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The Cueva del Angel (Lucena, Spain): An Acheulean hunters habitat in the South of the Iberian Peninsula

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ABSTRACT

The Cueva del Angel archaeological site is an open-air sedimentary sequence, remnant of a collapsed cave and part of a karst complex. The faunal assemblage dominated by *Equus ferus*, large bovids and cervids has been subjected to intense anthropic actions reflecting selective predation. The fauna may be correlated with European faunistic associations of the end of the Middle Pleistocene to the beginning of the Upper Pleistocene. The Cueva del Angel lithic assemblage (dominated by non-modified flakes and abundant retouched tools with the presence of 46 handaxes) appears to fit well within the regional diversity of a well developed non-Levallois final Acheulean industry. A preliminary $^{230}Th/^{234}U$ age estimate, the review of the lithic assemblage and faunal evidence would favour a chronological positioning of the site in a period stretching from the end of the Middle Pleistocene to the beginning of the Upper Pleistocene (MIS 11–MIS 5). The Acheulean lithic assemblage found at the Cueva del Angel fits very well with the hypothesis of a continuation of Acheulean cultural traditions in the site, distinct from the contemporaneous uniquely Mousterian complexes witnessed in other parts of the Iberian Peninsula, and Western Europe.

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1. Introduction

This paper reports a new archaeological discovery, the Cueva del Angel, a site located on the outskirts of the town of Lucena, province of Cordoba, Spain (Fig. 1). Part of a karst system (Fig. 2), the Cueva del Angel is a collapsed open-air cave with a stratigraphy displaying a Middle to Upper Pleistocene human occupation. It is situated in the lower southern slope of the Sierra de Araceli (orientated SW–NE) at an elevation of 600 m a.s.l. (37° 22′ 10 N, 4° 28″ 43.83 W).

As documented in a local chronicle (Ramírez de Luque, 1792), the Cueva del Angel site was historically exploited by miners looking for “marble water” (travertine rock utilized in the past in the construction of church bays). In 1995 a team led by C. Barroso and D. Botella discovered a rich stratigraphy on top of the site. After delineating the extent of the archaeological deposit, the open-air site was cleared of substantial disturbed red clay deposits covering the sequence and enormous blocks of limestone rock were removed, revealing within the site a well and a trench remnants of the former mining activities. This clearing operation enabled us to study the morphological evolution of the stratigraphic deposits. In 2002, 2003, on-site work was initiated to obtain a proper stratigraphic section of the potentially 5 m deep sequence and to prepare various zones for full fledged excavations which started in 2005 under a 6 year project approved by the Junta de Andalucia, and funded by the Junta de Andalucia and the municipality of Lucena. To date, six excavation campaigns have yielded numerous faunal remains and substantial Middle Palaeolithic type lithic artifacts, including a number of handaxes, but so far no human fossils.

A preliminary ^{230}Th/^{234}U dating of a calcite flowstone partially sealing the sedimentary sequence in zone L6 of bed VIII (Fig. 3) has given an age of 121 + 11/−10 ka with an error less than 10% (Zouhair, 1996). To the extent that this flowstone sample is deemed to be contemporaneous with the related level in the stratigraphy, it

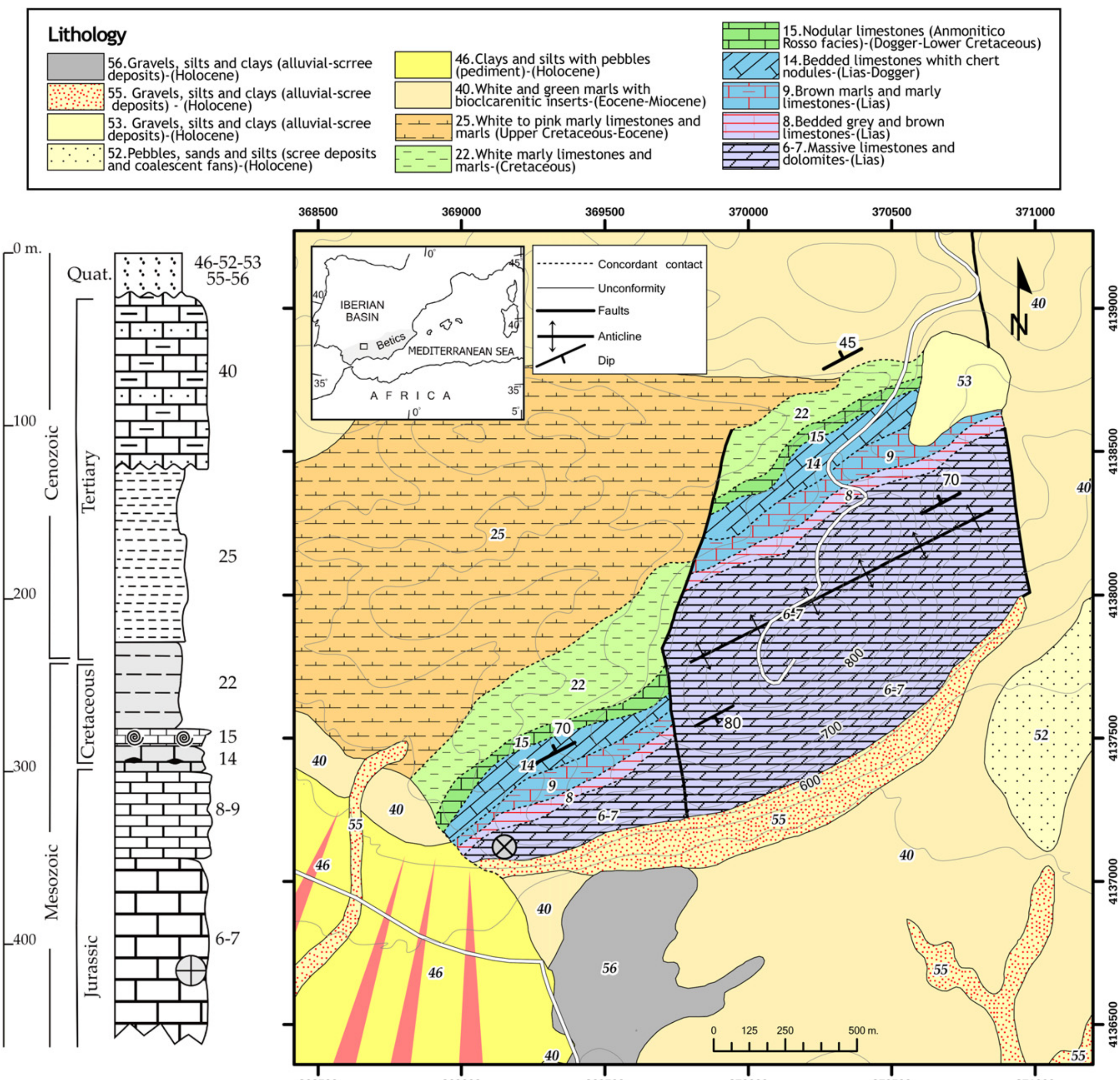

Fig. 1. Geological map and lithostratigraphic column of site area. ⊠ Cueva del Ángel.

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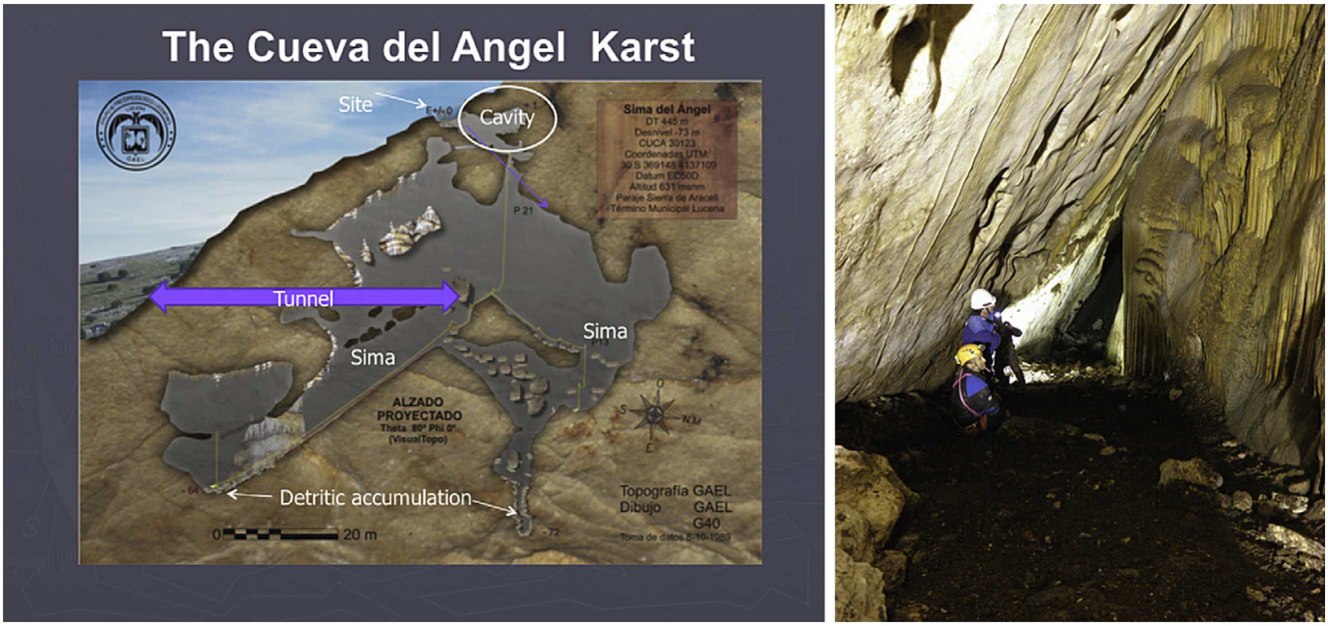

Fig. 2. The Cueva del Angel karst complex.

would indicate that the top of the Cueva del Angel sequence coincides with the beginning of MIS 5. Further dating is presently being undertaken to assess more precisely the chronology of the sequence. Thus, the research developed in this paper highlights the preliminary findings of an important new site which will contribute to a better understanding of the presence in a cave context of the late Acheulean industry in the South of the Iberian Peninsula.

2. Geology

2.1. Geological setting (Fig. 1)

The karst complex of the Sierra de Araceli, where the Cueva del Angel is located, is part of a Mesozoic (Lias) carbonate unit (limestone and dolomite) belonging to the External Meridional Subbetic Domain of the Betic Cordilleras, the large orographic and geological formation in the South–Southeast of the Iberian Peninsula that originated as a result of the Alpine orogenesis (García Dueñas, 1967; Molina Cámara, 1987). The lithostratigraphic series of the Sierra de Araceli comprises materials stretching from the Triassic to the most recent Quaternary. The Triassic materials do not appear at the surface directly, although they have been noticed in the north and northwest parts of the Sierra. They possibly constitute the base of this series and are essentially made of red clays, sometimes green or purplish, and as they crop out become powerful masses of gypsum (López Chicano, 1985).

The Sierra de Araceli corresponds to an anticline affected by various faults with sinistral displacement, the Cueva del Angel being located in its northern flank. In the Sierra and its surroundings, two chronostratigraphic units are differentiated: the oldest, comprised of Mesozoic materials, principally limestone, dolomite and carbonated marl, and the most recent, formed of Cenozoic materials composed of marl, biocalcarenite (Eocene–Miocene) and recent detrital sediments (Quaternary). The Quaternary is well represented in extensive clay filled surfaces resting on top of the materials just described. They correspond principally to fluvial deposits, glacis and piedmont deposits. Its dominant lithology is made of dark and red clay, and to a lesser extent of sand, conglomerate and breccia, of alluvial or colluvial origin (López Chicano, 1985).

The geomorphological structure of the Sierra de Araceli was finalized towards the end of the Miocene, period during which a regression started through the depression of the Guadalquivir river. This withdrawal isolated the Sierra de Araceli from other mountains in the East and Southeast (López Chicano, 1985). The major carbonate composition of the Sierra de Araceli favoured its important karst evolution, notably as it relates to the groundwater network.

2.2. Karst complex (Fig. 2)

In the Sierra de Araceli complex, the Mesozoic carbonates (Jurassic-Cretaceous) stand out in the form of five cartographic units (Fig. 1). The Cueva del Angel is included in Unit I, composed of 200 m of dolomite, calcitic dolomite, dolomitic limestone and limestone in successive order from the base to the top (lithologies 6 and 7 of Fig. 1). These carbonates, cropping out in large banks, dip in an N–NW direction and have been affected by frequent distensive N–NW/S–SE faults and diaclases, as the result of which important karstification processes have given rise to the formation of sinkholes and various cavities, such as the Cueva del Angel.

