A chrono-cultural reassessment of the levels VI-XIV from El Cuco rock-shelter: a new sequence for the Late Middle Paleolithic in the Cantabrian Region (northern Iberia)

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Abstract

A large number of sites dated to the Late Middle Paleolithic and the Early Upper Paleolithic have been recorded in the Cantabrian region (northern Iberia), making this area a key location to investigate the lifeways of the last Neanderthals and the first anatomically modern humans. The stratigraphic sequence from El Cuco rock-shelter was originally attributed to the Early Upper Paleolithic based on radiocarbon dates measured on bone apatite. However, new radiocarbon dates on shell carbonates from the lower levels produced inconsistent dates with those previously published. In order to clarify this anomaly, a reassessment of the chronology of levels VI to XIV was undertaken. The review was based on new radiocarbon dates performed on bones and shells, and a re-evaluation of the lithic assemblages. Bone samples did not produce radiocarbon dates due to a lack of collagen preservation but radiocarbon dating of shell carbonates provided dates ranging from 42.3 to 46.4 ka BP. These dates are significantly older than that previously obtained for level XIII using biogenic apatite from bones (~30 ka uncal BP), suggesting that the bone apatite used for radiocarbon dating was rejuvenated due to contamination with secondary carbonate. Lithic assemblages, defined in the first place as Evolved Aurignacian, have now been confidently attributed to the Mousterian techno-complex. These results suggest a Middle Paleolithic chronology for this part of the sequence. The new chronology proposed for El Cuco rock-shelter has significant implications for the interpretation of Neanderthal subsistence strategies and settlement patterns, especially for coastal settlement and use of marine resources, not only in northern Iberia, but also in Atlantic Europe.

Keywords: radiocarbon, shell, bone, chronology, Mousterian, Iberia

1. Introduction

The Cantabrian Region (northern Iberia) is a key location to investigate important questions about human evolution, such as the behavioral variability and demise of Neanderthal populations, the expansion of Modern Humans towards Western Europe, and the origins of symbolic behavior, among others. This region contains good examples of Late Mousterian cave sites, including El Esquilleu, El Sidrón, Sopeña, El Castillo, Cueva Morín, Covalejos or Axlor, to name but a few (Baena et al., 2012; Pinto-Llona et al., 2012; Wood et al., 2013; Sánchez-Fernández and Bernaldo de Quirós, 2008; Maíllo-Fernández, 2007; Sanguino and Montes 2005; González-Urquijo et al., 2005; Rios-Garaizar, 2012a; 2016; Santamaría et al., 2010), several cave and open air Châtelperronian sites, as Cueva Morín, Aranbaltza and Labeko Koba (Arrizabalaga 2000, Maíllo-Fernández 2005, Rios-Garaizar et al., 2012b, 2012c), and some Proto/Early Aurignacian cave sites, as La Viña, Cueva Morín, El Castillo and Labeko Koba, among others (Arrizabalaga, 2000; Maíllo-Fernández, 2002; Maíllo-Fernández et al., 2010; Santamaría Álvarez, 2012; Wood et al., 2014). A number of investigations on the Late Middle Paleolithic and the Early Upper Paleolithic have recently been undertaken in the region, significantly increasing the knowledge of the different techno-complexes and their characteristics. Studies on chronology (e.g. Maroto et al., 2012; Higham et al., 2014; Wood et al., 2014), environmental conditions (e.g. Iriarte et al., 2005; López-García et al., 2011; Rofes et al., 2015; García-Ibaibarriaga et al., 2015), bioanthropology (e.g. Bermúdez de Castro and Sáenz de Buruaga, 1997; Rostro Carmona, 2013; Torres et al., 2011; Rosas et al., 2015), technology (e.g. Carrión Santafé et al., 2008; Rios-Garaizar, 2008) and subsistence practices (e.g. Altuna and

Mariezkurrena, 2000; Castaños, P., 2005; Yravedra, 2013; Rios-Garaizar and García Moreno, 2015) have provided crucial data to establish a better framework for the interpretation of the important biological and cultural changes that occurred in this period.

One of the most significant sites for the study of this period is El Cuco rock-shelter. The site is located in the eastern part of the Cantabrian region and it was excavated in 2005 by an archaeological team led by one of us (PR). In 2007 a monograph including studies of different materials, such as lithics, pollen and macrofaunal remains, was published (Muñoz et al., 2007). Two test pits were excavated at the site. One test pit was located at the entrance of a small cave, called "Covacha" (Sector A). Here, a 1 m^2 test pit was dug revealing a 2.2 m sequence composed of 13 levels that were assigned to the Holocene and to the Gravettian (levels D-M). Another test pit was carried out in the eastern part of the rock-shelter (Sector B). Excavation in this area revealed a 2.5 m deep stratigraphic sequence that comprised 14 archeological levels (I-XIV). Two radiocarbon dates were obtained from the apatite fraction of macromammal charred bones from levels XIII and III, as poor bone collagen preservation prevented dating of this material. The results obtained for the sample dated from level XIII was 30,020 +160 -150 uncal BP (GrA-32436), leading the authors (who were at that time unaware of the fact that bone apatite was used for radiocarbon dating) to attribute the lower part of the sequence (levels VI to XIV) to the Evolved Aurignacian, while the result obtained from level III was 23,400 ± 210 uncal BP (GrA-32097), suggesting a Gravettian cultural attribution for the upper levels (V-III) of the sequence (Muñoz et al., 2007; Maroto et al., 2012).

Recently, in the framework of a project developed by one of the authors (IGZ) to assess the environmental conditions prevailing during the Upper Paleolithic (UP) in northern Iberia, additional radiocarbon dates were undertaken using limpet shells from level X. The results obtained contradicted the cultural attribution of this level to the Aurignacian and placed the occupation in an earlier period. Also, considering the regional record, the characteristics of the published lithic assemblages were found to be quite anomalous when compared to assemblages from other Early Upper Paleolithic (EUP) levels in the region. This was noted in a recent synthesis about the Gravettian and Evolved Aurignacian in the Cantabrian region (de la Peña, 2011; Ríos-Garaizar et al., 2013).

