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GEOARCHAEOLOGY AND CHRONOSTRATIGRAPHY OF THE MIDDLE-UPPER PALAEOLITHIC TRANSITION AT THE CAVE OF LA GÜELGA (CANGAS DE ONÍS, ASTURIAS, SPAIN)

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Abstract

The cave of La Güelga (Asturias, Spain) is located in the eastern region of the Asturian Massif within the carboniferous limestone of the Calizas de Montaña. A small river runs through the cave, and this has formed several marks on the walls and terraces at the cave entrance. This cavity is large and has the morphology of a rock shelter. In one terrace, an Upper Pleistocene deposit containing archaeological and palaeontological remains from the Middle-Upper Palaeolithic transition has been excavated. These deposits have been AMS dated at the Oxford Radiocarbon Accelerator unit (ORAU). Bones were pre-treated using the ultrafiltration protocol, which aims to purify the collagen selected for dating by removing contaminants. In many cases, dates on collagen processed in this way are significantly older than those where collagen has not been ultrafiltered. The new dates place the lower deposits from zone D between 55,710 – 44,940 years calBP, during MIS 3c.

Keywords

Geoarchaeology, Chronostratigraphy, Radiocarbon, Middle-Upper Palaeolithic transition, Mousterian, Châtelperronian, Aurignacian, Cantabrian area

Introduction

The cave of La Güelga (Narciandi, Cangas de Onís, Asturias) (Fig. 1) is located in the eastern part of the Asturian Massif or central zone of the Cantabrian Cordillera that corresponds with the Cantabrian zone of the Iberian Massif (Vera et al. 2004). The karstic complex of La Güelga developed within the pre-Stephanian (Namurian) Upper Carboniferous Barcaliente formation. This formation is comprised of grey and black fetid limestone (micrites, microsparites and dolomicrites) frequently dolomitised and with occasional collating marls with a massive to platy stratification and a thickness between 140 and 300 m (I.G.M.E. 1986). The cave mouth is located at the base of a cliff with a strong relief, at 182 m asl and at the bottom of a blind valley in which the La Güelga or La Brava stream disappears into a subterranean karstic complex. It re-

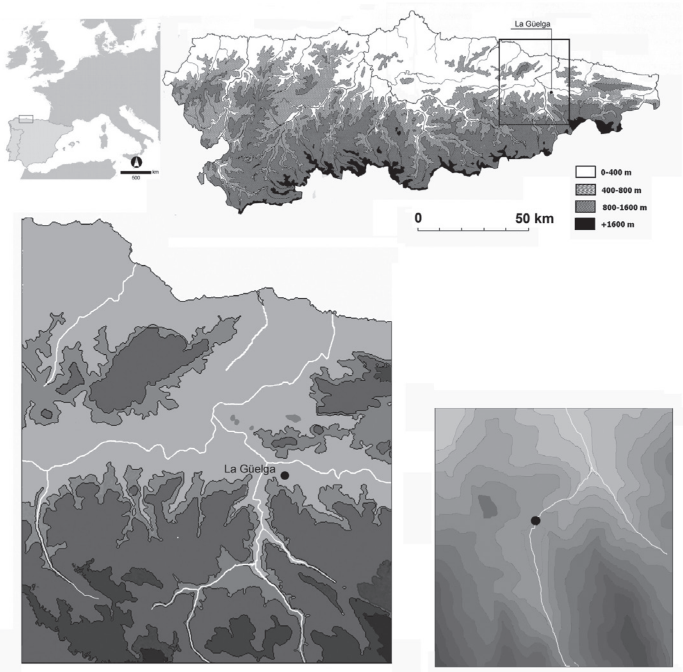

Fig. 1 Geographic location of La Güelga cave (Narciandi, Cangas de Onis, Asturias, España).

emerges at Cabielles where it is named Las Entradas, before eventually discharging into the Güeña river, a tributary of Sella on its left margin.

The entrance of the La Güelga cave morphologically resembles a large stony rock shelter in which the river incised its course. Successive phases of incision during karst phases have left traces on the walls of the cliff and the rock shelter. Significant evidence for such events can be seen in ancient drains of the river, hanging subterranean galleries and up to seven stepped terraces or shelves and notches of smaller or larger span, all of fluviokarstic origin, created during episodes of stabilisation of the stream at different elevations, the uppermost of which is some 13 m above the present river bed. The Upper Pleistocene archaeological contents of the deposits in these terraces are variable (Menéndez et al. 2006). The most significant of these is situated at 11 m above the current river level, lying on top of a chaotic deposit of large limestone blocks detached from the outcrop, and consisting of 2 m of sediment. At this level, there was an ancient entrance to the cave where the stream once flowed. The sediments that fill the cavity are presently connected to the ones located to the outside and on top of the terrace. These two groups of deposits (interior and exterior) comprise the so-called zone D of La Güelga cave and they contain archaeological material attributed to the end of the Middle Palaeolithic and the initial Upper Palaeolithic (Menéndez et al. 2005, 2006).

Excavations carried out at La Güelga between 1989 and 2008 initially focused on lower zone A (Solutrean and Lower Magdalenian) and in continuation on the upper zone of the site or zone D (Fig. 2). In zone D, the focus of this paper, the small cavity (zone D, interior sector) produced a sequence of nine layers, although the bedrock has not yet been reached. The succession of industries begins with the Mousterian, followed by the Aurignacian and the Châtelperronian (Menéndez et al. 2005). In order to confirm this sequence, excavations were carried out in the outside of zone D in what remained of the stony rock shelter, probably the ancient roof of the cave, after its collapse and infilling (zone D, exterior sector). The sequence in the exterior sector was comprised of four levels. Moreover, in the interior of the cave, a deposit originat-

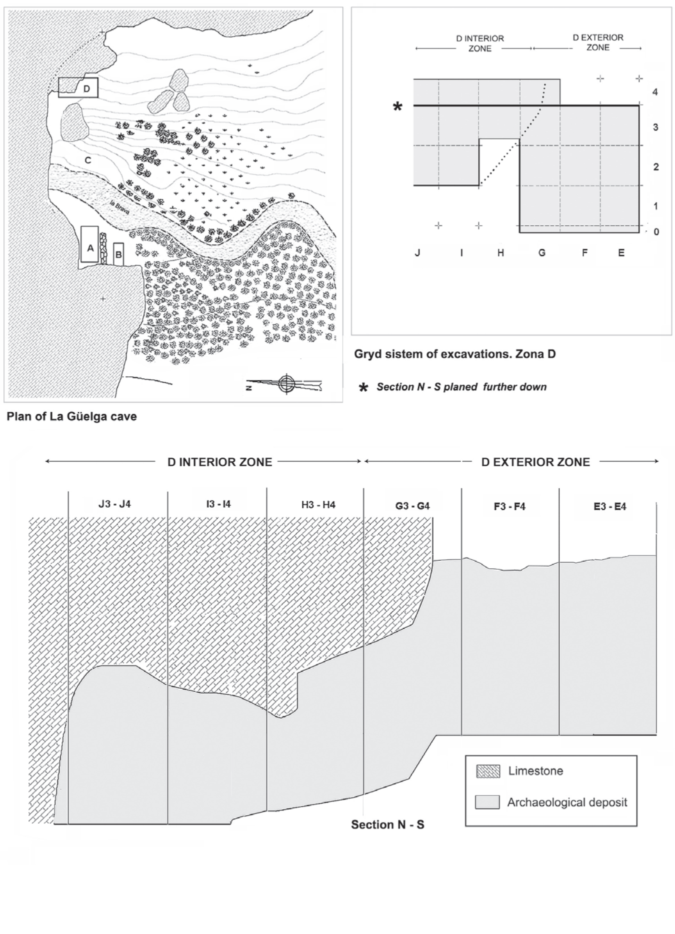

Fig. 2 Top left: Plan of La Güelga in which the excavated zones are indicated. Top right: Ground plan of the excavation. Down: Longitudinal section (NS) of the deposits excavated in exterior and interior sectors.

ing in zone D was found to contain chipped stone artefacts (baked knives and Levallois flakes) and abundant charcoal that provided the date GrN-18256 (Menéndez et al. 2005).

The scope of this paper is to present a synthesis of the main results of the geoarchaeological, chrono-stratigraphic and archaeological research on the La Güelga deposits that cover the Middle-Upper Palaeolithic transition. In this way, we pay tribute to Gerd-Christian Weniger who continues to work extensively on this particularly interesting transitional phase.

Methods

Geoarchaeology

Geoarchaeological research at La Güelga included initial field work during which the geological context of the site was investigated along with a sampling of the deposits and a study of the lithostratigraphy. This was followed by laboratory analysis. Study of the lithostratigraphic sequence and sampling of the profiles in zone D was carried out during four field seasons (2005, 2006, 2007 and 2008).

Laboratory work included sampling and analysis of sedimentology (texture, insoluble residue and mineralogical analysis – XRD), which was carried out at the laboratories of the *Departamento de Geología del Museo Nacional de Ciencias Naturales de Madrid*. Edaphological analysis (colour, pH, total carbonates -CaCO3-, organic matter and organic carbon) were carried out at the *Laboratorio de Edafología del Departamento de Geología y Geoquímica de la Universidad Autónoma de Madrid*.

The results of the granulometry analysis were investigated using GRADISTAT 4.0 software (Blott & Pye 2001), which allows statistical analysis and the creation of triangular diagrams and granulometry curves. X-Ray diffraction analysis (XRD) of fractions less than 0.063 mm, previously ground to unify grain size, were carried out to assess the mineralogical character of the samples. All samples were analysed following the dust method for the identification and quantification of the predominant mineral phases. The analysis was carried out using a Philips PW 1830 diffractometer with a Cu cathode and a wavelength of ka = 1.54051, with an angular run from 3° to 65° 2θ and with data recording using a Philips PW 1710 digital register. The XPowder (ver. 2004.04) software for qualitative and quantitative analysis of samples (Martín-Ramos 2004) was used for controlling and treating the diffractograms. In order to obtain an objective description and a normalised determination of colour, both dry and wet samples were classified using Munsell Soil Color Charts (Munsell 1981). The pH was measured using a soil to water ratio of 1:25, following Soil Science Society of America criteria (Thomas 1996).