The Cueva del Angel karst complex is presently made up of 3 differentiated parts:

1) **The Cueva del Angel archaeological site (Site, Fig. 2):** excavated and well-preserved sedimentary sequence object of the present research, found in the north of a 300 m^2 platform sloping slightly southward. It incorporates blocks of calcareous breccias, limestone rocks and speleothems. The archaeological deposit has been covered by a metallic roof structure to protect it from the weather and unwelcome visitors. This open-air platform is probably the remnant of a collapsed cave, the walls and roof of which have been lost due to unknown causes during possibly the Upper Pleistocene.
2) **The nearby cavity (Cavity, Fig. 2):** located on the slope of the hill, a few meters NE of the platform, is 18 m long/3 m wide and is littered with collapsed limestone blocks. Parts of the almost disappeared original sedimentary deposit are found at the bottom of a steep gradient and have provided indications of a new stratigraphy. In the deepest part of the cavity there is an

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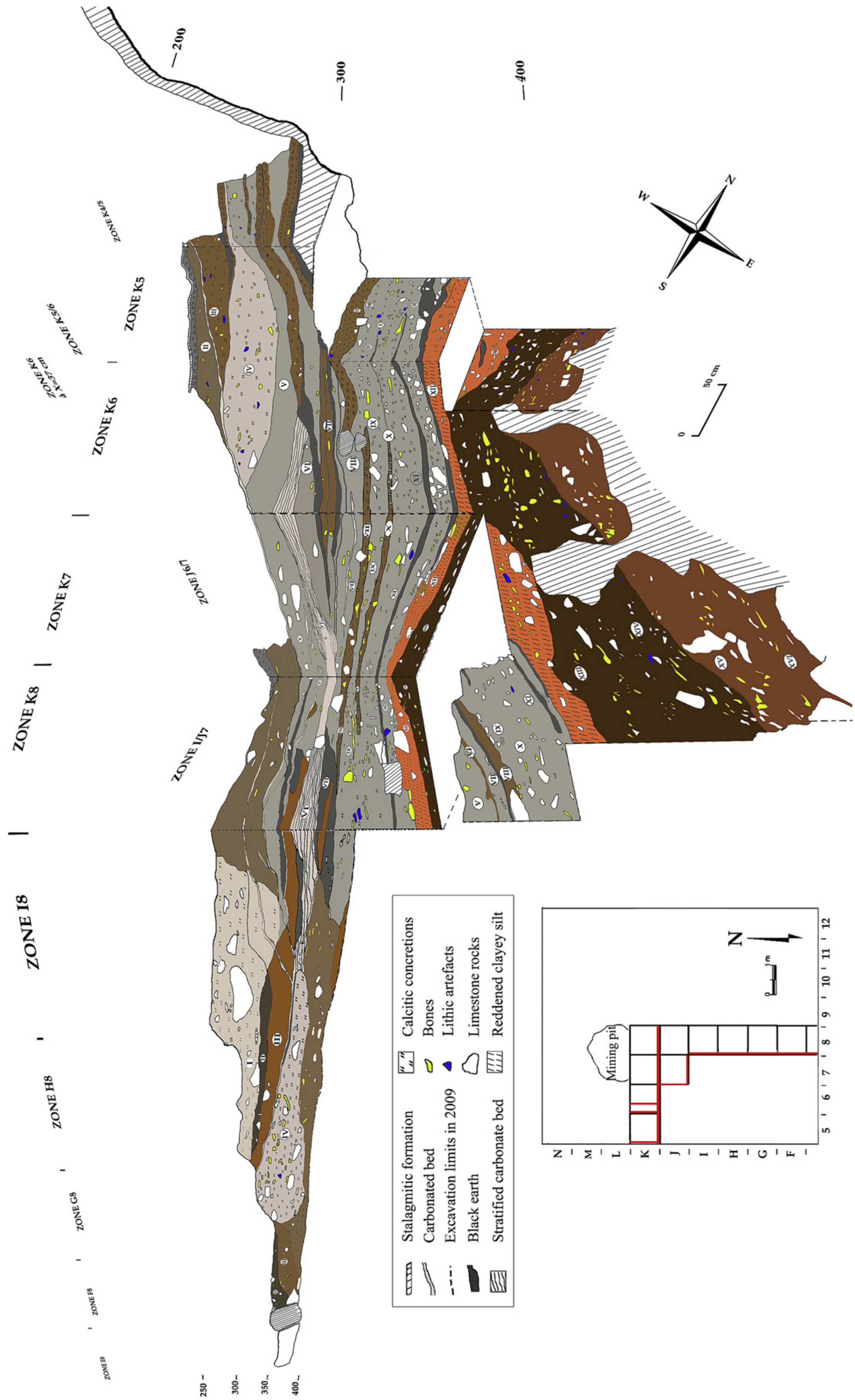

Fig. 3. Stratigraphy of the open-air Cueva del Angel (Drawings by S.Khatib and T.Saos).

opening on the floor giving access to a sinkhole (Sima) that has been explored by speleologists. This cavity probably connects to the original and now disappeared cave of the Site.

3) **The sinkhole (Sima, Fig. 2):** located beneath the platform and cavity, it has a 100 m vertical depth. It is filled at the bottom with substantial detrital accumulations that form a 70 m dejection cone made up of rock blocks included in a finer matrix (sand to clay clasts) in which are embedded numerous animal bones and lithic artifacts.

In the summer of 2009, a 30 m long tunnel was drilled (Tunnel, Fig. 2) at a lower elevation than the site to access the sinkhole (Sima). It is anticipated that the access cavity and the sinkhole (Sima) will be excavated in order to further study and better understand the nature of the human occupation of this archaeological complex.

2.3. *Stratigraphy of the Cueva del Angel (Fig. 3)*

After the probable collapse of the roof and walls of the cave, the sedimentary register was sealed off from external influences with a thin speleothem. Thus, this exceptional formation is due to the well-preserved diversity of facies, its anthropic characteristics and its post-depositional chemical evolution. The excavated area has been partitioned into a system of Cartesian coordinates of 1 m^2 squares with letter and number axes. The following zones have been excavated: F8, G8, H8, I8, J8, J7, K5, K6, K7 and K8. The sedimentary sequence uncovered to date is over 5 m deep with the lower layers visible in the mining well (zones corresponding to vertical sections L/M and 7/8). A multi-faceted stratigraphic cross-section of the zones excavated to date from top to bottom is shown in Fig. 3 and a detailed description of the complex excavated stratigraphy is presented in Appendix.

The richest part of the sequence from an archaeological standpoint is found in transversal stratigraphic sections of an area including the zones defined by the letters J/K and numbers 5–8. This area with a maximum sedimentary depth of 365 cm is partially covered at the top by a 2–3 cm thick speleothem layer. The considerable amount of archaeological material is composed in the majority of large mammal bone remains and numerous lithic artefacts. Also observed, particularly from the middle to the bottom part of the sequence, were fragments of calcite. Their presence in the middle of the deposits can only be explained by their fall from the place of original formation.

The sediment has a loamy texture with colours rarely homogeneous and consistency varying between indurated and cemented. The heterogeneity of the colours is due to the presence of numerous burnt bone splinters and the alteration of some coarse stone elements. The sedimentary structure is organized in lumpy polyhedral aggregates, rarely foliated. The porosity is vacuolar and depending on the zones, it is rare or frequent. Also characteristic is the presence of some sub-horizontal to sub-vertical fissures and the absence of metallic inclusions. Secondary calcite precipitations have allowed the development of a generalized encrustation and layers of concretion around objects as the result of stratification (Huet, 2003).

Mention should be made that 88% of the faunal bone remains are burnt with colours ranging from brown and black to grey, white and blue. These various colourations reflect the intense use of fire in the site at different temperatures. At present, no hypothesis on the various modes of use of fire is possible. It appears that, instead of well-situated small hearths, an extensive combustion structure is present. This structure may have resulted from the intense and continuous use of the cave as a place of butchering and cooking of animal meat resources rather than as a camp used only for shelter. Such an abode was probably in the vicinity of the cave, which is the reason why future excavations will take place in the adjoining cavity with access to the sinkhole. The use of fire in the site will be the object of a future detailed study.

2.4. *Sedimentary texture and composition (Fig. 4)*

Several analyses including texture, mineralogy and total organic carbon were conducted with 52 samples (21 TOC) taken along stratigraphic sections in zones J/K. Grain-size distribution was determined by dry sieving for the coarser fractions. The fractions lesser than 100 μm were analysed by photosedimentation (MicromeriticsR SediGraph 5100 ET) after using Na-hexametaphosphate as a dispersing agent.

The mineralogical analysis of the samples was carried out by means of X-ray diffraction (XRD) using a SIEMENS D-5000 equipment. In addition, the medium to fine sand fraction (0.10–0.25 mm) was examined under the optical microscope to recognize the presence of heavy minerals. The abundance of total and organic carbon (TOC) of 21 samples has been performed using an Eltra CS-800 Elemental Analyzer. The hosted rock, speleothems and rock cobbles included in sediments have been studied with petrographic microscope after thin section elaboration and staining with red alizarin S.

Taking into account the archaeological content and the proportion of coarse-sized rock fragments, the sedimentary sequence has been partitioned vertically into three major units. The grain-size distribution, mineralogical composition and organic carbon analysis from these three differentiated stratigraphic units are shown in Fig. 4 and summarized as follows (Z measured from preset 0 level):

- **Unit I ($Z = -215$ to -265 cm, with limited archaeological material):** in this slightly eastward sloping unit, the average coarse to fine-grained fraction ratio is 18/82, and the grain-size (mean values: gravel 18%, sand 36%, silt 32% and clay 14%) and mineralogy (mean values: quartz 8%, phosphates-hydroxyapatite 11%, phyllosilicates 29% and calcite 52%) distributions are relatively homogeneous. The dominant colour is dark grey brown to dark brown, with a sedimentary structure that varies between granular and blocks reaching 5 cm diameter, and showing a variable degree of compactness. The clay mineral assemblage is composed of highly disordered phases including a swelling clay, probably smectite or/and illite–smectite randomly mixed layers. The average total organic carbon (TOC) content is 1.45%.
- **Unit II ($Z = -265$ to -450 cm, with a great abundance of archaeological material):** the average coarse to fine-grained fraction ratio is 22/78. This also slightly eastward sloping unit shows a substantial textural heterogeneity as indicated by the volatility of the grain-size distribution (mean values: gravel 22%, sand 40%, silt 27% and clay 11%), but with still a predominance of sand and silt. The colours are more variable with dark brown and reddish shades standing out and a 2 cm thin black level appearing at around − 410 cm. The dominating structure of the sediments is granular with mineralogy mean values of quartz 7%, phosphates 15%, phyllosilicates 30% and calcite 48%. The clay mineral assemblage is similar to that described in Unit I with the noteworthy identification of smectite, illite and traces of kaolinite in the lowest levels. The petrographic study of the rock fragments found in this unit shows that they are mainly of carbonate origin (biomicrite, dedolomite and speleothemic calcite) with size ranging between 1 and 10 cm. The total organic carbon content (TOC) varies between 0.56 and 2.37% with an average of 0.90%.

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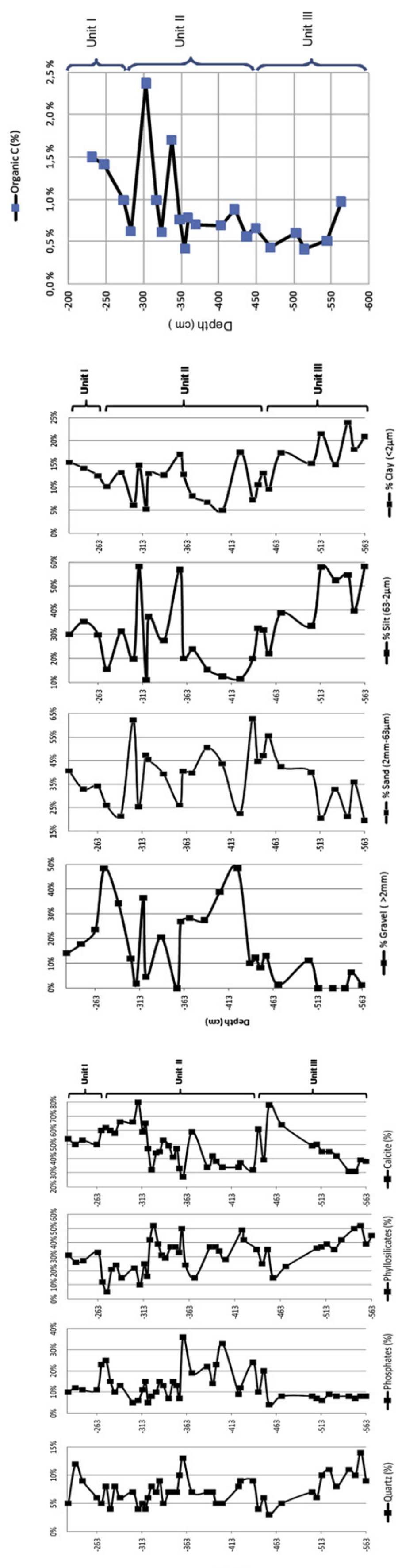

Fig. 4. Grain size, mineralogy and organic carbon distribution along the stratigraphy.

- **Unit III ($Z = -450$ to -580 cm, with limited amount archaeological material):** the average coarse to fine-grained fraction ratio is 4/96 resulting in the highest proportion of sand and silt of the sequence. Grain-size mean values are: gravel 4%, sand 34%, silt 45% and clay 17%. While the content of silt increases, the content of sand and gravel decreases compared to Unit II, this being compensated by a higher clay proportion. Mineralogy mean values are: quartz 9%, phosphates 7%, phyllosilicates 38% and calcite 46%. Compared to Unit II, the average mineralogical value of phylosilicates increases and the phosphate one diminishes. Reddish shades dominate and the structure of the sediment is granular. The clay mineral assemblage is made up of smectite (>50%) with subordinated illite and kaolinite. The petrographic study of the rock fragments found in this unit shows that they are mainly of carbonate origin (dedolomite and dolomite) with sizes in the same range as in Unit II. The total organic carbon content (TOC) varies between 0.41 and 0.97% with an average of 0.58%.