In order to clarify these anomalies, and given that radiocarbon dates taken from biogenic apatite should be considered cautiously (Taylor, 1987; Zazzo and Saliège, 2011), a reassessment of the chronology of the entire sequence at El Cuco was undertaken. In this paper we present data obtained from the reassessment of Sector B at the site. This review was based on new radiocarbon dates performed on bones and shells, and a re-evaluation of the lithic assemblages. Up to now only results for the oldest levels (VI to XIV), supposedly corresponding to the Evolved Aurignacian, are available. Results will be used to discuss the chronology originally proposed for the site and to provide a new framework for the study of human populations occupying the Cantabrian region during the Late Middle Paleolithic (LMP) and the Early Upper Palaeolithic.

2. El Cuco rock-shelter: description and archaeological evidence

2.1 The site

El Cuco rock-shelter is located in the town of Castro-Urdiales, in the Autonomous Community of Cantabria (Cantabrian region, northern Iberia) (Fig. 1). The rock-shelter presents an arc-shaped plant and measures 34 m long and five meters deep. A test pit covering a surface of 2 m^2 was excavated in Sector B, situated on the eastern side of the rock-shelter (Fig. 2). Excavation revealed a 2.5 m deep sequence composed of 14 levels (I-XIV). Bedrock was not found at the base of the excavation, suggesting the existence of additional stratigraphy below level XIV. Levels I and II were found to be reworked, and contained mixed materials of different chronologies, some of them modern in appearance. The rest of the sequence was well preserved with clear sedimentological differences that allowed the identification of different stratigraphic units (Muñoz et al., 2007). In this paper we will only refer to the lower part of the stratigraphy, from levels VI to XIV (Fig. 3). The sequence revealed a succession of sedimentary episodes, including roof fall events and stalagmite crust formations. Levels VI and VIII consisted of soft and loose crusts whilst levels IX and XI were formed by hard and compact crusts. All of these levels presented very limited amounts of archaeological material. The other stratigraphic levels, in which artifacts and other archaeological items were found abundantly, were defined as follows: level VII was characterized by brown silty sediment, slightly damp, with some limestone blocks arranged horizontally; level X was composed of very loose brown silt with abundant limestone blocks of small and medium size, and some isolated blocks of calcite crust; level XII consisted of loose and damp yellow silt with limestone inclusions; level XIII was formed by brown silty clay, slightly damp, with some small limestone blocks; and level XIV was dark brown clay (this level was excavated in a very limited extension so it was difficult to properly define its features).

2.2 Faunal assemblages

The macrofaunal assemblage (Castaños and Castaños, 2007) is quite rich but very fragmented, probably due to a mixture of human activity and postdepositional processes, although a full taphonomic study has not been performed so far at the site. Given the poor state of preservation, species identification turned out to be challenging and only 161 remains out of the 6,702 recovered in levels VI to XIV were possible to identify. The presence of carnivores is evident in levels XII and XIII, but their frequency and importance in the taphocenosis are very limited. The most represented species in the entire sequence is the red deer (*Cervus elaphus*), which is also the dominant species in the bone assemblages from all levels, followed by the tribe Bovini (only one specimen was identified as *Bison priscus*). Other species such as horse (*Equus ferus*) (levels VII, XIII), ibex (*Capra pyrenaica*) (X, XI), chamois (*Rupicapra pyrenaica*) (XII, XIII), roe deer (*Capreolus capreolus*) (VII, XII) and woolly rhinoceros (*Coelodonta antiquitatis*) (X, XIII) appear in low numbers. Recently, Proboscidea teeth fragments were found in level XII by one of us (ABMA). Given the state of preservation of the fragments it was not possible to identify the dental elements. However, it was possible to determine that the fragments belonged to the genus *Mammuthus*. Among the species belonging to this genus, *Mammuthus primigenius* has been found in the Paleolithic archaeological record of the Cantabrian region until the Solutrean, *c.* 20 kys cal BP (Mariezkurrena, 2011 and references therein).

Shell assemblages were recorded throughout the stratigraphic sequence at El Cuco (see Gutiérrez-Zugasti et al., 2013a for a detailed description and discussion), although most of the shells were found in the oldest portion of the sequence (levels X, XI and XII). A good number of marine and terrestrial taxa were identified, although only limpets from the *Patella* genus were found in any significant quantity. The presence of other marine taxa, including *Ocenebra erinaceus*, *Acanthocardia* sp., *Gibbula* sp. and the sea urchin *Paracentrotus lividus* can be considered as marginal. Land snails have also been recorded at the site but only in levels X to XIII. Most of the land snails were found in limited quantities (e.g. *Elona quimperiana*, *Oestophora silvae*, *Pomatias elegans*, *Cochlostoma* sp. and *Oxychilus* sp.) and *Cepaea nemoralis* was the only land snail species to be found in any substantial quantity within level XII. While the *Patella* and probably the sea urchin *P. lividus* were collected by humans as food, the accumulation of land snails was considered a natural taphocenosis, as these species usually live near rock-shelters and caves. Only shells of the land snail *C. nemoralis* could have been used as food, although in this case it is difficult to establish whether they were brought to the site by humans for food or reached the site by themselves. Shells used as ornaments have not been identified within levels VII to XIII. The evidence for the procurement of coastal resources at El Cuco suggests that their exploitation was carried out at a relatively low intensity (Gutiérrez-Zugasti et al., 2013a).

2.3 Environmental conditions

Environmental conditions throughout the sequence were deduced from the presence of pollen (Ruiz Zapata and Gil García, 2007), mollusks (Gutiérrez-Zugasti et al., 2013a), microvertebrates (Muñoz et al., 2007) and macrovertebrate remains (Castaños and Castaños, 2007). Pollen data for these levels is limited but some changes have been identified in the sequence. The oldest levels (XIV-X) show a transition from low temperatures in level XIII, with few arboreal species present, to more temperate conditions in level X with a notable expansion of woods. Levels IX to VI show a decrease of woodland and some evidence of aridity (Ruiz Zapata and Gil García, 2007). Marine mollusks showed a similar pattern, with presence of temperate species such as *Patella depressa* and *Patella ulyssiponensis* in levels X and XII, indicative of warmer temperatures. Similarly, the land snail assemblage is also typical of temperate and humid conditions, with presence of *Cepaea nemoralis* in levels XII and XIII (André, 1975; Gutiérrez-Zugasti et al., 2013a). The presence of micromammals such as *Talpa europaea* (VII, VIII, XIII, XIV), *Pytimis* sp. (level XII) and *Apodemus* sp. (level XIII) also suggests temperate climatic conditions. The macrofaunal assemblage is dominated by ungulates ecologically adaptable to both warm and cold conditions and from diverse topographical conditions, and no precise environmental information can be deduced from their presence. Only the identification of *Coelodonta antiquitatis* in levels X and XIII might indicate that the site was occupied during a cold period.

