual ranging over 5 to 8 cm. The groundmass of Level XII (thin section SP6b) is exclusively calcareous, unlike Level XI. The sediment has a well-developed spherical to lenticular microstructure (Figure 13a). In the matrix, gray dusty micrite resembling wood ash has been reworked to cryogenic aggregates (Figure 13b), so some of the original combustion structures are not discerned. There are a lot of vesicles. A few gravel-sized *éboulis*, many vughs, and gastropod shells occur. Although less common than in Layer XI, some rounded coprolite fragments also occur. In summary, the sediment of this level is a mixture of wood ash and fine clastic material post-depositionally disturbed by intensive freeze-thaw activity. There are no signs of chemical alteration as above.

Level XIII is dark grey brown clay silt that grades laterally to almost black towards the northern profile. In the middle of the thin section SP7a, Level XIII, an *in situ* combustion feature has burnt bone associated with charcoal fragments in a unit that appears to have some fine layering (Figures 14a, 14b). The feature rests on more gravelly sediment that has a more complex microstructure, probably derived from combined bioturbation and cryoturbation. The ash aggregates, are larger and isolated. The groundmass becomes downwards gradually granular with open spongy microstructure and many channels. The sediment looks highly bioturbated and certainly ashy (thin section SP7b, Figure 14c).

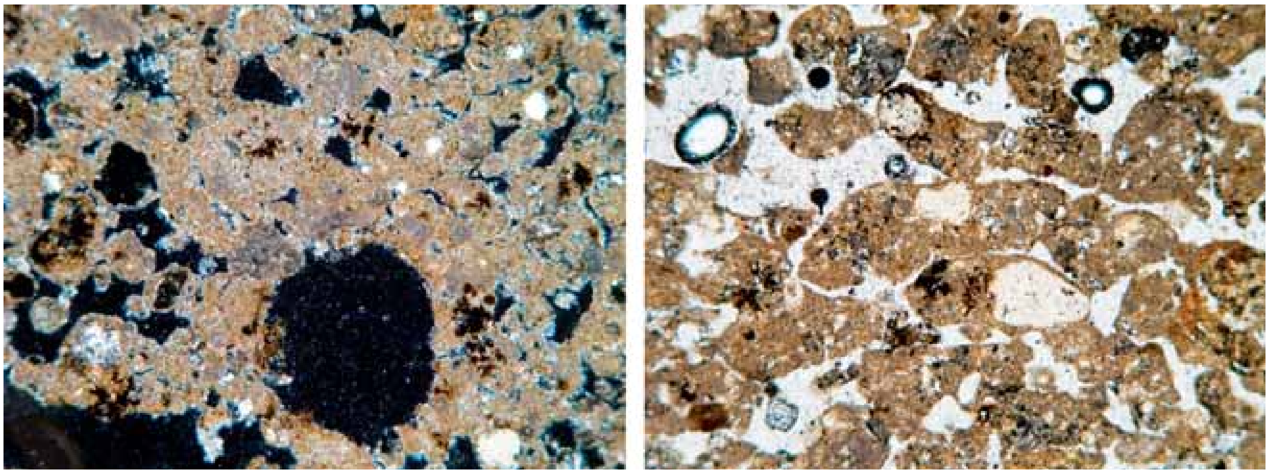


Fig. 13. Level XII, a, microphoto of SP6b. Note the dusty dotted gray aggregates attributed to ash crystals. Crossed polarized light (XPL). Width of view 2.7 mm. b, macrophoto of thin section SP6b showing well developed lenticular structure due to freeze-thaw activity, PPL. Width of view 2.7 mm.

Fig. 14. Level XIII, a, Macrophoto of SP7a. Note the dark thin combustion feature in the middle of the thin section. Height of view 7.5 cm. b, Detail of the combustion features shown in a. Note the burnt bone (yellowish to reddish) and the black charcoal fragments. Their association implies a mostly intact feature,PPL. Width of view 11 mm. c, microphoto of dark gray dusty wood ash aggregates, PPL. Width of view 2.7 mm.

It might represent dumped ashes, since no charcoal and no in situ structures occur, although the post-depositional alteration prevents more detailed observations. The few bones are mostly unburnt and few coprolite fragments occur. Some calcareous gastropod shell fragments are present.

Levels XIV and XV represent a complex sequence of lighter and darker sublayers and stringers. They contain clay, but also fine granular *éboulis*. Toward the back, the unit contains more clasts. In the test pit, Level XV was not fully exposed, making observations difficult. In the photos, it looks browner and more distinct from the layers above. Towards the bottom of thin section SP7b (Figure 14c), Level XIV, the gravel becomes better sorted and horizontally aligned possibly due to slopewash, while the matrix gets more clay-rich with less ash. Nonetheless, the bioturbated and spongy microstructure is still evident.

Levels XIV, XIII and XII formed thanks to anthropogenic processes. They all contain a high concentrations of wood ash, but only a sublayer within Level XIII appears to be an *in situ (sensu lato)* combustion feature. The majority could represent dumped or raked hearth debris. Bioturbation and cryoturbation has affected these units, suggesting that the sediment froze sometime after deposition.

5. DATING OF SOPEÑA

5.1. ^{14}C dates

Radiocarbon dates are now available from Levels II, III, X, XI, and XII, listed below (Table 1). Samples for these dates have been taken from the west area of the test excavation, since sediments by the eastern wall were more friable. Given that no vertical positions were taken during excavation of the test pit, samples were taken for radiocarbon dating from the last day Level XI was excavated and from the first day Level XII was dug.

Sample Number	Level	Material	Lab. No.	Conventional BP	Fairbanks 05 cal BC	CalPal 05 cal BC
SPN02-42137	II	tooth	Beta-198143	24300±170 BP	26937±197 BC	27274±423 BC
SPN02-45124	III	tooth	Beta-198144	21020±100 BP	23269±118 BC	23244±377 BC
SPN02-67606	X	tooth	Beta-198145	23550±180 BP	26145±209 BC	26462±349 BC
SPN02-06/07-I6	XI	bone	Beta-171157	32870±530 BP	35832±729 BC	36160±782 BC
SPN02-18/07-J6	XII	tooth	Beta-198146	38630±800 BP	43069±685 BC	41119±685 BC

Tabla 1: Sopeña, AMS 14C dates.

Although few in number, the dates from Levels III and X suggest a relatively rapid accumulation of the upper sequence over about four millennia (c. 27.2-23.2 ky BC, using the CalPal 05 determinations). The Level 2 date came from disturbed sediments and could well be intrusive.

The dates are consistent with the Gravettian or the late Aurignacian in the region. The earliest, and only arguably Upper Paleolithic Level XI, is apparently about nine millennia older (c. 36.2 ky BP). Unequivocally Mousterian Level XII dates to around 41.1 ky BC, again in keeping with late Mousterian dates north of the Ebro (ZILHÃO 2006). Although these small samples preclude more informed discussion of the industries present, recent work by Zilhão (2006, ZILHÃO *et al*. 2010), Szmidt *et al*. (2010), and Martínez-Moreno *et al*. (2010) suggest that a case can be made for assigning Level XI to a Proto-Aurignacian on purely chronological grounds (i.e., there are no artifacts in the small sample from the 2002 test that link Level XI to the Proto-Aurignacian). There is a second hiatus between Levels XI and XII, but there is little question that Level XII is Mousterian.

At present, and again keeping in mind that we are dealing only with a test pit here, there are no indications of a Châtelperronian occupation, such as has been reported at A Valiña Level III or IV North (FERNÁNDEZ *et al*. 1995, cf. VILLAR and LLANA 2001) in Galicia; Cueva Morín Level 10 (GONZÁLEZ ECHEGARAY and FREEMAN 1971, 1973), El Pendo (Level VIII) (GONZÁLEZ ECHEGARAY 1980) and possibly at El Castillo Magdalenian β (CABRERA *et al*. 2001) in Cantabria; Labeko Koba Level IX base (ARRIZABALAGA *et al*. 2003) in País Vasco; Cova dels Ermitons (MAROTO 1994), L'Arbreda Level H (ORTEGA and MAROTO 2001), and arguably at Reclau Viver Level 1-2 (MAROTO 1994, cf. ZILHÃO 2006: 32), in Catalunya.

In a long and comprehensive evaluation of Middle-Upper Paleolithic radiocarbon dates and their stratigraphic contexts from the Iberian Peninsula, Zilhão (2006) argues for a general Mousterian, Châtelperronian, Proto-Aurignacian, Aurignacian sequence for those few north Spanish sites (Labeko Koba, Morín) who dates and contexts he considers reliable. According to Zilhão, there is no good evidence for the Châtelperronian in Asturias. This reassessment, and above all its dating implications, has been contested by a number of authors (e.g., MARTÍNEZ-MORENO *et al*. 2010) who take issue with Zilhão's interpretations of both chronology and context.

Zilhão's skepticism about Middle-Upper Paleolithic transition chronologies arises from the fact that in the Greenland Ice Cores, the time interval before and after Heinrich Event 4, dated at c. 40 kya cal BP, is characterized by significant climatic instability, instability – he claims – that is widely manifest in Iberian cave and rockshelters by the formation of palimpsests due to geological disturbances, and to erosional or depositional hiatuses (2006: 64). Thus radiocarbon dates in the transition interval should be subjected to particularly intense critical scrutiny (2006: 64). Whatever the case, Zilhão maintains that north of the Ebro Valley, from Asturias in the west to Catalunya in the East, and in those sites that pass his taphonomic 'test', (1) a well-defined Proto-Aurignacian can be detected above the latest Mousterian levels (and above the Châtelperronian in those few sites where he believes it can be documented), (2) that the Proto-Aurignacian and Châtelperronian, when reliably dated, are contemporaneous and date to c. 42 ka cal BP, and finally, that (3) this chronological horizon marks the latest persistence of Neandertal-associated technocomplexes in these regions (2006: 66).

5.2 ESR dates of Sopeña

Although samples below Level XII were submitted for ^{14}C dating, these yielded results that may not be reliable. At Sopeña, the older deposits cannot be dated with ^{14}C, because their age exceeds the reliable limit for this method (MENDONÇA *et al.*, 2006; CONARD & BOLUS, 2003). Therefore, five teeth were dated using electron spin resonance (ESR). ESR can date fossils whose ages fall between the minimum 39Ar/40Ar and maximum ^{14}C dating limits, a critical time in human evolution (SKINNER *et al.*, 2005). Since few teeth were recovered in the test excavation at Sopeña, we used those available (Table 2). During the test excavation, few coordinates of individual finds where taken. Furthermore, the wall on the eastern side of the test pit slopes towards the east (Figure 5) Sediment lying nearby was more friable (Figure 5). Since the vertical position for each tooth within each level is not known, these dates remain less precise than we would like.

Number		Location		Sample	
Sample	Catalogue	Layer	Location	Species	Tooth
FT52	2005SP02	XI	Test Pit	Cervid	molar
FT53	2005SP03	XII	Test Pit	Cervid	molar
PT7	2005SP05	XIII	Test Pit, J6	*Bos/Cervus*	Upper left incisor 1
PT9	2005SP08	XIV	Test Pit, I6	*Rupicapra*	Right lower molar 1 or 2
PT8	2005SP10	XV	Test Pit, J6	*Rupicapra*	Lower left molar 1 or 2

Tabla 2: Teeth dated by ESR in the study.

5.3 ESR Theory

The ESR signal results when ionizing radiation (*α, β,* or *γ*) from internal and external radiation sources, such as U, Th, Rb, and K, produces unpaired electrons trapped in a crystal lattice. As radiation increases, the ESR signal height increases proportionally. At signal saturation, where no traps are empty, electrons can no longer be trapped at the defect, and ESR signal growth stops. Therefore, adding more radiation does not increase the signal height, and thus, sets the maximum ESR dating limit. The minimum detectible peak height sets the minimum dating limit.

In tooth enamel, the ESR hydroxyapatite signal at g = 2.0018, is extremely stable with a mean signal lifetime of ~ 10^{19} years at 25°C. Heating enamel does not zero its signal until temperatures exceed 300°C. Grinding the enamel does not affect the signal (SKINNER *et al.*, 2000). To calculate ESR ages for teeth, the following equation is used:

$$A_{\Sigma} = A_{int} + A_{ext} = \int_{t_0}^{t_1} D_{\Sigma}(t)\, dt = \int_{t_0}^{t_1} (D_{int}(t) + D_{ext}(t))\, dt$$

where A_{Σ} = the total accumulated dose in the sample,

A_{int} = the internally derived accumulated dose component,

A_{ext} = the externally derived accumulated dose component,

$D_{\Sigma}(t)$ = the total environmental dose rate,

$D_{int}(t)$ = the dose rate from internal sources: U, its daughters, and any other radioisotopes,

$D_{ext}(t)$ = the dose rate from external sources: sedimentary U, Th, and K, and the cosmic dose,

t_1 = the sample's age,

t_0 = today (Blackwell, 2006).