The results of the grain-size analysis highlight the predominance of silt and sand in all the units with sporadic intrusion of gravel rich levels in Units I and II. The clay content is low with the highest values in Unit III. The lack of sedimentological continuity in the vertical grain-size distribution suggests that materials, especially in Units I and II, have been reworked. The total mineralogy shows the mixing of detrital minerals (phyllosilicates, quartz, bone-related hydroxyapatite and carbonates such as calcite and dolomite from rock fragments) with others originating from solution precipitation such as calcite and authigenic phosphates (withlockite). The results of the clay mineralogy are particularly interesting because the differences in the mineral assemblages from Unit III and Unit II would indicate the existence of a process responsible for the degradation of illite and smectite and the loss of kaolinite. This process could be related to a thermal event with temperature values higher than 500 °C. The variable content of TOC demonstrates that organic matter is not evenly distributed in the deposit, the lowest percentages being observed in Unit III and the highest, implying a higher availability of organic matter in Units I and II. The presence of withlockite especially in Unit II suggests the chemical and/or thermal alteration of hydroxyapatite from bones and reaction with Mg^{2+} sourced in the dolomite rich host-rock.

In a previous study, Huet (2003) suggests that the absence of pores and bioturbation would indicate that the sedimentary accumulation has not been subjected to many biological or chemical post-depositional alterations, other than carbonation, as further indicated by the good conservation of lithics and bones. The diffuse or widespread incrustation in various beds may be caused by the precipitation of carbonates during climate warming. These carbonates are probably endogenous and originate from calcareous dissolution or the disintegration of the walls of the cave. Huet indicates that clay in the sedimentary deposits probably originates from surface formations around the cave with infiltration from fissures in the karst as the result of water drips. The majority of quartz grains are translucent. The presence of a substantial number of worn quartz grains shows that a certain proportion of the sediments are of allochthonous origin. Huet hypothesizes that these worn quartz grains could have come by aeolian transport from the sands of neighbouring river terraces.

3. Palaeontology: amphibians and reptiles

A preliminary palaeoclimatic indication of the environment of the site is provided by the herpetofauna assemblage of the Cueva del Angel which is characterized by the presence of taxa typical of the Mediterranean domain: *Testudo hermanni*, *Timon lepidus*, *Blanus* *cinereus*, *Malpolon Monspessulanus* y *Hemorrhois hippocrepis* (presence to be confirmed for this later species). The present geographical distribution of the majority of these species has a climatic threshold linked to temperature and summer insolation: average annual temperature greater than 10 °C, minimum average temperature of summer months greater than 21 °C and average annual insolation of between 2500 and 3000 h (Cheylan, 1981; Blazquez and Pleguezuelos, 2002; Pleguezuelos and Feriche, 2002).

3.1. Amphibia

Fifteen remains have been attributed to this group. The determined taxa, based on the methodological work of Sanchiz (1977) and Bailon (1999), are: *Discoglossus* sp., Alytidae ind. (Alytidae), *Bufo bufo* and *Bufo calamita* (Bufonidae). A sacral vertebra shows a morphology of the *Discoglossus* type: presence of one anterior and two posterior condyles, and enlarged sacral apophyses, although in lesser proportion than in the case of *Alytes*. Furthermore, a distal femur fragment exhibits a pronounced diaphyseal curvature characteristic of the Alytidae family without the possibility of a more precise attribution. *B. bufo* and *B. calamita* are represented by typical elements: humeri and ilia. Both species are widely distributed in the Iberian Peninsula where they occupy a great diversity of habitats.

3.2. Chelonia

Based principally on the morphology of the epiplastron and hypoplastron [see differentiating characters in Cheylan (1981) and Hervet (2000)], the studied material is attributed to *T. hermanni*. Actually only present in the Catalan region, this species had in the past a wider geographical distribution in the Peninsula, including Andalusia, probably until the Upper Pleistocene as shown in the Boquete de Zafarraya (Lapparent de Broin and Antunes, 2000; Bailon, 2001; Barroso Ruíz and Bailon, 2003).

3.3. Squamata

A total of 39 remains have been attributed to this group. The represented taxa are: *Chalcides* sp. (Scincidae), *T. lepidus*, *Podarcis* sp. and Lacertidae ind. (Lacertidae), *B. cinereus* (Blanidae), *Coronella* sp., *M. monspessulanus* and cf. *H. hippocrepis* (Colubridae). The taxonomic attribution follows the work of Bailon (1991) and Blain (2009). Although a species attribution has not been possible, dentary evidence demonstrates accurately the characters of *Chalcides*: open Meckel's canal and presence of monocuspid pleurodont teeth with ornamented crowns showing fine striae in medial norma.

The lacertids are represented by an ilion belonging to a large size lizard (*T. lepidus*) and by various elements attributed to small lacertids, among which a representative of the genus *Podarcis*.

B. cinereus is the best represented squamous in the Cueva del Angel (14 vertebrae and 3 dentaries). The morphology of these elements is well characterized (Bailon, 1991; Blain, 2009) and does not offer any problem of identification. Snakes are exclusively represented by colubrids. Two well-characterized morphological vertebral types have been observed: a vertebra belonging to a representative of the genus Coronella (*Coronella* sp.) and another one corresponding to the model *Malpolon* (*M. monspessulanus*) [see characters in Bailon (1991) and Blain (2009)]. Another rather fragmented vertebra exhibits various characters affine to *H. hippocrepis* (cf. *H. hippocrepis*).

4. Palaeontology: large mammals

Since the discovery of the Cueva del Angel in 1995, an amount in excess of 120,000 bone remains have been recovered, of which more than 7000 have been dug out from the archaeological sequence, while the rest were found in the early years during the clearance of disturbed deposits covering the site as part of the clean-up operations prior to excavations. A few post-cranial bones of hare (*Oryctolagus* sp.), tortoise (*Testudo* sp.) and avifauna (5 burnt small fragments) have also been identified in the sequence.

4.1. Material

Out of the more than 7000 coordinated remains, 2959 have been taxonomically determined as large mammals and have been attributed to the following taxa:

Order *Carnivora* Bowdich, 1821
 Family Ursidae Gray, 1825
  Ursus arctos Linnaeus, 1758
  Ursus spelaeus Rosenmüller and Heinroth, 1794
 Family Canidae Fischer von Waldheim, 1817
  Canis lupus Linnaeus, 1758
 Family Felidae Gray, 1821
  Felis silvestris Schreber, 1777
  Lynx pardinus Temminck, 1827

Order *Perissodactyla* Owen, 1848
 Family Equidae Gray, 1821
  Equus ferus Boddaert, 1785
 Family Rhinocerotidae Gray, 1821
  Stephanorhinus hemitoechus (Falconer, 1968)

Order *Artiodactyla* Owen, 1848
 Family Bovidae Gray, 1821
  Bos primigenius Bojanus, 1827
  Bison priscus Bojanus, 1827
  Capra sp. Linnaeus, 1758
 Family Cervidae Gray, 1821
  Cervus elaphus Linnaeus, 1758
  Dama dama Linnaeus, 1758
 Family Suidae Gray, 1821
  Sus scrofa Linnaeus, 1758

Order *Proboscidea* Illiger, 1811
 Family Elephantidae Gray, 1821
  Palaeoloxodon antiquus Falconer and Cautley, 1847

The most important taxonomic group found in the sequence is the large herbivores, while the presence of carnivores although appreciable is more modest. The faunal assemblage is dominated by the horse *Equus ferus*, followed by large bovids *B. primigenius*/*B. priscus* and cervids *C. elaphus* and *D. dama* with, although less abundant, a good representation of the suid *S. scrofa*, the rhinoceros *S. hemitoechus*, the brown bear *U. arctos* and the lynx *L. pardinus spelaeus*. The elephant *P. antiquus* and the wolf *Canis lupus* are scarce while the Ibex *Capra* sp. is practically inexistent. This faunal accumulation is not representative of the ambient palaeo-biodiversity and reflects essentially human predation.

Taxonomic diagnostic observations are presented in order of NISP importance:

- *Equus ferus* (NISP = 1200):

Tooth morphology of the Cueva del Angel equid (Fig. 5d) and its skeleton are typical of the true horse. Teeth dimensions do not vary much along the stratigraphy (Table 1). Its body size (Variability Size Index, V.S.I.) (Meadow, 1999) is close to the one of *E. f. torralbae* from the Acheulean sites of Torralba (Prat, 1977) and Solana del Zamborino

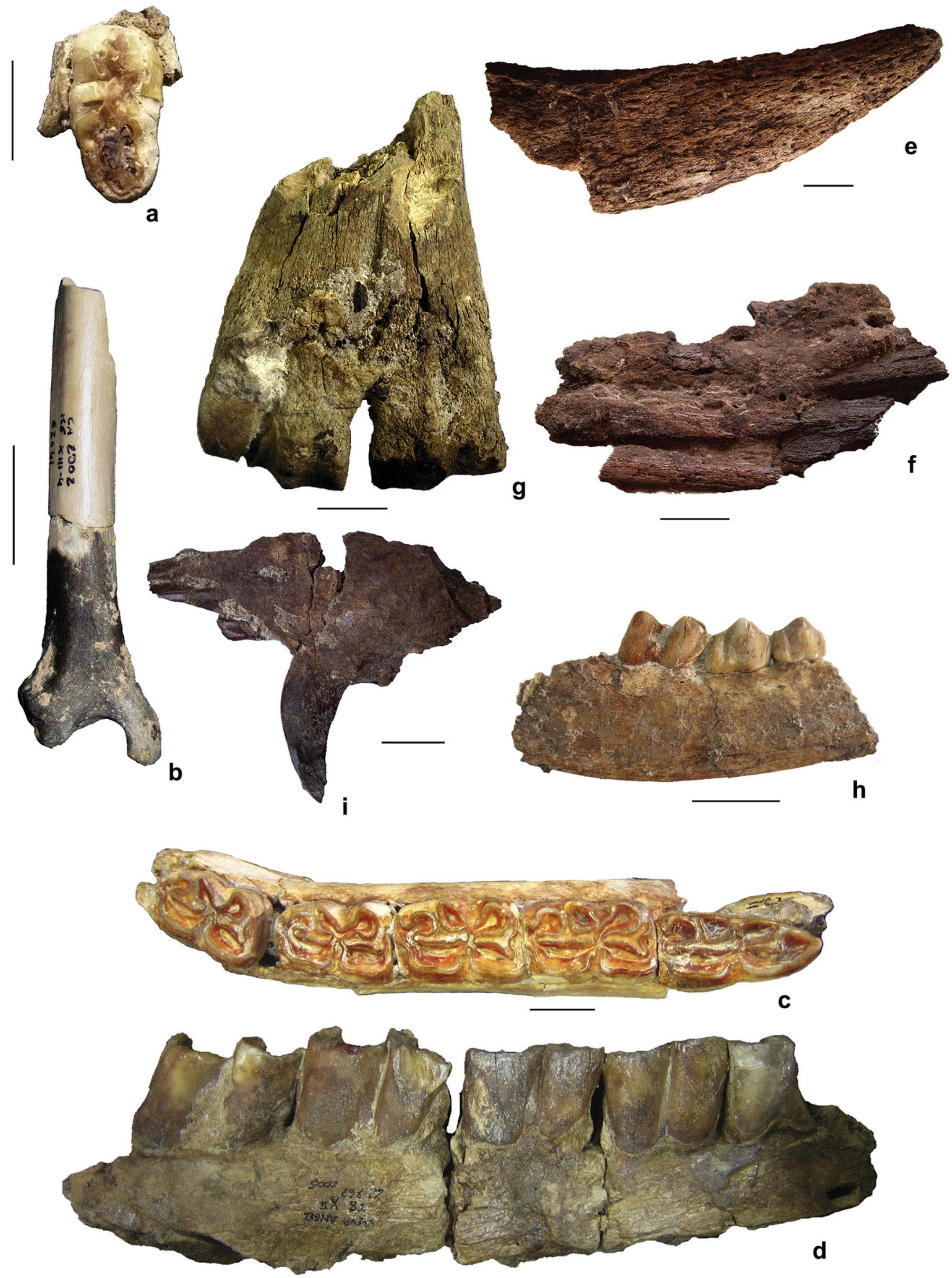

Fig. 5. (a) *Sus scrofa*, trace on fragmented left tibia distal end; (b) *Ursus arctos*, right M^2, occlusal view; (c) *Lynx pardinus spelaeus*, right tibia distal end, dorsal view; (d) *Equus ferus*, right mandible, occlusal view; (e) *Stephanorhinus hemitoechus*, right mandible, labial view; (f) *Bos primigenius*, horn core, distal part; (g) *Bison priscus*, horn core fragment; (h) *Bos primigenius*, distal right metacarpal; (i) *Dama dama*, right mandible, labial view; (j) *Sus scrofa*, left mandible, superior view. Scale bar 2 cm.

Table 1
Equus. Selected comparative measurements of cheek teeth (in mm) from Cueva del Angel and other Middle and Upper Pleistocene horses.