3. Materials and methods

3.1 Radiocarbon dates

Four bones (two from level X, one for level XIII and one for level XIV) with no evidence of heating and four limpet shells belonging to the species *Patella vulgata* (two from level X, one from level XII and one from level XIII) were selected for AMS radiocarbon dating. All samples were taken from the Museum of Prehistory and Archaeology of Cantabria (MUPAC, Santander). Three bones and three shells were dated at the Oxford Radiocarbon Accelerator Unit (ORAU) following routine pretreatments and standard dating procedures that included ultrafiltration and measurement of stable isotopic composition and carbon and nitrogen content (and C:N ratio) for bones (see Brock et al. 2010b and references therein for a description of procedures). A diaphysis from an ungulate bone was dated at the Center for Applied Isotopes Studies (CAIS) of the University of Georgia (USA) following procedures described in Cherkinsky et al. (2010) and Vogel et al. (1984). Additionally, one shell was dated at Beta Analytic (see procedures at the website of the company, www.radiocarbon.com).

3.2 Bone collagen preservation

In order to establish the bone collagen preservation, the amount of carbon and nitrogen contained in 40 additional non-charred bones collected from the MUPAC was determined using two different techniques. Firstly, carbon and nitrogen isotope ratios ($\delta^{13}C$ and $\delta^{15}N$) were analyzed in 26 bones of the red deer (*Cervus elaphus*) from levels VII to XIII within the EUROREFUGIA project aiming to reconstruct palaeoenviromental and paleoclimatic conditions during the LMP and EUP at the site. Red deer were one the most commonly consumed prey during the Paleolithic in the Cantabrian region (Altuna, 1972; Altuna and Mariezkurrena 2000; Altuna et al., 2011), making it a suitable species for isotopic analysis. Specimens from deposits directly associated with human activity (e.g. with cut marks, anthropogenic breakage) found in association with stone tools were targeted. The selected samples were prepared and analyzed at the Department of Human Evolution, Max Planck Institute for Evolutionary Anthropology, Leipzig, Germany. Collagen extraction was undertaken following procedures outlined in Richards and Hedges (1999) with the addition of an ultra-filtration step (Brown et al., 1988). Samples ranging between 0.7-0.9 g were drilled and cleaned using aluminium oxide air abrasion. Samples were demineralized in 0.5M HCL at 6-8 °C for between 3-10 days, and then washed three times using de-ionized water before being gelatinized in a weak acidic solution (pH3 HCL) at 70 °C for 48 hours. Samples were filtered using 5–8 μm Ezee® mesh filters (Elkay Laboratory Products), before being ultra-filtered to separate out the larger >30 ka collagen chains. The >30 ka fraction was then frozen and lyophilized for 48 hours. Between 0.2 and 0.45 mg of collagen was weighed into tin capsules for analysis of stable carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) isotope ratios. Specimens were analyzed in duplicate, using a Delta XP mass spectrometer coupled to a Flash EA 2112 elemental analyzer. The $\delta^{13}C$ values and $\delta^{15}N$ values are reported relative to the V-PDB standard and AIR standards. A series of international and internal standards were used to calculate analytical error which was ± 0.1‰ (1σ) or better. The mean difference observed between duplicate measurements was 0.03 for $\delta^{13}C$, and 0.01 for $\delta^{15}N$.

Secondly, the % carbon and % nitrogen within each bone was obtained from 14 specimens from levels X to XIV using elemental analysis performed at the research facilities (UAQiE) of the University of Girona. Samples were run in an elemental analyzer Perkin Elmer EA2400 series II. Samples of bone powder ranging between 1 and 5 mg were placed in an autosampler and then combusted at 925-930 °C in the presence of highly pure O_2. Combustion gases were measured using a thermal conductivity meter. Quantification was made after calibration using Acetanilide as standard. Detection limits for carbon, hydrogen and nitrogen were 0.72%, 0.20% and 1.20% respectively.

3.3 Lithic analysis

Lithic assemblages archived at the MUPAC were studied by one of the authors (JRG) in order to validate or refute the previously published results (Muñoz et al., 2007). Materials from level VII were assessed in more detail, whilst lithics from levels

VIII to XIV were preliminarily evaluated. The objective of this analysis was not to offer a complete description of these lithic assemblages, which is beyond the scope of this research, but to provide sufficient evidence to validate or refute the attribution of these assemblages to the Middle Paleolithic or the Initial Upper Paleolithic. The raw material was classified according to the major raw material categories, namely flint, mudstone, quartz and quartzite. Flint varieties were classified following the flint-types defined by Tarriño (2006) and Rissetto (2008). The technological interpretation of each assemblage was performed according to the presence/absence of typical cores, blanks and formal tools present in Middle to Upper Paleolithic regional techno-complexes (Arrizabalaga, 2000; Arrizabalaga et al. 2014; Rios-Garaizar, 2008, 2012; Rios-Garaizar et al., 2013a).

4. Results

4.1 Radiocabon dates

Bone samples did not produce radiocarbon dates due to poor collagen preservation, except the sample UGAMS-9076, which produced a date of 14.5 ka uncal BP for level X (Table 1). However, this date should not be trusted for two reasons: a) the radiocarbon laboratory reported a very low amount of collagen in that sample, and b) lithic and faunal assemblages found in level X are incompatible with a Lower-Middle Magdalenian cultural attribution.

The total collagen yield is an important indicator of the preservation state of the bone and its suitability for dating. If the amount of collagen extracted from the original sample is <1% of the starting weight of bone material used, the sample is usually rejected prior to dating. The percent carbon content of the sample should be within 30–50% of the weight of the collagen; values higher or lower than this can be indicative of contamination or degradation. In addition, the C:N atomic weight ratio should be in the range of 2.9–3.5 (van Klinken, 1999). Samples with higher ratios may have been contaminated with exogenous carbon; those with lower ratios may be badly degraded. In both cases, the samples should be rejected (Brock et al., 2010b). The negative results obtained from El Cuco bone samples led us to follow a new dating strategy, and so data generated by the project EUROREFUGIA was used, among other aims, to assess the general state of collagen preservation in bones from El Cuco. In total 19 out of 26 analyzed bones produced collagen (Table 2). Although C:N ratios were between 2.9 and

3.6 in four samples, only one specimen yielded %C values greater than 35% and %N values over 10%, which are indicative of good collagen preservation. However, none of the samples produced collagen yields higher than 0.4% and therefore dating was not attempted. A similar approach was followed by the project HAR2010-22013, in which elemental analysis (C and N) was conducted on 14 bone samples from levels X to XIV. The %N content of whole bone has been documented to be a successful technique to identify bones with good collagen preservation (Brock et al., 2010a). Results showed very low amounts of nitrogen, and only in one sample from level XII (spit 22) nitrogen exceeded 0.5% of the bone weight (Table 3). However, given the presumable limited amount of collagen preserved in that sample, no radiocarbon dating was attempted. Two bone samples that failed to be dated (CUCO 5 and CUCO 6) were selected for elemental analysis. Results confirmed the absence of collagen in those samples (Table 3).