Radiocarbon

Eleven radiocarbon dates from bone fragments are available so far from zone D at La Güelga, of which four correspond to the interior sector, six to the exterior and one to outer sediments that migrated into the cave. Table 1 summarises the stratigraphic contexts of the dates. Four were carried out by Beta Analytic Inc (Beta) in Miami and a fifth by the Isotopes Physics Laboratory (GrN) of the University of Groningen in the Netherlands, and previously published by Menéndez et al. (2006, 2007). In 2008, we contacted the Oxford Radiocarbon Accelerator UNIT (ORAU) to initiate a new series of dates on ten bone samples. These were selected on the basis of clear marks of human manipulation, thus securing the association between the bones and the archaeological units. The ORAU uses ultrafiltration for collagen purification of bone samples, the advantages of which have recently been highlighted (e.g., Higham et al. 2006).

Preservation of bone at La Güelga was suspected to be poor and so %N measurements were taken to identify bones most likely to produce enough collagen for a reliable date. Most nitrogen within a bone is contained in collagen, and so measurement of the nitrogen content of a bone can be used as a proxy for the amount of collagen remaining (Brock et al. 2007). Six of the ten bones screened at ORAU contained enough nitrogen to warrant an attempt to extract collagen.

At ORAU, collagen was extracted using the ultrafiltration protocol (Ramsey et al. 2004). After a series of acid and base washes to remove carbonates and humic acids respectively, the residue was gelatinised at 75° C for 20 hours and large insoluble contaminants were removed with a pre-cleaned 9-μm polyethylene Eezi-filter™. Finally, a pre-cleaned 30 kDa MWCO ultrafilter (VivaspinTM15) was used to remove the smallest contaminants, such as degraded peptides. To produce a reliable date using this method, more than 10 mg of collagen needs to be extracted, representing a >1 % yield. Whilst there is not always a difference in the age of collagen before and after ultrafiltration, where there is, the latter is always older. This is attributed to the increased removal of contaminants, and is particularly significant for Palaeolithic aged bone where differences between the two methods can be greater than 10,000 years (e.g., Higham et al. 2006). Collagen was combusted to produce CO_2 in a CHN sample analyser furnace, linked with an IR-MS (isotope ration-mass spectrometer) for measurement of $\delta^{13}C$, %C and the C:N ratio. Combined with the collagen yield, these provide a general indication of the quality of the collagen extracted. For a reliable date, the $\delta^{13}C$, %C and C:N ratio should be between -22 and -18 ‰, >30 %, and between 2.9 and 3.4 respectively (Van Klinken 1999). Samples were graphitised and measured in an AMS as described in Ramsey et al. (2004).

Of the six bones treated, four produced sufficient collagen to date. Although all other collagen quality indicators of these four were good, two (OxA-20123 and OxA-20125) produced less than 10 mg of collagen or less than 1 %. This suggests that these dates should be treated as minimum ages because of the potential for contamination from younger carbon. However, this was implicit in the dates as both samples were of infinite age.

The 14C dates from zone D were calibrated with the CalPal-2007$_{Hulu}$ curve included

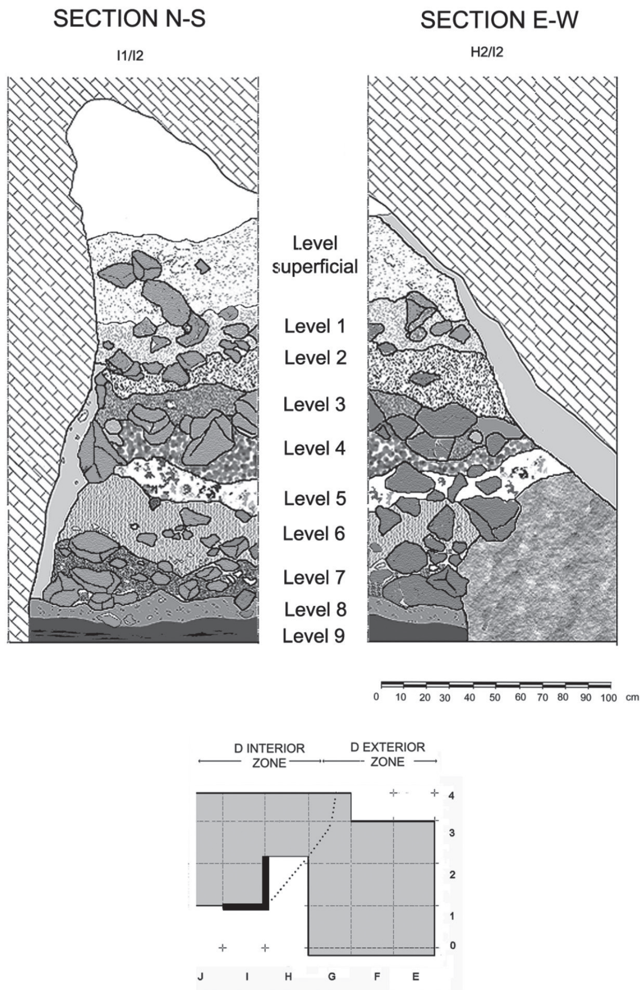

Fig. 3 Stratigraphic profile of the interior sector of zone D at La Güelga.

in the June 2007 version of CalPal software (www.calpal.de; Weninger & Jöris 2004). Once calibrated, for the comparison of the nine dates we used a 95 % probability or twice the standard deviation, in order to improve the probability that the intervals included the real calibrated date expressed in calendar years.

Finally, we used CalPal to situate the dated layers as precisely as possible with the Quaternary chronostratigraphy. This allows for comparison of the accumulated probability curves of the radiocarbon dates with the numerous high resolution palaeoclimatic proxies like the GISP2 $^{18}O/^{16}O$ (Grootes et al. 1993; Meese et al. 1994; Sowers et al. 1993) and GRIP-SFCP ^{18}O (Shackleton et al. 2004) curves obtained from the GISP2 and GRIP ice cores in Greenland. The latter provide a very precise chronology for the Upper Pleistocene that at present constitutes the temporal framework of reference (Björck et al. 1998; Walker et al. 1999; Sánchez Goñi & d'Errico 2005; Jordá Pardo & Aura Tortosa 2006).

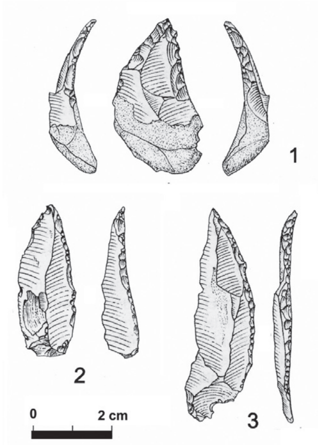

Fig. 4 Châtelperronian industry of level 1 from the interior sector of zone D at La Güelga: 1 and 3, Châtelperronian points; 2, atipic Châtelperronian point.

STRATIGRAPHY

LITHOSTRATIGRAPHIC CHARACTERISTICS

ZONE D, INTERIOR SECTOR

The deposits of the interior sector in zone D fill a small cavity located at the base of the outcrop and in a part of the cave where its morphology is similar to a rock shelter. The cavity can only be accessed from the 11 m terrace via three openings, two of them circular while sediments covering the third were removed during the excavation in the exterior sector. Prior to the excavation, the cavity was filled with recent sediments. Once these were removed, the exposed stratified deposits were cleaned and partially excavated to obtain a stratigraphic profile, although the bedrock was not reached. From top to bottom, the following sequence of levels was observed (Fig. 3):

- Surface level 1 (GU.D.INT.1SUP): 30 cm of brown clays with abundant autochthonous clasts (percentile 30 cm, mean 4 cm) of chaotic and disorganised distribution. The

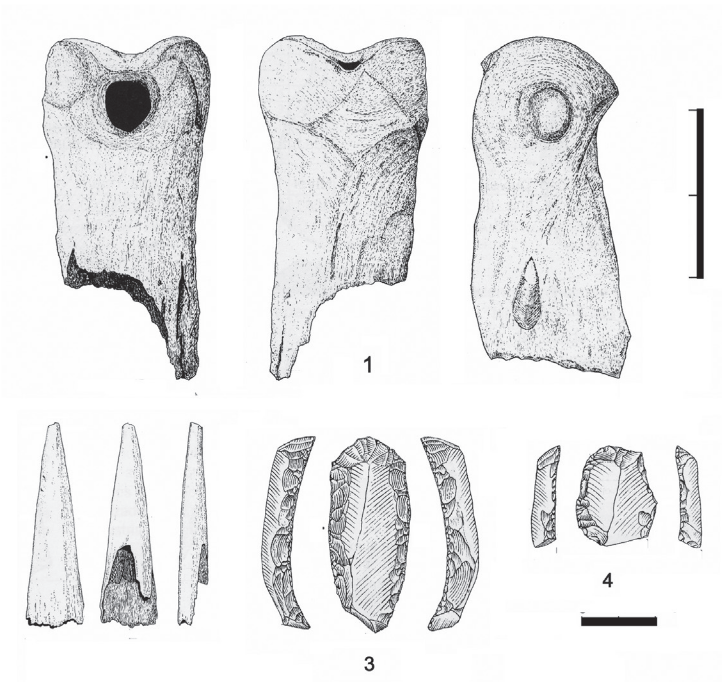

Fig. 5 Aurignacian industries of level 6 from the interior sector of zone D at La Güelga cave: 1, perforated red deer phalange; 2, antler point; 3, scraper.

deposit is wedged opposite the roof of the cavity and slopes towards the interior of the cavity, filling it up totally. It is affected by roots.