			P^{3-4}					M^{1-2}				
			N	L	W	P	IP	N	L	W	P	IP
Spain/Portugal												
Torralba[a]	Mindel-Riss	pt. P	5–6	29.2	–	–	46.8	20–21	25.4	–	–	49.7
Solana del Zamborino[b]	Mindel-Riss	occ.	114–125	29.9	27.5	13.6	45.5	105–115	27.2	25.8	13.0	47.8
Monteaqudo del Castillo[c]	–	occ.	8–10	30.0	28.2	14.0	46.8	8	26.8	27.0	13.6	51.0
Zafarraya[d]	MISS	occ.	–	–	–	–	–	1–2	26.4	27.6	13.7	52.5
Portugal[e]	MIS 2	occ.	11	28.3	27.1	13.3	47.3	14–15	25.0	24.7	12.7	50.8
Cueva del Angel	I to VI	occ.	9–10	30.3	27.2	13.8	45.7	16–17	26.2	25.9	13.5	51.4
Cueva del Angel	VII to XVI	occ.	7–8	29.8	27.6	13.7	45.9	11–12	26.2	25.9	13.9	53.0
Cueva del Angel	Total	occ.	34–38	30.0	27.5	13.8	46.0	48–49	26.2	25.9	13.5	51.6
Europe												
Orgnac 3 [2–1][f]	MIS 9/8	occ.	35–43	31.7	29.4	13.9	44.4	49–66	27.8	26.9	13.5	48.2
Taubach[g]	MIS 5e	occ.	20–23	30.2	29.4	14.3	47.7	20–23	27.4	27.6	14.7	53.6
Poftel-Ouest F[f]	MIS 4/3	occ.	53–57	30.6	28.8	13.7	45.0	59–64	27.0	26.9	14.2	52.4
Combe-Grenal [35–1][h]	MIS 3	occ.	67–73	30.3	28.3	13.8	45.7	60–72	26.8	26.9	14.1	52.7
Jaurens[c]	end MIS 3	occ.	38	28.3	28.0	12.5	44.4	37	25.1	26.1	13.5	53.9

[a] Prat, 1977.
[b] Martín Penela, 1988.
[c] Eisenmann et al., 1990.
[d] Barroso Ruíz et al., 2003.
[e] Cardoso and Eisenmann, 1989.
[f] Boulbes, pers. data.
[g] Eisenmann, pers. comm.
[h] Guadelli, 1991.

(Martín Penela, 1988 and Fig. 6). However, the average IP (Protoconal Index) of the M^{1-2} is relatively higher (Table 1), character which is generally considered as progressive. Teeth and skeletal dimensions are greater than Upper Pleistocene Portuguese *E. f. antunesi* (Cardoso and Eisenmann, 1989). Other caballine sub-species in Spain are microdont (Torres Pérezhidalgo, 1970; Altuna, 1973a; Alférez et al., 1985). European Middle Pleistocene caballine equids from North of the Pyrenees are larger in both body and tooth size (Fig. 6, Table 1); IP increases at the end of Middle Pleistocene (Table 1).

The biochronological question of caballine equids *sensu stricto* in the Iberian Peninsula is relatively complex (Maldonado, 1996; Sesé and Soto, 2005; Cerdeño and Alberdi, 2006).Geographical variations of size and proportions of horses in Europe (Cramer, 2002; Eisenmann et al., 2002; Bignon, 2003) show the difficulty one faces in relying on extra-regional models for equid taxonomic attribution, in particular in Spain where horses are often smaller than their contemporaries in the rest of Europe. The Cueva del Angel horse, by its size close to the ones encountered in other Spanish Acheulean sites but with a higher IP, may be reasonably situated chronologically between the end of the Middle Pleistocene and the beginning of the Upper Pleistocene.

- *B. primigenius* and *B. priscus* (NISP = 601):

Numerous large bovid remains are found throughout the stratigraphy. Many teeth were found, generally of a large size, with very high hypsodonty. Horn cores are rare; however, a complete extremity allowed the determination of *B. primigenius* (Fig. 5f) while a few fragments show neat wide and deep grooves generally observed on *Bison* horn cores (Fig. 5g). These two genera are rarely observed together in Spanish sites (Altuna, 1973a; Martín Penela, 1988; Van der Made, 1999a,b). Several criteria generally attributed to *Bison* are present in teeth and skeleton bones such as radius, femur, tibia and calcaneus (Hue, 1909; Bibikova, 1958; Olsen, 1960; Stamplfi, 1963). Its presence is highly probable, unless these criteria are interpreted as adaptive convergence of morphological characters. Overall criteria used to discriminate between the two forms indicate a marked predominance of *B. primigenius* (Fig. 5h), which in the Cueva del Angel is of a smaller size than the large Middle Pleistocene aurochs from Europe (Brugal, 1983; Sala, 1986). Important size differences are assigned to sexual dimorphism (proximal transverse radius diameter between 108.7 and 128.5 mm).

- *C. elaphus* (NISP = 514) and *D. dama* (NISP = 143)

C. elaphus is present throughout the sequence. Its lower molars and premolars are short and narrow. The dimensions of the post-cranial remains found correspond to a midsize deer, similar to the form of Solana del Zamborino (Martín Penela, 1988), but more bulky than the one from Cova Negra (Pérez Ripoll, 1977).

The *D. dama* remains are very fragmented (Fig. 5i). This species is found in various Middle Pleistocene sites of the Iberian Peninsula (Martín Penela, 1988; Azanza and Sanchez, 1990; Arribas, 1994; Van der Made, 1999a,b; Canals et al., 2003). The small sample and the lack of antlers do not allow attribution of this material to one of the sub-species described in other Iberian sites (*D. dama clactoniana*, *D. dama dama* ou *D. dama geiselana*).

- *S. scrofa* (NISP = 150)

Wild boar remains are found all along the stratigraphy (Fig. 5j). The richness of the sample makes it a reference for Pleistocene populations. Molar and premolar dimensions (Table 2) are comparable to those of Taubach (MIS 5e) and Petralona (Hünermann, 1977), which would indicate that this boar is rather robust, more so than the one from Solana del Zamborino (Martín Penela, 1988). However, it does not reach the size of the ones from Terra-Amata (MIS 11) (Serre, 1987) or Orgnac 3 (MIS 9) (Aouraghe, 1992) and Mosbach (Lower Middle Pleistocene) (Faure and Guérin, 1983). This is confirmed from observations of the post-cranial material. The size of the boar decreases progressively during the Pleistocene (Faure and Guérin, 1983). The Cueva del Angel boar is rather more bulky than the extant ones. Individuals from the south of Spain are probably more gracile according to Bergmann's rule applied to this genus, namely that Mediterranean boars are smaller than those of Northern Europe. By its large size the boar of the Cueva del Angel may be slotted chronologically at the end of the Middle Pleistocene or during the Eemian.

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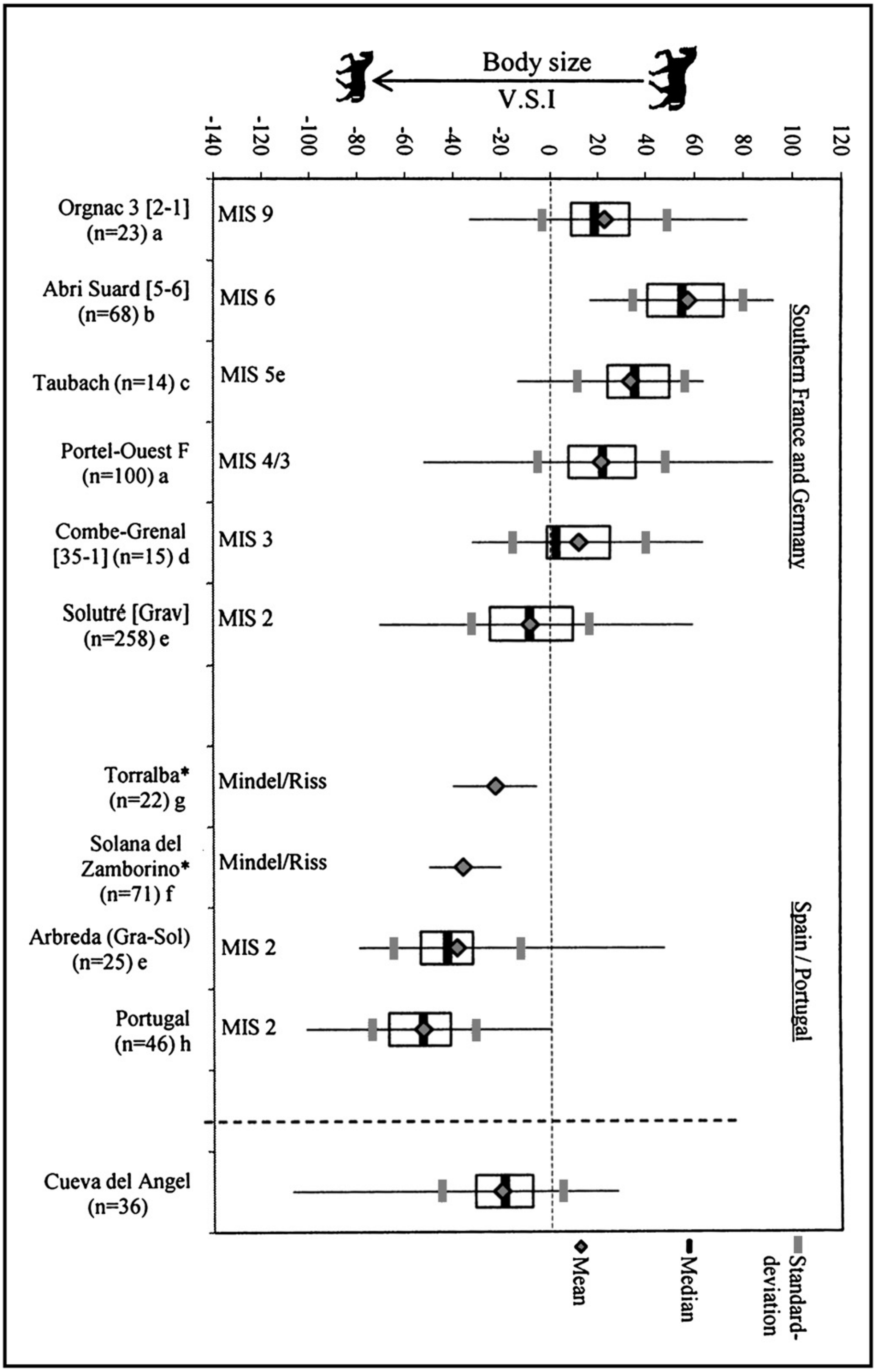

Fig. 6. *Equus ferus*, Cueva del Angel. Variation Size Index (V.S.I.) (from transverse and antero-posterior epiphysis diameters) for Middle and Upper Pleistocene horses. [a]Boulbes, pers. data; [b]Prat, 1968; [c]Eisenmann, personal comm.; [d]Guadelli, 1991; [e]Cramer, 2002; [f]Martín Penela, 1988*; [g]Prat, 1977*; [h]Cardoso and Eisenmann, 1989. Reference: Jaurens (www.vera-eisenmann.com). *V.S.I. after mean.

- *U. arctos* (NISP = 109) and *U. spelaeus* (NISP = 1)

The brown bear is the most abundant carnivore and is present throughout the stratigraphy. The dental morphology found in the site is typical of this species, namely P^4 composed of three well individualized cusps, a deuterocone well separated from the metacone and placed in a distal position, features characterizing *U. arctos* (Ballesio, 1983; Argant, 1991). The M_1 entoconid is constituted of a main denticle, often preceded by a more reduced one. A clear groove covers the talonid, individualizing smooth sided

Table 2
Sus scrofa, Cueva del Angel. Comparative length of upper and lower molars (in mm).

Sus scrofa	M^1	M^2	M^3	M^1	M^2	M^3
			L			
Cueva del Angel	18	23.7	38.7	16.6	23–24	42.3
Terra-Amata				18.6	22.9–23.4	44.2
Orgnac 3	19.5–22.5	25.2–27.2	41.8–42.6	18.2	24–26.6	42.8–46.2
Solana de Zamborino[a]			33.2–35.2			36.2
Taubach[b]	15–18	22–25	38.6–45.5	17.6		39.6–40.2

[a] Martín Penela, 1988.
[b] Hünermann, 1977.

reliefs, contrary to *U. spelaeus* where this groove is replaced by accessory cusps (Quiles, 2003). M^2 is simple, showing a flat talon marked only by several lines (“ridulations”); its occlusal width diminishes progressively towards the distal extremity (Fig. 5b). Dental dimensions fit perfectly within the variability of Iberian *U. arctos* (Table 3). *U. arctos* is present in the Iberian Peninsula starting in the Middle Pleistocene at Atapuerca TD 11 (*Ursus* cf. *arctos*, García and Arsuaga, 2001) and at the end of this period in Galeria Pesada (Trinkaus et al., 2003). A very robust metapod fragment confirms the presence of *U. spelaeus* in the site.

- *S. hemitoechus* (NISP = 124)

The rhinoceros of Cueva del Angel is attributed to the species *S. hemitoechus* found in several sites of the Iberian Peninsula, thus evidencing its widespread dispersal from North to South (Sarrión et al., 1987; Cerdeño, 1990; Fernández-Peris et al., 1997; Cuenca-Bescós et al., 2005; Sánchez et al., 2005; Van der Made and Montoya, 2007). The lower teeth dimensions are comparable to the values of *S. hemitoechus* found in the Caune de l’Arago. Their large size follows the reduction of the premolar segment and the development of the molar segment (Fig. 5e), which allows classification of *S. hemitoechus* of the Cueva del Angel in evolutionary stage 3 (MIS 7–3) (Guérin, 1980; Lacombat, 2003) corresponding to species of the end of the Middle Pleistocene and the Upper Pleistocene.

