

GEOMORPHOLOGICAL AND GEOARCHAEOLOGICAL EVOLUTION OF THE MONFORTE DE LEMOS BASIN (GALICIA, SPAIN). EROSION PHASES AND POST-DEPOSITIONAL PROCESSES IN NW IBERIA

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Abstract

The geomorphological and geoarchaeological study made on the Paleolithic sites of Monforte de Lemos basin (Lugo, Galicia), along with the available OSL datings, allowed us to correlate the Pleistocene deposits found in the basin with erosion phases previously detected in the glacial and coastal sequences of NW Iberia as well as in other Galician Paleolithic sites. Some of these phases may be attributed to Heinrich events. In this sense, the colluvial layers identified at Monforte de Lemos show the key role played by morphogenetic processes in the configuration of the continental deposits during the H4 event at the site of As Lamas and, probably, by H6 at the site of O Regueiral. These sites can be regarded as good examples of the role played by erosion phases on site formation and post-depositional processes in NW Iberia archaeological sites.

Keywords: geomorphological analysis; OSL chronology; Monforte de Lemos; Upper Pleistocene; Post-depositional processes; Heinrich events.

Resumen

El estudio geomorfológico y geoarqueológico de los yacimientos Paleolíticos de la depresión de Monforte de Lemos (Lugo, Galicia), así como las dataciones OSL nos permiten correlacionar los depósitos coluviales Pleistocenos de la cuenca terciaria con los procesos erosivos identificados en depósitos glaciares y costeros del NW de la península Ibérica, así como en otros yacimientos gallegos del Paleolítico. Algunas de estas fases pueden relacionarse con los episodios Heinrich. En este sentido, los niveles coluviales de Monforte de Lemos nos muestran la alta incidencia de los procesos morfogenéticos en los depósitos continentales durante el H4, en el caso del yacimiento de As Lamas y, probablemente, del H6, en el yacimiento de O Regueiral. Son una muestra del papel desempeñado por los episodios erosivos en la formación de los yacimientos y efectos post-deposicionales identificados en los yacimientos arqueológicos del NW Peninsular.

Palabras clave: análisis geomorfológico; dataciones OSL; Pleistoceno Superior en Monforte de Lemos; procesos postdeposicionales; episodios Heinrich.

1. INTRODUCTION

The investigation of the first human occupations of Galicia has consisted of occasional surveys focused on a certain site or on a certain period of the Paleolithic. Consequently, only partial knowledge of the first phases of the human occupation of Galicia has been obtained. This research has four main geographical areas: O Baixo Miño and the South-western coast, the surroundings of the city of Ourense, O Alto Miño (Serra do Xistral, Terra Chá) and the

eastern part of Galicia. The most studied areas are linked to the Miño river valley where stands out the site of As Gándaras de Budiño (AGUIRRE 1964; VIDAL ENCINAS 1982; CERQUEIRO LANDIN 1996) and the fluvial formations, where eight different terrace levels were identified (CANO *et al.* 1997a; GILES PACHECO *et al.* 2000).

Nevertheless, little attention has been paid to the geoarchaeological context of those occupations. The few attempts undertaken, as those made on the Louro basin (GRACIA *et al.* 2004), open air sites of Ourense

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province (COSTA CASAIS *et al.* 1998) and the Upper Paleolithic rock-shelters of northern Lugo province (LLANA RODRIGUEZ *et al.* 1992; MARTÍNEZ CORTIZAS & MOARES RODRIGUEZ 1995) have yielded huge information about site formation processes of Middle-Upper Pleistocene and Early Holocene geomorphological evolution. On the other hand, geological research developed on glacial and coastal deposits has provided data about the paleoenvironmental evolution of the Upper Pleistocene (COSTA CASAIS *et al.* 1994, 1996, 2002; PÉREZ ALBERTI & VALCARCEL DÍAZ 1998; PÉREZ ALBERTI *et al.* 1997, 1998a, 1998b, 1998c, 1999, 2009a, 2009b; PÉREZ ALBERTI 2011; BLANCO CHAO *et al.* 2003, 2007; VALCARCEL DIAZ *et al.* 1998a, 1998b).

Out of these traditional areas of investigation the available information about the Paleolithic is very scarce and corresponds to chance and sporadic findings. In this paper a geomorphological and geoarchaeological preliminary approach is made on the Paleolithic sites of Monforte de Lemos basin (Lugo, Galicia). The geoarchaeological research and available OSL datings allow a comparison of the Monforte Pleistocene deposits with the timing of some of the Heinrich events as well as with erosive phases identified in the glacial and coastal deposits, showing their high influence on site formation and post-depositional processes on NW Iberia.

2. METHODOLOGY

Monforte de Lemos is a Tertiary basin located in the river Miño's middle course. The systematic investigation of this area began in 2006 under the framework of the project "Ocupacíons humáns durante o Pleistoceno na cunca media do Miño" and has revealed the existence of a long human occupation during the Paleolithic (FÁBREGAS VALCARCE *et al.* 2007, 2008, 2009, 2010; DE LOMBERA *et al.* 2008, 2011; RODRÍGUEZ *et al.* 2008).

For determining the erosional surfaces of the basin a mapping of landforms was made using stereo-photogrammetry based on 1:18,000 scale aerial photos of the IGME (Instituto Geológico y Minero Español). To complete the field mapping we consult the National Topographic Maps of Spain on a 1:25,000 scale from the IGN (Instituto Geográfico Nacional) and CNIG (Centro Nacional de Información Geográfica). Along the fieldwork (2007-2010) a series of geological surveys were carried out in order to review, when possible, the stratigraphy of the surfaces deducted by aerial photos, especially of those profiles that could indicate a fluvial or alluvial origin and could help us to reconstruct the

paleovalley. These surfaces were classified according to their mean pendant, altitude and sedimentology (AMEIJENDA IGLESIAS 2008, 2011).

Once identified and described the quaternary surfaces in the Monforte de Lemos basin, digital topographic maps on a 1:5000 scale published by the Xunta de Galicia were used and processed with AutoCAD 2007 and CorelDRAW 12 for the geomorphological mapping. For this purpose the different erosional surfaces and their height over the Cabe river were considered. We also worked with the IGME geological maps at E. 1:50.000, that provided us a rough geochronology.

Finally, a 10 m resolution digital elevation model (DEM) was applied for an expanded cartographic mapping of the depression using ArcGis 9.3 (USC license). All these tools allow us a better understanding of the formation process and the behavior of Monforte de Lemos basin.

3. THE MONFORTE DE LEMOS BASIN

Monforte de Lemos is one of the main sedimentary basins of tectonic origin in the hinterland of Galicia, containing several Tertiary and Pleistocene deposits, visible on the slopes (SANTANACH PRAT 1994). It is located in the Northwest of the Iberian Peninsula, in Lugo province, to the east of the river Miño and to the north of its principal tributary, the river Sil (Fig. 1) in the IV geological Zone described by Matte (Galicia media-Tras os Montes) (MATTE 1968).