- Surface level 2 (GU.D.INT.2SUP): 18 to 35 cm of autochthonous angular boulders and cobbles (percentile 30 cm, mean 10 cm) as well as allochthonous rounded cobbles embedded in a pale brown clay-silt matrix. It contains fragments of karstified limestone.
- Level 1 (GU.D.INT.1): 10/20 cm of pale brown clays with autochthonous angular pebbles (percentile 5 cm, mean 1 cm) and rounded cobbles originating from the outside (percentile 12 cm). It presents a light depositional gradient towards the interior of the cave. Archaeological and palaeontological remains were included in this level. A lithic assemblage on flint and quartzite was recovered that included quartzite side scrapers and denticulates as well as a few flint burins and retouched blades. It is worth pointing out the presence of some Levallois blanks and two Châtelperronian points (Fig. 4). Among other diverse lithics, an atypical flint point with semi-abrupt retouch is also worth mentioning, while the rest are retouched flakes. Worked bone was not found in this level. The AMS date on a bone sample from this level is (Beta-172343) 32,460 ± 440 BP, 38,680-35,080 calBP.
- Level 2 (GU.D.INT.2): 5/10 cm of light brown clays and silt with autochthonous limestone gravel in continuation with the overlying level. Archaeological and paleontological remains are present but not abundant. Some side scrapers, denticulates and retouched blades were recovered and attributed to the Châtelperronian. There is no clear discontinuity from the overlying level which is very similar. In relation to this, it was possible to reconstruct an ungulate hemimandible with an old breakage from two fragments recovered, one in each of these two levels. The AMS date on a bone sample from this level is (Beta-172344) 30,210 ± 340 BP, 34,950 -33,910 calBP.
- Level 3 (GU.D.INT.3): 10 cm of large autochthonous slightly rounded clasts (percentile 35 cm, mean 20 cm). The interstitial matrix consists of brown clays and silt. In the course of the archaeological excavation, two sublevels were differentiated; one with clasts (3a) and another with fill (3b). Only a few quartzite notches and some retouched flakes were recovered from this level.
- Level 4 (GU.D.INT.4): 12/20 cm of light brown clays and silt with autochthonous pebbles and rounded gravel (percentile 6 cm, mean 2 cm) and chaotic disposition. The archaeological remains are scarce: Two double side scrapers in flint and quartzite respectively.

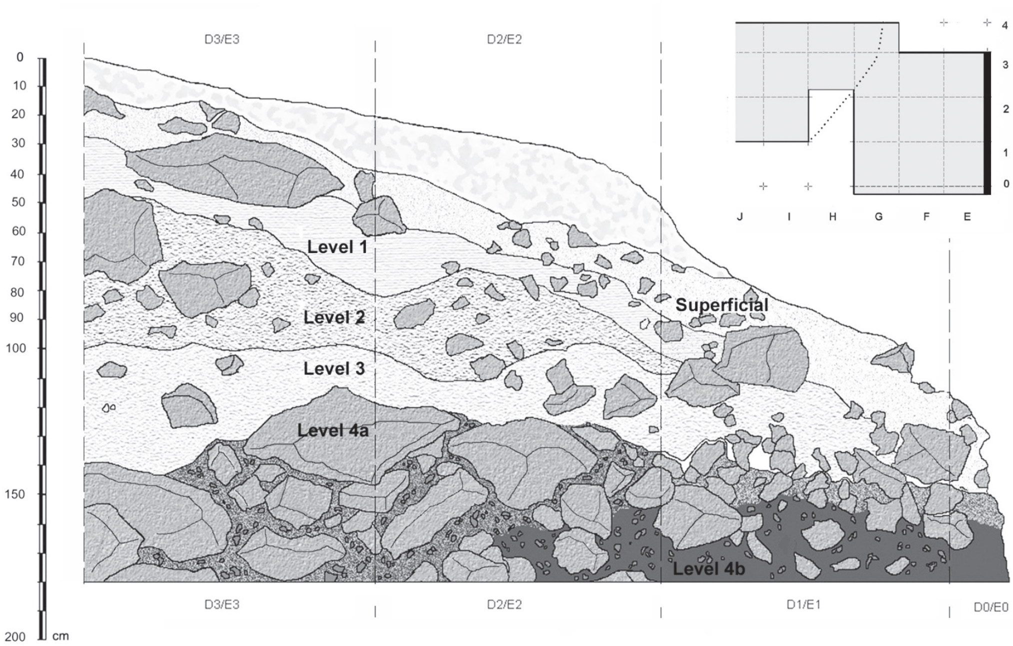

Fig. 6 Stratigraphic profile of the exterior sector of zone D at La Güelga.

- Level 5 (GU.D.INT.5): 6/20 cm of brown clays and silt with autochthonous pebbles (percentile 4 cm, mean 0.5 cm). The lithic industry is different in respect to the overlying levels, the types are more laminar and the flint component is important.
- Level 6 (GU.D.INT.6): 30/40 cm of a clastic level formed by autochthonous cobbles and pebbles (percentile 10 cm, mean 2 cm) with an abundant dark brown clayey-silty matrix. The disposition of the clasts is quite planar and parallel to the sub-horizontal depositional surface of the studied profile. The level contains archaeological remains among which we should point out some bones with intentionally modified aspect, the mesial part of a broken sagaie with a flat section (Fig. 5) and a perforated red deer phalange identified as a whistle. This level and the overlying one may be ascribed to the Aurignacian on the basis of their positioning in the sequence, the type of lithic industry that they include and the presence of bone/antler industry.
- Level 7 (GU.D.INT.7): 35 cm of large autochthonous slightly rounded boulders and cobbles (percentile 30 cm, mean 15 cm) that presented a light interstitial matrix of dark brown clays. Some of the limestone cobbles were altered. Only quartzite side scrapers were recovered.
- Level 8 (GU.D.INT.8): 8/10 cm of dark brown sandy clays with gravel and small size pebbles (percentile 2 cm, mean 0.5/1 cm). We should highlight the increase of lithic production debris and a typical Levallois point among the archaeological remains.
- Level 9 (GU.D.INT.9): 12/15 cm visible of black clays with abundant organic material. Autochthonous, limestone prismatic pebbles with robust edges due to dissolution are present (percentile 2 cm). The level is horizontal and includes combustion areas marked by rubefaction and dispersed ashes. It contains lithics in quartzite and Levallois type blanks as well as side scrapers, backed knives and retouched flakes.

Zone D, exterior sector

The deposits of the exterior sector of zone D are located to the outside of the cavity in the part of the cave that resembles a rock shelter, and on top of a rocky terrace or shelf formed by large limestone blocks. The bedrock on which the deposits rest has not yet been reached while their upper surface is located at 11 m above the river bed. The lithostratigraphy of these deposits was obtained from the study of profiles of the test trench and core samples from squares G-0 and G-1. From top to bottom the sequence consists of the following levels (Fig. 6):

- Surface level 1 (GU.D.EXT.1SUP): 25 cm thick surface level, formed by massive black clays and silt, sparse, disperse autochthonous clasts (percentile 10 cm, mean 2 cm) and abundant organic matter. It contains mixed materials of variable chronology.
- Surface level 2 (GU.D.EXT.2SUP): 20 cm thick formed by brown/black clays with autochthonous limestone boulders, cobbles and pebbles (percentile 60 cm, mean 5 cm), originating from the collapse of the rock shelter roof. The deposit slopes towards the exterior.
- Level 1 (GU.D.EXT.1): 15/20 cm thick. Conglomerate of autochthonous cobbles and pebbles

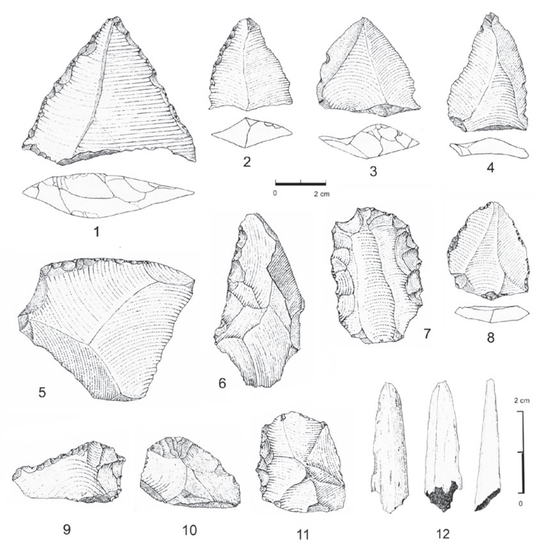

Fig. 7 Mousterian lithic industry of level 4b from the exterior sector of zone D at La Güelga: 1, Mousterian point; 2-4 and 8, Levallois point; 5-7, side scraper; 9 and 10, scrapers; 11, denticulate; 12, bone point.

(percentile 10 cm, mean 2 cm) with a light brown clayey matrix. The archaeological content is very poor with just some lithic production debris.

- Level 2 (GU.D.EXT.2): 45/20 cm thick with autochthonous cobbles and pebbles (percentile 10 cm, mean 2 cm) and abundant clayey matrix. It contained scarce lithics (some laminar and Levallois blanks in an industry without retouch) and does not constitute an occupation level.
- Level 3 (GU.D.EXT.3): 40/30 cm thick. A conglomerate of autochthonous boulders, cobbles and pebbles (percentile 15 cm, mean 2 cm) with a light brown clayey matrix, which appears partially carbonated leading to a breccia towards the contact zone with the rock shelter wall. In this lower part of the level, a few archaeological materials with Mousterian characteristics, the majority with crust adherent on them, were found. Actually, these materials represent the topmost remains of the underlying level.
- Level 4: From top to bottom it includes two sublevels:
- Sublevel 4a (GU.D.EXT.4a): 60/40 cm thick with large boulders and cobbles (percentile 60 cm, mean 10 cm) and light brown clayey matrix that fills up the interstitials between the clasts. Abundant lithic debris, some burnt bones and various tools appear among the boulders. The AMS date on a bone sample from this level is (Beta-172345) 29,550 ± 310 BP, 34,540-33,220 calBP.