- *L. pardinus spelaeus* (NISP = 88), *Felis silvestris* (NISP = 3) and *Canis lupus* (NISP = 17)

The lynx is represented mainly by post-cranial remains (Fig. 5c) belonging in their majority to one individual (level XIII). It is of a relatively large size, comparable to Upper Pleistocene specimens of southern France. The important question is the systematic position of the Pleistocene Iberian Lynx and its phyletic relationship with the French Mediterranean form (*L. spelaeus* Boule, 1906). The Iberian form *L. pardinus spelaeus* found for example in Atapuerca SH (García and Arsuaga, 2001) is different from the French Mediterranean one and would seem to evolve towards the extant *L. pardinus*. This speciation pathway would be limited to the Iberian Peninsula (Hemmer, 2004). The species name “*L. pardinus spelaeus*” ought to be used only for this Iberian type, as a transition form in the anagenetic lineage *Lynx issiodorensis* → *L. pardinus spelaeus* → *L. pardinus*.

Three post-cranial remains are attributed to *Felis silvestris* (levels XI–XIII). This wild cat is known in the Iberian Peninsula starting in the Middle Pleistocene in Atapuerca SH (García and Arsuaga, 2001) and in various other sites such as Solana del Zamborino (Martín Penela, 1988).

The wolf *Canis lupus* is represented by several fragmentary remains of small size.

- *P. antiquus* (NISP = 8)

The elephant remains correspond to fragments of tusk, small calcined ivory lamellae and characteristic splinters.

- *Capra* sp. (NISP = 1)

A slightly worn M_1 of *Capra* sp. was discovered in the lower part of the sequence (level XVII-2). It is more robust ($L_{max} = 15.8$; $W = 9$) than the Upper Pleistocene *Capra pyrenaica* of the Iberian Peninsula (Granados et al., 1997; Barroso Ruíz et al., 2003) and extant forms (Couturier, 1962).

4.2. Taphonomical and archeozoological discussion

Most of the bone materials of the Cueva del Angel are made up of bone splinters and fragments of long bone diaphyses, and consequently are difficult to identify taxonomically. The size of the bone splinters is predominantly small between, 2 and 10 cm, and in 90% of long bones the circumference does not reach 180°. This gives

Table 3
Ursus arctos, Cueva del Angel. Selected comparative measurements of M^2 and M1 (in mm).

		M^2								M_1							
		L				W max				L				W max			
Ursus arctos		*N*	min	max	m	*N*	min	max	m	*N*	min	max	m	*N*	min	max	m
Cueva del Angel		3	34	37.9	35.4	3	17.2	20.9	18.6	1			22.7				10.7
Spain[a]		53	28	41.7	35.2	51	16.3	21.5	18.6	34	21	27.8	24.3	39	10.4	14.2	12.4
Basque Country[b]	Upper Pleist./Holoc.	10	30.5	39	34.3	10	15.6	21.1	17.9	6	22	26	23.3	6	10.3	13.5	11.25
Orgnac 3, France[c]	MIS 9	2	29	29.6	29.3	2	14	14.1	14.1					2	11.7	11.7	11.7
Extant, males[e]		27	34	41.5	38.1												
Extant, females[d]		33	31.7	38.7	35.7												
Extant[e]										39	18.7	26.8	22.91				

[a] Torres, 1988.
[b] Altuna, 1973b.
[c] Quiles, 2003.
[d] Kurtén, 1973.
[e] Ballesio, 1983.

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an idea of the strong and advanced process of fracture that this material has suffered

- Physico-chemical considerations

The fossil material of the Cueva del Angel presents a number of specific physico-chemical characteristics.

A substantial proportion of the bones show strong mineralization, with the frequent presence of oxides (manganese oxides more abundant than iron oxides) on the cortical part of the bones in almost all the levels of the sequence. This would indicate that flooding was quite common during the formation of the palaeostratigraphical record. In general, fossils are found in a good state of preservation and frequently amalgamated in a mass of concrete sedimentary matrix. There are a few elements with dissolution alteration on the cortical surface associated with diagenetic processes of the karst system and a few evidences of vermicular processes, actions of bacteria, fungi or lichens. The effect of weathering and abrasion is almost inexistent, which means that there was almost no subaerial exposure and practically no transport.

With regard to bone breakage, orthogonal and staggered breaks produced by sediment compaction are observed. These occur where bone accumulation is greater, and especially in areas of contact between bone elements or with lithic industry. Evidence of trampling is minimal.

- Anthropic actions

Important characteristics of the herbivore faunal assemblage (Figs. 7 and 8) are a significant proportion of fragmentation of the bones for marrow extraction with an appreciable number of cutmarks and striations (9% of the material) related to defleshing, filleting and disarticulation, and the high proportion of burnt elements (88% of the material). This represents unequivocal evidence of anthropic actions reflecting selective predation and the use of animal food resources available in the surroundings of the cave by humans.

Pointed longitudinal and spiral fractures are the most common with usually smooth, straight or oblique surfaces. These features together with a large number of cortical percussion notches are proofs of the intentional anthropic nature of the fracture processes (Fig. 8a). All the cranial and post-cranial anatomical elements have been affected by these processes, with anterior and posterior long bones being logically over-represented. Long bones are fractured from the center of the diaphyses towards the epiphyses by various impacts until they are reduced into small splinters. This process applies also to numerous short bones and longitudinally sectioned first phalanges. For ribs, there is evidence of fracture by flexion. On the cranial skeleton, there is a high degree of fracture of the neurocranium to access the brain elements and a lesser degree to reach the splanchocranium, source of less nutrients. In the majority of individuals, particularly of large size, mandibles are fractured longitudinally in the basal part of the horizontal body. The high degree of fragmentation of the fossil remains is evidence of the maximum utilization of the nutrients and animal resources available in the near environment by the human occupiers of the cave.

Cutmarks are observed throughout the sequence. They usually appear in clusters showing a repeated action on a particular area. On long bones they can be found in the mid-shaft section. These cutmarks are oblique and unidirectional, and sometimes overlapping in opposite directions. The substantial proportions of cutmarks on bones made by stone tools are for example elongated curved cutmarks related to defleshing (Fig. 8b,d–f) or thick short and deep cutmarks related to filleting (Fig. 8c).

Action of carnivores is rare (0.20% of the material) and manifests itself by grooves, gnawing traces, punctures, cupules and gastric acid etching (Haynes, 1983).

Traces of fire on bones are the major taphonomic characteristics of this assemblage. Approximately 88% of the material has been subjected to fire at different grades of combustion as follows: bones partially burnt on the extremity (5%), bones heated with brown colour (47%) and bones subject to complete calcination with black, grey and white colours (36%). Many teeth subjected to fire have cracked, particularly those of carnivore and boar mandibles. This would indicate that the presence of carnivores is due to human transport of these species into the cave for consumption.

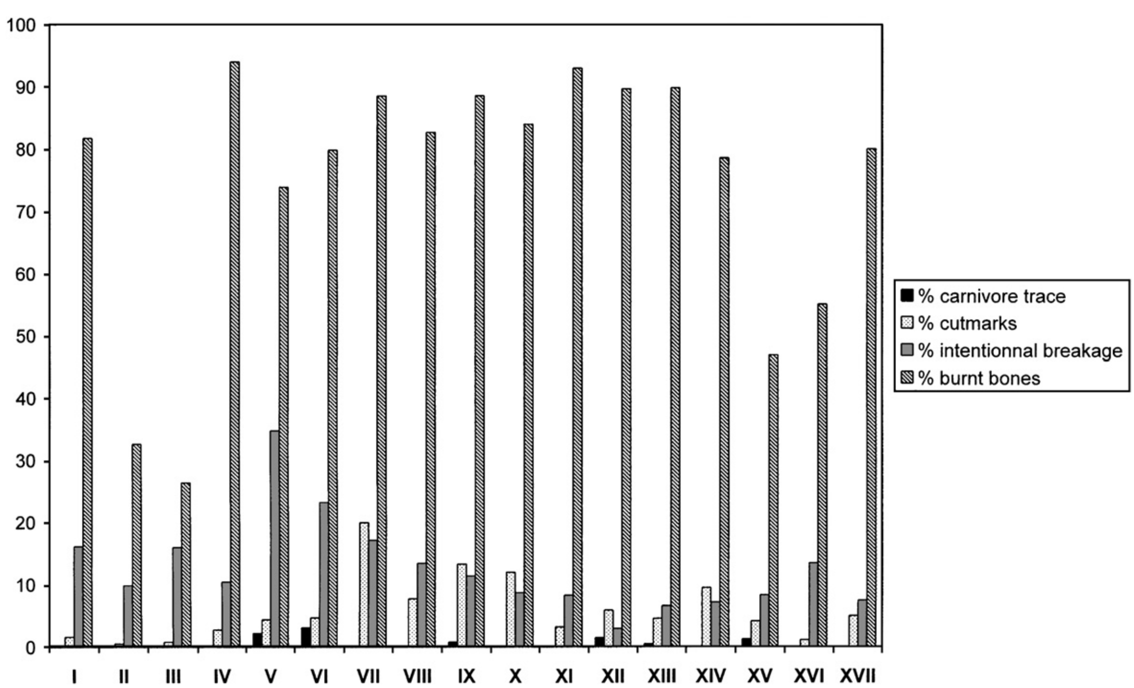

Fig. 7. Percentage distribution of anthropic and carnivore actions on large herbivores remains.

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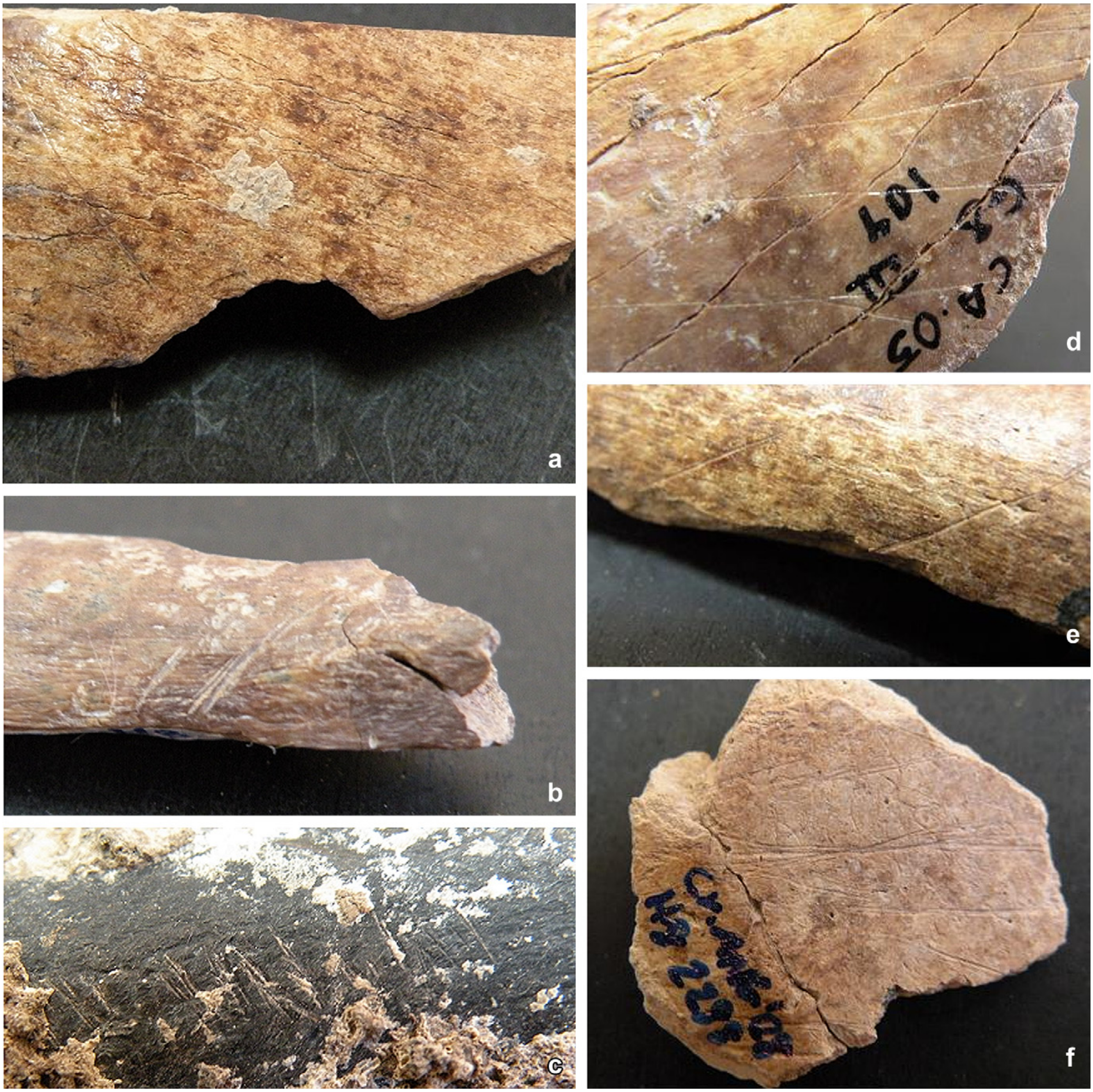

Fig. 8. Anthropic actions: (a) impact notches on long bone shaft; (b, d, e, f) elongated curved cutmarks related to defleshing; (c) thick short and deep cutmarks related to filleting.

Populations of large herbivores of the Cueva del Angel have identical mortality profile, with adults being the most abundant group while juveniles are few and old adults are practically absent. Remains of skeletal limbs are abundant as illustrated in Fig. 9. These factors would indicate a selective transport of bones, rich in meat content and of high marrow utility, by humans.