To determine the accumulated dose, A_{Σ}, with the additive dose method, 10-15 aliquots are irradiated with precisely known added radiation doses. After graphing their peak heights versus their added doses, the exponential growth curve is extrapolated to the x-intercept, A_{Σ} (BLACKWELL, 2006).

In fossil teeth, U is the major contributor to the internal dose rate, $D_{int}(t)$. Live teeth do not contain U. As teeth fossilize, they absorb U from the surrounding groundwater, but the U uptake rate can vary. Although coupled $^{230}Th/^{234}U$-ESR dating can determine the U uptake rate, models are often used to calculate preliminary ESR ages. Early uptake (EU) assumes that the tooth absorbed its U immediately after deposition, giving a minimum age for the tooth. The linear uptake (LU) model assumes that the tooth absorbed U at a constant rate throughout its burial history. LU yields a median age for the tooth. By assuming that the tooth absorbed its U late in its history, recent uptake (RU) yields the maximum age for a tooth. LU often works best for teeth from 30-100 ka (BLACKWELL, 2001).

U decays to produce radon gas (Rn). Rn can escape from any cracks in the tooth which causes the tooth to have a smaller $D_{int}(t)$ due to the lost radiation from the Rn and its daughters. This lost Rn causes the age of the tooth to be underestimated. To test the effect from Rn loss, ages are recalculated using different Rn losses. If the losses do not produce a significant change in the ages, then the effect is assumed to be unimportant.

Radioactive elements, such as U, Th and K, in the surrounding sediment, and cosmic radiation contribute to the external dose rate, $D_{ext}(t)$. γ radiation penetrates 30 cm, *β* radiation, 3 mm, and *α* radiation, 20 *µm*. Neutron activation analysis (NAA) is used to measure the sedimentary trace element concentrations. When the sediment in a level is heterogeneous or thinly bedded, different minerals or layers contain different U, Th, and K concentrations that emit different radiation doses. Therefore, the trace element concentrations must be measured and averaged by their sedimentary volumetric percentage to the sphere within the 30 cm around tooth which generates $D_{ext}(t)$ (BLACKWELL & BLICKSTEIN, 2000).

Reworking occurs when an animal or erosion moves a tooth from its original location. Moving the sample changes its Dext(t) by exposing the sample to a different sedimentary dose rate than that at its initial location. Reworked teeth can usually be recognized by dating 3-5 teeth from the same layer. If all the sample ages agree, reworking for any is unlikely (BLACKWELL, 1994). Sedimentary water absorbs radiation. In karst systems, where the water levels can change rapidly as subterranean pipes fill and empty affecting the water saturation within the layers, $D_{ext}(t)$ also changes, because high water concentrations absorb more of the radiation, reducing that received by the teeth. At Sopeña, for example, the cave mouth has been constantly eroded back, as the cliff face has eroded back by valley downcutting, making the cave shallower and, probably, the sediment less damp as air circulation improved. Therefore, $D_{ext}(t)$ has likely changed over time for the samples in the lowermost layers. To find the effect of fluctuating water content on $D_{ext}(t)$, the modern moisture sediment moisture content percentages were calculated. Moisture contents were measured by comparing the sediment sample masses before and after, heating the sample to remove water.

5.4 Analytical Method

After drawing and photographing the tooth from six different perspectives, the enamel and dentine thicknesses were measured using a CD-4C digital caliper. All dentine was removed from the enamel using a hand-held diamond-tipped Dremel drill. With a Mitutoyo ID-C112CEB micrometer, enamel thicknesses were measured in 20-40 places before shaving 20 μm off each enamel side to remove the α-doped enamel. The enamel was powdered with an agate mortar and pestle to 200-400 mesh (38-76 μm). After weighing the enamel into 10-16 aliquots each weighing 20.0 ± 0.2 mg, the aliquots were irradiated by ^{60}Co γ source with doses ranging from 0-256 krad at ~ 9.7 rad/s and annealed at 90°C for 3 days to remove short-lived interference signals (SKINNER *et al.*, 2000). The ESR spectra were measured in a JEOL RE-1X spectrometer at microwave frequency of 9.45 GHz at 2.0 mW, under 100 kHz field modulation of 0.5 mT centered at 360 mT, with a 0.1 s time constant, samples were scanned for 8 minutes with receiver gains set to maximize peak height measurement precision.

About 700 g of each powdered sediment and ≥ 1-1.5 g of powdered enamel and dentine for each tooth were analyzed by NAA. For U, samples were counted for 60 s in a delayed neutron counting (DNC) system following a 60 s irradiation and a 10 s delay. For K, samples were irradiated for 60 s, and then counted for 20 min using a γ counter after a 24 h delay. For Th, samples were irradiated for 60 min with a 1 week delay and analyzed on a γ counter for 20 min.

5.5 Data and Error Analysis

The accumulated dose, A_{Σ}, and its errors were found by plotting the peak heights versus the added dose and then extrapolating from the exponentially fitted curve using the VFit program, using a 1/*f* weighting. The ESR ages, dose rates, and their errors were calculated using Rosy v. 1.4.2, which corrects for attenuation in β and γ doses from sedimentary water, enamel and dentine density and thicknesses, and tissue composition. Rn loss was assumed to be 0 ± 0%. The α/γ efficiency was assumed to be 0.15 ± 0.02. For the age calculation, the sediment dose rates were corrected to 15 ± 3 wt% water, as determined from the drying experiment. External dose rates, $D_{ext}(t)$, were calculated by averaging the different dose rates from each sediment sample within a given level (Table 3). To determine volumetric averages for

		Concentrations			External Dose Rates[1]	
Layer		[U]	[Th]	[K]	$D^{BG}_{ext,\beta}(t)$[2]	$D^{BG}_{ext,\gamma}(t)$[3]
(analyses)		(ppm)	(ppm)	(ppm)	(mGy/y)	(mGy/y)
VIII		1.30	1.78	0.42	0.113	0.269
(1)	±	0.06	0.14	0.08	0.009	0.009
IX		2.10	4.31	0.96	0.281	0.587
(1)	±	0.49	0.32	0.47	0.023	0.017
X		1.27	1.87	0.35	0.108	0.269
(1)	±	0.02	0.14	0.01	0.009	0.008
XI		1.73	3.81	1.68	0.292	0.592
(1)	±	0.20	0.13	1.68	0.026	0.020
XII		1.38	2.74	0.72	0.180	0.340
(4)	±	0.22	1.17	0.32	0.014	0.010
XIII		1.49	2.47	0.56	0.157	0.365
(3)	±	0.25	0.52	0.12	0.030	0.069
XIV		1.60	2.09	0.47	0.140	0.335
(4)	±	0.30	0.46	0.07	0.011	0.010
XV		1.52	3.42	0.65	0.201	0.462
(3)	±	0.50	1.09	0.38	0.016	0.012
éboulis		0.79	-[4]	0.50	0.111	0.187
(1)	±	0.02	-	0.01	0.011	0.011
Detection	~	0.01	0.20	0.001	-	-
limits[4]	±	0.02	0.50	0.002	-	-

[1] Abbreviations:

$D^{BG}_{ext,\beta}(t)$ = external dose rate derived from β sources

$D^{BG}_{ext,\gamma}(t)$ = external dose rate derived from γ sources

[2] Calculated assuming
enamel water concentration, W_{en} = 2. ± 2. wt%
sedimentary water concentration, W_{sed} = 10. ± 5. wt%
enamel density, ρen = 2.95 ± 0.02 g/cm³
sediment density, ρsed = 2.65 ± 0.02 g/cm³

[3] Calculated assuming
cosmic dose rate, Dcos(t) = 0.000 ± 0.000 mGy/y

[4] Below detection limit: For calculations assumed to be 0.0 ± 0.0 ppm.

[5] Typical NAA limits depend on sample mass and mineralogy.

Tabla 3: Mean radioactivity in the sediment from Sopeña.

the five test samples, the minimum and maximum possible $D_{ext}(t)$ for each tooth was calculated from an average of its possible $D_{ext}(t)$, given its range of possible positions within the layer. This enabled us to estimate ESR ages and their maximum and minimum values for each tooth (Table 4). Possible systematic errors for ESR dates can include incomplete annealing, α attenuation, and contamination. Incomplete annealing allows short-lived signals to remain, and thus, causes errors in determining the accumulated dose. Because α radiation penetrates 20 µm in hydroxyapatite and Rosy v. 1.4.2 ignores α attenuation, the $D_{int}(t)$ values would be underestimated if 20 μm were not removed off the enamel surfaces. If sediment, dentine, or cementum contaminated the enamel, the enamel U concentrations would be overestimated and cause $D_{int}(t)$ to be overestimated. Since much more than 20 μm was removed from the enamel surfaces, neither of these is likely a source of substantial error.

5.6. Results of the ESR analysis

Five teeth from the test pit were dated by standard ESR. In the dentine, the maximum U concentration was

3.06 ppm, while enamel U concentrations averaged < 1 ppm. These values are typical for teeth less than 100 ka from cave systems (BLACKWELL *et al.*, 2001). As a result of the low U concentrations, Rn loss and the differences in the assumed U uptake model does not greatly affect the calculated ages (Table 4). Only LU ages are discussed here since, the LU model provides a median age, when the actual U uptake model is unknown. To assess the external dose rates, $D_{ext}(t)$, 19 sediment samples were analyzed by NAA (Table 2). The U concentrations are fairly consistent throughout the sedimentary sequence ranging from 1 to 2.44 ppm. The Th show more variation ranging for 1.52 to 5.06 ppm, suggesting higher clay or organic matter contents in those locations (BEDNAR *et al.*, 2003). Several sediment samples show unusually high K concentrations, which may have resulted from the recent addition of goat feces to the surfaces of exposed layers. Nonetheless, $D_{ext}(t)$ for the layers remain reasonably consistent, averaging between 300 and 400 μGy/y, except for Layers 9 and 11. As might be expected, however, the *éboulis* has a much lower $D_{ext}(t)$. Thus, when higher concentrations of *éboulis* occur within a layer as small fragments in the sediment, or sit near the tooth as large blocks, the volumetrically averaged external dose rate, $\overline{D}_{ext}(t)$, drops in response. Because precise XYZ coordinates were not available for the teeth dated here and no sediment samples were available from Layer XVI, $\overline{D}_{ext}(t)$ reported here have larger uncertainties than if the sediment had been collected and volumetric averaging had been done with precise locations.

			U Concentrations		External Dose	Accumulated	Standard ESR Ages[1]		
Sample	Layer		Enamel	Dentine	Rate, $\overline{D}_{ext}(t)$	Dose, A_Σ	EU	LU	RU
			(ppm)	(ppm)	(mGy/y)	(Gray)	(ka)	(ka)	(ka)
FT52en1+2	XI		0.05	2.33	0.444	22.97	32.7	40.3	48.6
		±	0.02	0.02	0.063	0.91	3.4	4.8	6.9
FT53en1-4	XII		0.05	2.34	0.407	27.24	38.4	49.3	69.2
		±	0.02	0.02	0.058	1.04	3.4	5.3	7.4
PT7en1	XIII		0.05	2.97	0.365	23.70	50.3	57.1	64.9
		±	0.02	0.02	0.071	1.20	9.6	12.5	15.8
PT9en1	XIV		0.72	3.06	0.346	22.00	41.1	50.4	62.7
		±	0.02	0.02	0.069	1.50	6.0	8.7	11.7
PT8en1	XV		0.93	3.002	0.358	23.88	49.3	57.2	64.7
		±	0.02	0.02	0.089	1.50	9.2	12.3	16.3

[1] Abbreviations: EU = assuming early U uptake, p = -1
LU = assuming linear (continuous) U uptake, p = 0
RU =assuming recent U uptake, p = 10
Calculated using αefficiency factor, k_α = 0.15 ! 0.02
initial U activity ratio, $(^{234}U/^{238}U)_0$ = 1.20 ! 0.20
enamel water concentration, Wen = 2. ! 2.wt%
dentine water concentration, Wden = 5. ! 2.wt%
cementum water concentration, Wcem = 5. + 2.wt%
enamel density, $®_{en}$ = 2.95 ! 0.02 g/cm³
dentine density, $®_{den}$ = 2.85 ! 0.02 g/cm³
cementum density, $®_{cem}$ = 2.75 ! 0.02 g/cm³
radon loss from the tooth, Rn_{tooth} = 0. ! 0.%
sediment density, $®_{sed}$ = 2.66 ! 0.02 g/cm³
[2] Assumed value based on average for nearby layers.

Tabla 4: Preliminary ESR Ages for the Sopeña Teeth.