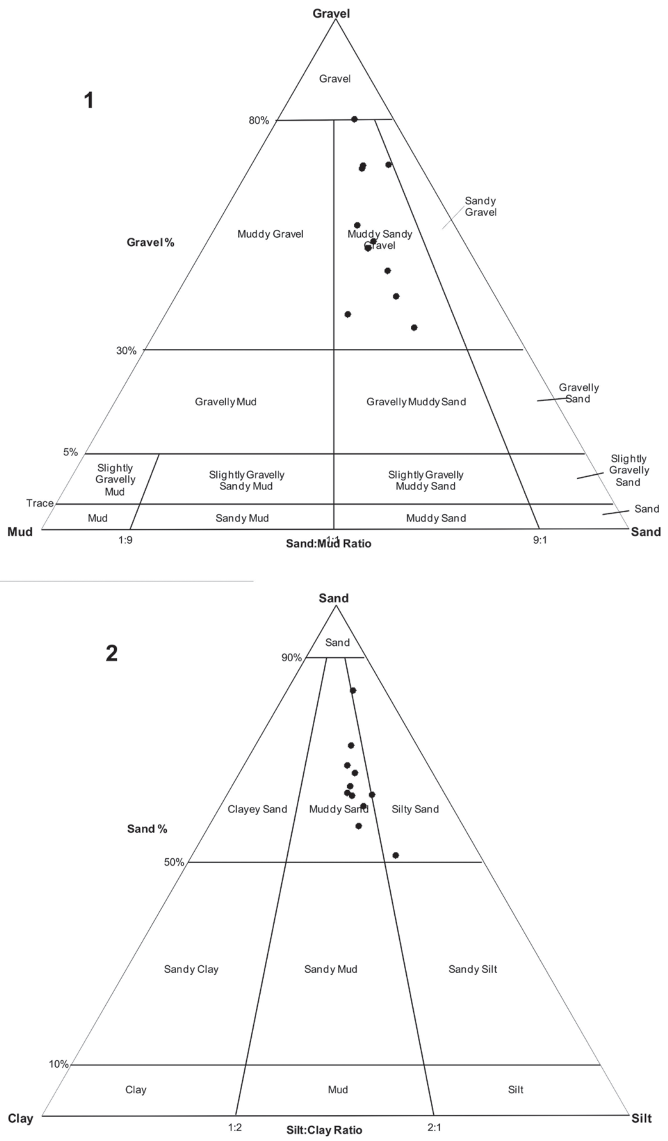

Fig. 8 Granulometry of the interior sector levels of zone D at La Güelga: 1, global triangular diagram; 2, triangular diagram of the matrix (<2 mm).

- Sublevel 4b (GU.D.EXT.4b): 30 cm thick. A conglomerate of autochthonous, prismatic, tabular, angular boulders and cobbles and pebbles (percentile 20 cm, mean 5 cm, downward percentile 10 cm, mean 2 cm) with dark brown clayey-silty matrix. This is an occupation level with numerous anthropogenic remains disposed horizontally, directly below the large boulders of sublevel 4a that seal this occupational phase (Fig. 7). The level contains abundant lithic and bone remains attributed to the Mousterian together with some rounded cobbles transported by humans. The high percentage of Levallois pieces and the presence of worked bone stand out (Fig. 7). In this level a right maxillary second premolar was recovered, most probably from a Neanderthal. The individual would have been more than 15 years of age following the present development model and would have lived long enough for the crown to bear a degree 3 wear. The AMS date on bone from this level is (Beta-186766) 29,020 ± 260 BP, 34,200-32,800 calBP.

- Level 5 (GU.D.EXT.5): 60 cm thick sands with light brown silty clays and autochthonous boulders and cobbles (percentile 40 cm) that progressively decrease in size towards the base. The level presents a massive aspect without internal organisation, although an increase of sands can be observed towards the base. The archaeological materials are scarce and they progressively decrease downwards until the level becomes completely sterile. The cobbles are angular and many of them are completely altered. The molar of an infant mammoth was recovered in a small core from this level.

Sedimentary and digenesis processes

The deposits in the interior of the cavity (interior sector of zone D) are approximately 2 m thick, although the bedrock has not yet been reached. The sediments of all levels correspond to the granulometry class of poorly classified muddy sandy gravels (Fig. 8,1), with bimodal, trimodal and polymodal characters. The matrix (<2 mm) corresponds to muddy and silty sands (Fig. 8,2). The granulometry curves of the global frac-

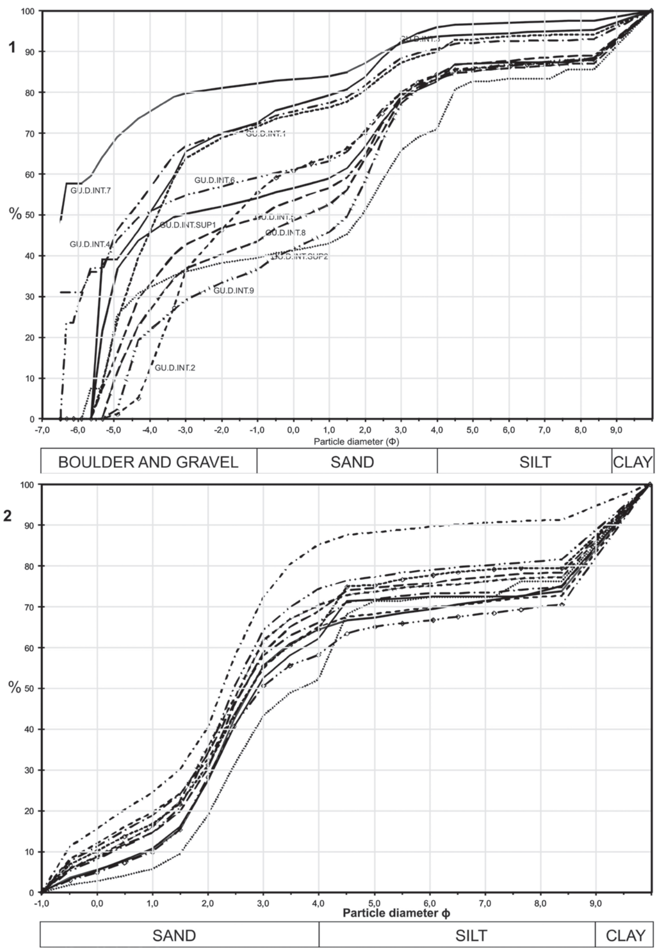

Fig. 9 Granulometry curves of the interior sector levels of zone D at La Güelga: 1, global granulometry curves; 2, matrix granulometry curves (<2 mm).

tions are of two types; those which are frequently convex upward, indicating the dominance of coarse compared to fine fractions. The second type has a sigmoidal tendency with a predominance of sands accompanied by coarse and lutitic fractions. The first type of curves includes the strongly clastic levels of the upper part of the sequence (levels 1, 3 and 4) and level 7 while the second comprises the lower levels in which fine fractions predominate (levels 2, 5, 6, 8, and 9), along with the surface levels (Fig. 9,1). Granulometry curves for the matrix (<2 mm) are sigmoidal, dominated by medium and fine sands, limited amounts of silt and a predominance of clays, which reach a maximum in level 6 and a minimum in level 3 (Fig. 9,2). The mineralogy of the lutitic fraction (Fig. 10) of the entire sequence is markedly siliceous with two phases that can be clearly differentiated. The lower level is characterised by abundant quartz, feldspars, muscovite/illite and clinochlorite (absent from the two basal levels), accompanied by smaller proportions of calcite, some kaolinite in the basal levels, and dolomite and gypsum in level 7. In the upper phase, quartz and muscovite/illite dominate, compared to feldspars, calcite and gypsum, while kaolinite and clinochlore are present in the uppermost part of the sequence. The colour of the sediment matrix of the interior sector ranges from very dark greyish brown to dark yellowish brown (10YR 3/2 a 10YR 4/4) to brown (7.5YR 5/4 a 7.5YR 5/5). The pH-value varies between values closer to 7 but slightly basic, to more alkaline ones between 8 and 8.44. The organic matter fluctuates between 0.15 % in level 7 and 1 % to 1.14 % in levels 3 and 9 respectively. These values match those of the organic carbon. The presence of carbonates is higher in levels 1 and 4, with values ranging between 13 % and 15 %, while in the remaining levels, the values are around 5 %. The sediment matrix is mainly formed by insoluble minerals with values over 70 % (see table 2 for a full list of values used in this discussion). The basal level of the sequence is horizontal while the remaining levels slope towards the interior of the cave. The general geometry of the deposit resembles the body of a cone with the apex located at the exterior sector of zone D. The lithostratigraphic succession comprises nine levels in which sandy-lutitic sediments generated by low energy processes, alternate with autochthonous limestone boulders and cobbles resulting from gelifraction and other gravity-slope processes that have a lutitic matrix. In general, the sequence increases in coarseness towards the top with at least three clastic events, while the contacts between different levels are gradual. No evidence for erosion or abrupt colour changes is observed.