All shell carbonate samples were successfully dated (Table 1). Samples from level X produced two dates of 42.3 and 46.2 ka uncal BP, whilst sample from level XII was dated to >43.5 ka uncal BP and the sample from level XIII was dated to 46.4 ka uncal BP. Given the uncertainties of the radiocarbon method on chronologies close to the limit of the method (~50 ka uncal BP), the high standard deviations associated with the dates and the lack of information on the ΔR of the ocean reservoir effect for that period in the region, the available dates were not calibrated.

4.2 Lithic assemblages

The re-evaluation of the lithic assemblages found at El Cuco sequence offers a clearly different overview from what was originally published (Muñoz et al., 2007). Although the work is still in progress due to the overwhelming amount of lithic artifacts recovered at the site (lithic assemblages from levels VII to XIII total more than 20.000 pieces), some qualitative impressions can be drawn for a key level at the site, such as level VII (Fig 4).

Level VII, with 11,382 lithic artifacts, is one of the richest of the entire sequence. The most used raw-material is flint (>95%, Muñoz et al., 2007), with the Upper Cretaceous Flysch varieties the most common. The closest sources of these raw materials nowadays are found at Kurtzia, located 20 km east from the site, where several Middle Paleolithic workshops with Levallois technology have been identified

(Muñoz, 2004; Rios-Garaizar et al., 2010, 2013b; Rios-Garaizar, 2014). Other local and non-local flint varieties appear in smaller proportions. There are local flints that appear in the Lower Cretaceous limestones. The most represented non-local variety is a translucent flint with irregular color zones, abraded neo-cortical surfaces, diomorphic dolomite rhombs and chalcedony geodes. The closest described outcrop for this silex variety is found in the Eocene external marine platform from Virgen del Mar, near Santander (Tarriño et al., 2015), 50 km to the West. Longer-distance transportation can be inferred from the presence of some clear Treviño variety flints and some Paleocene flints, whose main sources are located more than 80 km away. Other raw materials such as quartzite, sandstone, limestone or mudstone have been also used in relatively minor quantities.

Lithic technology in level VII is characterized by the presence of a ramified Levallois strategy (Rios-Garaizar et al., 2015). The overall small size of lithic artifacts, the abundance of recurrent- centripetal Levallois cores on flakes, kombewa flakes and typical micro-Levallois flakes distinguish the lithic production in this level. Also, a limited number of larger flakes, many of them cortical, and usually retouched as Quina or half-quina side-scrapers, are characteristic from this level. The blade technology described in the original publication was presumably inferred from several typometrically blade-like fragments, but no core and no indisputable blade product has been identified in this review. The exploitation of rocks other than flint follows different strategies, aiming at the production of large flakes. The retouched toolkit is dominated by side-scrapers and denticulates, while mousterian points are very rare. Most of the UP types described in the monograph were misinterpreted, for example the so called end-scrapers on platform are in fact Levallois flakes with facetted platforms; the end-scrapers are atypical or convergent side-scrapers; the pieces interpreted as burins do not have clear intentional burin-removals; the borers are atypical (*Bec*), and are not uncommon in Middle Paleolithic assemblages; the piece described as an Aurignacian blade is a distal fragment of Mousterian point; and all the truncated pieces are flakes with distal retouch.

In level VII, three fragments of antler were initially identified and interpreted as a distal fragment of point, a fragment of a rod and a distal part of a chisel (Muñoz et al., 2007). A closer reexamination of these pieces has not revealed any trace of manipulation, and their interpretation as bone tools should be rejected.

A quick evaluation of levels VIII-XIV revealed similar characteristics to level VII, with a flint based toolkit, with Levallois technology, side-scrapers and denticulates and almost no UP-like tools and artifacts.

5. Discussion and conclusions

Despite our continuous attempts to obtain radiocarbon dates from bone collagen, taphonomic alterations (probably during both the biostratinomic and fossil-diagenetic phases) induced poor collagen preservation and were responsible for negative results on ungulate bone samples. Results of carbon and nitrogen isotope ratios and elemental analysis confirmed the low bone collagen preservation throughout the lower stratigraphic sequence at El Cuco. Only radiocarbon dating performed on shell carbonates produced positive results, providing dates ranging from 42.3 to 46.4 ka BP. Shell samples used for radiocarbon dating are affected by the marine radiocarbon reservoir effect, which produce an offset in ^{14}C age between contemporaneous organisms from the terrestrial environment and organisms that derive their carbon from the marine environment (Ascough et al., 2005; Soares and Martins, 2009). The average difference between a radiocarbon date of a terrestrial sample such as a bone, and a marine shell is about 400 radiocarbon years (Stuiver and Braziunas, 1993). This means that the true age of the shell carbonate might be actually younger than the measured radiocarbon age. However, in the case of El Cuco, even taking into account a similar correction, most of the dates are still clearly older than 41 ka BP. In addition, samples dated close to the limit of the radiocarbon method (~50 ka BP) should be treated cautiously as finite ages that can be taken at face value. In the case of El Cuco, the >43.5 and the two 46 ka BP results should almost be considered as lying beyond the radiocarbon limit and therefore, not finite dates, opening the door to the possibility of an older chronology, at least for levels X to XIV.