The basin can be divided into two sectors separated by a transversal Paleozoic Range: "Serra do Moncayo" and "Serra de Cubas", made of materials geologically known as "Dominio de Ollo de Sapo". The northeastern sector, the Bóveda-Brollón depression is known as "Somoza Maior de Lemos", and the southwestern sector is the Monforte de Lemos basin strictu sensu (VERGNOLLÉ 1985). Our investigation is focused in this last sector (Fig. 2). Monforte de Lemos basin s.s. is limited to the North-East by the Dominio de Ollo de Sapo. It is an important structure of the third folding phase that spreads approximately 300 km from the north of Galicia to Zamora province in the southeast, where it disappears under the Tertiary deposits of the Meseta. This domain is characterized by the absence of Cambrian materials on the eastern end, laying the Ordovician directly on the porphyry series of the Ollo de Sapo, which is of Precambrian age. The southern limit is defined by surfaces modeled on the Paleozoic substratum that appears in a NE-SW direction at Sober. The western limit is defined by an asymmetrical fault,

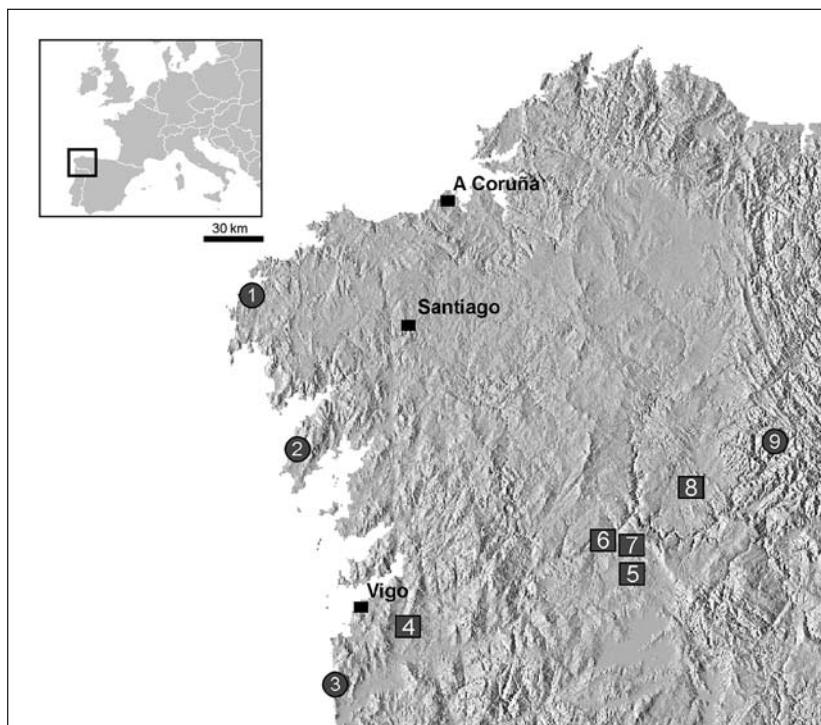


Fig. 1. Location of the main archaeological sites (squares) and deposits (circles) mentioned in the text. 1 – Moreira, Arnela. 2 – Caamaño, Fonforrón. 3 – Sanxián, Oia. 4 – As Gándaras de Budío. 5 – A Veiga – Campo da Mama. 6 – A Piteira. 7 – A Chaira. 8 – Monforte de Lemos. 9 – O Courel.

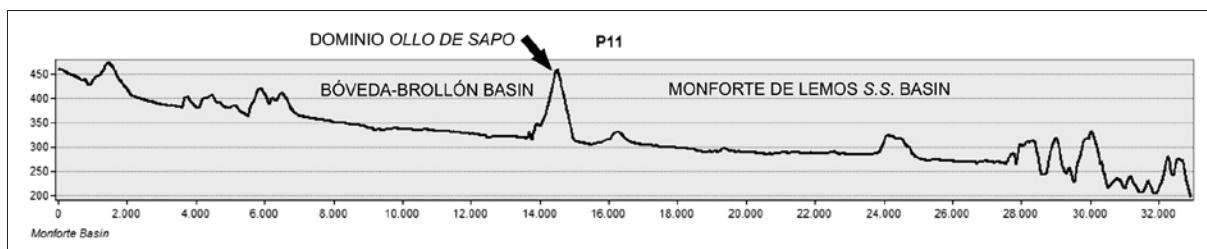


Fig. 2. Topographic profile (N-S) of Bóveda-Brollón and Monforte de Lemos sub-basins.

with an orientation NNE-SSW to NE-SW. Monforte is bounded by the main rivers of Galicia: Miño (W) and Sil (S). Both courses deeply cut into the granitic surfaces due to antecedence phenomena that explain why they flow around the basin instead of crossing it even when Monforte is located at lower altitude (PÉREZ ALBERTI 1991). The river Cabe is the main fluvial course of the basin.

The Monforte basin has a tectonic origin (Fig. 3), generated by subsidence and emersion of adjacent blocks defined by the existing network of Hercynian orogeny faults and presenting a NE-SW and WNE-ESE direction. These subsided areas or basins (graben) were shaped later by the Pliocene geodynamic external processes forming the current Tertiary depressions of Galicia. Based on its position with respect to the Pyrenean Overthrust the Monforte de Lemos basin is defined as a hinterland depression (SANTANACH PRAT 1994).

The basin was infilled with Tertiary deposits,

gray and green clays distributed in horizontal strata all over the area. The different sedimentary processes that originally affected the basin are closely related to an alluvial fan depositional scheme, working as a closed sedimentary system characterized by a decrease in the energy of sedimentation from the periphery to the interior of the basin (OLMO SANZ 1985). After a neotectonic phase and a reorganization of the hydrographic courses, Pleistocene sediments were deposited over the Tertiary substrate. These sediments are mainly composed of alluvial layers of pebbles, three to five meters thick. During the Quaternary, the lower deposits were strongly eroded by the fluvial courses generating two types of superficial formations that R. DE GROOT (1974) identified as glacis or fluvial terraces.

The changes affecting the infill of the depression took place in two different stages. The first took place in a lacustrine/marshy environment (Tertiary deposits); and a second one, once the depression opened



Fig. 3. Geological map of Monforte de Lemos and Bóveda-Brollón sub-basins.

up, when the course of the palaeo-Miño flowed along the basin before being displaced to the west, cutting deeply into the granitic “Chantada surface” (BIROT & SOLE SABARIS 1956).

This second period is reflected by a sequence of different terrace levels. The displacement by geotectonic processes caused their dislocation. In a subsequent phase several alluvial fans were formed, their thickness decreasing from the margins of the depression, especially in the eastern sector, to the center of the basin fossilizing the older Tertiary deposits. Thus, a complex mosaic of sedimentary forms occurs, characterized by different facies: those dominated by clays and sands of lacustrine/marshy origin, the fluvial ones with rounded and subrounded pebbles and strong imbrications, and finally the colluvial facies, generated by torrents

In the northern sector of the basin the alluvial deposits have a wider development and are better preserved. These alluvial deposits are characterized by abundant clast-supported pebbles embedded in other layers of pebbles and gravels, supported in clays, sands and gravels that lay directly on the Tertiary clays and arkoses of Monforte basin. The lithology is quite similar in the studied sections (quartzite, quartz and slate), though some differences in the abundance

of each type of material are observed. Besides the homogeneity in lithology a high degree of weathering and rubefaction (with presence of oxides concretions) in the deposits of the northern sector are observed, suggesting their great antiquity.