The sequence of the exterior sector comprises five levels with a maximum thickness in the core of 2.5 m. The sediments of these levels correspond to the granulometry classes of poorly classified gravels, sandy gravels and muddy sandy gravels (Fig. 11,1), with a bimodal, trimodal and polymodal character. The matrix (<2 mm) corresponds to sands, muddy sands and silty sands (Fig. 11,2). The granulometry curves of the global fractions split up into two types, those strongly convex upward indicating the predominance of coarse fractions and low proportions of fine fractions, and those with a sigmoidal tendency and a predominance of sands with coarse and lutitic fractions. The first type includes

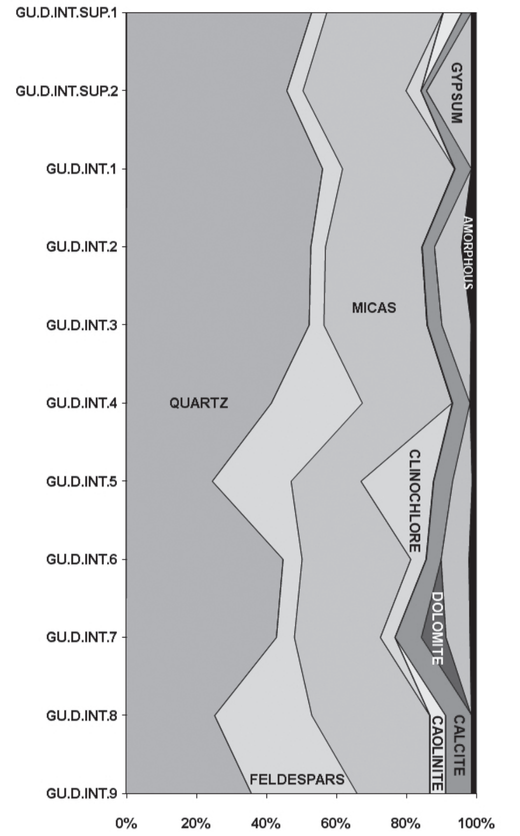

Fig. 10 Mineralogy of the silt and clay fraction (<0,063 mm) of the interior sector levels of zone D at La Güelga.

the strongly clastic levels of the upper phase (levels 1 to 4a), while the second corresponds to the lower levels in which fine fractions predominate (levels 4b and 5lower and matrix of level 4a), as well as the two surface levels (Fig. 12,1). The granulometry curves of the matrix (<2 mm) are sigmoidal with a predominance of medium to fine sands, scarce silt and abundant clays which reach their maximum in the lower part of level 5 (Fig. 13,2). The samples from the upper level 2 and level 4a contained low proportions of silts and clays and a predominance of sands. The mineralogy of the lutitic fraction (Fig. 13) is characterised by predominance of siliceous minerals (quartz, feldspars and muscovite/illite) compared to calcite, presence of kaolinite in the upper and lower part of the levels and gypsum in the middle and upper part. The presence of hydroxylapatite, a mineral of the phosphate group, in the entire sequence stands out. The colours (in dry) of the sediment matrix from the exterior sector are basically brown and strong brown (7.5YR 4/2 to 7.5YR 5/6) with very dark greyish brown tones (10YR 3/2 to10YR 5/3). The pH value is slightly alkaline with values that range between 7.70 and 8.40. The organic matter fluctuates between 0.40 % in levels 3 and 4, and 1.60 % and 4.58 % in levels 5 lower and 2 upper respectively. These values fit together with those for organic Carbon. The presence of carbonates is higher in levels 1, 2 and 4b with values between 17.25 % and 28 % while in the rest of the levels they are lower than 10 %. The sediment of the matrix is mainly composed of insoluble minerals with values between 49 % and 78.5 % (see table 2 for a full list of values used in this discussion).

The data point to this as a typical rock shelter, with sedimentation taking place on

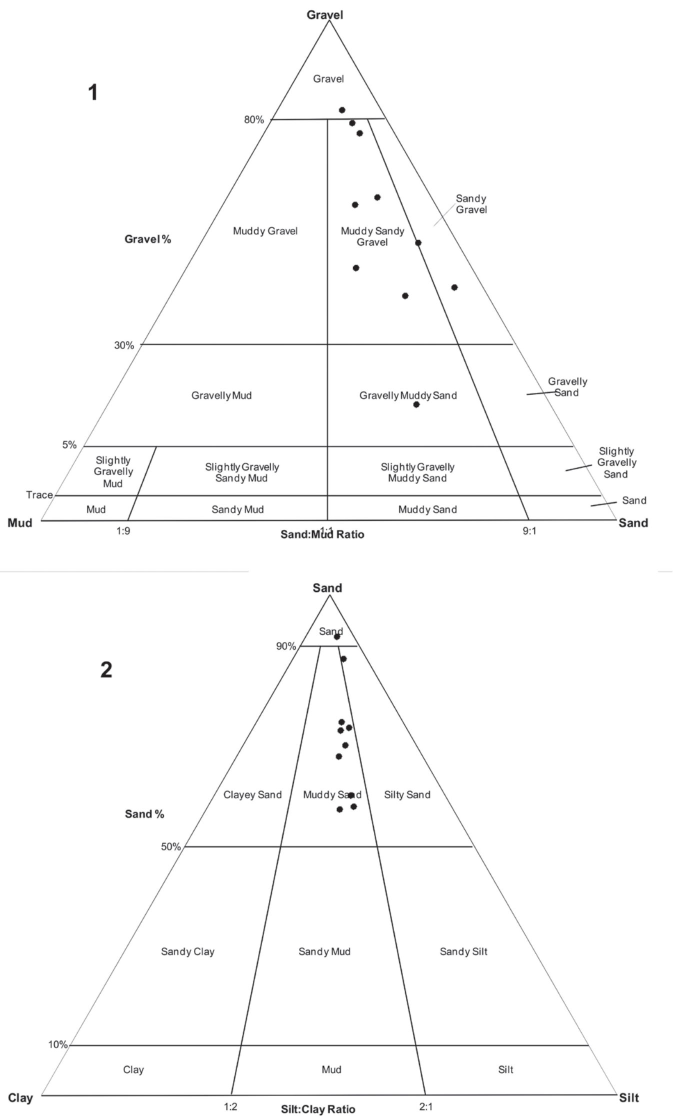

Fig. 11 Granulometry of the exterior sector levels of zone D at La Güelga: 1, global triangular diagram; 2, triangular diagram of the matrix (<2 mm).

a shelf or rocky terrace of fluvio-karstic origin, formed earlier as the river incised its course and large blocks detached from the roof. The deposits are primarily composed of autochthonous clasts produced by gravity processes including gelifraction, which towards the base are substituted by lutitic sands indicating low energy conditions with autochthonous clasts. In some levels these may be found cemented by calcium carbonate, forming breccias. These cementation processes are related to dripping from the roof of the rock shelter. In general, the sequence coarsens towards the top with two marked roof fall events, a very clear one in level 4a and a less intense episode at the top.

The mineralogy of the fine fraction of the sediments is comparable with that of the zone and is mainly comprised of tectosilicates, filosilicates, clays originating from the siliceous bedrock (quartzites, lutites and sandstones of the Palaeozoic) located upstream from the cavity, and a few grains of calcite and to a lesser extent dolomite, both autochthonous. The composition is similar to that of the natural deposits of the slope, located under the rocky cliff outside of the area of the site, which are mainly formed by quartz, feldspars and clays. The presence of hydroxylapatite in the exterior sequence may be attributed to the dissolution of bones resulting from human activities (Jordá et al. 2008). Any relation between hydroxylapatite and the urine of goats browsing in the area of La Güelga may be excluded since this mineral does not appear in the analysis of the slope deposits outside of the area of the site (Fig. 14).

The two lithostratigraphic sequences of zone D (interior and exterior) are very similar in terms of granulometry. They correspond to a single depositional system in which a gravity induced slope process played a significant role, filling the rock shelter with predominantly autochthonous material, along with the small cavity. The large boulders are the result of roof falls, with clasts due to cryoclastic processes. Finer materials were laid down by widespread low energy flooding, although more energetic flow is suggested by the presence of rounded cobbles and abundant sands. Dissolution pro-

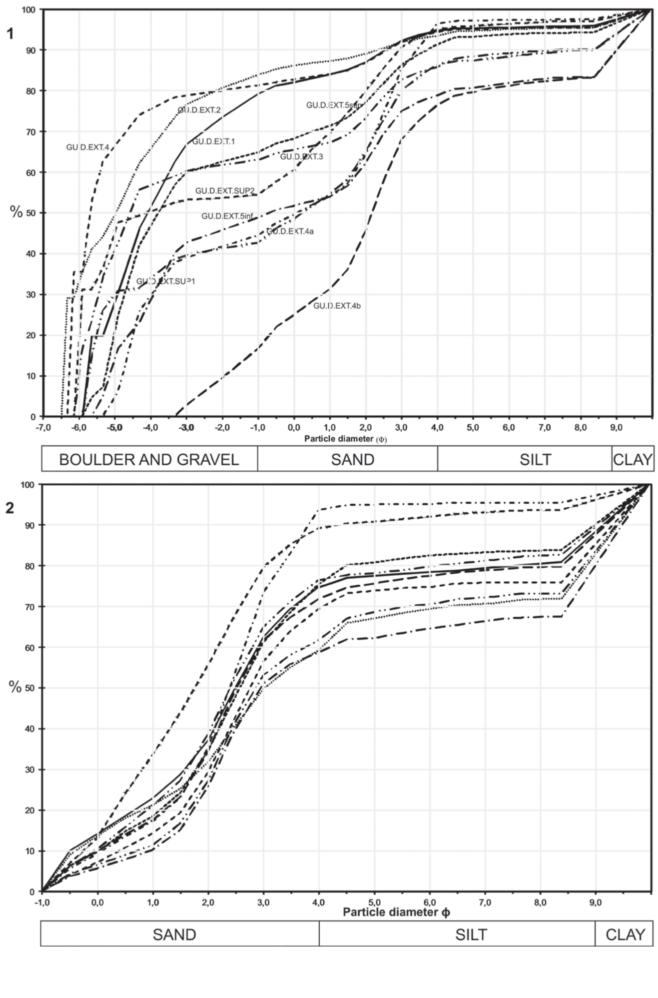

Fig. 12 Granulometry curves of the exterior sector levels of zone D at La Güelga: 1, global granulometry curves; 2, matrix granulometry curves (<2 mm).

cesses during diagenesis are detected in the rounding of angular limestone clasts. The colour of the sediments of both sequences is homogeneous and ranges between beige, yellowish and grey (10YR) to orange and beige (7.5YR). The minerals included in the lutitic fraction of both sequences originated in the surroundings of the cave. Siliceous minerals may include the solid residue produced by dissolution of the autochthonous limestone and the alteration and erosion of the siliceous lithologies located upstream. Calcite and dolomite result from disintegration of the host rocks while the presence of hydroxylapatite only in the levels of the exterior sector is the result of gravitational infiltration of phosphorus during the diagenesis of the sediments. The presence of hydroxylapatite in the sequence from the exterior sector at less than 10 % suggests the possible existence of an underlying phosphate crust overlying a clayey deposit or the bedrock. Future excavations will allow us to verify or reject this hypothesis.