Some scholars have suggested that biogenic apatite from cremated bones can be reliably dated (Lanting et al., 2001). Under this assumption, and following the method proposed by those authors, bioapatite from a charred bone from level XIII at El Cuco was used for radiocarbon dating. Results produced a date of 30 ka uncal BP that led the excavators to place most of the stratigraphic sequence in the Aurignacian (Muñoz et al., 2007). However, recent studies have demonstrated that biogenic carbonate can be contaminated by secondary carbonate derived from the CO_2 of the local atmosphere during combustion (Hüls et al., 2010; van Strydonck et al., 2010). Zazzo and Saliège (2011) have also stressed the complications of radiocarbon dating on bone apatite. They analyzed unburned bones and found large intra-individual differences in ^{14}C age in Late Pleistocene and Holocene sites from Europe and America (in contrast with arid environments where no significant differences were found), showing that both bone and enamel apatite can suffer from rejuvenation due to isotopic exchange during fossilization. The four radiocarbon dates obtained from shell carbonate at El Cuco show significantly older dates than that previously obtained for level XIII (~30 ka uncal BP) on biogenic apatite from charred bones, suggesting that, although isotopic exchange during fossilization cannot be discarded, the bone apatite used for radiocarbon dating was most likely rejuvenated due to contamination with secondary carbonate during combustion.

Results from shell carbonates at El Cuco are used to propose a new chronocultural attribution at least for levels X to XIV. The regional Middle to Upper Paleolithic chronological framework has been significantly improved in recent years. New dates obtained from LMP assemblages show that these techno-complexes did not last beyond the 40 ka uncal BP frontier (Maroto et al., 2012; Higham et al., 2014). Recent dates obtained from Châtelperronian levels at Labeko Koba also suggest that this techno-complex can be dated around 40 ka uncal BP (Higham et al., 2014). The first Aurignacian evidence in the region is significantly younger, and it has been dated around 38–35 ka uncal BP at sites such as for example Labeko Koba, La Viña, Morín and Isturitz (Fortea-Pérez, 1996; Maillo-Fernández et al., 2001; Szmidt et al., 2010; Wood et al., 2014). Considering this chronological framework and the dates obtained for levels X, XII and XIII at El Cuco we can confidently propose that human presence at that time was contemporaneous with the regional LMP. This strongly suggests that archaeological assemblages originally attributed to the Evolved Aurignacian techno-complex (levels VI to XIII) should be indeed attributed to the LMP.

This hypothesis is fully supported by the reassessment of the lithic assemblages. Level VII, located on top of the stratigraphic sequence evaluated here, can be confidently attributed to the Mousterian techno-complex. The intensive use of flint, although ~~quite~~ uncommon in the Central Cantabrian MP (Sarabia, 1995) is relatively common in the Eastern Cantabrian MP, but probably to a lesser extent than at El Cuco (Rios-Garaizar, 2016). This intensive use of flint can be well explained by the proximity of Urgonian and Flysch flint sources, as in many other Middle Paleolithic sites from

Europe. The presence of distant (<50 km) and very distant (>50 km) flint, noted in El Cuco, has been previously described in Axlor and Amalda assemblages (Rios-Garaizar, 2012; Rios-Garaizar, 2010). No blade or bladelet productions have been identified in this level, although this is a well known feature of Cantabrian Middle Paleolithic (see Maillo-Fernández, 2001, Maillo-Fernández et al. 2004, Sánchez-Fernández & Maillo-Fernández, 2007, Tafelmaier & Pastoors 2013). Also, as we have mentioned, most of the retouched tools previously described as typical Upper Paleolithic, have either been misinterpreted, as the so-called "end-scrapers on platform", or are atypical for this period, such as the endscrapers, borers or burins. There is no tool that could be considered typical of the Aurignacian. The technological strategy identified in this level has a clear Levallois component, more precisely a ramified Levallois production. The abundance of Levallois cores on flakes, and the presence of small or even micro Levallois flakes, relates this assemblage to the lithic collections from level VIII at Amalda and levels VIII-N at Axlor (Rios-Garaizar et al., 2015). Nevertheless, there are some differences between El Cuco and these levels. The main difference with the lithic assemblages from Amalda is the absence of heavy tools as cleavers or handaxes, and the differences with Axlor are characterized by the high use of flint and the practical absence of Mousterian points. Despite these differences, which could be explained in terms of behavioral variability of late Neanderthal groups, the main technological features of this assemblage clearly link it with the regional Late Middle Paleolithic (LMP) (Rios-Garaizar, 2016).

The new MP chronology proposed for levels VII to XIV at El Cuco rock-shelter has significant implications for the interpretation of Neanderthal subsistence strategies and settlement patterns, especially for coastal settlement and use of marine resources, not only in northern Iberia, but also in Atlantic Europe. Firstly, the attribution of those levels to the MP expands the geographical framework of evidence for exploitation of coastal resources by Neanderthals. Exploitation of marine resources has been recorded in Iberia at sites such as for example Los Aviones, Perneras, Humo Complex and Bajondillo (Cortés-Sánchez et al., 2008, 2011; Montes, 1988; Zilhão et al., 2010) located in Mediterranean Iberia, Gorham's cave and Vanguard cave in Gibraltar (Fa, 2008), and Figueira Brava and Ibn Ahmar on the Atlantic coast of Portugal (Bicho et al., 2004, 2008; Callapez, 2000; Zilhão, 2012). But the appearance of coastal resources in MP sites to the north of Lisbon (Portugal) was very limited up to now and just a few sites containing a few shells had been recorded (e.g. Morín, El Pendo and Amalda caves, located in northern Iberia). Evidence of systematic shell collection has been found in levels X to XIII at El Cuco (see Gutiérrez-Zugasti et al., 2013a for a detailed study of the shells assemblages). The increasing abundance of sites with evidence of coastal resource exploitation shows not only that these resources were not exclusively utilized by anatomically modern humans but also that they were extensively exploited by Neanderthals. From a more general point of view, the available evidence shows that in addition to terrestrial mammals, other resources such as small game, birds, molluscs, fish and marine mammals were present in the diet of MP and EUP humans in Iberia (Bicho et al., 2004, 2008; Brown et al., 2011; Cortés et al., 2011; Fa, 2008; Gutiérrez-Zugasti et al. 2013b; Manne and Bicho, 2011; Stringer et al., 2008; Villaverde et al., 1996, 1998), which suggests the presence of dietary diversity in both periods and therefore, to some extent, the use of similar subsistence strategies (Gutiérrez-Zugasti et al., 2013a). Information from shell assemblages at El Cuco should be added to the list of sites supporting this interpretation.

Our re-evaluation of the chronology at El Cuco rock-shelter demonstrates that the site contains one of the most interesting and richest MP sequences in northern Iberia. The reinterpretation of the site in the light of the new chronology will provide in the near future very useful information in terms of settlement patterns, technology and subsistence strategies of Neanderthals in the region. However, the new chronological interpretation also demands a reassessment of the rest of the sequence, especially for levels III to Vb originally attributed to the Gravettian. The available radiocarbon date for level III was also obtained from biogenic apatite and therefore it might present the same problems as level XIII reviewed in this paper. Consequently, further research is needed to establish a precise chronology for the rest of the sequence at El Cuco rock-shelter.