In the southern part, the Quaternary formations are less developed and badly preserved. In addition we found a lithologic heterogeneity, with a predominance of angular and subangular fragments of quartz and slate over quartzite pebbles. We may emphasize the absence of oxide concretions or extreme rubefaction in the deposits of this sector.

The analysis made using the DEM analysis allowed the definition of 9 levelling-surfaces in the sub-basins of Monforte de Lemos and Bóveda Brollón: S1=900-1000 m asl.; S2=700-800 m asl.; S3=600-650 m asl.; S4=500-550 m asl.; S5=450-500 m asl.; S6=400-450 m asl.; S7=350-400 m asl.; S8=300-350 m asl. and S9=250-300 m asl.

Below the levelling-surfaces in the Monforte de Lemos Basin 51 relics of old surfaces modeled on the Tertiary and Quaternary deposits were identified. For the study and presentation of this information we have elaborated a preliminary geomorphological map (Fig. 4) in which these surfaces are grouped in 7 levels according to their average height over

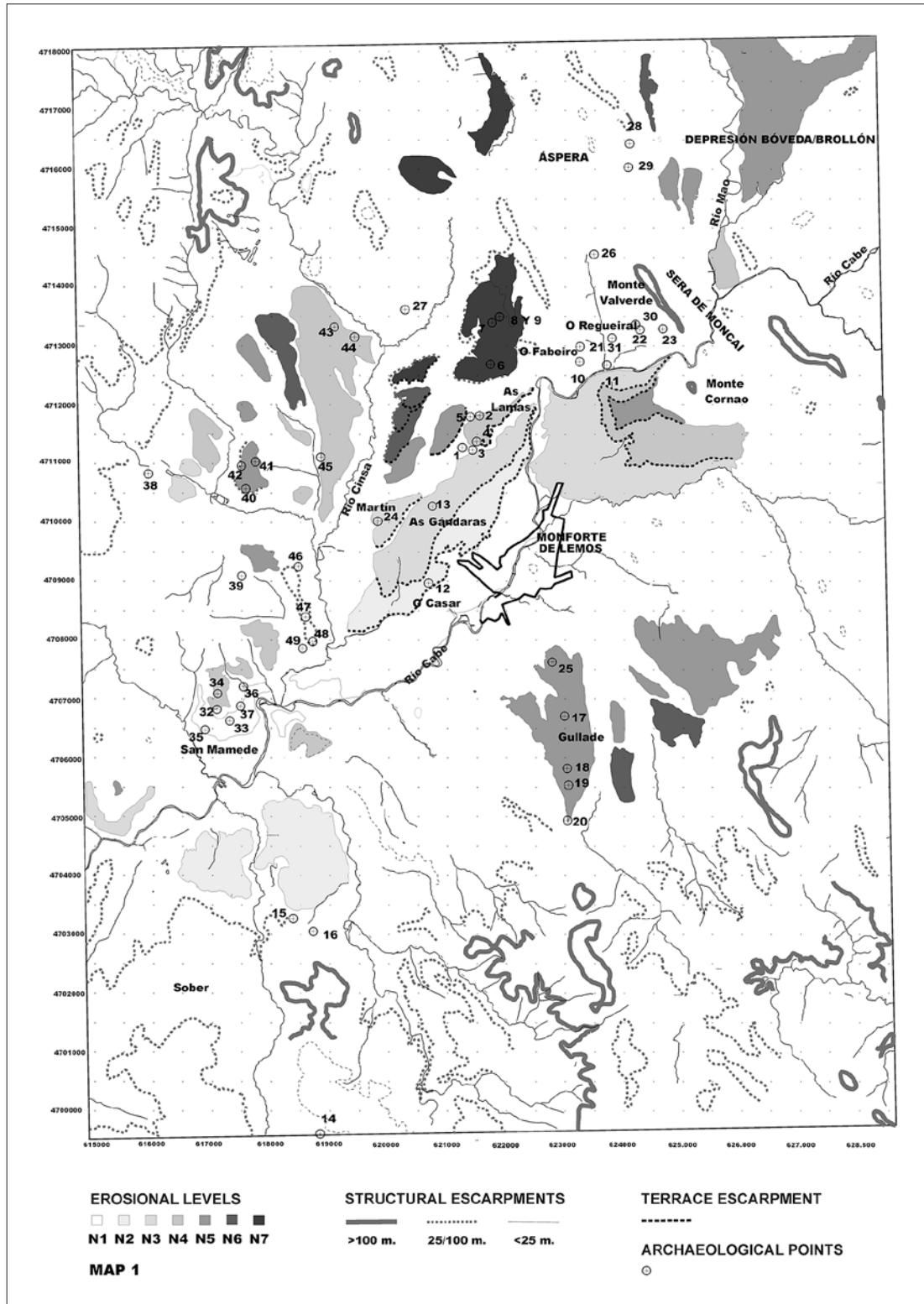


Fig. 4. Geomorphologic map of the Monforte de Lemos basin. Old surfaces and levels modeled on the Tertiary and Quaternary deposits.

the Cabe river: N1=0-5 m; N2=5-12.5 m; N3=12.5-20 m; N4=20-40 m; N5=40-60 m; N6=60-80 m and N7>80 m (AMEIJENDA IGLESIAS 2008). Further analysis will deal with the specific geotectonic and geomorphological processes affecting those surfaces in order to provide an accurate sequence.

Based on the information obtained with the geomorphological analysis, and the data gathered in the geological surveys we could establish a sequence of 9 alluvial and fluvial terraces in Monforte basin that softly descend from 100 meters high to the current river course (AMEIJENDA IGLESIAS 2008). This sequence is represented in the profile B-B' (Fig. 5): surfaces 11 (T9 +100 m), 10 (T8 +87.5 m), 9 (T7 +85 m), 6 (T5 +50 m), 7 (T6 +55 m), 4 (T4 +32.5 m), 3 (T3 +25 m), 2 (T2 +15 m) and 1 (T1 +10 m).

4. PALAEOLITHIC SETTLEMENT

Thanks to the discoveries made by Jose Antonio Peña in the Monforte de Lemos basin, archeological surveys started in 2006 in order to study the Paleolithic settlement of Galician hinterland. The previous references to Paleolithic finds in this area were the handaxes found in Os Peares and in Vilaescura (Lugo), the latter in the southern sector of the Tertiary depression (CANO 1991). Field work allowed the identification of more than 80 surface lithic scatters, ranging from the Lower to the Upper Paleolithic (FÁBREGAS VALCARCE *et al.* 2007, 2008, 2009, 2010; DE LOMBERA *et al.* 2008, 2011; RODRIGUEZ *et al.* 2008). Their technical features and degree of roundness show a great homogeneity in every scatter, pointing out to the synchronicity of the artifacts and their position in loco. In addition, several test pits were dug and radiometric datings of the Quaternary surfaces obtained. At the site of As Lamas two archaeological layers were identified in the fluvial sediments of the T5 (FÁBREGAS *et al.* 2010). In addition, other findings were made in stratigraphic

sequences such as those at the sites of O Regueiral and Áspera (RODRÍGUEZ *et al.* 2008), providing more information on the sedimentary and chronological context of the artefacts finds.