- Conclusions

The sedimentary and taphonomical evidence gathered in the cave sequence indicates an extensive combustion structure extending from bed IV to bed XII in the stratigraphy (Fig. 3) with a maximum thickness of approximately 1.50 m. This structure does not show specific individual hearth characteristics, such as for example in Abric Romani (Vaquero et al., 2001; Vaquero, 2008). In light of the substantial anthropic actions on bones of large herbivores (Figs. 7 and 8), the nature of the conserved skeletal limbs (Fig. 9) and the very high proportion (88% average – Fig. 7) of material subjected to fire at different grades of combustion, as corroborated in the mineralogical study by a process responsible for the degradation of illite and smectite and the loss of kaolinite related to a thermal event with temperature values higher than 500 °C, Cueva del Angel was a site of intense and continuous occupation, and suggest that it might have been a place of butchering and cooking of animal meat resources predated and transported into the cave by humans.

Humans brought large quantities of meat into the cave from essentially horses and bovids in the form of dismembered and cut

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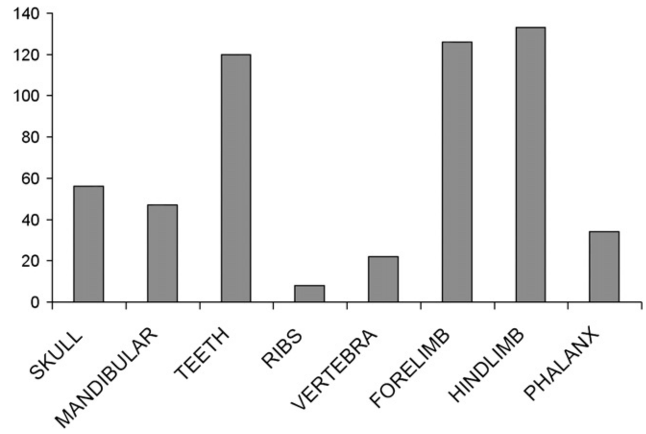

Fig. 9. Conservation of the various elements of large bovids skeleton (Ndsp = 601).

up carcasses. The animals were carried whole or in large pieces into the cave for defleshing and consumption after being killed in the near surroundings. The numerous fragmented and processed cranial and post-cranial remains (mainly made up of maxillae, mandibles, skull and horn fragments, and post-cranial rests such as vertebrae, tarsus, phalanx as well as numerous highly splintered long bones, mainly femurs and tibiae) found throughout the sequence would seem to confirm the hypothesis of an almost continuous human occupation of the cave. The hominins who occupied the Cueva del Angel were specialized hunters of large and heavy herbivores, occasionally hunting smaller animal preys less rich in nutrient resources.

Most of the carnivore remains found in the site are burnt, which would indicate that they also were brought in the cave and consumed in the same way as herbivores. The small percentage of carnivore remains and the low degree of carnivore action on bones would indicate a limited use of the site by carnivores as shelter or habitat.

The high percentage of bone fragments in the deposit caused by anthropic action to obtain bone marrow, food rich in fat with a high nutritional value, illustrates the generalized use of the fragmentation method to such an extent that no long bone has been recovered complete. This method was even applied to short bones such as phalanx or mandibles, elements with low calorific content. The overwhelming percentage of burnt bones from top to bottom of the sequence is testimony of the intensive use of fire in the South of the Iberian Peninsula. The presence of highly carbonized bones may be construed as evidence that they were used as combustible material.

This assemblage of large mammals in the Cueva del Angel corresponds to an accumulation of anthropic origin during a long period from the end of the Middle Pleistocene to the beginning of the Upper Pleistocene. The large hypsodont herbivores are the most abundant species with cervids and boars well represented. This association reflects a mixed environment of wooded grasslands, with probably a more humid climate than today. Given the latitude of the site and the average size of the species identified, smaller than the same species of northern Europe, this fauna may be correlated with faunistic associations of the end of the Middle Pleistocene.

5. Lithic assemblage

5.1. Type distribution and raw material

In excess of 80,000 lithic artifacts have been found in the site. Out of this extraordinary large number, 5253 pieces have been extracted from the stratigraphy and coordinated, the rest coming from the early cleaning operations of disturbed sediments covering the site prior to excavation. The present analysis will therefore be based on 5571 pieces, 5253 coming from the stratigraphy and 318 gathered from the disturbed sediments (IND) used to better characterize the industry ensemble. The lithic spatial distribution along the stratigraphy is shown in Table 4.

The levels with the most abundant lithics are beds IV, IX, X and XV. There are no sterile beds which would indicate a continuous occupation of the site by humans. The assemblage is relatively well-preserved despite, in many instances, the difficult extraction of some pieces out of brecciated matrix. Some of the flint is highly desilicified. Evidence of fire is observed on about a third of the artifacts throughout the sequence with display of varying forms of heat exposure, such as rubefaction, bleaching, cracks, cupula and breaks. Some of the material shows a more or less developed white or cream coloured patina; this reflects various stages of surface alteration. A differentiated patina suggests that some elements were reworked.

Non-modified flakes are largely the dominant category of the assemblage (53.71% of the total) while retouched tools are found in

Table 4
Lithic type distribution along the stratigraphy.

Bed	Retouched tools	Handaxes	Flakes <2 cm	Flakes <2 cm	Blades & bladelets	Cores	Debris	Pebble tools	N	%
I	64		148	168	10	25	269		684	12.3
II	30		64	33	4	1	21		153	2.7
III	62		118	41	9	8	60	1	299	5.4
IV	109	4	293	169	12	17	142	1	747	13.4
V	48		55	20	2	5	22		152	2.7
VI	60	2	166	87	6	5	233	1	560	10.1
VII	31		85	31	5	3	36		191	3.4
VIII	26		65	21	2	7	18		139	2.5
IX	67		210	146	15	12	144		594	10.7
X	51	1	130	46	9	3	75		315	5.7
XI	18	1	64	10	2	3	16	1	115	2
XII	27		74	23	0	3	22		149	2.7
XIII	38	1	98	38	3	5	89		272	4.9
XIV	13	1	59	24	2	3	40		142	2.5
XV	107	1	237	96	8	17	111		577	10.4
XVI	23		31	8	3	2	22		89	1.6
XVII	8		49	6	1	2	8		74	1.3
XVIII	2			0	0				2	0
IND	44	35	67	12	0	151	8		318	5.7
Total	828	46	2013	979	93	272	1336	4	5571	100%
%	14.9	0.8	36.1	17.6	1.7	4.9	24.0	0.1	100	

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significant numbers (15.76%), particularly in beds IV and XV, including the presence, although modest, of 46 handaxes. Handaxes and flakes from handaxe production are present throughout the sequence. Whole pebbles, percussion instruments, and pebble tools are extremely rare.

Many of the large flakes (>2 cm) show signs of use wear with thin or flat irregular retouch. There is a relatively low frequency of small flakes from retouched tools at all levels, which may suggest that some of these tools were produced elsewhere than in the Cueva del Angel. The general type artefact representation varies little throughout the stratigraphy.

Macroscopic analysis of the stone tools from the Cueva del Angel was undertaken along with systematic surveying of an area within a 60 km radius around the site in order to identify the different raw materials used and locate their possible sources. Three main petrographical categories have been distinguished: flint, quartzite and limestone. Out of the 5571 total number of artefacts, 5422 (97.33%) are made of flint while only 101 (1.81%) are made of quartzite, 26 (0.47%) of limestone and the rest 22 (0.39%) is unidentified.

The source of flint raw material identified comes principally in the form of pebbles, and less frequently small slabs or cobbles, with four different types macroscopically differentiated. The various raw materials utilized were as follows:

- **T1 flint**, very fine and opaque with considerable colour variation (grey, beige-olive green, caramel red or multicoloured). Elements knapped from this type of flint sometimes present a more or less covering white or cream coloured patina, with in some instances a display of residual siliceous pebble neocortex. It is similar to the Jurassic Bayocian flint outcrops of the Sierra de Araceli and from the Rio Genil river terraces, the nearest being located approximately 20 km from the site.
- **T2 flint**, very fine and homogenous, of a translucent brown or grey colour and often displaying a white patina, at times containing cracks. It is similar to the Jurassic Oxfordian flint pebbles of the Rio Genil river basin with less variable facies than those of type T1.
- **T3 flint**, oolithic and grey, often patinated with numerous micro fossil inclusions characteristic of a reef environment. It is known in the Jurassic Bayocian–Bathonian formations south of Lucena and found as pebbles on the alluvial terraces of the Rio Genil.
- **T4 flint**, silexite, black with oxidized patina from unknown provenience.
- **Quartzite**, fine or coarse grained, with grey, pinkish or red colour, and a rounded pebble-like neo-cortex. Probably originates from the terraces of the Guadalquivir river, at some distance from the site (approximately 40 km).
- **Limestone**, beige to white colour, rather marly. It is frequently altered and is available from several sources in the surroundings of the site.

5.2. Typology

Out of 828 retouched tools (Tables 5 and 6; Fig. 10), the overwhelming majority (823 pieces) representing 99.4% of the total are made of flint while the rest (5 pieces) were produced from other rock types.

5.2.1. Small retouched tools

Side scrapers (single plus composite side scrapers represent 75% of total retouched tools) are largely dominant throughout the stratigraphy, with lateral single scrapers being the most numerous (294 out of 490 pieces). Transverse side scrapers are well represented (17.3% of single scrapers and 60% of composite scrapers) and so are double-edged scrapers (15.5% of single scrapers). The scrapers were most often shaped by thin (28%), semi thick (26%) or flat (17%) retouch, with 10% of the scrapers shaped by semi-Quina and Quina retouch. Retouch direction was most often direct (76%), sometimes reverse (14%) or bifacial (10%). The relatively high percentages of inverse and bifacial retouch may reflect optimal exploitation of raw materials and supports, and frequent tool sharpening. Edge morphology was most often convex (64%), rectilinear (26%), sometimes concave (7%) and rarely sinuous (3%). Finely worked pieces with few denticulated edges and a relatively strong representation of rectilinear scrapers characterize the assemblage.

Notched tools (notches, denticulates and becs) representing 23.43% of the total (single plus composite) are the second most numerous retouched tools with single Clactonian (59 pieces) and retouched notches (41) being the most frequent types, and single denticulates (22) and becs (17) being the least frequent. Two convergent-edge denticulates may be assimilated to Tayac points.

Combined (single plus composite) Upper Palaeolithic tool types (end scrapers, awls, *burins* and truncated tools) are less frequent (6.40% of total retouched tools). Within this group, end scrapers, *burins* and truncated tools are the most numerous. Awls are dihedral or simple. Fractures or worked edges served as platforms. Truncated tools are a specificity of the Cueva del Angel industry and may relate to Kostienky type thinning. Burinoïde removal negatives were also produced at the Cueva del Angel when making retouch edge flakes.

Pointed tools in general are scarce (1.33% of total retouched tools) and include four Quinson points and two *proto-limaces*.

Table 5
Single retouched tools distribution.

Retouched tool type	*N*	%	Group	*N*	%
End scraper	14	2.0	Upper Paleolithic types	42	6.1
Burin	13	1.9			
Awl	2	0.3			
Truncated tool	13	1.9			
Clactonian notch	59	8.6	Notched tools	143	20.8
Retouched notch	41	6.0			
Multiple notch	4	0.6			
Bec	16	2.3			
Double bec	1	0.1			
Lateral denticulate	15	2.2			
Transverse denticulate	7	1.0			
Lateral scraper	294	42.9	Side scrapers	490	71.4
Transverse scraper	85	12.4			
Double-edged scraper	76	11.1			
Triple-edged scraper	9	1.3			
Convergent-edged scraper	26	3.8			
Point	3	0.4	Points	11	1.6
Quinson point	4	0.6			
Protolimace	2	0.3			
Tayac paint	2	0.3			
Total	686	100%		686	100%

Table 6
Composite retouched tools distribution.