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Figures

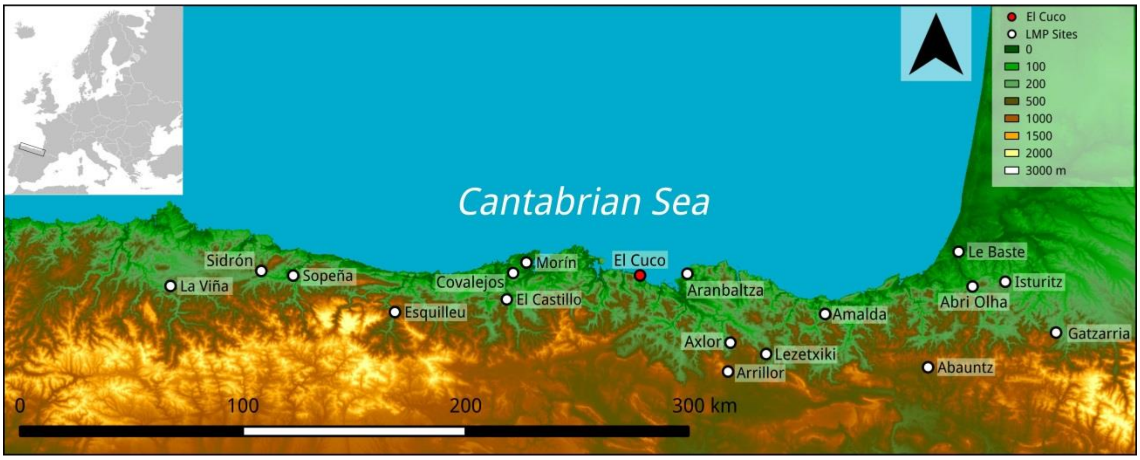

Figure 1: Map of the Cantabrian region with the main sites mentioned in the text.

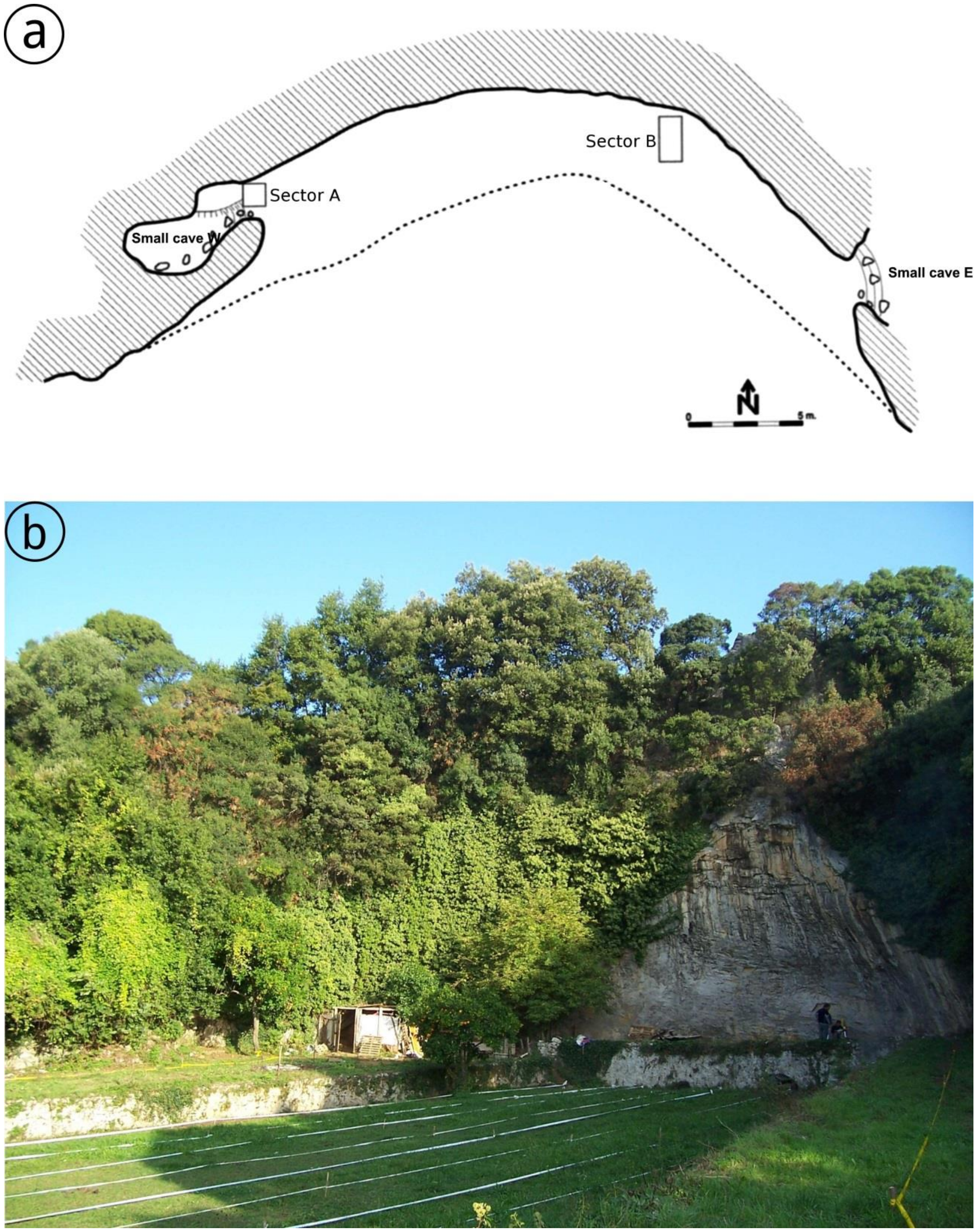

Figure 2: a: Synthetic plan of the El Cuco rock-shelter with the position of the excavated sectors (A and B). b: General view of the rock-shelter during the excavation in 2005.