The accumulated doses, A_Σ, did not show large variations among the teeth. All A_Σ have less than a 5% uncertainty, but the uncertainties in the LU ages averaged ~ 10-15 %, due to the large associated uncertainties in $\overline{D}_{ext}(t)$. Because the teeth were small, each tooth yielded only a small amount of enamel, and only one subsample per tooth. When more teeth have been analyzed from each layer, the uncertainties will be reduced. Dating more teeth would also help to ascertain if any of the layers contain reworked teeth.

From Level XI, FT52en1+2 yielded an LU age of 40.3 ± 4.8 ka, which agrees well with the calibrated AMS ^{14}C age of 38.3 ± 0.7 ka for a bone fragment from the same layer. While these two ages are statistically identical, at this time range, a consistent age underestimation for AMS ^{14}C age compared to $^{230}Th/^{234}U$ and ESR ages has been reported at other sites in this time range (e.g., BLACKWELL *et al.,* 2008). The ages for the teeth from Layers XII-XV ranged between 49.3 ± 5.3 ka to 57.2 ± 12.3 ka. The LU ages for FT52en1-2 and FT53en1-4 showed a 9 ky gap between Layer 11 and Layer 12. When tested, assuming other values for the Rn loss. Given their uncertainties, little difference in age may exist between Layers XII to XV. Even Layers XI and XII do overlap in age at the 95% confidence limit, although this apparent time gap appears somewhat more robust given the ages now available. Only more dating of all the layers can hope to answer these questions. Therefore, the Sopeña teeth yielded preliminary ages ranging from 40.3 ± 4.8 ka for Level XI and 49.3 ± 5.3 ka to 57.2 ± 12.3 ka for Level XII-XV.

6. LITHIC ANALYSES

6.1 The Middle Paleolithic Sequence (Levels XII-XVI)

The Middle Paleolithic sequence consists of Levels XII-XVI, although the deepest level for which we have complete data is Level XV, and Level XVI is not included in these analyses. Bedrock was not reached in the 2002 test, and ground penetrating radar assays indicate as much as 7 m of so-far untested deposits below Level XV. The transition to the Middle Paleolithic is marked stratigraphically by a dramatic change in color and texture from overlying Upper Paleolithic Level XI (Figure 6). A typical Mousterian point was recovered from Level XII, and sidescrapers are abundant in it and in the underlying levels (especially in Levels XIV, XV) (Figure 15).

Level XII yielded a total of 187 lithics, 18.2% of the combined total (1029) of lithics and organic remains (bone, antler, teeth = 842 pieces). Organic remains far exceed lithics throughout the sequence, and on any index (i.e., number, weight) (Figure 16). Débitage was classified according to 25 categories developed by CLARK *et al.* (1986) to monitor the various phases in the reduction process. This should allow us to determine whether and to what extent primary reduction, secondary retouching etc. was taking place in any given level, and to compare levels with one another. Cores were also classified according to nine categories, and were scored as exhausted if it appeared that no additional flakes >2.5 cm could be detached from them (Table 5).

CORES 2, SHATTER & RAW MATERIAL												
	chunk/	core ren	Plat		RM	RM	RM	RM	RM			
glob'lar	Frag	flk	Tablet	shatter	qt'zite	limest	flint	quartz	other			
RETOUCHED PIECES 1												
ES on	ES on	ES fan	ES	ES	ES	ES	ES ret	ES ret			SS	
Blade	Flake	shpd	circular	thumb	keeled	nosed	flk	bld	ES/BU	ES/SS	strait	SSconv
RETOUCHED PIECES 2												
SS	SS	SS	SS	SS	SS	BU dih	BU dih	BU dih	BU	BU on	BU trc	BU mlt
convav	Dbl	déjeté	trnsvrs	inverse	other	st	angle	mult	carn't	trunc	mult	mix
RETOUCHED PIECES 3												
BU on		BU	BU		notch		notch +					
Break	BU flat	parrot	Other	notch	Clacton	dentic	dentic	CRP 1	CRP 2	CRB 1	CRB 2	
RETOUCHED PIECES 4												
		backed	natbk	backed	backed	pointd	bkdptd	curved	truncat	Gravet	Chatel	ret bldt
perfor	Bec	blade	blade	flake	bldt	bldt	bldt	bk bldt	bldt	point	point	other
RETOUCHED PIECES 5												
Pièce		Moust	Moust	Moust	Tayac	Moust	Moust	Moust	Moust	HD	HD chp	HD
Esqil'è	Wedge	point	lev pt	lev flk	point	cleaver	clv flk	biface	various	chop'r	chpng	ham'st
RETOUCHED PIECES 6												
	Dufour	notch'd	dentic	geom	micro	Aurig	Aur str	After Clark *et al.*, 1986				
raclette	Bldt	bldt	bldt	bldt	gravet	blade	blade					

Tabla 5: Categories of classification for lithic analyses.

Level XII metrics underscore a striking difference in size and weight when compared with overlying Level XI (Figs. 17, 18; Table 4). Average lithic length was 35.5 mm (v 25.2 mm in Level XI); weight was 10.3 g (v 3.7 g in Level XI). This increase in lithic metrics is unrelated to raw material shifts, as quartzite is the dominant raw material type throughout the sequence. In fact, quartzite accounts for only 52.5% of the lithic total in Level XII; the other levels in the Mousterian sequence (XIII-XVI) average 75.2%, only slightly higher the average for Upper Paleolithic Levels IX-XI (71.3%) (Figure 19, Table 4). The increase is most likely due to increased emphasis on the production of larger flakes and thick sidescrapers made on those flakes and on small quartzite pebbles. Level XII does show a sharp increase in the use of limestone (26.7% v bracketing Levels XI [14.6%] and Level XIII [13.1%]). Flint accounts for 7.5%, very close to Upper Paleolithic Levels X (7.8%) and XI (8.2%). Raw material diversity (‘other’) reaches a maximum (13.3%) in Level XII.

The Level XII débitage component closely resembles that of bracketing levels so far as primary decortication flakes (1DC) are concerned (2.8%, v 3.2% in Level XI, 4.8% in Level XIII). In fact, Levels IX-XVI all exhibit low numbers of 1DC flakes, suggesting that primary reduction took place off site, or at least outside the area sampled by the 2002 test excavation. Secondary decortication flakes (2DC) account for 21.4%, and in that respect resemble Level XIV (20%), suggesting a relatively large amount of secondary reduction compared to the rest of the lower sequence (Levels IX-XVI) (Figure 20). Plain flakes (those exhibiting no cortex) account for 55.7% of the débitage total, surpassed only by Level XIII (66.1%). Plain flakes tend to dominate the débitage total in all levels, and it is likely that many of them were utilized, although no edge ware studies have been undertaken as yet to ascertain the extent of utilization. In contrast to bracketing levels, trimming flakes are uncommon in Levels XII (12.9%) and XIII (12.1%). These are flakes that measure <1.0 cm along their longest axis, generally taken to be too small to use as is. In some contrast, bracketing Levels IX-XI and XIV-XVI all show much higher trimming flake frequencies (32.5-63%), suggesting that relatively little secondary retouching was taking place in Levels XII and XIII when compared with the rest of the lower sequence. Blades are generally uncommon in the lower sequence. In Level XII, 2DC blades account for 2.9%, first and second order blades for 1.4% each, and bladelets (blades <3 cm) for 1.4% of the débitage total. As is true of the entire Sopeña 2002 test sequence, opposed or multiple cores are the most common type in Level XII (100%). There are no Levallois pieces, nor evidence of Levallois technology, with the possible exception of the single - but typical - Mousterian point, perhaps made on a Levallois point blank. Shatter accounts for 26.6% of the Level XII débitage total (Figure 21). Only nine retouched pieces were recovered (7.6%), the only diagnostic piece being the Mousterian point. Ubiquitous, ‘expedient’ notches and denticulates, and a single sidescraper were also recovered (Figure 15).

Level XIII yielded a total of 130 lithics, 16.1% of the combined total (808) of lithics and organic remains (bone, antler, teeth = 678 pieces) (Figure 16). The incidence of lithics closely resembles that of Level XII (18.2%); in underlying Levels XIV and XV the relatively frequency of lithics declines further still (7.9, 5.4% respectively). Level XIII lithic metrics show an average length of 33.8 mm, slightly less than Level XII (35.5 mm) and part of a gradual and regular decrease in size that continues to the end of the sequence (Level XIV 32.6, Level XIV/XV 31.1, Level XV 28.2 mm) (Figure 17). Weights, on the other hand, display a less regular pattern. Level XIII lithics (9.0 g) are lighter than expected given their size, suggesting a relatively high incidence of long, thin pieces. Levels XIV (10.3 g), XIV/XV

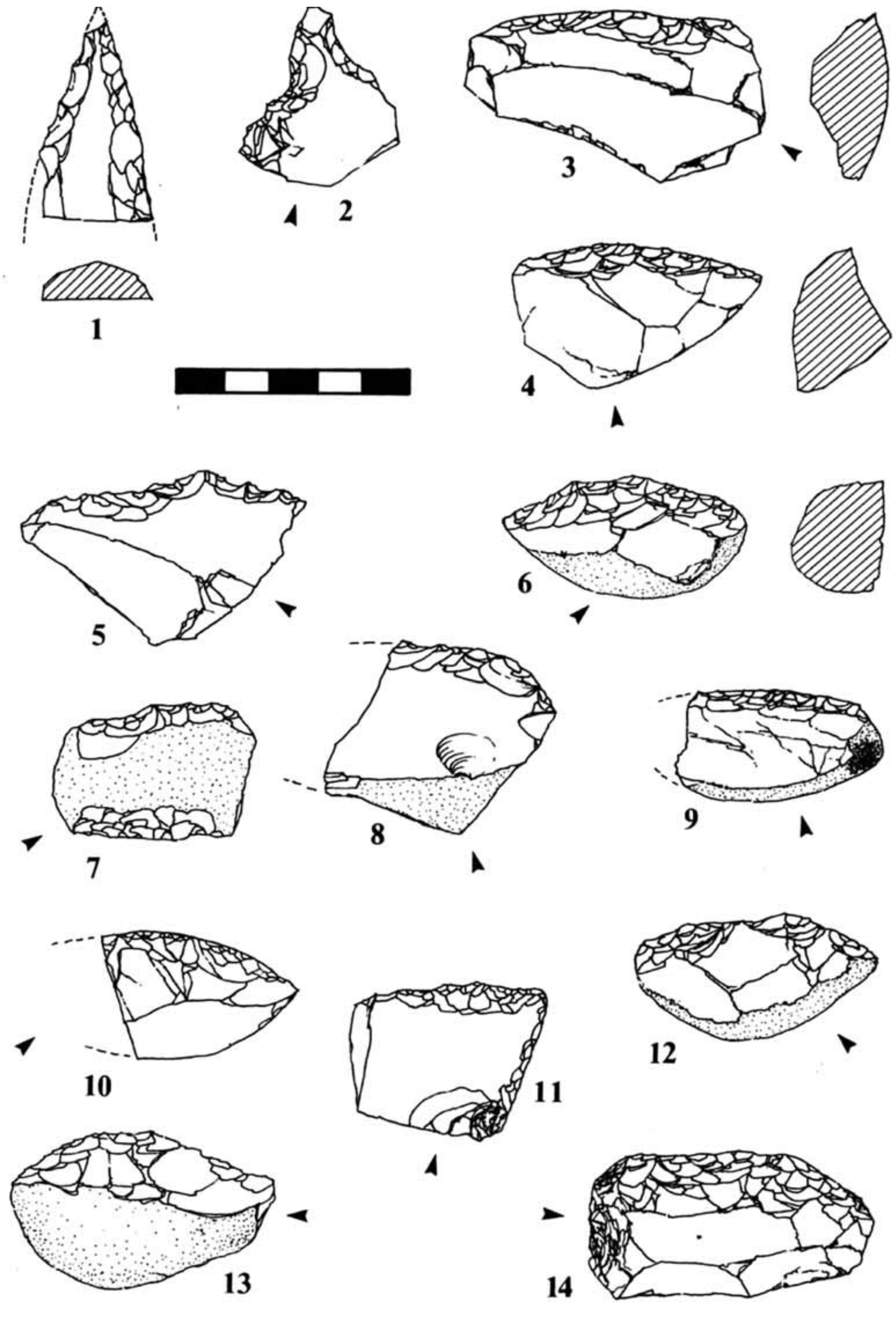


Fig. 15. Middle Palaeolithic Mousterian tools from Sopeña: 1 Mouste-rian point, 2 notch/bec, 3 & 4 convex sidescrapers, 5 denticulate, 6 con-vex sidescraper, 7 double sidescraper, 8 convex sidescraper fragment, 9 straight sidescraper with battering on one end, 10 convex sidescraper fragment, 11 double convergent sidescraper, 12 & 13 convex sidescrapers, 14 straight sidescraper. All in quartizite, scale 5cm.