In terms of the geometry of the deposits, those from the interior sector are inclined towards the interior, while those from the exterior sector have a double gradient, both towards the interior and the exterior. It is for this reason that the greatest accumulation of sediments took place in the zone of gradient change. On the basis of the analysis of the nature, geometry and elevation of the deposits in both sectors it has been possible to correlate them. Levels 4a and 4b of the exterior sector and levels 7 and 8 of the interior were used as a reference both in the field (physical aspect, geometric relation, topographic location) (Fig. 15) and in comparing their textural and mineralogical characteristics. In terms of texture, there is a correlation between the two clearly clastic levels in both deposits, level 7 of the interior sector and 4a of the exterior, the granulometry curves of which are practically identical (Fig. 16). The levels that underlie these clastic deposits correspond both in the interior and exterior, and include fine sediments that are rich in archaeological materials and organic matter. The possible remains of hearths, undisturbed by post-depositional pro-

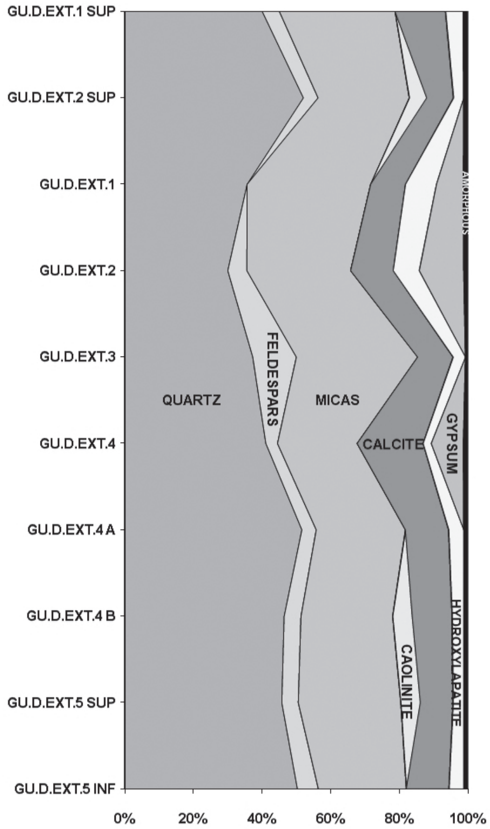

Fig. 13 Mineralogy of the silt and clay fraction (<0,063 mm) of the exterior sector levels of zone D at La Güelga.

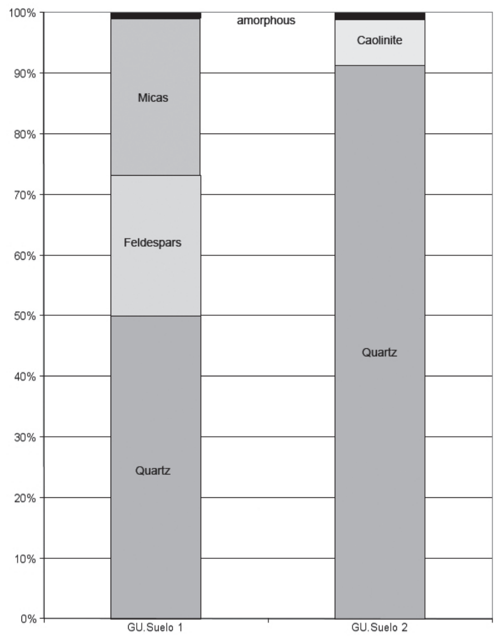

Fig. 14 Mineralogy of the silt and clay fraction of the deposits from the slope at La Güelga from outside of the cave.

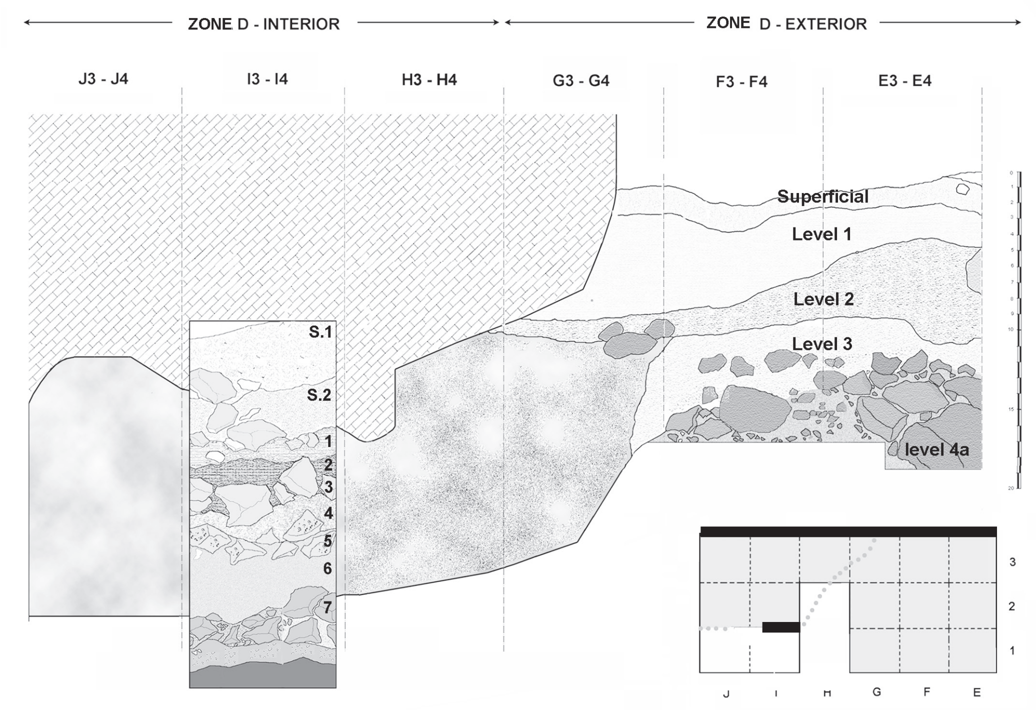

Fig. 15 Correlation between the interior and exterior sequences of zone D at La Güelga.

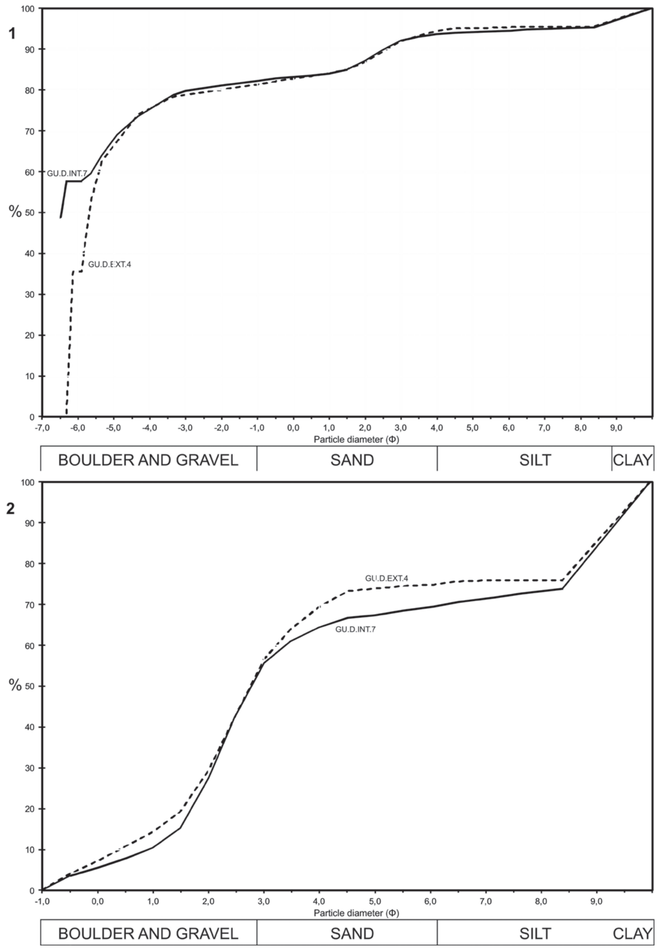

Fig. 16 Granulometry curves of levels 7 (interior) and 4b (exterior) of zone D at La Güelga: 1, global granulometry curves; 2, matriz granulometry curves (<2 mm).