We must take into account some handicaps affecting the surveys, such as the dense vegetation and extensive cultivated areas that largely reduce the surface available for surveying and the visibility of the surface scatters. As we stated before, the spread of these deposits is quite variable on the different sectors of the basin, conditioning the spatial distribution and density of the archaeological sites. Only 20% of the lithic scatters found in the basin yielded more than 20 artifacts per site, some of them reaching hundreds of elements, such As Lamas or Valverde. Although their artifact densities cannot be compared to those found in other areas of the Iberian Peninsula (CASTELLANOS 1986; DÍEZ MARTÍN 2000; RODRIGUEZ DE TEMBLEQUE 2005) we must take into account the reduced surface of the fields surveyed (usually less than 1 Ha) preventing us from checking larger areas and recovering more artifacts.

According to the erosional levels identified in the basin on the basis of the geoarchaeological research and the technological features of the lithic assemblages, a relative chronology of the Quaternary surfaces and related sites can be established.

Most of the archaeological locations are placed in the middle levels (N4 +20-40 m and N5 +40-60 m), mainly linked to the fluvial/alluvial terraces, while their presence on the other levels, except N1, is scarcer. Taking into account the technological characteristics of the lithic collections (DE LOMBERA *et al.* 2011), Mode 2 sites are placed on the middle and upper levels (N3-N7), while the Mode 3 sites are located on the lower surfaces (N1) (Fig. 6). The presence of Mode 3 and even Mode 4 lithic assemblages on older levels is not necessarily controversial since the concurrence of Lower and Middle Paleolithic occupational landscapes suggests similarities in settlement patterns between these two periods,

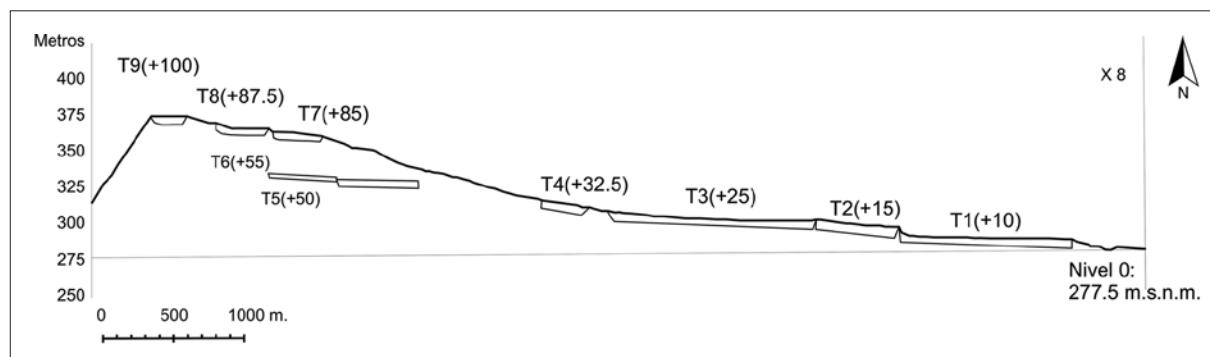


Fig. 5. Profile B-B'. Terraces Sequence of terraces in the Monforte de Lemos basin.

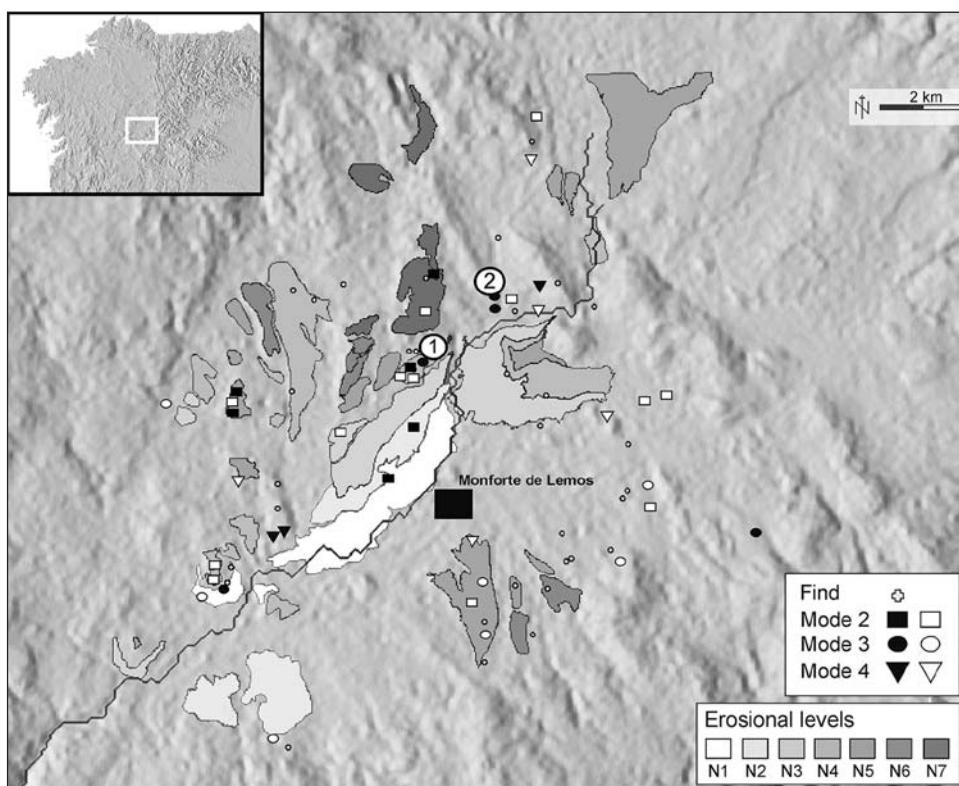


Fig. 6. Location of the main Paleolithic sites identified in Monforte de Lemos Basin.
1 – As Lamas.
2 – O Regueiral.

as shown by the finds of As Lamas. On the other hand, the presence of Mode 2 lithic industries on Upper Pleistocene surfaces might be explained by postdepositional processes (AMEIJENDA IGLESIAS 2011).

Although the Quaternary surfaces belonging to the seven levels spread over the whole basin, the better preserved surfaces are located in the central sector where a sequence of 9 alluvial/fluvial surfaces can be identified (profile B-B') providing a good geoarchaeological sequence (Fig. 5).