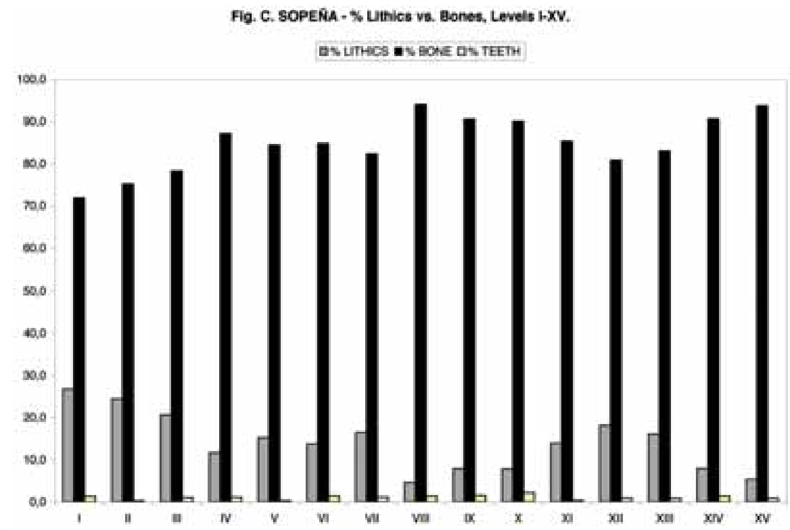


Fig. 16. Sopeña. Frequency of lithics, bones and teeth, Levels I-XV.

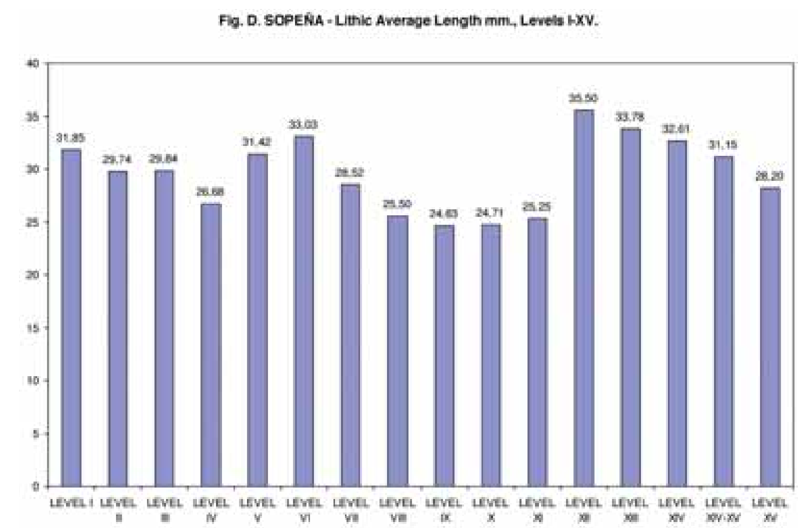


Fig. 17. Sopeña. Lithics, average length of complete pieces in millimetres, Levels I-XV.

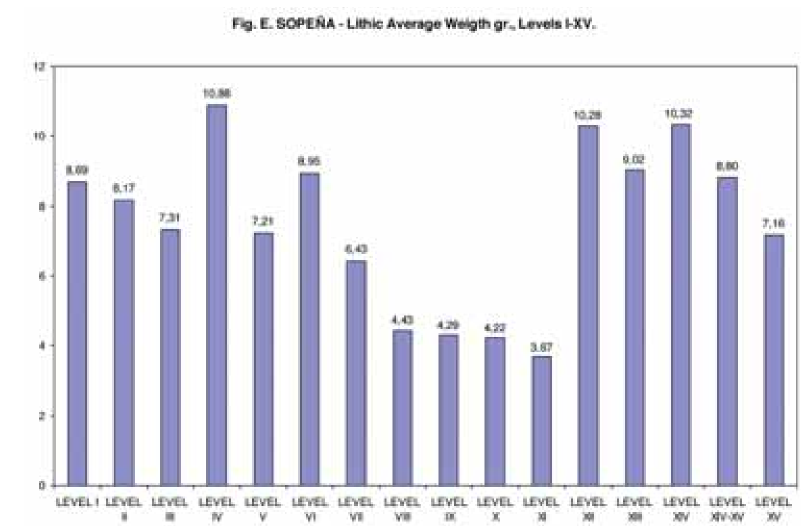


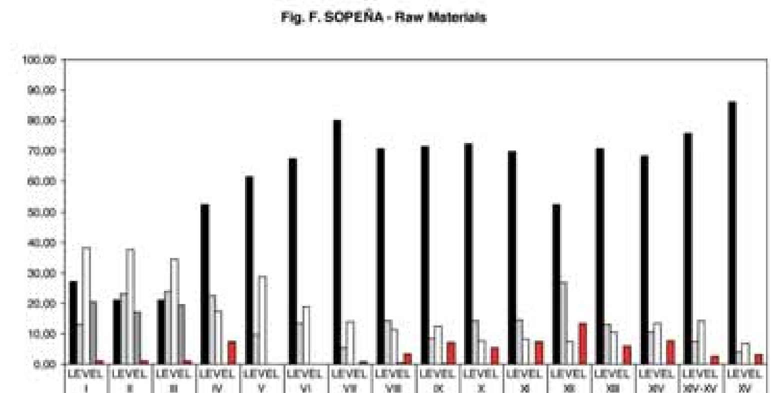
Fig. 18. Sopeña – Lithichs, average weight of all pieces in grams, Levels I-XV.

(8.8 g), and XV (7.1 g) exhibit the expected relationship between size and weight (Figure 18). Level XIII raw material distributions are broadly similar to those of bracketing levels, and are again dominated by quartzite (70.6% v 52.5% in Level XII, 68.3% in Level XIV), followed by limestone (13.1%), flint (10.5%) and other (5.9%). It is interesting to note that there is no quartz in any of the Mousterian levels, whereas quartz is common in Levels I-III, and traces show up Levels VIII and IX, all in the Upper Paleolithic sequence (Figure 19).

Débitage characteristics do not differ significantly from those of Level XII. Primary decortication flakes (4.8%) are slightly more common, and secondary decortication flakes (13.7%) are somewhat less frequent than in Level XII. Plain flakes (66.1%) reach their highest values in the lower sequence, perhaps suggesting more secondary reduction. Like Level XII, trimming flakes are rare (12.1%), an observation that sets these two levels apart from all the rest of the lower sequence (Figures 20, 21). Cortical blades are generally rare in Levels IX-XVI, but are somewhat less common in Level XIII (1.6%) than in Level XII (2.7%). First order blades are slightly more numerous (1.6%) in Level XIII than in Level XII (1.4%), whereas second order blades and bladelets are absent altogether. There are no cores in Level XIII, only core fragments and chunks. Small numbers of opposed and multiple platform cores are found in all the rest of the lower levels. Shatter accounts for 13.6% of the collection (v 26.2%, 10.5% in Levels XII and XIV respectively) (Figure 21). Only eight retouched pieces were recovered, all non-diagnostic notches, denticulates and continuously retouched pieces (CRPs).

The small collection from Level XIV resists statistical analysis, but it should be noted that Levels XIV-XVI were sometimes combined due to difficulties in distinguishing them from one another in the test pit. This results in a combined Level XIV-XV and a separate Level XV, to be discussed below. Level XIV proper yielded only 90 lithics, 7.9% of the combined total (1132) of lithics and organic remains (bone, antler, teeth = 1042 pieces), the lowest relative frequency of lithics in the site (Figure 16-18). Average length is 32.6 mm, squarely in the middle of the regular decrease in lithic length over the Mousterian sequence (Figure 17); the average lithic weight is 10.32 g, virtually identical to that of Level XII (10.29 g) (Figure 18). The raw material composition is unexceptional, with quartzite once again dominant (68.3%), followed by limestone (10.6%), flint (13.5%) and other (7.7%) (Figs. 19, 20). The débitage frequencies are 1DC flakes (2.7%), 2DC flakes (20%), plain flakes (33%, rather low v bracketing levels), and trimming flakes (37.3%, about average for the lower sequence and markedly higher than Levels XII and XIII) (Figure 21). Blades and bladelets are always rare (cortical blades, 1.3%; first order blades, 1.3%; second order blades, 2.7%; bladelets, 1.3%). The two formal cores are both opposed and multiple platform types; one is a flake core, the other a mixed flake and blade core. Shatter makes up 13.6% of the débitage (Figure 22). Despite the small sample size, five sidescrapers were recovered; the rest of the retouched pieces were non-diagnostic.

Level XIV-XV constitutes a combined sample that, together with Level XV, comprises 5886 pieces. These two collections will be analyzed together. The combined collections yielded a total of 319 lithics, a meagre 5.4% of the combined total (5886) of lithics and organic remains (bone, antler, teeth = 5567 pieces). Because of the very high incidence of organic remains, these levels represent the lowest lithic relative frequencies in the Mousterian sequence (Figure 16). Average artifact lengths are 31.5 mm (Level XIV-XV) and 28.2 mm (Level XV) respectively, the smallest (shortest) pieces in the Mousterian sequence and the inception of a regular increase in length that ends with Level XII (Figure 17). Average lithic weights also decline monotonically from Level XIV (10.3 g), to Level XIV-XV (8.8 g) to Level XV (7.2 g), suggesting that lithic debris preserved in this part of the site, near the east wall of the cave, tends on average to be smaller and lighter the deeper one goes in the sequence. This would perhaps be the case if trash were swept to one side of the cave to clean up the central living area located more toward the



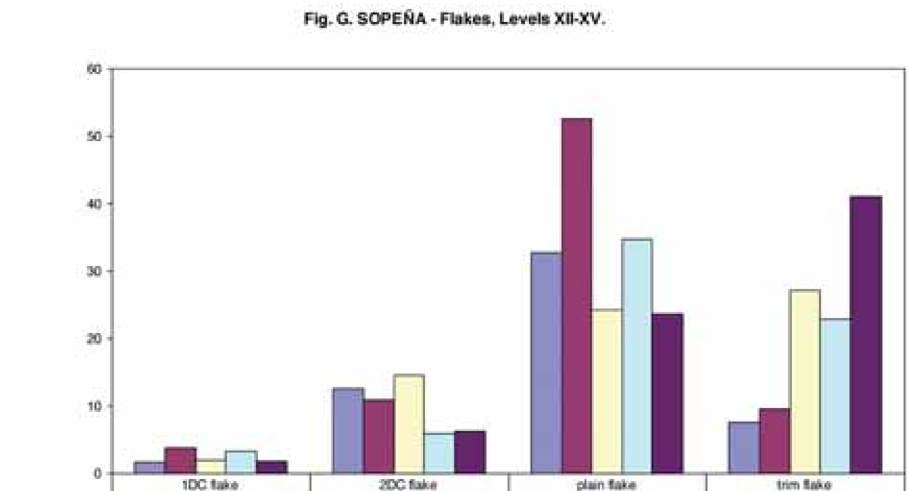
	LEVEL I	LEVEL II	LEVEL III	LEVEL IV	LEVEL V	LEVEL VI	LEVEL VII	LEVEL VIII	LEVEL IX	LEVEL X	LEVEL XI	LEVEL XII	LEVEL XIII	LEVEL XIV	LEVEL XIV-XV	LEVEL XV
% q'zite	27,12	21,01	20,99	52,5	61,54	67,57	80,1	70,62	71,5564	72,3629	69,9029	52,5	70,5882	68,2692	75,8333	86,087
% limest	12,99	23,08	23,99	22,5	9,62	13,51	5,28	14,12	8,58676	14,346	14,5631	26,6667	13,0719	10,5769	7,5	3,91304
% flint	38,14	37,57	34,58	17,5	28,85	18,92	13,91	11,3	12,5224	7,80501	8,25243	7,5	10,4575	13,4615	14,1667	6,95652
% quartz	20,62	17,16	19,4	0	0	0	0	0,56	0,17889	0	0	0	0	0	0	0
% other	1,13	1,18	1,03	7,5	0	0	0,72	3,39	7,15564	5,48523	7,28155	13,3333	5,88235	7,69231	2,5	3,04348

% q'zite % limest % flint % quartz % other

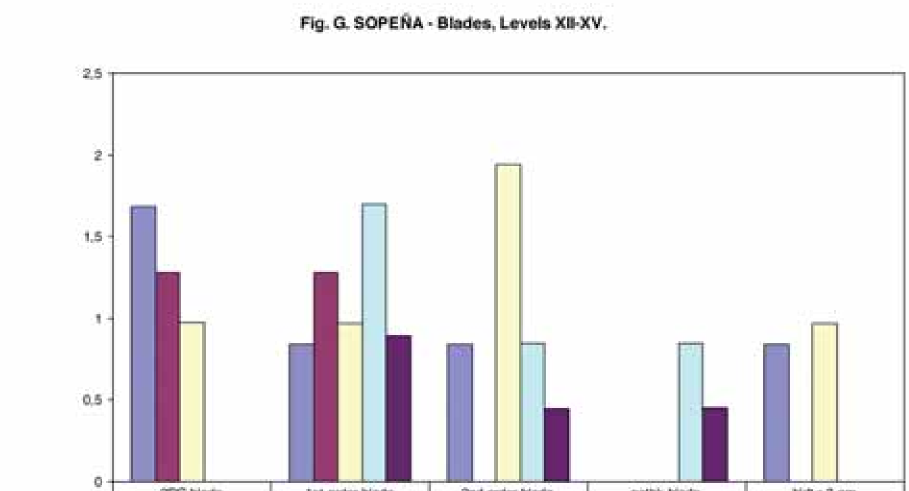
Fig. 19. Sopeña. Raw material types by levels, relative frequencies in Levels I-XV.

entrance (Figure 18). Quartzite frequencies reach their highest values in Levels XIV-XV (75.8%) and XV (86.1%). Limestone (7.5, 3.9%), flint (14.2, 7.0%) and other (2.5, 3.0%) are the only other raw materials represented (Figure 19). In general, raw material diversity declines over time in the Mousterian part of the sequence, although it would probably be more accurate to say that Level XII is exceptionally diverse *vis à vis* both Upper Paleolithic Levels IX-XI and Middle Paleolithic Levels XIII-XVI (Figure 19).