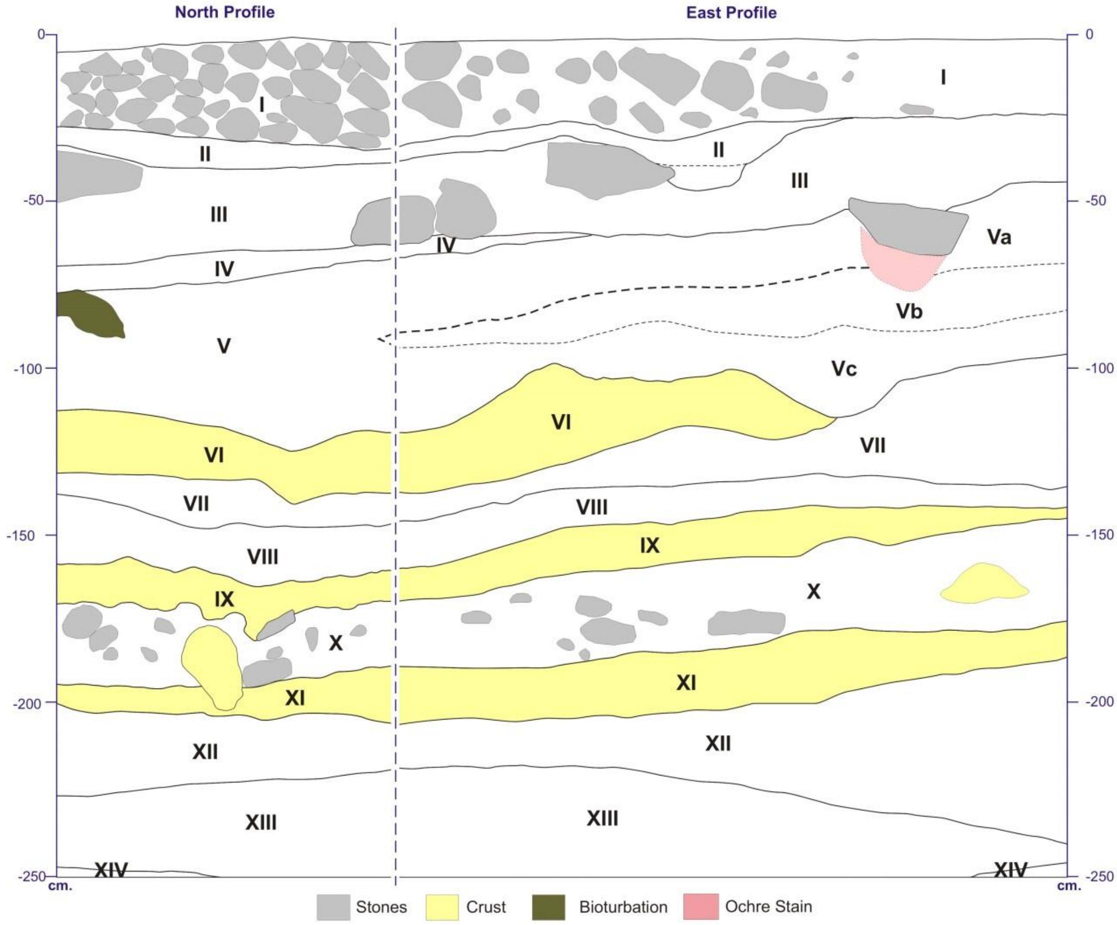

Figure 3: North and East stratigraphic profiles from the test pit excavated in Sector B.

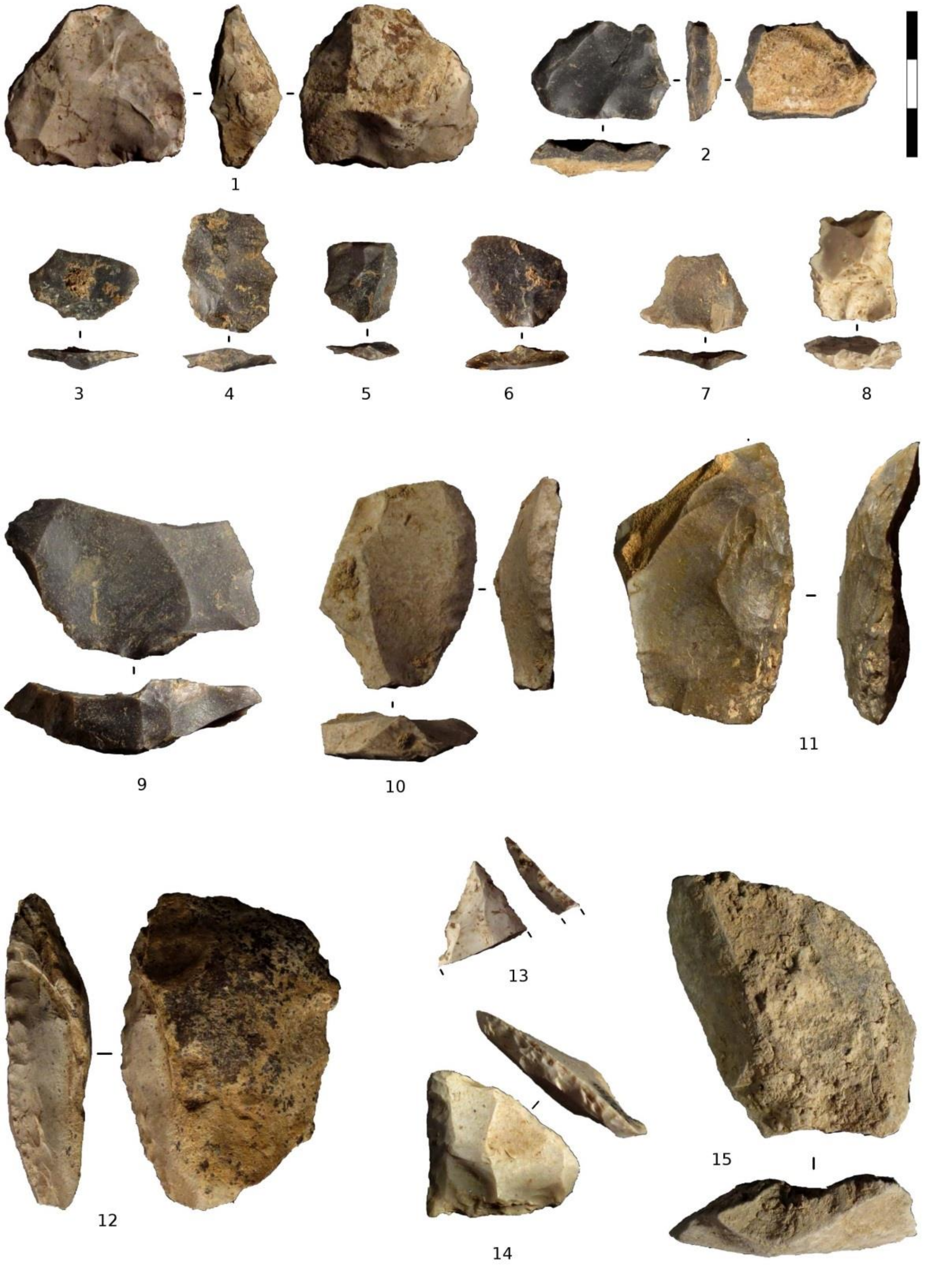

Figure 4: Lithic materials from level VII at El Cuco. 1-2: Small Levallois cores; 3: Kombewa flake with prepared platform; 4-8: Small Levallois Flakes; 9: Levallois flake; 10-12: Lateral side-scrapers; 13: Distal fragment of Mousterian point; 14: Convergent side-scraper; 15: Limestone flake.