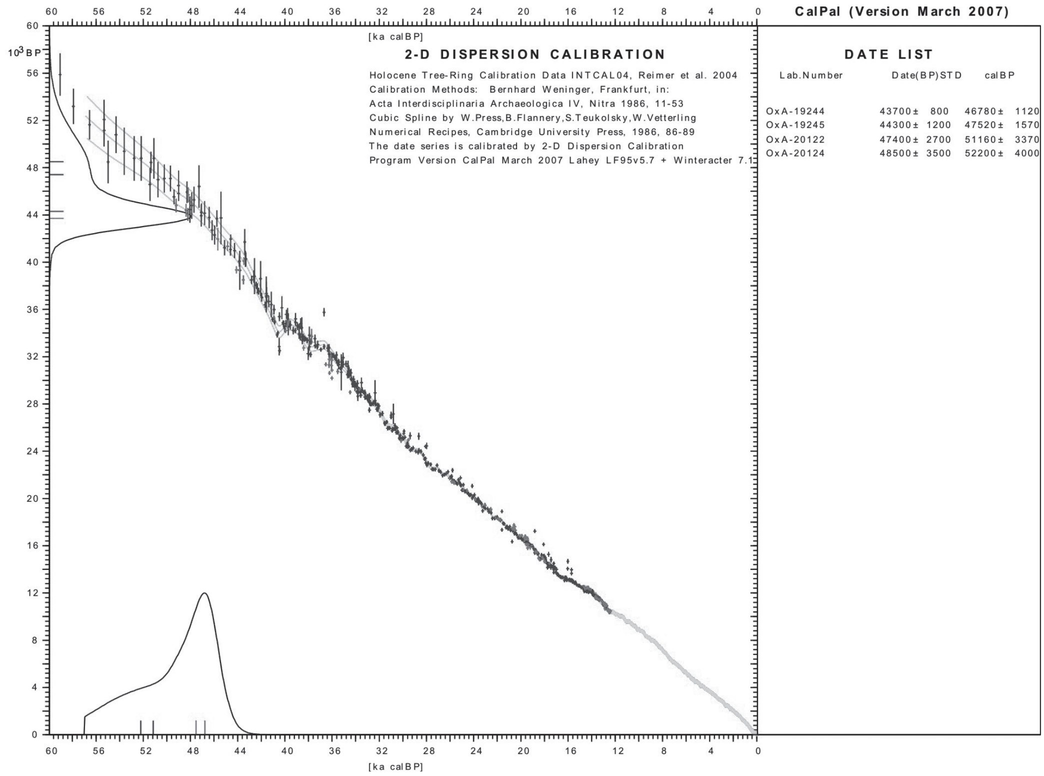

Fig. 17 Accumulated probability curve for the four 14C dates (ORAU) from zone D, calibrated using the CalPal-2007$_{\text{Hulu}}$ curve, June 2007 version (www.calpal.de; Weninger & Jöris 2004).

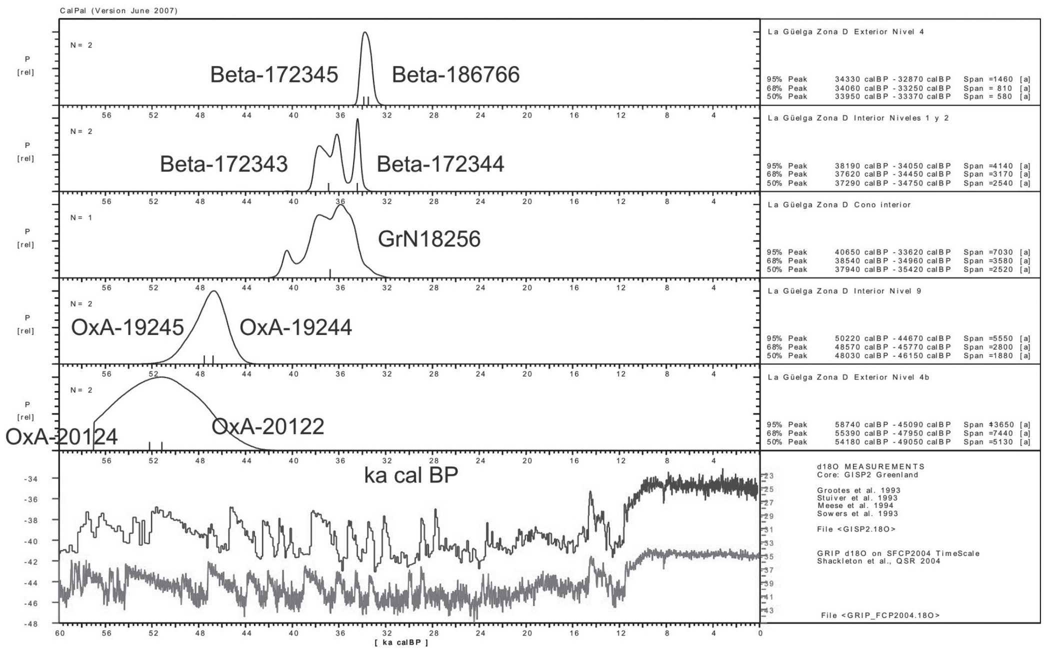

Fig. 18 Comparison of the accumulated probability curves by levels for the 14C dates by ORAU and other laboratories, calibrated using the CalPal-2007$_{\text{Hulu}}$ curve, June 2007 version (www.calpal.de; Weninger & Jöris 2004).

cesses, are preserved in these levels (level 9 of the interior sector). In terms of the mineralogy of the deposits, the presence of kaolinite in level 4b of the exterior sector and level 8 in the interior is an important element which establishes a correlation based on textural criteria.

ARCHAEOLOGICAL SEQUENCE

The sequence of lithic industries that was identified in the interior sector of zone D below the two surface levels provided three clearly defined phases: An upper attributed to the Châtelperronian, a middle assigned to the Aurignacian and finally a lower Mousterian unit (Quesada & Menéndez 2009). Between each of these phases were other levels which pointed to either minimal use of the cave or the result of roof collapses. The presence of these levels allowed the three main lithic horizons to be delimited. The basal Mousterian level must be considered as the final Mousterian occupation of the exterior sector (zone D) towards the interior of the cave.

In the interior sector, the attribution of levels 1 and 2 to the Châtelperronian is supported by the presence of diagnostic pieces, among which a typical Châtelperronian point stands out. It was found in an intact part of level 1 and is characterised by conventional morphology but was made using a quite elaborated technique (Fig. 4). Level 1 was also described as Mousterian with Châtelperronian points (Maroto et al. 2005), which does not change the general argument. The tool assemblage is small but quite homogeneous and very similar to that, which would be expected in conjunction with Châtelperronian points. These included a fragment of a clearly backed blade, a delicate pointed laminar flake that resembles an atypical Châtelperronian point and various quartzite flakes with Levallois characteristics. The lithic tool-kit in level 2 is less diagnostic and is characterised by abundant medium and small size quartzite flakes with occasional or discontinuous simple retouch.

The character of the industry from levels 3 and 4 could not be clearly defined due to the small numbers of artefacts, which included retouched flakes and side scrapers. The industry in level 5 on the contrary produced blade blanks and diagnostic pieces that could be unambiguously attributed to the Aurignacian. In particular, a delicate flat nosed end scraper on a retouched flint blade, a proximal blade fragment with Aurignacian retouch, an atypical end scraper with a low and very abrupt nose, and a small distal sagaie fragment (Fig. 5). However, it is the bone and antler industry of level 6 that securely dates the interior sector of the cave to within the intermediate Aurignacian phase. A mesial fragment of a sagaie with flat section, an awl made on a diaphysis and a whistle made on a phalange with intentional circular perforation were found in level 6 (Fig. 5).

The third lithic phase is separated from the second by a horizon of collapse (level 7).

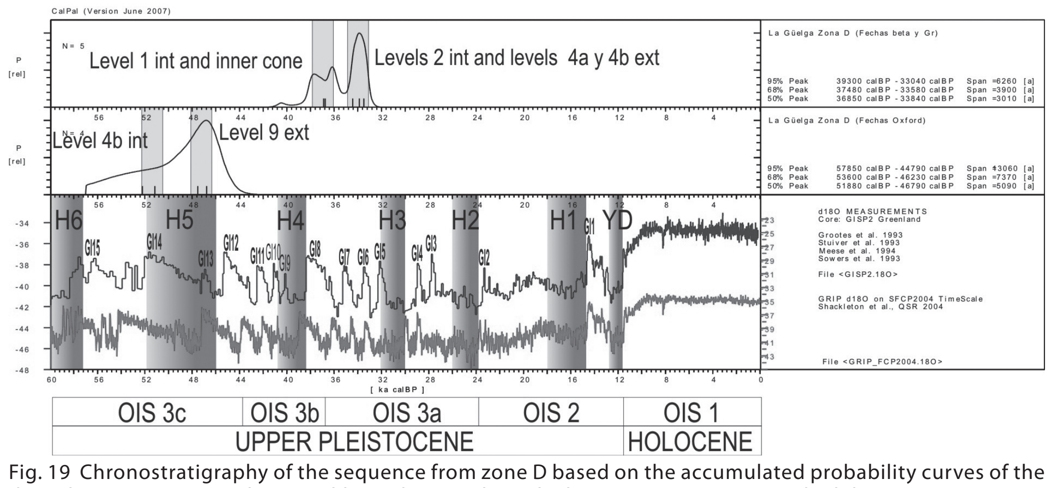

Fig. 19 Chronostratigraphy of the sequence from zone D based on the accumulated probability curves of the dates by ORAU, Beta and GrN, calibrated using the CalPal-2007$_{Hulu}$ curve (www.calpal.de; Weninger & Jöris 2004) and in comparison with the high resolution proxies GISP2 $^{18}O/^{16}O$ (Grootes et al. 1993; Meese et al. 1994; Sowers et al. 1993) and GRIP-SFCP ^{18}O (Shackleton et al. 2004).

Level 8 contains the first clear signs of Mousterian occupation with *in situ* remains. The lithics are characterised by an absence of laminar pieces made of flint, instead replaced by an industry of quartzite flakes. These characteristics, which are incipient in level 8, become clearer in level 9. This is a horizontal deposit with an intense concentration of ash, rubefact clays and charcoal dispersed in a concentric manner that may suggest an area of hearth cleaning. The lithic industry is homogeneous and is characterised by quartzite flakes and highly elaborate pieces of the Levallois tradition, basically side scrapers, retouched flakes and a few delicate baked knives.