Primary decortication flakes account for 4.8% and 2.4% respectively in Levels XIV-XV and XV, figures that change hardly at all throughout the lower sequence, ranging from a low of 2.2% (Level IX) to a high of 4.8% (Level XIII). At 8.4% for both levels, secondary decortication flakes fall toward the lower end of the range (5.6-21%). Plain flakes account for 49% (Level XIV-XV) and 31.7% (Level XV) of the débitage totals, whereas trimming flakes are especially common in Level XV (55.1%); they account for 32.5% in Level XIV-XV (Figure 20). These levels are noteworthy for a complete absence of cortical blades. First and second order blades are uncommon (2.4, 1.2% respectively in Level XIV-XV; 1.2, 0.6% respectively in Level XV), but blades in general are not prevalent in the lower sequence. Naturally backed blades show up uniquely in these levels (one in each); bladelets are totally absent (Figure 20). Cores are also scarce, and are comprised exclusively of oppo-



	1DC flake	2DC flake	plain flake	trim flake
LEVEL XII	1,680672269	12,60504202	32,77310924	7,56302521
LEVEL XIII	3,846153846	10,8974359	52,56410256	9,615384615
LEVEL XIV	1,941747573	14,5631068	24,27184466	27,18446602
LEVEL XIV-XV	3,389830508	5,93220339	34,74576271	22,88135593
LEVEL XV	1,785714286	6,25	23,66071429	41,07142857



	2DC blade	1st order blade	2nd order blade	natbk blade	bldt< 3 cm
LEVEL XII	1,680672269	0,840336134	0,84	0	0,84
LEVEL XIII	1,282051282	1,28	0	0	0
LEVEL XIV	0,970873786	0,97	1,94	0	0,97
LEVEL XIV-XV	0	1,694915254	0,847457627	0,85	0
LEVEL XV	0	0,892857143	0,446428571	0,45	0

Fig. 20. Sopeña. Proportional representation of flake (above) and blade (below) debitage, Mousterian levels XII-XV.

sed/multiple platform flake and mixed flake/blade types. The shatter component is 12.5% of the débitage total in Level XIV-XV, 13.0% in Level XV (Figure 21).

The combined levels produced 40 retouched pieces, over half of which (22) were sidescrapers. Unilateral straight and convex types accounted for 19 of the 22 (86.3%), and underscore the strong ‘Mousterian’ character of these assemblages, although it should be noted that sidescrapers are also present in the Upper Paleolithic levels (e.g., Level IX), albeit at much lower frequencies (Figure 15). Although lithics are scarce in Levels XIV-XVI, they are nonetheless typical of the regional Mousterian.

In sum, Mousterian Levels XII-XVI yielded 726 stone artifacts and 69 retouched pieces. The smaller number of pieces (726 v 4018 in Upper Paleolithic Levels I-XI) and lower mean level counts (181 v 365) and weights (1347 v 2241 g) are usual for Mousterian deposits in northern Spain, and suggest a more ephemeral Mousterian use of caves and rockshelters – on average – than is typical for the Upper Paleolithic. This could mean that Mousterian populations were generally smaller than those of the Upper Paleolithic, and/or that they were simply spending less time in caves and rockshelters – on average – than their Upper Paleolithic counterparts, as has been suggested by a number of authors (e.g., JELINEK 1988, 1994).

Raw material in the Mousterian levels is dominated by the same fine-to-medium grained grey quartzite found in the upper part of the sequence. Although a more in depth analysis of these is pending, we can say now that in Levels XII-XV, 72.8% of the artifacts by weight are made on quartzite, 18.2% on limestone and other materials, and 9% on flints and cherts. Quartzite is even more important than in the Upper Paleolithic levels (50.7%), but quartz – present in small quantities in Levels I-XI – drops out of the picture entirely. By far the most important levels in the Mousterian sequence are Levels XIV and XV, which account for 45.5% by weight of the worked stone recovered from the test pit (Figure 19).

Despite significant differences in the retouched tools, the débitage fraction from Levels XII-XV closely resembles that from Levels I-XI (Figure 22). There is more evidence for primary reduction in that primary and secondary decortication flakes are slightly more numerous, accounting for 13% of the débitage total. Plain flakes are significantly more prevalent, accounting for 40% of the débitage total (v 27% in the Upper Paleolithic levels). The only disk cores in the sequence come from the Upper Paleolithic levels, however (Figure 23). In keeping with evidence from El Castillo (CABRERA 1984), El Pendo (GONZÁLEZ ECHEGARAY 1980) and Cueva Morín (GONZÁLEZ ECHEGARAY and FREEMAN 1971, 1973), there is little evidence of Levallois technique, probably because of raw material constraints. In other words, the main raw material type consists of quartzite pebbles and cobbles, whereas good flint in large ‘packages’ is practically non-existent in northern Spain.

Retouched pieces accounted for 9.5% of the Level XII-XV lithic total, which is higher than the average for the regional Mousterian, and more than twice as high as the corresponding statistic (3%) for Levels I-XI. Forty-seven percent of the retouched total consists of sidescrapers made on quartzite flakes and pebbles. Notches and denticulates account for an additional 27%, and there is a modest representation (11%) of retouched flakes (Figure 24). Classic Upper Paleolithic tools like endscrapers and burins are rare, lending additional confidence that the basic cultural stratigraphy exposed in the test is essentially correct (Figure 6). Textbook examples, the sidescrapers are generally unilateral, convex and steeply retouched. They conform to the Quina variant of the Charentian facies, as defined by Bordes (1968, 1974) (Figure 15). Although this

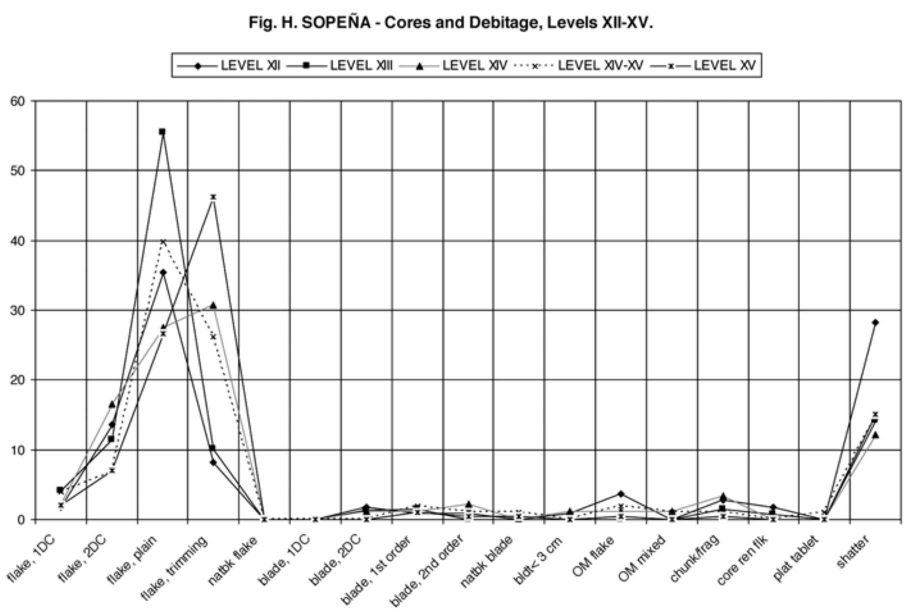


Fig. 21. Sopeña. Frequency graph, cores and debitage, Mousterian Levels XVII-XV.

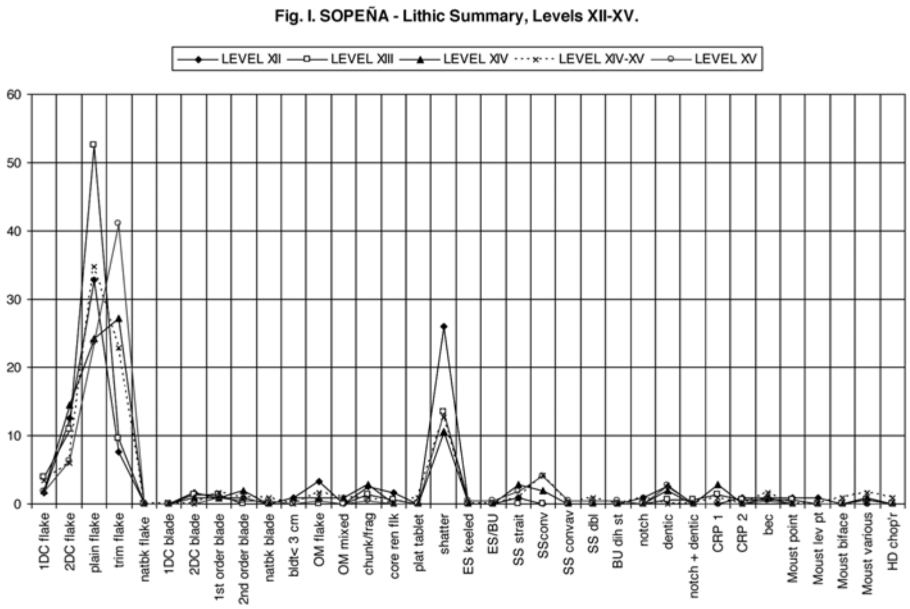


Fig. 22. Sopeña. Lithic Summary, Mousterian Levels XII-XV.

observation carries with it no chronological or behavioral implications, it is interesting to note that Cabrera (CABRERA *et al*. 1996) also remarks on the prevalence of Quina-type Mousterian industries at El Castillo and in Cataluña. She points out that, at present, no Ferrassie-type Charentian facies, nor MTA Mousterian sites or levels are known with certainty from northern Spain, and that the most prevalent Mousterian facies are the Denticulate variant, best represented at Cueva Morín, and the Typical Mousterian, regarded by many as a 'catch-all' category which lacks an adequate definition. Unlike Morín, however, where ophite cleavers are well-represented in Mousterian deposits (FREEMAN 1971), the Sopeña test did not yield any cleavers, nor the characteristic transverse flakes detached to produce them. In a recent comparative study, Freeman (1994) questions the technological and typological discreteness of the Bordesian facies in Cantabria and comes to the conclusion that the facies are arbitrary constructs, and that formal variation is more or less continuous across the 'key' north Spanish Mousterian sites (i.e., El Castillo, Cueva Morín, El Pendo, La Flecha). A radiocarbon date of 41,250 + 642 cal BC (CalPal05, Beta-198146) on a tooth from Level XII lends strong support to a mid MIS-3 age for these deposits, separated in time from overlying Level XI by about five millennia, as indicated by a bone date from that level of 36,160 + 782 cal BC (CalPl05, Beta-171157).

6.2 The Early Upper Paleolithic Sequence (Levels I-XI)

Levels I-XI are tentatively assigned to the Gravettian (more generally to the Early Upper Paleolithic), although there is a good possibility that later Upper Paleolithic deposits might be uncovered in the ongoing excavations in the main part of the site. A Gravette point occurs in Level I; one fragmentary bone point and some antler awl fragments in Levels III, V and VII, and a keeled endscraper in Level VII (Figure 23). Radiocarbon dates, discussed below, suggest that Levels I-XI accumulated over about 13 millennia between 25.2 and 39.8 ky BP.