Retouched tool type	End scraper	Burin	Awl	Notch	Bec	Denticulate	Side scraper	Total
End scraper				4				4
Burin				1				1
Awl								
Notch								
Bec								
Denticulate				4	2			6
Side scraper	3	2	1	25	8	7	85	131
Total	3	2	1	34	10	7	85	142

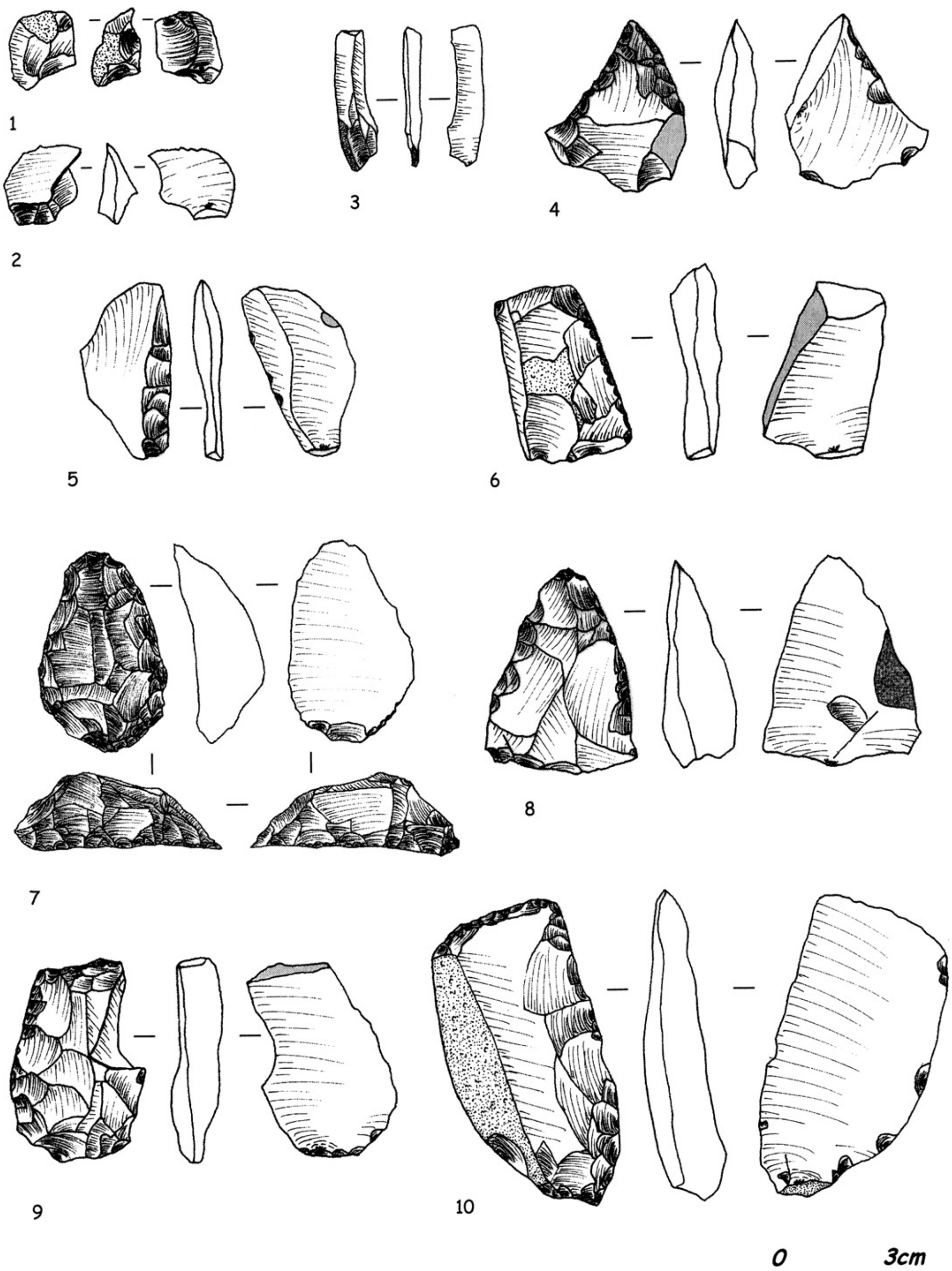

Fig. 10. Retouched tools from Cueva del Angel: (1) unidirectional flint micro core on a small flint cobble; (2) Kombewa flint flake; (3) flint bladelet; (4) flint Quinson point; (5) flint retouched edge flake; (6) flint retouched edge flake and side scraper; (7) flint *protolimace*; (8) flint point; (9) flint side scraper with Kostienki thinning; (10) flint side scraper. (Drawings by Vincenzo Celiberti).

One of the outstanding characteristics of the Cueva del Ángel industry is the frequency of flakes and retouched tools with thinned edges. Such thinning is observed on support bases but also on their lateral and distal edges. Thinning removals are simple or multiple. Given the recurrent knapping techniques identified from the cores (most often on flake supports), “thinning” may be confused with simple flake production.

5.2.2. Handaxes and heavy duty tools

There are a total of 46 handaxes (Fig. 11), of which only 11 were found in a stratigraphic position. The handaxes are rather small (average length = 84.2 mm) but do show considerable size variability (largest: 118 mm long; smallest: 54 mm). Two-thirds of the total (21) are made of flint with 9 pieces in quartzite and 6 in limestone.

The handaxe tools were configured mainly on large flakes or fractured pebbles, and some conserve more or less cortical residue. Initial removals are covering and bifacial and there is a second phase of shorter and more numerous removals followed by retouch in the final shaping phases. Edges are sometimes, but not always, sinuous and some handaxes conserve plane surfaces that may have served for gripping. The distinction between secondary shaping retouch and scraper like tools realized on the handaxe-support is significant.

All of the handaxes show relatively thin pointed extremities. Overall, the pointed pieces show a low degree of convergence. Lateral edges are commonly short, although there are exceptions such as the cordate (cordiform) shape which is the most abundant type found (17). There are 7 bifacial pieces further re-shaped into scrapers, 6 oval shaped handaxes with a low degree of convergence, 3 lanceolated types and 1 subtriangular piece. Present are 7 broken handaxes, mainly bases (5), only 1 handaxe point, and 4 bifacial pieces present a terminal bevelled edge, 2 of which in quartzite may be considered as atypical cleavers.

The assemblage includes a single chopper on a quartzite pebble (83 × 66 × 46 mm) and a trihedral pick (82 × 63 × 44 mm). The chopper edge is shaped by 9 unidirectional removals and shows some irregular retouch on one angle. The pick, also shaped on a quartzite pebble fragment, has a trihedral point. The pebble was apparently broken on an anvil and the point configured afterwards by a long voluntary fracture. The pointed extremity, as well as the two lateral edges of the tool, show irregular mixed retouch.

5.3. Technology – discussion

There is an almost total absence of cortical flakes or large flakes in the stratigraphy, which might mean that raw materials were introduced into the site as large preconfigured cores or exceptionally under the form of blocks or pebbles, with initial reduction stage performed off-site. However, given the large number of residual plane face artifacts of the Kombewa type, one cannot discard the possibility that part of the raw materials were introduced into the site as large flakes, or sometimes prepared by split fracture technique. These large primary supports would have been reduced in the site by intense *debitage*, and this would explain their absence from the assemblage. In any case, the identification of original core supports is made difficult by the intensity of the reduction processes they were subjected to. Operational schemas were directed towards progressively smaller supports as volumes were repeatedly reduced using the flake-core technique.

Out of 272 analyzed cores (Table 4), 121 were found in a precise stratigraphic position. Their frequency varies within the stratigraphy and represents generally less than 4% of the total. Most of the cores (95%) were knapped from flint (all types) and the rest from quartzite, reflecting flake raw material distribution. Recurrent unipolar flaking dominates for flint pieces and bifacial discoidal flaking is most commonly observed for the quartzite ones. Recurrent unipolar reduction on flint was performed from natural or prepared platforms (Fig. 12, 1–4). Extraction surfaces are convex or planar, the latter producing fine flakes. This technique closely resembles "thinning", but the boundary between these two methods is rather unclear (Fig. 12, 1). Each successive recurrent knapping sequence is followed by a change in striking platform (direction), exploited surfaces sometimes becoming in turn striking platforms. Core morphology evolves as combined algorithms produce forms approaching recurrent centripetal or preferential Levallois type flakes (Fig. 12, 4,9) or even partial discoidal types, along with their typical components. This technique also occasionally produces blades and/or bladelets (Fig. 10, 3; Fig. 11, 3; Fig. 12, 2). Levallois flaking methods are however absent in the site. Final knapping stages are often discoidal (unifacial or bifacial, Fig. 12, 8,9), producing flakes smaller than 2 cm long. A few pyramidal cores are present (Fig. 12, 7), with centripetal removals following core morphology and raised central apex points. These cores come close to notch or denticulate types. This knapping method was most often applied at the end of knapping sequences on depleted cores.

Flaking was intense and most of the cores present low average dimensions and numerous removal negatives. Flake dimensions are relatively homogenous with mean length between 30 and 40 mm. The abundance of *éclat débordant* and *éclat outrepassé* illustrates intentional systematization in maintaining convex exploitation surfaces.

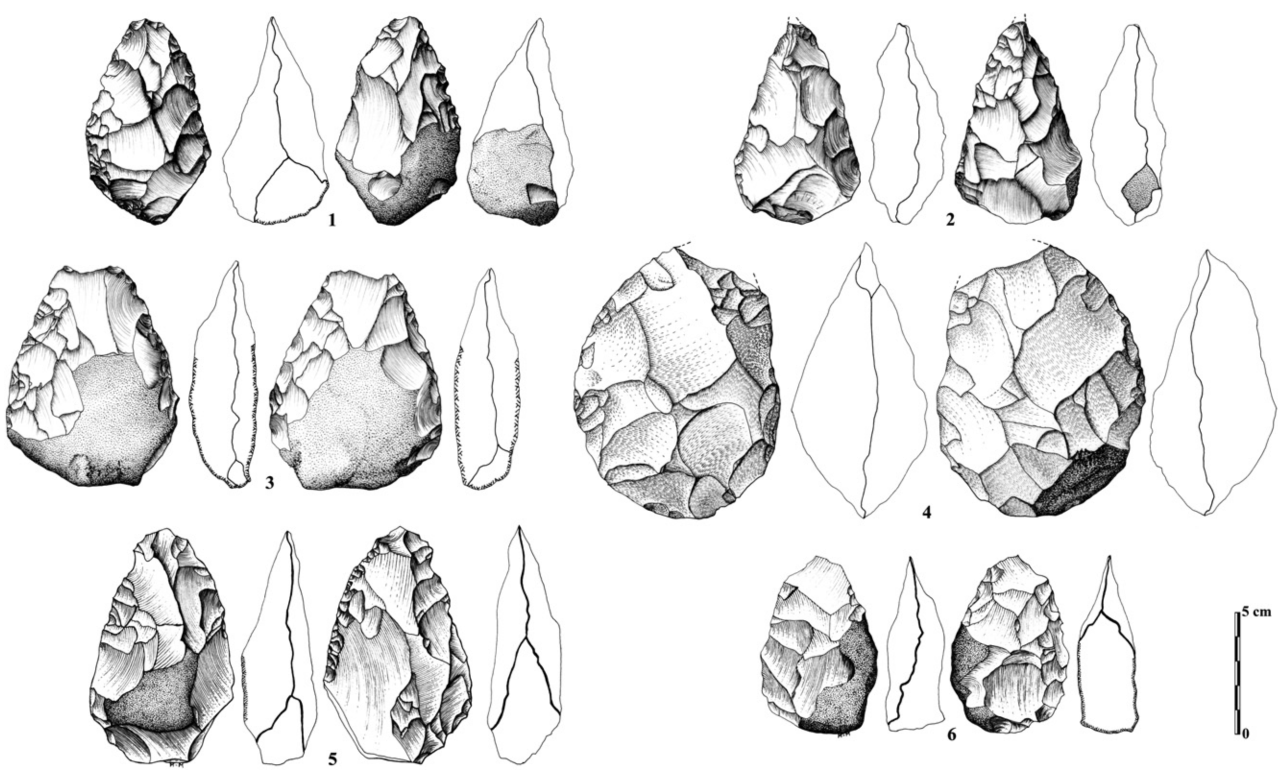

Fig. 11. Handaxes from Cueva del Angel: (1) lanceolated; (2) subtriangular; (3) cordate-cordiform; (4) oval; (5) lanceolated; (6) oval. (Drawings by D. Cauche and R. Guilard).

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The Cueva del Angel lithic assemblage appears to fit well within the regional diversity of a well developed final Acheulean industry, observed generally at the end of the Middle Pleistocene in Western Europe. Raw material procurement is mainly local, which is a typical behavioural characteristic found in many Western European final Acheulean and Mousterian sites (Geneste, 1985).

The originality of the Cueva del Angel stone industry may perhaps be interpreted as another expression of regional variability

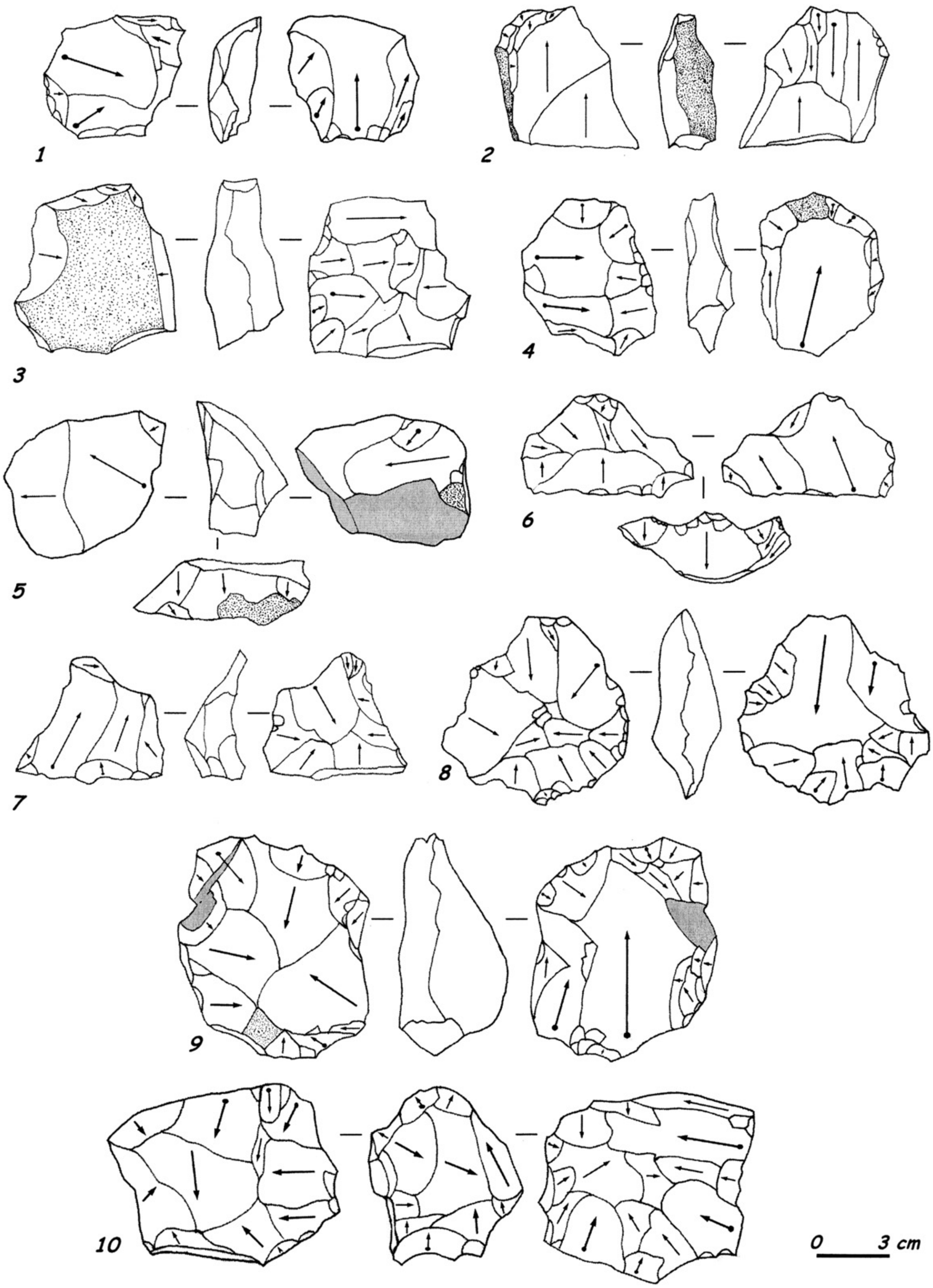

Fig. 12. Core types from Cueva del Angel: (1) unidirectional flint core on a Kombewa flake; (2) unidirectional flint core; (3) unidirectional flint core with radial removals; (4) unidirectional flint core with radial removals and a preferential removal on one face; (5) orthogonal flint core with a prepared striking platform; (6) orthogonal flint core with a prepared striking platform; (7) "pyramidal" shaped flint core with radial removals; (8) bifacial discoidal flint core; (9) bifacial discoidal flint core with a preferential removal on one face; (10) multiplatform flint core. (Drawings by Vincenzo Celiberti).