The Mode 2 assemblage located at a higher elevation is Chao Fabeiro (N7 >80 m), on the northern margin of the basin, where 26 artefacts were recovered. Large cutting tools such as handaxes were recovered along with some choppers and chopping tools made on quartzite pebbles. Their geomorphological position and the higher abundance of choppers and chopping tools may indicate an older adscription of this assemblage compared to other Acheulian sites. Most of the Mode 2 lithic assemblages are located in the middle levels. In the western sector an intermediate level with Mode 2 industries was identified in Chao do Vilar, I, II, III (N5 +40-60 m). The largest collection comes from As Lamas in the northern margin of the basin: more than 200 lithic implements were recovered over a flat surface of 20-25 Ha, related to the terrace T(5) (+50 m) (FÁBREGAS VALCARCE *et al.* 2007, 2010). The lithic assemblage

is composed of handaxes made on cores and flakes, as well as cleavers and light-duty tools (scrapers, denticulates) made on quartzite of local provenance (Fig. 7). According to the reduction and configuration sequences this assemblage is adscribed to the technological Mode 2 (Acheulian). Excavations carried out in 2009 yielded two archaeological layers on the fluvial terraces, linked to colluvial sedimentation (FÁBREGAS VALCARCE *et al.* 2010). Though in these layers the lithic artefacts are in secondary position, their technical features and the presence of oxides on the cortex of the pieces lead us to correlate them with the surface findings. Based on the degree of roundness of the pieces, the technological homogeneity of the lithic assemblage as well as the topographical features of the site (slightly concave), the source of the lithic artifacts must not be far away, pointing out to an *in loco* context, a common situation in other Lower and Middle Paleolithic sites (COSTA CASAIS *et al.* 1998; RAMIL REGO *et al.* 1993). The archaeological site of Martin is located to the southwest of As Lamas on the T4 (+32.5 m) where we also recovered lithic industry adscribed to the Mode 2. As Gándaras is located in a surface on the T3 (+25 m) just below As Lamas. The industry recovered in this site belongs also to the Acheulian period. O Casar is located southward from As Gándaras, on the T2 (+15 m) also with Acheulian industry. Finally San Mamede, at the depression's southwest, provided

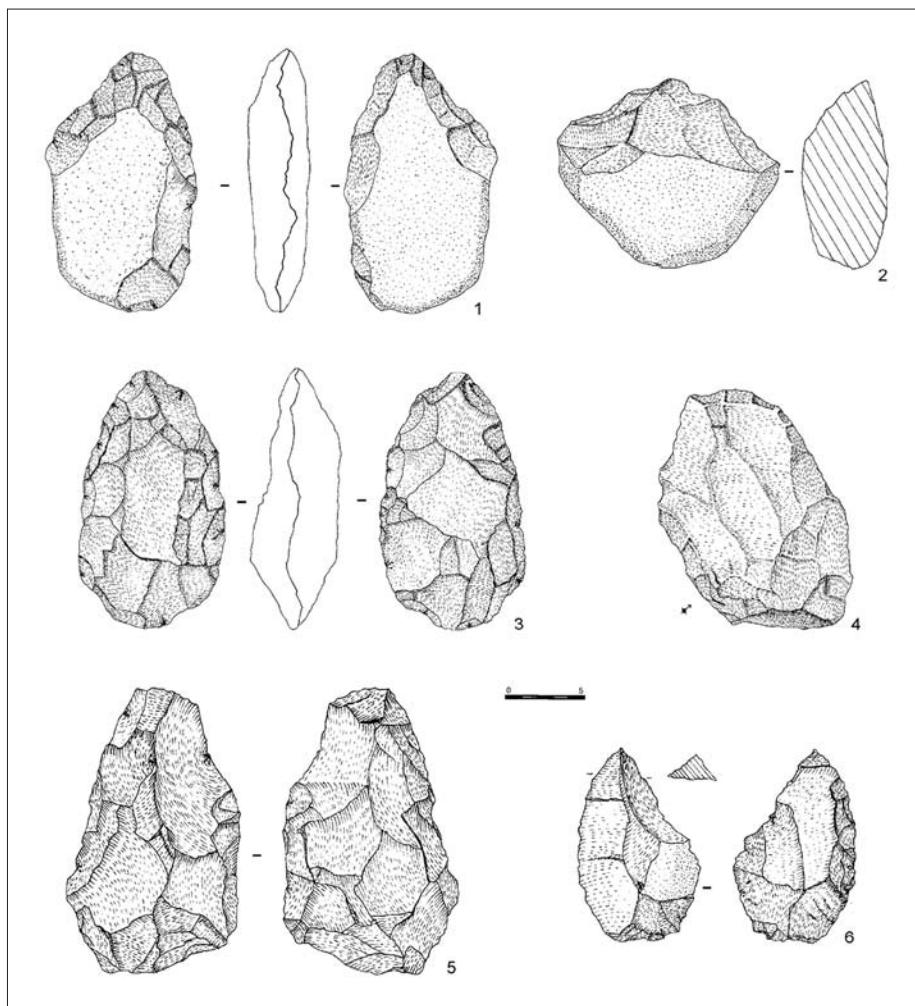


Fig. 7. Lithic industry from Chao Fabeiro (1, 2) and As Lamas (3-6).
 1 – Handaxe.
 2 – Chopper.
 3, 5 – Handaxes.
 4 – Cleaver.
 6 – Side-scraper.

Middle Paleolithic industry (Mode 3). This surface is a fragment of the terrace T1 (+10 m) dismantled by erosive processes of major intensity. Close to this deposit there are other archaeological sites with lower densities of material that provided the same kind of industry, such as Mañente (FÁBREGAS VALCARCE *et al.* 2009). Several Mode 2 and Mode 3 lithic assemblages were found in other sectors of the basin, most of them related to Quaternary deposits. Upper Paleolithic sites are placed at higher altitudes, usually on Paleozoic substratum, with a great visual control of the natural entrances and paths across the basin, showing a clearly strategical settlement pattern (DE LOMBERA *et al.* 2008; RODRIGUEZ *et al.* 2008) similar to that documented in the rock-shelters of northern Lugo (LÓPEZ CORDEIRO 2003; RAMIL REGO & RAMIL SONEIRA 1996).

Assuming a synchronicity between the lithic scatters and those surfaces where they are found (as shown by some stratigraphical finds) and based on the technological features of the lithic assemblages as well on the geomorphological position of the finds-

pots, a Middle Pleistocene settlement of the Monforte de Lemos basin can be proposed. Absolute datings of the fluvial surfaces are underway and are expected to provide a proper chronological framework.