Tables

Table 1: New radiocarbon dates on bones and shells from El Cuco rock-shelter and samples that failed to be dated due to poor bone collagen preservation.

Sample ID	Lab Ref	Level	Spit	Material	Taxa	Date BP	$\delta^{13}C$ (‰)	Method
CU.X.B	UGAMS-9076	X	20	Bone	Ungulate	14550 ± 80	-21.2	^{14}C AMS
CU.X.B1	P-32155	X	20	Bone	*Cervus elaphus*	No collagen		
CU.X.8	OxA-27196	X	20	Shell	*Patella vulgata*	42350 ± 700	0.08	^{14}C AMS
CU.X.6	OxA-27115	X	20	Shell	*Patella vulgata*	46200 ± 650	-0.46	^{14}C AMS
CUCO 7	Beta - 382681	XII	22	Shell	*Patella vulgata*	>43500	0.8	^{14}C AMS
CU.XIII.S1	OxA-30851	XIII	24	Shell	*Patella vulgata*	46400 ± 800	0.85	^{14}C AMS
CUCO 5	P-35524	XIII	25	Bone	Ungulate	No collagen		
CUCO 6	P-35523	XIV	26	Bone	Ungulate	No collagen		

Table 2: Results on collagen (%) and carbon and nitrogen isotope ratios ($\delta^{13}C$ and $\delta^{15}N$, %C, %N, C:N)) from ungulate bones.

Sample ID	Level	Species	Element	% Collagen	$\delta^{13}C$	$\delta^{15}N$	%C	%N	C:N
CUC17	VII	*C. elaphus*	carpal	0.2	-20.06	5.06	41.80	15.17	3.21
CUC18	VII	*C. elaphus*	pelvis	0.3	-20.51	7.98	28.34	9.79	3.38
CUC19	VII	*C. elaphus*	pelvis	0.0	n/a	n/a	n/a	n/a	n/a
CUC20	VII	*C. elaphus*	humerus	0.4	-20.50	5.56	15.84	5.76	3.22
CUC21	VII	*C. elaphus*	tibia	0.7	-21.21	5.91	6.51	3.58	2.13
CUC22	VII	*C. elaphus*	metatarsal	0.7	-13.07	0.00	0.34	0.00	-
CUC23	VII	*C. elaphus*	metacarpal	0.5	-20.58	4.10	6.05	2.78	2.54
CUC24	VII	*C. elaphus*	metatarsal	0.4	-21.60	2.89	2.40	1.14	2.46
CUC25	VIII	*C. elaphus*	metacarpal	0.0	n/a	n/a	n/a	n/a	n/a
CUC26	VIII	*C. elaphus*	femur	0.3	-20.26	4.58	22.01	7.97	3.23
CUC27	VIII	*C. elaphus*	femur	0.0	n/a	n/a	n/a	n/a	n/a
CUC28	X	*C. elaphus*	metacarpal	0.5	-13.45	0.00	0.33	0.00	-
CUC29	X	*C. elaphus*	1st phalanx	0.5	-12.68	-1.59	0.63	0.08	-
CUC30	X	*C. elaphus*	tibia	0.0	n/a	n/a	n/a	n/a	n/a
CUC32	X	*C. elaphus*	metapodial	0.4	-12.63	0.00	0.42	0.00	-
CUC31	X	*C. elaphus*	humerus	0.3	-12.52	0.00	0.36	0.00	-
CUC33	X	*C. elaphus*	tibia	0.4	-25.85	0.00	0.75	0.00	-
CUC34	XII	*C. elaphus*	tibia	0.4	0.00	0.00	0.00	0.00	-
CUC40	XII	*C. elaphus*	metacarpal	0.2	-12.87	0.00	0.33	0.00	-
CUC35	XIII	*C. elaphus*	metacarpal	0.6	-12.58	0.00	0.34	0.00	-
CUC36	XIII	*C. elaphus*	metatarsal	0.1	0.00	0.00	0.00	0.00	-
CUC37	XIII	*C. elaphus*	1st phalanx	0.5	-13.19	0.00	0.44	0.00	-
CUC38	XIII	*C. elaphus*	tibia	0.0	n/a	n/a	n/a	n/a	n/a
CUC39	XIII	*C. elaphus*	metatarsal	0.1	n/a	n/a	n/a	n/a	n/a
CUC41	XIII	*C. elaphus*	metacarpal	0.0	n/a	n/a	n/a	n/a	n/a
CUC42	XIII	*C. elaphus*	metatarsal	0.0	n/a	n/a	n/a	n/a	n/a

Table 3: Results on elemental analysis (%C and %N) from ungulate bones. The analysis of sample P11 was duplicated and in both cases results were close to 0.5%. We present here the mean of the two values.

Sample ID	Level	Spit	Weight (mg)	% Carbon	% Nitrogen
P05	X	20	1.096	5.23	0.05
P06	X	20	1.440	3.09	0.02
P07	X	20	1.251	2.76	0.00
P08	XI	21	1.342	3	0.01
P09	XI	21	1.223	4.59	0.00
P10	XI	21	1.321	3.84	0.07
P11	XII	22	1.207	3.7	0.53
P12	XII	22	1.401	6.38	0.02
P13	XII	22	1.117	3.66	0.00
P14	XIII	24	1.171	2.14	0.02
P15	XIII	24	1.163	2.22	-0.02
P16	XIII	24	1.079	1.89	-0.02
CUCO 5	XIII	25	1.449	1.98	0.00
CUCO 6	XIV	26	1.419	1.73	-0.01