observed at numerous other sites in Spain as elsewhere in Western Europe at the end of the Middle Pleistocene. There are a handful of sites dating to this period (globally around MIS 6, 5) in a well documented stratigraphical context in Spain: Bolomor (Fernández Peris, 2007), TG 11 at Atapuerca (Carbonell et al., 1999) and several localities in central Spain such as for example Teruel (Cuesta de la Bajada; Santonja et al., 1990). In Southwestern France, a number of sites sometimes attributed to *Acheuléen méridional*, such as Combe-Grenal (Debenath, 1976), show similar regional variation (Turq, 1992). In Southern France, a handful of sites have also yielded various assemblages dating to the same period where Levallois knapping capacities are present but not yet developed or generalized, such as the Baume Bonne (Ensemble II, Level D2, MIS 8, Alpes de Haute Provence, Notter, 2007; Gagnepain and Gaillard, 2005) and the Lazaret (Lumley et al., 2004, 2008).

6. Conclusions

The Cueva del Angel archaeological site discovered in 1995 is an open-air sedimentary sequence (over 5 m deep), a remnant of a collapsed cave, part of a karst complex (Fig. 4) that also includes a nearby cavity giving access to a sinkhole (Sima) filled at the bottom with a 70 m dejection cone. A tunnel has been dug up from the side of the hill in 2009 that reaches the sinkhole horizontally. The nearby cavity and the sinkhole will be excavated in future years. Six excavations campaigns have generated a considerable amount of archaeological material composed essentially of large mammal bone remains and lithic artifacts.

Taphonomical characteristics of the herbivore faunal assemblage (dominated by the horse *Equus ferus*, large bovids and cervids) include the intense fragmentation of the bones for marrow extraction with a significant number of cutmarks and striations, and the high proportion of burnt elements. These anthropic actions reflect selective predation and the use of animal food resources available in the surroundings of the cave by humans. The assemblage corresponds to an anthropic accumulation over a long period from the end of the Middle Pleistocene to the beginning of the Upper Pleistocene. Given the latitude of the site and the average size of the species identified, smaller than the same species of northern Europe, this fauna may be correlated with faunistic associations of the end of the Middle Pleistocene. About 88% of the faunal bone remains and a third of the lithic artifacts are burnt with a broad spectrum of colours. Instead of well situated small hearths, an extensive combustion structure resulting from the intense and continuous use of the cave is present.

The Cueva del Angel lithic assemblage (dominated by non-modified flakes and abundant retouched tools with the presence of 46 handaxes) appears to fit well within the regional diversity of a well developed final Acheulean industry, observed generally at the end of the Middle Pleistocene in Western Europe. Knapping patterns at the Cueva del Angel reflect exhaustive, well standardized and economic use of relatively fine quality materials. Early phases of knapping are not represented in the assemblage since initial shaping was performed outside of the cave. The Cueva del Angel hominins practiced a singular *branching* operational schema based on repeated application of recurrent unidirectional, often radial, knapping from prepared striking platforms. This economical method sometimes produced cores with a morphology akin to Levallois forms, although they were achieved through an entirely different technological process. Unifacial and bifacial discoidal cores are also present, although not dominant. Another technological specificity at this site concerns the flakes extracted from retouched tool edges giving a product with a particular morphology, rarely observed elsewhere. This singular product is a hallmark of the Cueva del Angel industry.

A preliminary ^{230}Th/^{234}U date of 121 + 11/−10 ka (Zouhair, 1996), the review of the lithic assemblage and faunal evidence would favour a chronological positioning of the site in a period stretching from the end of the Middle Pleistocene to the beginning of the Upper Pleistocene, from MIS 11 to MIS 5. Further dating will help to ascertain more precisely the chronological framework of the site. It is clear that the significance of the Cueva del Angel new discovery needs to be assessed in the context of the archaeological record of the Acheulean industries of the Iberian Peninsula.

Most of the well known and researched middle Middle Pleistocene Acheulean assemblages of the Iberian Peninsula located in terraces of major rivers such as the Guadalquivir, Guadiana, Tagus and Duero would seem to be of an antiquity of ca. 400 ka and may be earlier (Santonja and Villa, 2006). Technologically, the industries of these river terraces are far removed from the one encountered in Cueva del Angel. They are essentially made with quartizite cobbles with, according to these authors, the radial exploitation of the *debitage* surface made with only limited preparation of the periphery forming the striking platform and preferential predetermined removals being few.

Although there is evidence of assemblages with progressive traits reminiscent of the Middle Palaeothic in Ambrona such as uses of Levallois technology and standardization of small tools (Santonja and Villa, 2006), the sites that would help to clarify where the industry of the Cueva del Angel would fit are to be found in a cave context, such as TG 11 at Atapuerca (Carbonell et al., 1999) and in particular Cova del Bolomor. According to Fernández Peris (2003), three phases are distinguished in the industrial complex of Cova del Bolomor: phase A (MIS 9-7), the oldest, represents a technocomplex of flakes with little presence of Levallois technique and absence of handaxes with denticulates more abundant than side scrapers and a low degree of technological elaboration; phase B (MIS 6), ensemble almost exclusively made of large limestone flakes with little transformation of the material, and phase C (MIS 5e), period of intense occupation with small tools, large reworking of flint artifacts, diversified core usage with large presence of side scrapers and large retouched diversity of the tool kit. Thus the author concludes that the passage to the Upper Pleistocene (MIS 5e) at Cova del Bolomor shows an increase of the Mousterian tool kit in terms of types and technology, and attributes the upper levels to a non-laminar Charentien Mousterian without Levallois technology.

With these premises in mind, it would appear that the Cueva del Angel represents an important and rare opportunity to further study and comprehend the presence of late Acheulean industries in a cave environment in the Iberian Peninsula. This late cave Acheulean occurrence may be interpreted as one of three possible explanatory hypotheses: 1) it represents a transition to a Mousterian industry, or 2) the acquisition by acculturation of an innovative and more generalized Mousterian knapping mode by Acheulean human groups, or 3) the perpetuation of Acheulean cultural traditions with more complex cultural and behavioural characteristics arising by a process of convergence, in parallel with the contemporaneous existence of uniquely Mousterian complexes in other parts of the Iberian Peninsula and Western Europe.

What is evident from a cursory comparison with, on the one hand the non-Acheulean industry of Bolomor, illustrative of the Mediterranean Middle Palaeolithic technocomplex, and on the other hand the Acheulean ensemble of Ambrona with Levallois technology in the upper levels and the quartzite based assemblages of the river terraces, all presumed to be contemporaneous, is that this diversity fits very well with the archaeological evidence encountered in other regions of Western Europe (Villa, 2009). This author stipulates that in Western Europe, including Spain, industries with handaxes and non-Levallois *debitage* (e.g. Cueva del Angel) co-exist in MIS 8 to 6 with industries without handaxes and without Levallois *debitage* (e.g. Bolomor) or industries with Levallois *debitage* and some handaxes (e.g. upper levels of Ambrona) and industries with Levallois *debitage* and without handaxes. This would tend to confirm the view that there is no clear boundary between the Lower and Middle Palaeolithic in the Iberian Peninsula, and that tools made on flakes, once considered a feature of the Middle Palaeolithic are common in Acheulean industries, as apparent in the Cueva del Angel, as well as in Middle Palaeolithic industries such as in Cova del Bolomor. Therefore it is the authors' view that the Acheulean lithic assemblage found at the Cueva del Angel fits very well with the hypothesis of a continuation of Acheulean cultural traditions in the site resulting in more complex adaptive cultural and behavioural characteristics related to geographical and climatic constraints, local availability of raw materials and animal food resources. The in situ technologically evolved assemblage found in the Cueva del Angel represents an adaptive convergent process distinct from the contemporaneous uniquely Mousterian complexes witnessed in other parts of the Iberian Peninsula, and Western Europe, and arising out of different environmental survival constraints.

Appendix. Cueva del Angel stratigraphy description (Fig. 3)

The excavated Cueva del Angel sequence is presently more than 3.50 m deep. Its lower levels are visible in the mining well (zones corresponding to vertical sections L/M and 7/8).

- **Bed I:** located at the top of the sequence and visible between zones G and J, it is made of a stony breccia and limestone blocks with a few speleothem fragments. Bone remains, a few of which are burnt, and some flint flakes are present. This generally indurated level with a maximum thickness of 35 cm is of a pale brown colour.
- **Bed II:** a crumbly grey brown layer, with maximum 15 cm thickness, found between zones F to K below the breccia. It has a granular consistency and contains a few altered small stones. It is also found at the top of the sequence where zone I is truncated. There is no archaeological material.
- **Bed III:** consists of brown-red sandy clay with prismatic structure. It appears in zone H and changes structure and colour starting in zone I8. Its structure then becomes compact and its colour turns to orange with black spots.
- **Bed IV:** visible in zones G7, H7 and K5, it is made of breccia with bones and indurated rocks. Its maximum thickness is 40 cm. It is underlined by a 5 mm thick carbonated encrustation. Inside this bed are burnt bones and calcined sediment at the top marked by a black line. In the other zones it becomes a 13 cm thick stratified carbonate level.
- **Bed V:** this level is in reality the stratigraphic continuity of Bed III but with lateral sedimentary variations. It consists of orange loam and grey-white carbonate beds surmounted by a black layer. The maximum thickness of this level, sloping down from west to east, is 25 cm. Its structure is loose but locally hardened, with the presence of midsize stones and sparse archaeological material.
- **Bed VI:** this level is apparently the stratigraphic continuity of Bed IV. It changes from a superimposition of ashy white carbonate layers to a mix of loose light gray ash over a length of 60 cm in zone J7. There is no archaeological material or stones. Its slope goes from West to East and it is truncated in zone J5.
- **Bed VII:** an ensemble of black and reddish layers, 25 cm thick in zone J6 and 10 cm in zone I7. Large stones and a mix of little whitish stones are present in zone J7. A double slope is noticed, from South to North and West to East. There is very little archaeological material.
- **Bed VIII:** reddish concreted layer, very rich in archaeological material and at times of angular stones. Its thickness varies from 5 to 10 cm with a double slope in northern and eastern directions. A speleothem sample in the northern part of the well near this bed has been dated at 120 ky + 11/−10 by the $^{230}Th/^{234}U$ dating method (Zouhair, 1996).
- **Bed IX:** blackish bed, 5–8 cm thick with few archaeological artifacts and stones. Bones are often burnt. There is a double slope in northern and eastern directions.
- **Bed X:** 15 cm thick carbonated encrustation of brown-red colour rich in archaeological material with slope in north-eastern direction.
- **Bed XI:** 10 cm thick black earth with high number of stones (often angular), a few blocks and speleothem fragments. Slope is identical to preceding beds. There is a layer of stones situated in zones J6 and K6. Presence of burnt bones and flint lithic artifacts.
- **Bed XII:** highly indurated orange sandy clay layer with thickness varying between 7 and 20 cm. Very rich in burnt bones and flint artifacts, with presence of stones, some of which are whitened by fire and becoming crumbly. It slopes in northern and eastern directions.
- **Bed XIII:** blackish earth less rich in archaeological material than Bed XII. This approximately 30 cm thick deposit is highly indurated. It contains some burnt bones and many stones and speleothem fragments.
- **Bed XIV:** dark brown-red indurated layer with a high number of stones and bones, many burnt. It reaches a maximum thickness of 60 cm and slopes down towards the East. It is only present in the mining well.
- **Bed XV:** sandy brown-red clay with maximum thickness of 35 cm, rich in bones and stones and essentially identical to Bed XIV above. This bed is spread on top of a speleothem floor visible only along the western wall of the mining well.
- **Bed XVI:** sandy brown-red clay containing bones and stones, found at the bottom of the mining well between zones J7 and J8.

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