4.1. Archaeological excavations in As Lamas

At the site of As Lamas, where more than 220 lithic artefacts were found, two test pits were made in order to find lithic implements in stratigraphic context. In the first one a colluvium, 1.5 m thick, was identified lying directly on the pebbles layer of the fluvial terrace (T5 +50 m) (FÁBREGAS VALCARCE *et al.* 2010). A second test pit (8 m²) was made 25 meters far from the first one, providing a high number of lithic artefacts adscribed to the Mode 2 (lower colluvium) and Mode 3 (upper colluvium). The stratigraphic sequence identified in the east section is (Fig. 8):

Layer I: Maximum thickness 38 cm. Current soil surface. Layer formed by a silty matrix with some

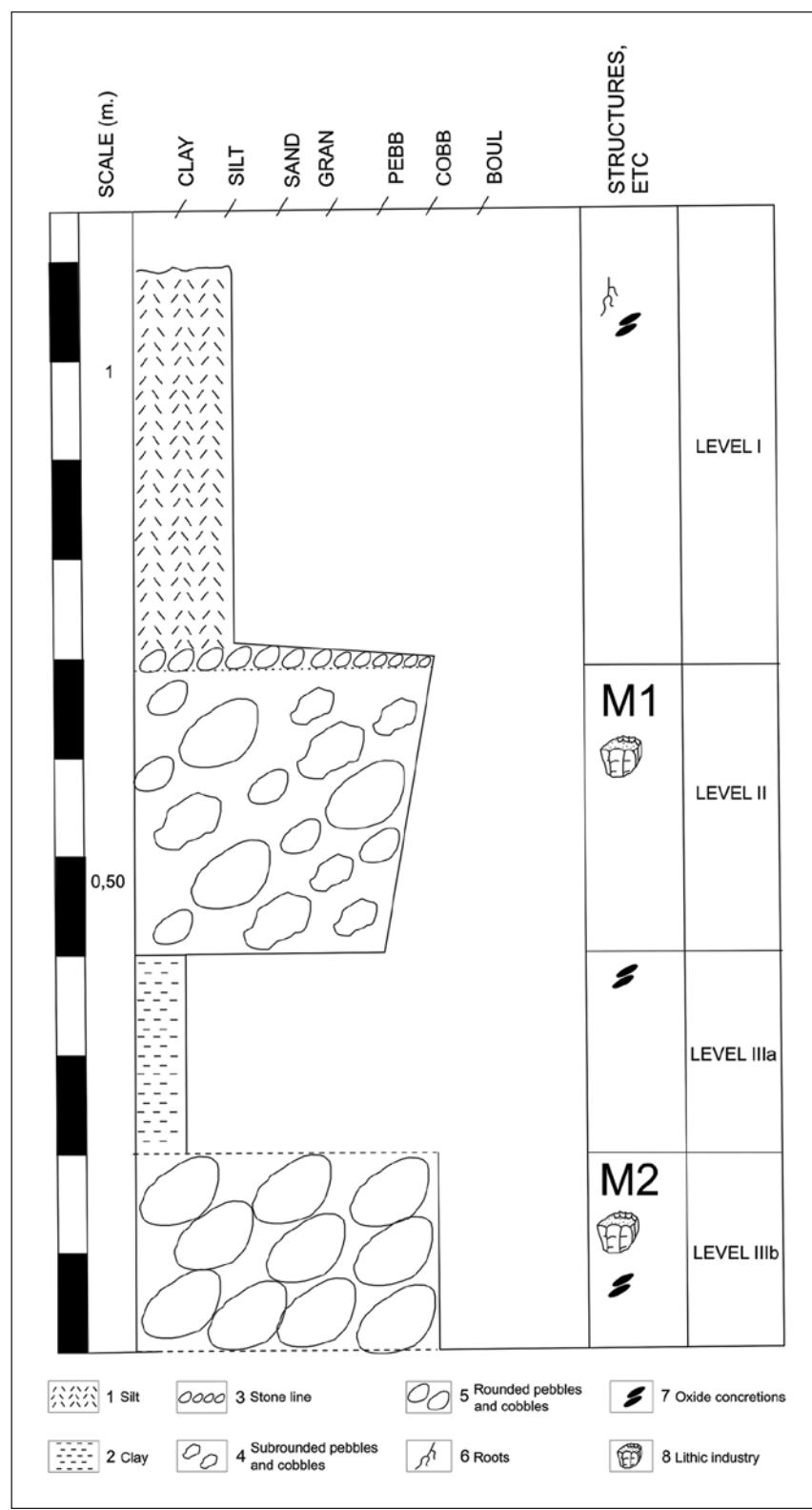


Fig. 8. Stratigraphic column of As Lamas site. 1 – Silt; 2 – Clay; 3 – Stone line; 4 – Subrounded pebbles and cobbles; 5 – Rounded pebbles and cobbles; 6 – Roots; 7 – Oxide concretions; 8 – Lithic industry. M1 and M2 – OSL samples.

angular and subangular gravels of quartz and quartzite (maximum axis of 10 mm) and angular clasts of maximum axis of 40 mm. Highly bioturbated it is the present soil. Its lower limit is irregular defined by a stone line with blocks smaller than 130 mm.

Layer II: Maximum thickness 28 cm. Clay matrix with some rounded and subrounded gravels. In addition, rounded and subrounded clasts appear with maximum axis ranging from 50-60 mm to 100 mm. The layer presents a subhorizontal slope with a slight inclination towards the SE. Archaeological layer with lithic implements which are not rounded and are of small size (1-5 cm), possibly indicating a slow sedimentation during the occupation with the absence of high energy deposition. An OSL dating is available: M1: 39,866 ±3554 BP (MAD-5600rBIN).

Layer III A: Maximum thickness 20 cm. Clay matrix layer with the same characteristics of Layer II, but higher gravel content and without clasts. This fact may indicate a decrease in the energy of sedimentation, without significant erosion. The base of this layer contains oxide concretions, probably as a result of groundwater level changes. Lower contact is gradual.

Layer III B: Maximum thickness 20 cm. Layer with clay supported matrix with some gravels and rounded pebbles with a maximum axis of 120 mm. There is a high abundance of oxide concretions adhered to pebble surfaces. Archaeological layer with medium and big sized core tools. An OSL dating

is available for this layer: M2: 38,947 ±3150 BP (MAD-5601rBIN)

The test pit enabled the identification of two colluvial layers (Layer II and IIIb) belonging to the Upper Pleistocene (MIS3), overlying the T5 (+50 m) fluvial terrace of Monforte basin (layer IV of test Pit 1). The archaeological record may represent two different human occupations. According to their technological features the upper one is adscribed to Mode 3, and the lower one to Mode 2. The technological features of the lithic implements of the Layer IIIb, as well as the presence of oxides on their cortex, are similar to the surface finds in that same spot (FÁBREGAS VALCARCE *et al.* 2007, 2010).

4.2. The site of O Regueiral

In the archaeological site of O Regueiral some lithic implements were found in a stratigraphic section along with 23 lithics recovered in the surface just below the section and, according to their technological features, they are adscribed to Mode 3 (Fig. 9) (FÁBREGAS VALCARCE *et al.* 2007; RODRÍGUEZ *et al.* 2008). The superficial formation in O Regueiral is an alluvial fan where 6 layers were identified in the section, of which only the layers IV and VI yielded lithic artefacts. The stratigraphic section is (Fig. 10):

Layer I: Tertiary clays.