In agreement with stratigraphic correlation across the site, the charcoal-rich horizon of level 9 in the interior sector should be considered as the inward extension of the Mousterian occupation identified outside of the cave. The characteristics of the lithic industry in level 4b of the exterior sector are very similar to those in the lower interior sector. Level 4b has a rich assemblage that allows the characteristics of lithic production during an intense phase of Mousterian occupation to be assessed (Fig. 7). Although our study of the lithics is still at a preliminary stage, our first assessment has identified the following key attributes of this level. There are medium sized quartzite flakes with simple and limited retouch, in some cases random notch denticulate in form, along with small to medium flakes with minimal marginal retouch. More sophisticated pieces include side scrapers of various forms such as double, deviated, transversal, or transversal with a natural or thinned back. The Levallois component of this industry deserves special mention, and is best reflected in various medium size Levallois points of very careful manufacture. At this stage of our research there is not enough data to confirm if there are differences between the industries of the lower Mousterian occupation (levels 5 and 4b, exterior sector) and the upper (level 4a, exterior sector). To interpret the industries of levels 4a and 4b exterior, an evaluation of the complicated sedimentary history of the site is required, in particular the processes of boulder collapse and chemical precipitation that have deeply affected the original structure of the deposits. It is this latter process that resulted in carbonate precipitation on the lithic artefacts, occasionally covering them completely. Bone and antler artefacts were similarly affected, along with breakage due to roof falls and trampling.

Radiocarbon dating and chronostratigraphy

Of the ten bone samples treated at ORAU, only six were suitable for AMS dating and the results are presented in table 1. Four of the samples provided valid concrete numerical ages though with a wide standard deviation of more than 500 years (OxA-19244, OxA-19245, OxA-20122, OxA-20124). The other two were of infinite age, older than 43 ka and 43.6 ka BP (OxA-20123, OxA-20125) respectively. Nevertheless, the minimum age provided by these dates is in agreement with the other dates from the same laboratory.

A comparison between the dates recently obtained from ORAU (OxA-20122, OxA-20124) and previously from Beta Analytic (Beta-186766) suggests that this same level is significantly older. The reason for this apparent discrepancy lies in the different pretreatment methods applied to the bone samples by Beta Analytic and ORAU. The latter uses the ultrafiltration protocol for the extraction and decontamination of bone collagen in samples to be AMS dated, a process that significantly increases the accuracy of the age estimated. The dates from Beta Analytic provide a minimum age for the samples.

Furthermore, a comparison between the new dates from the interior and the exterior indicates that the dates for level 9 (interior) are younger than those from level 4b (exterior). This inversion is less evident when the calibrated dates are compared. They overlap and can be grouped in a single accumulated probability curve (Figs. 17), confirming the correlation of the basal exterior and interior levels which belong to the same sedimentary unit, as discussed previously.

The new dates from zone D allow us to place with precision the interior and exterior sequences within the upper Pleistocene chronology. The two estimates from level 4b exterior were used to date bones with cut-marks to the time-span 56.24–46.32 ka calBP

(Fig. 18). In the case of level 9 interior, another two bones with cut-marks were dated between 49.6 ka and 45.17 ka calBP (Fig. 18). Given that the new dates correspond to levels from the same stratigraphic unit, they point to a time range of between 55.71-44.94 ka calBP. This places the sedimentary and archaeological units within MIS 3c, between Heinrich events 6 and 4, and during GI 15 and GI 12 and H 5 (Fig. 19).

The dates previously published (Beta and GrN codes) indicate that a minimum age for level 4b exterior should be somewhere between 34.2 ka and 32.8 ka calBP, while the minimum age for level 1 interior should be between 38.68 ka and 35.08 ka calBP. Given that the stratigraphic position of level 4b exterior is deeper than that of level 1, there is a clear inversion in these dates that chronologically place level 4b exterior later than level 1 interior. Inversions are also present in the dates Beta-186766, Beta-172345, Beta-172344 and Beta-172343, suggesting that these estimates should be disregarded. The date of 40.31-33.19 ka calBP (GrN-18256) is consistent with the inclusion of the dated sample in sediments that migrated into the cave from the outside.

CONCLUSIONS

The sediments investigated derived from the interior fill of a collapsed rock shelter. The original morphology of the fill would have been conical, with a double gradient towards the exterior and an interior that was absorbed towards the base, thus resulting in a sub-horizontal disposition. Parts of the original deposit are preserved in what would have been the interior of the rock shelter, the interior furthest extent of which is the fill of the cavity. Remains of the deposit located on the shelf would have formed part of the central zone (the apex) of the rock shelter deposit.

The geoarchaeological sequence of zone D consists of a series of levels created by anthropogenic and natural processes. The latter include roof falls, gelifraction and erosion due to low energy water flow. The archaeological sequence consists of a succession of levels that, from bottom to top, include material attributed to the Mousterian (levels 5, 4b, 4a and 3 of the exterior sector and levels 9, 8 and 7 of the interior), Aurignacian (levels 6 and 5 of the interior sector) and Châtelperronian (levels 2 and 1 of the interior sector).

The base of the sequence is dated to between 56.24 ka and 45.17 ka calBP, thus placing it within MIS 3c, between Heinrich events 6 and 4, and within temperate interstadials GI 15 to GI 12 (Fig. 19) and cold Heinrich event 5.

The interstratification of the Aurignacian between the Mousterian and Châtelperronian reopens the debate concerning the Middle-Upper Palaeolithic transition. Our primary aim is to clarify the nature of this succession, to define with precision the cultural signature of each of the levels, and to place them within a secure stratigraphic and chronological understanding of the site.

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TABLES

zone/sector	level	14C age BP	14C age calBP (2σ)*	material	lab-number	method
D interior	9	43,700 ± 800	49,020–44,540	bone	OxA-19244	AMS
	9	44,300 ± 1,200	50,660–44,380	bone	OxA-19245	AMS
D exterior	4b	47,400 ± 2,700	57,900–44,420	bone	OxA-20122	AMS
	4b	>43,200	-	bone	OxA-20123	AMS
	4b	48,500 ± 3,500	60,200–44,200	bone	OxA-20124	AMS
	4b	>43,600	-	bone	OxA-20125	AMS
D interior	interior cone	32,000 ± 1,600/1,350	40,310–33,190	bone	GrN-18256	conventional
	1	32,460 ± 440	38,680–35,080	bone	Beta-172343	AMS
	2	30,210 ± 340	34,950–33,910	bone	Beta-172344	AMS
D exterior	4a	29,550 ± 310	34,540–33,220	bone	Beta-172345	AMS
	4b	29,020 ± 260	34,200–32,800	bone	Beta-186766	AMS

Tab. 1 Radiocarbon dates of La Güelga calibrated using the CalPal-2007$_{Hulu}$ curve, June 2007 version (www.calpal.de; Weninger & Jöris 2004).

level	pH in H_20	colour (dry)	colour (wet)	% organic matter	% organic carbon	% $CaC0_3$	insoluble residue
GU.D.INT.SUP.1	7.63	7.5 YR 5/4	7.5 YR 5/4	0.44	0.26	2.50	82.00
GU.D.INT.SUP.2	8.10	10YR 3/6	10YR 3/6	0.49	0.28	6.25	88.50
GU.D.INT.1	7.70	10YR 3/4	10YR 4/5	0.84	0.49	13.00	76.50
GU.D.INT.2	7.50	10YR 3/3	10YR 3/4	0.64	0.37	6.25	78.00
GU.D.INT.3	8.44	10 YR 4/3	10YR 3/3	1.00	0.58	3.75	76.50
GU.D.INT.4	7.69	7.5 YR 5/5	7.5 YR 4/4	0.41	0.24	15.00	75.50
GU.D.INT.5	7.50	10 YR 4/4	10 YR 3/4	0.86	0.50	6.50	70.50
GU.D.INT.6	7.80	10YR 4/4	10YR 3/4	0.34	0.20	3.75	84.00
GU.D.INT.7	8.00	10YR 4/3	10YR 5/4	0.15	0.08	5.75	76.00
GU.D.INT.8	8.25	10YR 3/2	10YR 3/4	0.56	0.32	4.00	71.00
GU.D.INT.9	8.35	10YR 4/4	10YR 4/3	1.14	0.66	6.00	72.00
GU.D.EXT.1 SUP	7.70	10YR 3/2	10YR 4/4	0.43	0.25	8.00	72.50
GU.D.EXT.2 SUP	7.80	7.5YR 4/2	7.5YR 3/2	4.58	2.66	1.75	72.00
GU.D.EXT.1	8.10	7.5YR 5/4	7.5YR 3/4	1.17	0.68	17.25	67.00
GU.D.EXT.2	8.20	7.5YR 5/6	7.5YR 4/6	1.01	0.58	23.75	64.50
GU.D.EXT.3	8.20	7.5YR 4/6	7.5YR 5/6	1.39	0.81	7.25	74.00
GU.D.EXT.4	8.10	10YR 5/3	10YR 5/4	0.44	0.25	10.00	75.50
GU.D.EXT.4 A	8.30	7.5YR 3/4	7.5YR 4/6	0.43	0.25	7.00	78.50
GU.D.EXT.4 B	8.30	7.5YR 5/4	7.5YR 5/4	0.41	0.24	28.00	68.50
GU.D.EXT.5 SUP	8.30	7.5YR 4/6	7.5YR 3/4	1.20	0.70	3.75	49.00
GU.D.EXT.5 INF	8.40	7.5YR 5/6	7.5YR 4/6	1.60	0.93	7.50	68.50

Tab. 2 Edaphological analysis of La Güelga sediments.