Level I constitutes the earliest intact deposit, although a Level 0 was identified to distinguish superficial debris – rich in artifacts – from sediments that might reasonably be argued to be undisturbed. Level 0 produced 95 lithic artifacts, along with 124 pieces of antler, bone and teeth. The site had been used for generations as a corral and, when initially discovered, was covered by a layer of dung in some place more than 50 cm thick. Level I yielded 417 lithic artifacts, a relatively high 26.7% of the combined total (1558) of lithics and organic remains (bone, antler, teeth = 1141). Mean artifact length is 31.8 mm, slightly larger than the upper sequence mean of 28.3 mm, and very close to the Middle Paleolithic mean (32.2 mm). However, the average weight is 8.7 g, underscoring the generally lighter weight of the upper sequence lithics (Figure 17). The Level I-XI mean weight is 6.7 g, whereas that for Levels XII-XVI is 9.1 g. This likely suggests a higher incidence of compound tools in the Upper Paleolithic when compared with the Middle Paleolithic, and a greater emphasis on hafting. It is interesting to note that, with the exception of Levels IV and VI, lithic average weights tend to increase over the Upper Paleolithic sequence, with the lightest pieces concentrated in Levels XI-VIII. This runs counter to the tacit assumption of greater use of composite tools over the course of the Upper Paleolithic (Figure 18).

Uniquely in the entire sequence, Levels I-III are dominated by flint (38.1, 37.6 and 34.6% respectively), whereas quartzite and limestone are of secondary importance. The corresponding frequencies for quartzite are 27.1, 21.0 and 21%, whereas those for limestone are 13% in Level I, but increase rapidly to 23.1% (Level II) and 24% (Level III). Quartz is quite common in these three levels (20.6, 17.2

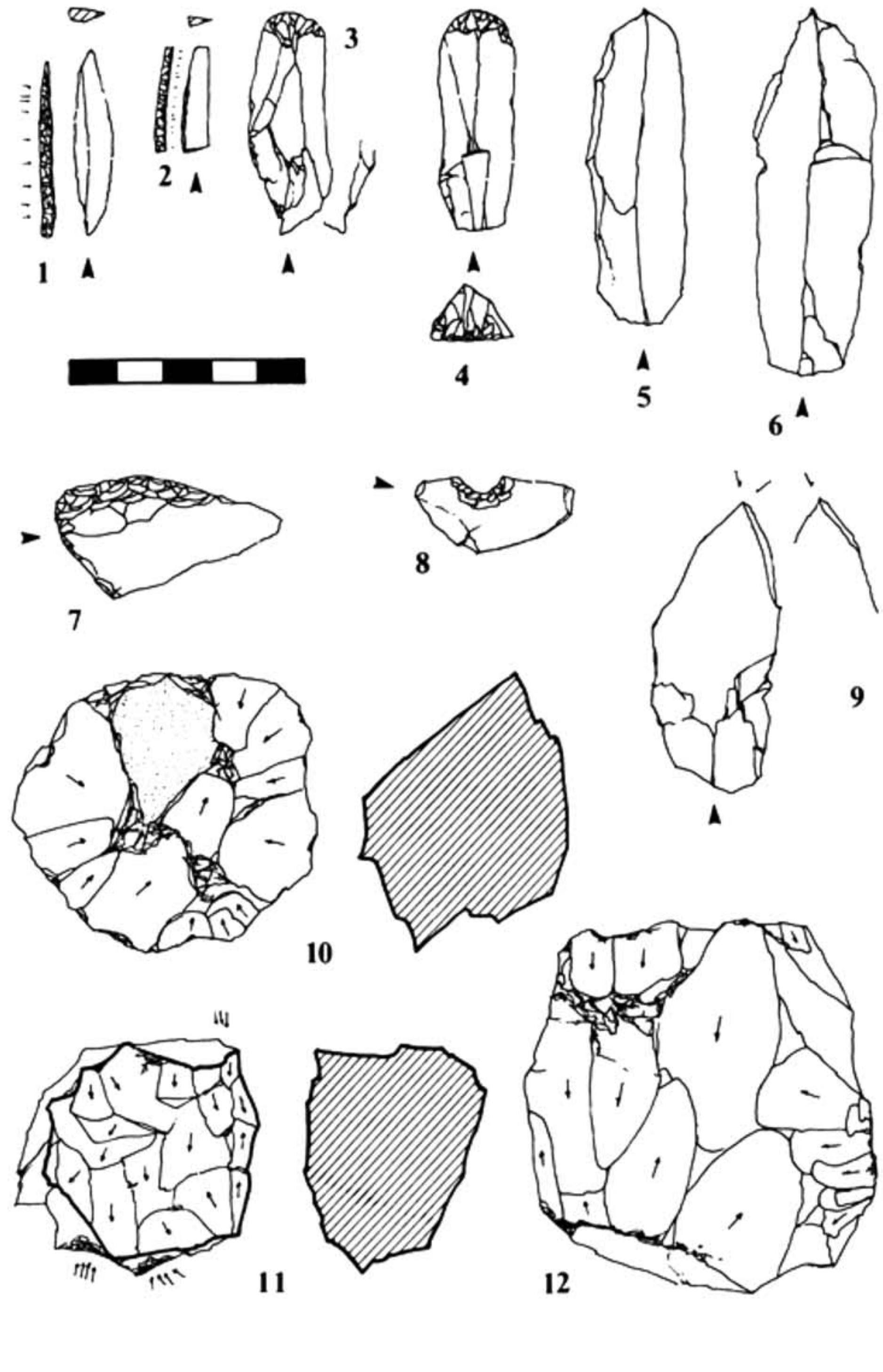


Fig. 23. Sopeña. Lithic artifacts from the Upper Paleolithic levels.1. Gravettian point, 2. Backed bladelet, 3. Endscaper/perforator on a blade, 4. Endscraper on a thick blade, 5. and 6. 1st order blades, 7. Sidescraper, 8. Notched flake, 9. Dihedral burin, 10. Disc core, 11. Mixed flake/blade core with multiple platforms, 12. Mixed core with multiple platforms.

and 19.4% respectively), but almost completely disappears in the rest of the site sequence, being represented only by traces (0.6, 0.2%) in Levels VIII and IX (Figure 19). It seems clear that some kind of a major shift in the raw material procurement network took place after the deposition of Level IV, but in default of a more secure chronological framework, we cannot date the change precisely nor, so far, ascertain the causes for it. Quartz figures prominently in many ethnographically-documented shamanistic activities, so it is not unreasonable to speculate that it might have had a similar ritual function at Sopeña.

In a pattern that extends throughout the upper sequence (Levels I-XI), primary (1DC) and secondary (2DC) decortication flakes are relatively uncommon in Level I (3.9, 4.9% respectively). These figures do not depart significantly from the upper sequence means (3.6, 6.8%), implying relatively little primary reduction in the area sampled by the test pit. Cortical blades are also very scarce: there are no 1DC blades at all in Levels I-III, and 2DC blades are uncommon (1.5, 2.3, 1.6% for Levels I-III), again consistent with very little primary reduction. The corresponding figures for plain (43.4%) and trimming (33.2%) flakes suggest more emphasis on secondary reduction and tool manufacture, maintenance and resharpening. Again, this pattern is consistent throughout the Upper Paleolithic sequence (Levels I-XI). First order blades account for 5.4, 7.5 and 5.4% of the débitage component in Levels I-III; the values for second order blades are 3.4, 2.3, and 3.2%. These figures compare favorably with the upper sequence means for non-cortical blades without anomalous Level IV (3.2, 1.6%). Level IV has 15% first order blades and no second order blades. If Level IV is included, the mean for first order blades jumps to 4.3%. With or without Level IV, there is good evidence for blade production in the upper sequence, lending some support to its assignment to the Upper Paleolithic (Figure 25).

As might be expected, bladelets are relatively common in the upper levels, at least when compared to the lower levels. They account for 4.4, 2.8 and 8.7% of the débitage fraction in Levels I-III. The mean for the upper sequence is 4.5%. Bladelets increase in frequency over time in the upper sequence, with lower values in Levels XI-VIII (0.6, 1.7, 0.9, 0.9%), higher ones in Levels VII-III (3.2, 6.1, 9.7, 10.0, 8.7%), followed by a decline in Levels I-II (2.8, 4.4%) (Figure 25). The near-total absence of bladelet cores (a single platform bladelet core was recovered in Level III) again indicates production of bladelets off-site, or at least outside the area sampled by the test pit. Cores are both more common and more variable in the upper than in the lower sequence. It is interesting to note that all four of the disk and partial disk cores come from Levels I-XI, as well as all 17 single platform flake cores, the only bladelet core recovered in the test, all 3 single platform mixed flake and blade cores, 21 of the 29 (72.4%) opposed/multiple platform flake cores, and 5 of the 7 (71.4%) opposed/multiple platform mixed cores. Core tablet and platform renewal flakes were recovered from Levels I-III, VI, and VIII-X. The relatively high incidence of cores and core renewal flakes implies more secondary reduction in the Upper Paleolithic levels (I-XI) than in the Middle Paleolithic levels (XII-XV). Shatter frequencies average 25.8%, nearly double the mean for their Middle Paleolithic counterparts (15.2%), suggesting relatively more primary reduction in the Upper Paleolithic levels than in the Middle Paleolithic at Sopeña (Figure 25).

Retouched pieces are uncommon in Levels I-XI (Figure 26). In total, only 69 retouched pieces were recovered from the upper sequence (coincidentally, the same number as in the lower sequence), but they account for only 1.7% of the lithic total (4018) for the upper sequence, v 9.5% (69 out of 726) for the lower sequence. The scarcity of retouched pieces in many large Upper Paleolithic collections was first noted by Sackett (1988), who remarked that the often-repeated notions of ‘greater standardization of form’ and ‘more imposition of shape supposedly present in the Upper Paleolithic might be more apparent than real, and that formal convergence constrained by rock mechanics and raw material package size might play a greater role in Upper Paleolithic tool form than is commonly recognized (CLARK 2002). The largest number of retouched pieces in the upper sequence is in Level VII (16, or 3.7%) and values otherwise range from 1 (Level VI) to 13 (Level IX). Levels IV and VIII lack retouched pieces altogether. Endscrapers on flakes and blades show up in Levels I, III, V, VII, IX and XI, and there is a supposedly diagnostic keeled endscraper in Level IX. Sidescrapers indistinguishable from their Middle Paleolithic counterparts are present in Levels III, V-VII, IX and X, mirroring the continuity observable in many aspects of raw material composition and in the characteristics of the débitage component.

So far as raw material is concerned, the same four types are represented throughout the EUP sequence (and, except for quartz, throughout the sequence as a whole). In descending order of importance, they are (1) quartzite, (2) limestone and others, (3) flints and cherts, and (4) quartz. By weight, 50.7% of the artifacts are made on quartzite, 23.6% on various kinds of limestone, 20.3% on flints and cherts, and 5.4% on quartz. By counts, the corresponding figures are 55.9% (quartzite), 18.0% (limestone and others), 20.8% (flints and cherts) and 5.3% (quartz) (Figure 19). Although there are marked differences in the relative frequencies of retouched pieces, and in some debitage categories, there is little change over time in the raw material ratios. The fundamental, universal raw material dichotomy between relatively large retouched pieces like denticulates and sidescrapers made on quartzite flakes, and smaller, relatively delicate retouched pieces like backed bladelets made on flints and cherts, is also strongly apparent in the Sopeña *sondage* (CLARK 1989). About 4% of the Level I-XI total comprises heavy duty tools like choppers, chopping tools and hammerstones, all of them made on quartzite pebbles and cobbles.

The débitage fraction in Levels I-XI comprises 97% of the artifact total, and is dominated by plain and trimming flakes (30% and 25% respectively), suggesting considerable secondary reduction. Shatter – indicative of primary re-

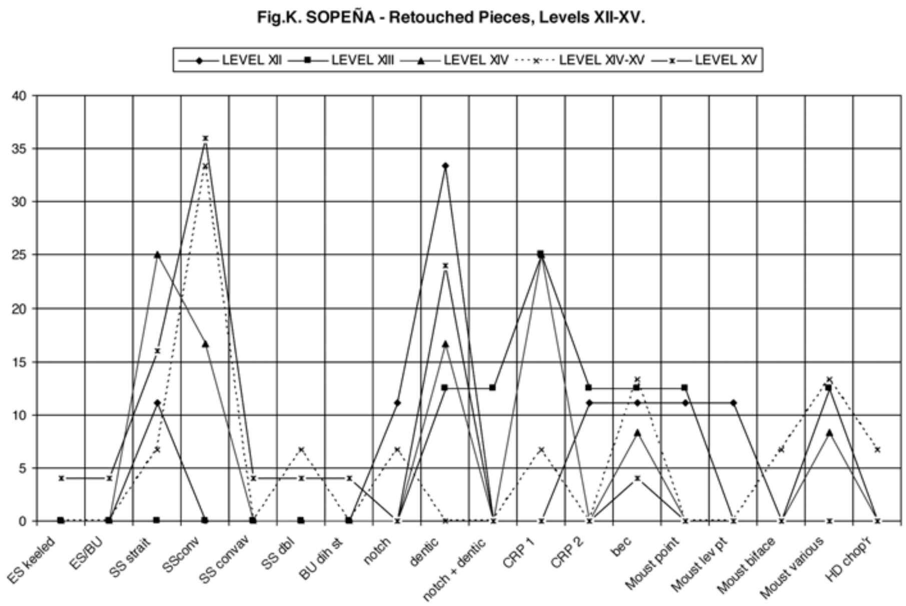


Fig. 24. Sopeña- Frequency graph, retouched pieces, Mousterian Levels XII-XV.