Layer II: Maximum thickness 43 cm. Silt-clayey matrix-supported with rounded quartzite and quartz

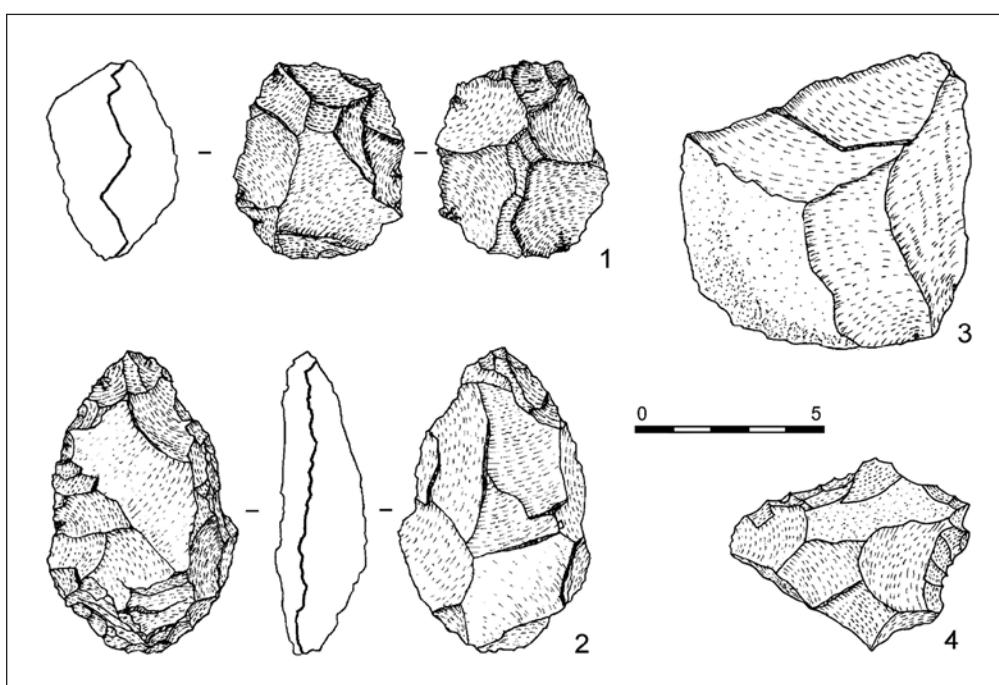


Fig. 9. Lithic industry from O Regueiral. 1 – Discoidal core; 2 – Bifacial side-scraper; 3 – Flake; 4 – Retouched flake.

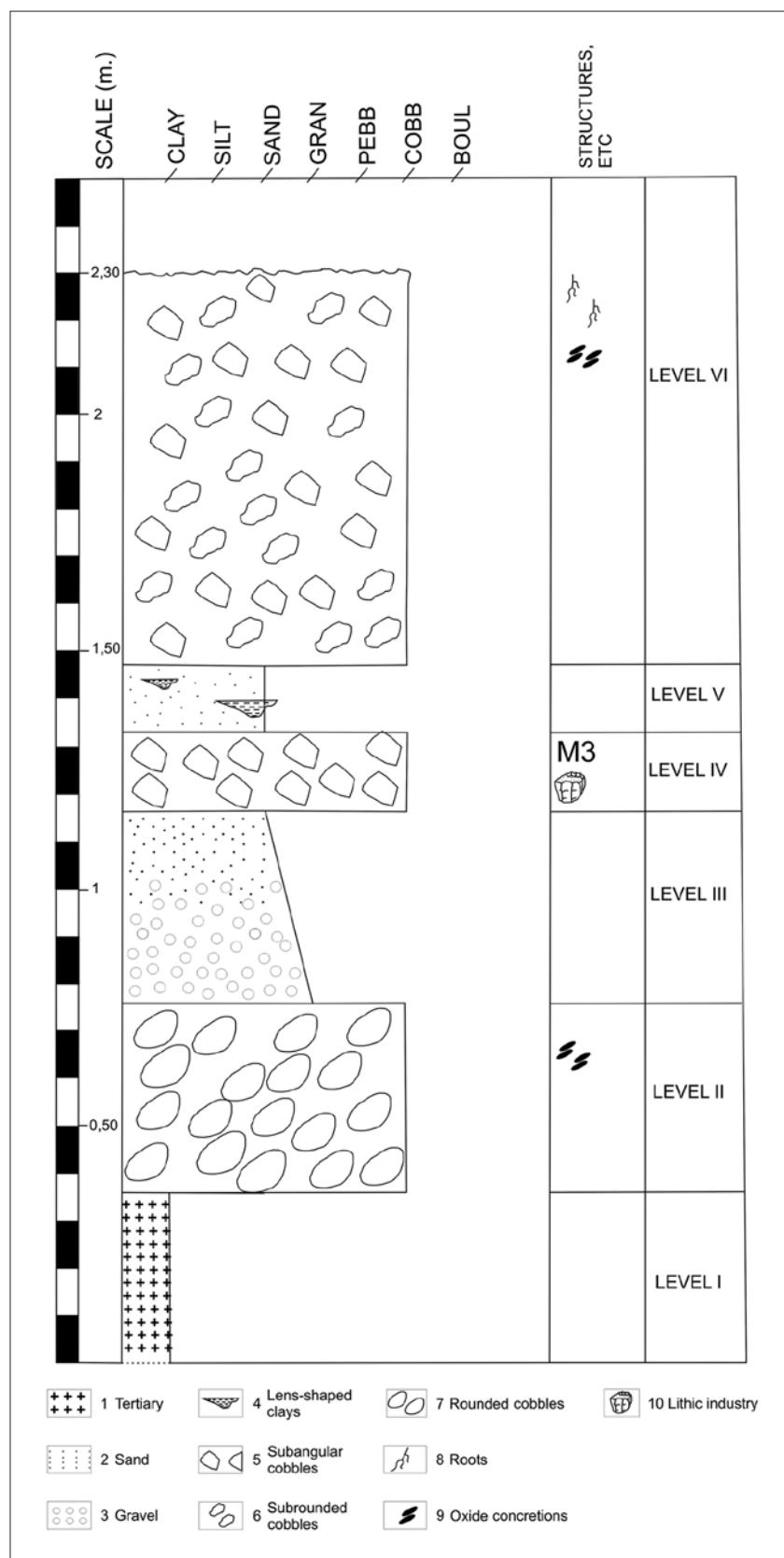


Fig. 10. Stratigraphic column of O Regueiral site. 1 – Tertiary; 2 – Sand; 3 – Gravel; 4 – Lens-shaped clays; 5 – Subangular cobbles; 6 – Subrounded cobbles; 7 – Rounded cobbles; 8 – Roots; 9 – Oxide concretions; 10 – Lithic industry. M3: OSL sample.

pebbles with a maximum axis of 180-220 mm. The materials, specially quartzites, show a high degree of rubefaction but low abundance of oxides, implying moisture and relatively high temperatures during formation.

Layer III: Maximum thickness 40 cm. Sandy matrix and gravels. The occurrence of gravels is higher at the base.

Layer IV: Maximum thickness 17 cm. Clayey matrix and subangular clasts with a maximum axis of 100 mm. The disposal and orientation of the clasts is not homogeneous. At the base of the layer a flake made on quartzite was found. Archaeological layer.

Layer V: Maximum thickness 14 cm. Sandy matrix strongly compacted, with horizontal stratification.

Layer VI: Maximum thickness 83 cm. Clayey matrix and gravels and subangular and subrounded clasts with a maximum axis of 140 mm, without orientation. The materials show a higher degree of rubefaction and abundant oxide concretions. Possibly they are reworked materials coming from the dismantlement of uppers deposits. In comparison with layer II it seems to have been formed in arid and drier conditions. At the top of the layer the present soil is developed.