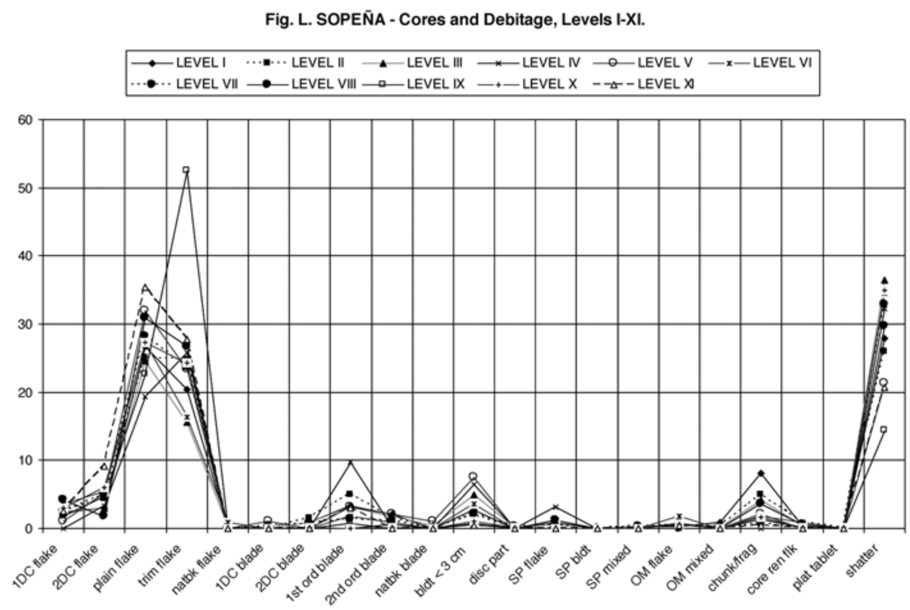


Fig. 25. Sopeña. Frequency graph, cores and debitage, Upper Paleolithic Levels I-XI.

duction – accounts for 25.8% of the débitage total, and there are also substantial numbers of cortical flakes, single and multiple platform flake and blade cores, and core renewal flakes. Although not numerous, blades and bladelets are more common in Levels I-XI than they are in Levels XII-XVI. Nevertheless, the débitage frequencies in the two major analytical units are strikingly similar (Figs. 21, 25).

Retouched pieces accounted for 3% of the Level I-XI artifact total, which falls within the range typical of most Upper Paleolithic assemblages (2-5%). Although there were substantial numbers of generic tools like notches and denticulates (19%), endscrapers and burins accounted for 14% and 13% of the retouched tools, significantly higher than in Mousterian Levels XII-XVI (Figure 26). Retouched blades and *pièces esquillées* were also more prevalent in these Upper Paleolithic deposits than in the Middle Paleolithic sequence. However, sidescrapers made on quartzite flakes and closely resembling their Mousterian counterparts account for 10% of the Upper Paleolithic retouched tool total.

An alignment of three wooden stakes or posts, implanted vertically in the floor of Level III from its surface, suggests some kind of structure (perhaps a hut or a lean-

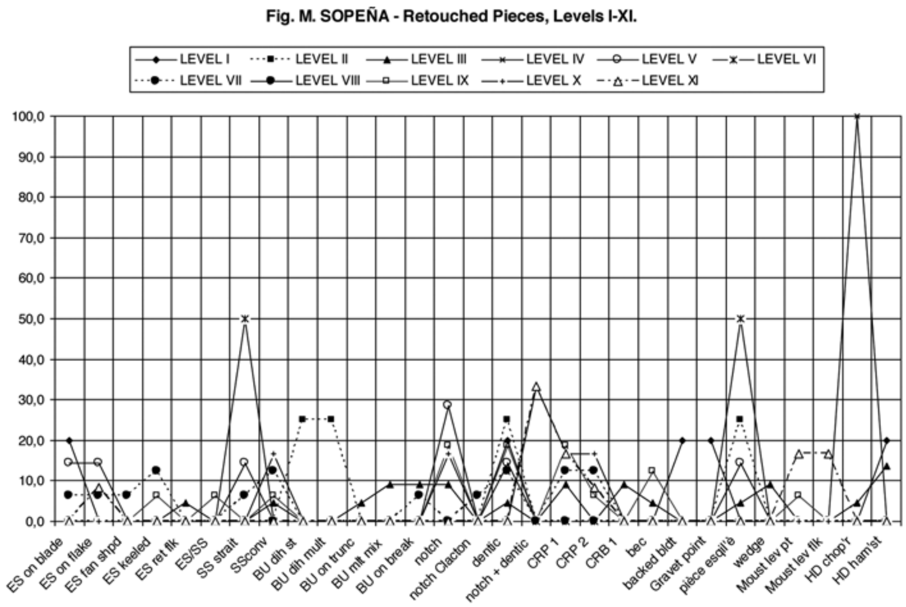


Fig. 26. Sopeña. Frequencly graph, retouched pieces, Upper Paleolithic levels I-XI.

to constructed against the back wall of the shelter). Levels III, V and VII are almost black, with much charcoal and burnt bone, hearths, and ochre. Although of limited extent, Levels I-XI yielded 4018 stone artifacts and 69 retouched pieces, suggesting a very considerable cultural component in the formation of at least some of these deposits.

7. THE FAUNA FROM SOPEÑA

Detailed taxonomic analysis of the faunal remains from Sopeña has not yet been done. Table 6 gives a preliminary faunal list of all vertebrates.

7.1 Taphonomy of the small vertebrate remains

The small vertebrate fauna from the test pit at Sopeña was examined for taphonomic modifications to determine how the bones accumulated in the rockshelter. It is likely that these bone accumulations, some of which are very large, entered the cave independently of the large mammals and of human activity. For example, assemblages in the range of hundreds of specimens per unit area, it is likely that they were accumulated by predators and not through any human agency. In this case, the small vertebrates constitute an independent source of evidence on the processes of bone and sediment accumulation in the cave and of the palaeoenvironment present at the time.

7.1.1 Taphonomic methodology

Counts have been made of vertebrate remains based mainly on the mammals but also including amphibians and birds. MNI for rodent teeth were calculated assuming 12 molars and 4 incisors per individual, taking uppers and lowers into account; counts for molars includes species dif-

Preliminary Faunal list, Sopena
Rana sp.
Aves sp.
snake
lizard
Chiroptera indet
Insectivora
Crocidura russula
Neomys fodiens
Sorex minutus
Sorex araneus
Talpa europea
Rodentia
Galemys pyrenaicus
Sciurus vulgaris
Microtus agrestis
Microtus arvalis
Microtus oeconomus
Microtus gregalis
Arvicola terrestris
Arvicola sapidus
Terricola llusitanicus
Apodemus sylvaticus
Eliomys quercinus
Felidae
Panthera pardus
Mustelidae
Meles meles
Mustela nivalis
Viverridae
Canidae
Canis lupus
Hyaenidae
Rhinocerotidae indet.
Equidae
Bovini
Bos primigenius
Rupicapra rupicapra
large caprine
Cervus elephas
Megalocerus
Capreolus capreolus

Tabla 6: Preliminary list of fauna at Sopeña.

ferentiation, but those for incisors only distinguish between murids and arvicolids. Counts for mandible, maxilla and postcrania were based on two per individual, not taking account of species differences.

Numbers of missing molars or incisors were reconstructed as a means of measuring destruction of mandibles and maxillae. Numbers of missing teeth is based on the numbers of upper and lower jaws present but missing molars and incisors; for example, 3 edentulous jaws are missing 9 molars and 3 incisors, and these totals were added to those of all other rodents in the fauna. The differences between numbers of teeth missing from the jaws can then be compared with numbers of isolated teeth present in the same levels, and the greater the numbers of the latter compared with the missing teeth, the greater is the destruction of mandibles and maxillae.

Breakage of postcranial elements is based on the methodology proposed by Andrews (1990). Only the femur and humerus were used, as it has been found that evidence from other elements is redundant, and the two limb bones were divided into complete, proximal articulation with at least half of the shaft, distal articulation with at least half of the shaft, and proximal and distal articulations. The presence of weathering, corrosion and/or root marks are described (ANDREWS, 1990). Digestion of articular ends is identified as localized corrosion of salient angles of the bone and is recorded as present or absent (ANDREWS, 1990), with percentages of digestion being given relative to the numbers of bones with proximal (for the femur) and distal (for the humerus) ends not damaged by post-depositional processes.

The most important source of evidence for predator assemblages is the degree and frequency of digestion on the teeth of the prey animals (ANDREWS, 1990). Digestion categories of molars and incisors are divided into five categories based on the degrees of alteration to arvicolid teeth, particularly the extent and depth of penetration of digestion along the salient angles of the molars and the extension of digestive alteration from the tip of the incisor. It is now recognized that lower crowned murid teeth, and insectivore teeth, follow a different pattern of alteration, being at least two stages behind the arvicolid stages such that a predator producing category 3 alteration of an arvicolid may produce no alteration to the teeth of these other taxa (work in preparation). Percentage digestion of in situ teeth is based on numbers of digested teeth compared with counts of teeth present in the mandibles and maxillae.

7.1.2. Taphonomic results

A summary of the results is given in the Appendix.

Level I has few finds, and the sample size is too small to determine how the vertebrate fauna accumulated. Five out of 26 teeth showed signs of digestion, but the near absence of cranial and postcranial remains makes it likely that the few teeth present are a lag deposit to which an unknown predator has contributed minimally.

Level II also has few finds, but sample sizes are marginally greater than in Level I. The relatively high degree of digestion, with up to half the bones and teeth affected, suggests it may have been accumulated by predation, possibly by a category 3 predator, particularly as some of the *Arvicola* molars have been digested. Amphibian remains have also been digested, and there is a single fish vertebra. There is a single cut-marked bone (Reed).

Level III bones have a distinctive appearance, being a dark dirty brown, and there are relatively many amphibians. Degrees of digestion on isolated molars are low, and the only mammals present are *Microtus* species.

Level IV bones are whitish in colour and quite different from those of Level III, and they have slightly higher degrees of digestion, with two molars and one incisor having categories 3-4 digestion (ANDREWS, 1990), but the majority being category 1, including two out of three *Arvicola* molars. This suggests a category 1 predator such as the barn owl as the accumulator of the Level IV microfauna.

The Level V fauna continues the degree of modification seen in Level IV, with the small assemblage having low Levels of category 1 digestion (ANDREWS, 1990). Root marks are present on 8% of the bones, but there is little corrosion present.

Root marks are also present on Level VI bones, similar to the Level above, and both have low levels of category 1 digestion (ANDREWS, 1990). Sample sizes for the six upper Levels range from 11 to 48 for the isolated teeth, and from 1 to 10 for the femur and humerus, and samples of this size are not big enough to interpret their mode of accumulation with any confidence.

The fauna from Level VII is very different from the six upper Levels. The large mammals from Levels I to VI are dominated by artiodactyls, but the Level VII fauna is dominated by equids. In the small mammal faunas, soricids and murids appear for the first time, and the sample sizes are 15 mandibles, 163 isolated teeth and 31 postcrania. The 15 mandibles and 4 maxillae have lost a total of 28 molars and 11 incisors, and this compares with 119 isolated molars and 44 isolated incisors, suggesting the loss from the assemblage of at least four times as many jaws as are present now. Digestion is low, both in degree and in numbers of teeth affected, and this strongly supports the action of a category 1 predator as accumulator of this fauna.

The Level VIII fauna has abundant soricids and arvicolids but few murids. The teeth have high overall levels of digestion, and unlike Levels I to VII, the incidence of higher categories of digestion is greater than that of category 1 digestion, with category 2 being strongly represented (ANDREWS, 1990). Many of the molars and incisors in place in the mandibles are also digested at similar levels, and this suggests that a category 2 predator accumulated this fauna. Breakage of mandibles, as indicated by loss of teeth relative to isolated teeth, and breakage of postcrania is low. A specialist category 2 predator is indicated by this evidence.

Level IX large mammals, artiodactyls are again the most abundant large mammals, and for the microvertebrate fauna, amphibians are at their highest abundance. Soricids, moles and birds are also abundant, and in Rodentia, arvicolids are most abundant. Digestion of teeth is high, both in degree and in numbers of teeth affected: category 1 digestion is the highest, but the presence of 27 category 3-5 digested teeth indicates that the predator could not have been a category 1 or 2 predator but was probably category 3 or 4. Many of the small vertebrate limb bones have puncture marks made probably by a small carnivore suggest that the assemblage may have been the prey assemblage of a small carnivore such as a viverrid or mustelid.

The small mammals from Level X occur in two colours, the most common light brown as in the upper Levels already described, and about 2% a uniform black colour. The former has moderate to low rates of digestion, mainly category 1 with smaller numbers category 2 and 3, but the latter, the blackened bones, show no evidence of digestion at all. It is likely that these two groups have independent origins, but other than colour and the presence of digestion in one group, there is little difference between them. There is no evidence of abrasion on either group, and no difference in corrosion or root marks. It is likely that the black bones represent a non-predator assemblage that either accumulated elsewhere or at an earlier time than the predator assemblage, and it may have been subjected to wet conditions leading to heavy staining with manganese. The light-coloured assemblage was probably accumulated by a category 1 predator and mixed with the earlier assemblage of black bones.

Levels XI and XII have similar degrees of digestion to unit X and probably accumulated in the same way, i.e. by a category 1 predator. Both have the same admixture of light-coloured bone and black bones, and both have moderate to low category 1-2 digestion. They also share relatively high degrees of completeness of femora and humeri, and Level 12 also has relatively complete mandibles, as measured by the number of molars missing from the mandibles and maxillae (172) compared with the number of isolated teeth (180).

The Level XIII fauna has high numbers of soricids and murids, with the former the most abundant species and murids nearly as numerous as arvicolids. Light digestion (category 1-2) is present on the arvicolids and almost no digestion on the murids and soricids. The category of digestion is probably anomalously low because of this taxonomic difference, for as described in the appendix, digestion progressed more slowly on murids and soricids compared with arvicolids, and the relative abundance of the former lowers the apparent rate of digestion. This makes it difficult to assess the fauna from this Level, and the presence of several teeth in the category 3-4 digestion Level, and digestion on molars of *Arvicola*, suggests that in fact a category 3 predator may have been responsible for the bone accumulation in Level XIII. Finally, the black bone element of Levels X to XII are absent from this Level.

The Level XIV small vertebrate fauna includes several bones from a large bird and four mole mandibles, but otherwise the fauna is similar to other Levels. There are relatively few postcrania, and they are heavily root marked and corroded. Teeth and mandibles are also heavily corroded and with extensive root marks, and this is particularly marked in square K6, whereas the bones in square I6 have less corrosion and almost no root marks. Level XV has low to moderate digestion and is similar to Level XIV: both have moderately high numbers of digested teeth, but they are mainly categories 1-2, particularly the incisors. A category 1 predator is indicated.

7.2 Faunal change in the Sopeña sequence

Most Levels are dominated by artiodactyls for the large mammals and arvicolid rodents for the small mammals. Exceptions are Level VII, where equids are the most abundant large mammal species and Level XIII where soricids and murids outnumber arvicolids. It is not clear at this stage if these differences are significant or not. Most of the faunas appear to have single sources, but Levels X, XI and XII have mixed faunas: 2-5% of the small vertebrate bones are stained a strong and uniform black colour, and these entirely lack evidence of digestion; while the majority of bones are a whitish colour as in other archaeological Levels.

Evidence of digestion is present at most Levels, but in some cases the sample sizes are too low to interpret. This is the case for Levels I, III, V and VI, and in the last two cases the low degrees of digestion are combined with abundant root marks which suggest the bones may be intrusive in the cave and derived from mainly natural deaths. In other cases, sample sizes are moderate to large, and four modes of accumulation of microvertebrates are indicated (Figure 27):

• category 1 predators (ANDREWS, 1990), probably barn owls, are indicated for Levels IV and VII and for the majority assemblages in Levels X, XI and XII; these assemblages are dominated by arvicolids, which is probably not a true reflection of their presence in the Sopeña area.

• category 2 predators (ANDREWS, 1990) are indicated by the higher degrees of digestion for Level VIII, where a specialist vole predator is indicated; arvicolids dominate the fauna at this Level, with few murids, and this is almost certainly due to the hunting preferences of the category 2 predator, which may have been long eared owl or short eared owl (Andrews, 1990).

• category 3 predators (ANDREWS, 1990) are indicated for Level XIII, and possibly also for XIV and XV, for all of which there is a broad spectrum of prey species as well as some teeth with high degrees of digestion; these faunas are likely to represent best the microvertebrate fauna present in the Sopeña area during the later Pleistocene. The high counts of soricids and murids in Level XIII could indicate a difference from the other Levels.

• a small mammal predator, such as a viverrid or small mustelid (ANDREWS, 1990), is indicated for Level IX, for which a category 3 or 4 predator is indicated; tooth marks are present on many of the bones as well as high degrees of digestion. This fauna is also likely to be representative of the Sopeña area.

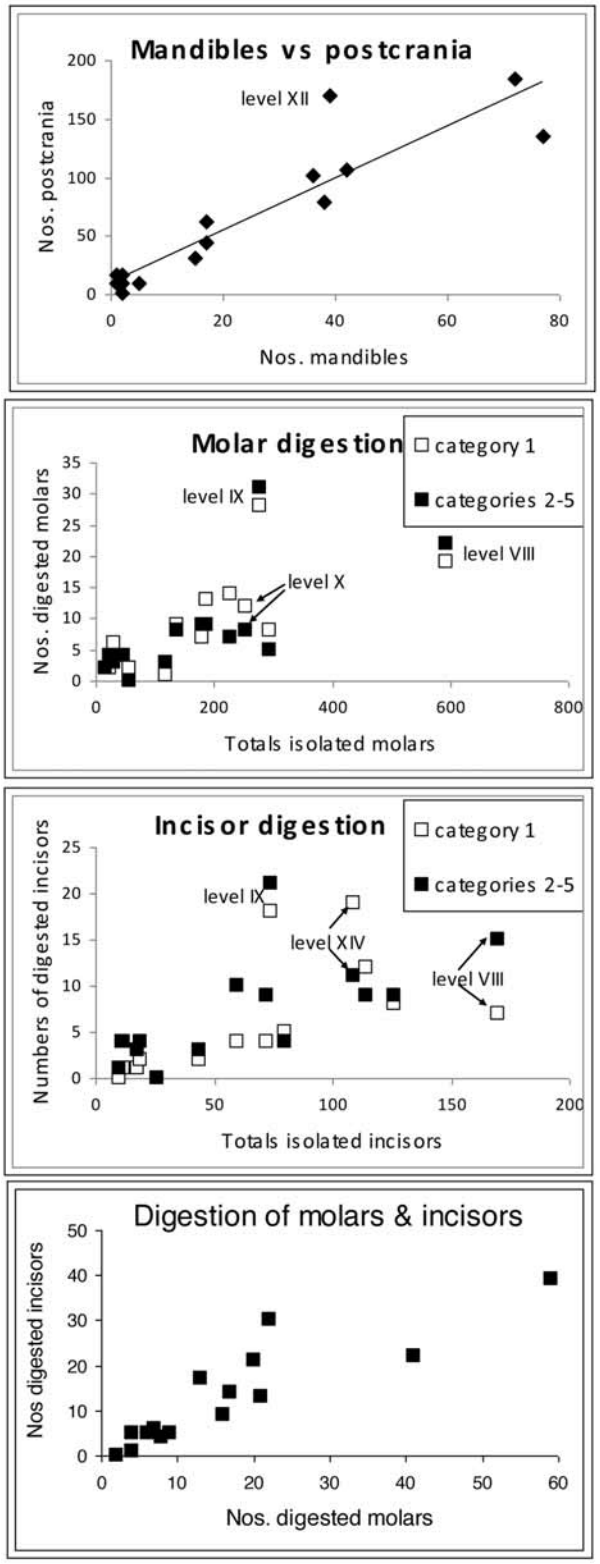


Fig. 27. Taphonomic modifications of the 12 small mammal faunas from Sopeña levels I to XII. From top to bottom, numbers of limb bones compared with numbers of mandibles; numbers of digested molars of rodents compared with total numbers of molars; numbers of digested rodent incisors compared with total numbers of incisors; and numbers of digested incisors compared with numbers of digested molars: definitions in text.

In summary, therefore, the least biased faunas come from Levels IX, XIII, XIV and XV; and the most biased fauna is that from Level VIII. The other Levels are either intermediate (IV, VII, X, XI, XII) or indeterminate (I, II, III, V and VI).

8. SUMMARY AND CONCLUSIONS

In situ and probably raked out burning features have been described in several Levels of Sopeña. Coprolites, probably from hyaena occurred in all layers from Level XII to Level XV, while guano was present in Level X. The micromammal taphonomy points to barn owls having accumulated some bones in Levels IV, VII, X, XI and XII and long-eared owl or short-eared owls in Level VIII, while in Levels XII to XV a category 3 predator is suggested. A viverrid or small mustelid is also present in level IX with toothmarks present and high degrees of digestion.

Throughout the Sopeña levels in the testpit, more mammal bones were recovered than lithics, but teeth were scarce. Mousterian tools are larger and heavier than the UP collection. Average tool length rose steadily in the Mousterian Levels from XV to XII (Figures 17 and 18), from an average of 28.2 mm to 35,5 mm long. In the UP levels XI to IX tools averaged 24 to 25 mm in length. Average tool weight rose from 7,2 g. in Mousterian Level XV to 10.3 g. in Level XII. The UP tools in Levels XI to IX average 3,7 to 3.3 g. Therefore, tools abruptly increase in size in the latter millennia of the Mousterian; small lithic size has been related to the presence of training knappers (SHEA, 2006), and this increase in size could therefore signal a demographic contraction in the later millennia of Mousterian occupation.

Not only average lithic byproduct size abruptly changes from the Mousterian increasing size trend to a much smaller average size from Level XI, but this change is also signalled by the disappearance of Mousterian tools after Level XII. Given the closeness of the ^{14}C dates for these levels, it can be said that the Transition was abrupt in Sopeña, with the disappearing Mousterian being closely followed by Upper Palaeolithic people.

At Sopeña, the use of quartzite, locally abundant, decreases steadily in the more recent Mousterian levels, from wt86% in Level XV to 53 wt% in Level XII. In the UP quartzite averages 69-71 wt%. Flint, which is scarce in the area, has sometimes been suggested to indicate long distance trade network in the local Upper Palaeolithic. Flint, which is scarce in the area (ARIAS *et al.*2005) has sometimes been suggested to indicate long distance trade networks in the UP. In the Mousterian of Sopeña, Flint ranges from 14 wt% in Level XV and decreases to 10.46 in Level XII, which seems suggestive of dercreasing geographical range in the latter millennia. The early UP levels X to XII have around wt% of Flint, rising to the 35 wt% in the Gravettian of levels I to III. change. Simultaneously, limestone, which is to be had anywhere in the surrounding landscape, increases from a 4 wt% in Level XV to 27 wt% in the last Mousterian Level XII. In the EUP Levels XI and X drops to >14 wt%.

The presence of quartz fragments has been documented in sites from very early in archaeological context, and is frequently counted amongst the non-utilitarian evidences (EDWARDS, 1978) that could bear testimony of symbolic behaviour. In Sopeña, quartz is absent throughout the Mousterian, and only appears in the EUP Levels IX and VIII, to reappear later, then in significant amounts, in the Gravettian Levels I, II and III.

As for lithic tools, both the later MP and the EUP have similar proportions of flakes and blades. Although retouched tools are few, Mousterian yielded 12.5% retouched tools compared to 5.2% in the UP. The Mousterian also had more formal tools. Taking into account the limited area of the text excavation, the EUP is quite distinct from the Middle Palaeolithic. Although the Sopeña excavation has just begun, the rockshelter has yielded evidence that:

1. Gravettian and Early Upper Palaeolithic levels are preserved in Levels I-XI.
2. The UP deposits range in age from 40 ka to < 25 ka, based on both ^{14}C and ESR analyses.
3. At least six well preserved Mousterian levels underlie the UP deposits.
4. The Mousterian layers range in age from ~ 43-49 to ~ 57 ka, based on ^{14}C and ESR ages on single teeth, and one ^{14}C date gave a later date of 40 ka

More cultural deposits may underlie those discovered so far, since the excavation has not reached the rockshelter floor yet. Undoubtedly, Sopeña will reveal much about modern human origins thanks to its long sequence of Middle and Upper Palaeolithic layers with their good preservation. Although not identified in the test excavation, given the closeness of the dates between the last MP and the first UP, Chatelperronian could occur at the site. More ^{14}C and ESR ages are needed, and TL ages should be attempted to establish an absolute chronology for the site. Research at Sopeña, with its abundant lithic and faunal remains, excavated and analyzed with modern methods should illuminate the shifting behavioural and cultural patterns marking the Middle to Upper Palaeolithic transition.

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