An OSL dating was obtained in the colluvial Layer IV yielding a date to $69,446 \pm 5472$ BP (MAD-5608rBIN), MIS 4. This is coherent with the technological adscription of the lithic assemblage, though it must be considered as ante quem since the lithics are in secondary position.

5. GEOMORPHOLOGICAL DYNAMICS IN MONFORTE DE LEMOS BASIN AND THEIR RELATIONSHIP TO EROSION AND POST-DEPOSITIONAL PROCESSES IDENTIFIED IN NW IBERIA

The geomorphologic analysis of Monforte de Lemos basin allows us to determine that most of the surfaces are located between 40-60 m (Level N5) and between 20-40 m (Level N4). The less represented are those between 5-12.5 m (Level N2). There are some differences regarding the spatial distribution and characteristics of the Quaternary deposits of the northern and southern margins.

We must bear in mind that erosion occurring after deposition could have modified the original slope of the surfaces with a variable intensity, altering the initial morphology. In this sense, some surfaces seem to be the remains of disturbed ones, as for example the two groups of surfaces belonging to different levels (surfaces 28-33, and 17-18) located in the southern

side of the Cabe (Fig. 4). On the other hand, the small surfaces located at the southwest of the depression, in San Mamede (surfaces 20 and 22), and the surface number 21 seem to be related to T1 (surface number 1) because of their morphology, belonging to the same level (N1=0-5 m). All these surfaces (20-22) might be the small relics of this one major original surface (T1), having therefore a fluvial origin (AMEIJENDA IGLESIAS 2008). Continuing with this hypothesis, the surface of Chao Fabeiro (surface 12, archaeological points 6-9) seems to have been a terrace exposed during a long time to the local erosive dynamics. Considering its mean relative height (97.5 m) and the associated industry, Mode 2, less evolved in relation to other Acheulian assemblages in Monforte (RODRÍGUEZ *et al.* 2008), it could be one of the oldest surfaces of the depression.

According to the northern location of the most and highest fluvial/alluvial surfaces identified by the geomorphological analysis, these were considered as the remains of the ancient paleo-Cabe valley. The tract between its entry in the depression and its joint to the river Cinsa would have been located in past times towards the north of the basin (AMEIJENDA IGLESIAS 2008), possibly above the high surfaces represented in the sequence B-B' (Fig. 5). Instead of descending towards the south after the first bend, the river would continue in NE-SW direction as shown by the presence of meanders in both fluvial elbows (Fig. 4). The Cabe may have progressively changed its course towards SE during the Middle Pleistocene, forming the fluvial/alluvial terraces due to neotectonic processes. In this way the structural Quaternary landforms of the Monforte de Lemos basin were built up and later exposed to morphogenetic processes.

Thus, as we can observe, the original landscape has been intensively affected by morphogenetic processes that modify the preceding landforms, not only by the erosion of Quaternary surfaces but also through the abundant presence of alluvial and colluvial layers in the Monforte basin. The increase in erosion intensity, scouring processes and the hydric sedimentation is recorded in the slopes and alluvial plains of the inland Tertiary depressions and in the coastal deposits of NW Spain. The geoarchaeological investigations carried out in Monforte basin have shown the important incidence of erosion during the Upper Pleistocene in the dismantling of the pre-existent continental deposits and their lithic assemblages. At As Lamas Test Pit-I colluvial layers have been identified covering the fluvial sequence, as well as in other sites like O Regueiral, or As Lamas Test Pit-II. But this is a common situation in other archaeological deposits. For instance, in the Louro basin (Pontevedra) three colluviation phases were

identified (BUTZER 1967): the first one, ca. 40,000 BP is identified in Mougás deposits. The next two phases are present in the archeological site of As Gándaras de Budiño and, if we consider the available radiocarbon datings, they could be related to the pleniglacial event occurring ca. 20,000 BP, with cold and dry conditions, and already identified in the Galician coast (PÉREZ ALBERTI *et al.* 1999; COSTA CASAIS *et al.* 1994, 2002, 2007-2008; TRENHAILE *et al.* 1999; BLANCO CHAO *et al.* 2003).

Thus, these erosion processes identified in Monforte de Lemos and other archaeological sites allow us to establish a comparison between them and those identified in the continental, glacial and coastal deposits, consequently providing a better understanding of the paleoenvironmental dynamics of NW Iberia and site formation processes. At present, the deposits that have been investigated in greater detail are the coastal ones, where the effect of the Heinrich events has been recorded (COSTA CASAIS *et al.* 2007-2008). The radiocarbon datings of the Galician coastal deposits in Sanxián and Oia (CANO *et al.* 1997b); Caamaño (TRENHAILE *et al.* 1999; COSTA CASAIS 1995); Arnela or Moreira (PÉREZ ALBERTI *et al.* 1999) have led to the identification of, at least, three main periods of soil formation during the late Upper Pleistocene. The first one dating to ca. 38,000-32,000 BP (Arnela: 37,550±690 BP, Sanxián IV: 38,830±2200 BP, Oia Sur: 32,980±530 BP; Caamaño: 36,050+1430-1210 BP and 32,340+2400-1800 BP); the second one by ca. 30,000-28,000 BP (Sanxián I: 28,000±230 BP; Caamaño: 30,120+670-620 BP); and the third one between ca. 20,000 and ca. 18,000 BP (Caamaño: 20,160±270 BP, Moreira: 18,980±110 BP) (Fig. 1 and Table 1). The sedimentological analysis of the coastal deposits of Oia and Caamaño, where periglacial conditions and colluvial layers were identified by the presence of heads, debris flows and ploughing blocs, embedded among the aforementioned paleosols, have led to the identification of the Heinrich events H1, H2, H3 and H4 (COSTA CASAIS *et al.* 2007-2008; PÉREZ ALBERTI *et al.* 2009a; PÉREZ ALBERTI 2011).

These Pleistocene soils, pointing to stability periods, are framed by colluvial sediments of sands, gravels, pebbles and ploughing blocks related to periglacial conditions, similar to those documented in the eastern mountains (PÉREZ ALBERTI & VALCARCEL DÍAZ 1997; PÉREZ ALBERTI *et al.* 1993; VALCARCEL DÍAZ & PÉREZ ALBERTI 2002). The latest evidence, related to H1, are the colluvial layers overlying the soils dated by ca. 18,000 BP, such as Sanxián, Arnela, Fonforrón and Moreira (PÉREZ ALBERTI *et al.* 2009a). The H2, ca. 26,000 BP, is defined by the colluvial layers occurring between the soil formation periods

dated in ca. 30,000-28,000 BP and ca. 20,000-18,000 BP. The gap between the dates ca. 32,000 BP and ca. 30,000 BP, where sands and gravels deposits were identified, as in Caamaño, can be adscribed to the H3 event. Finally, evidence for the presence of the H4 event is less clear, but we must bear in mind the morphogenetic conditions previous to the stability needed for the soil formation processes around ca. 38,000-37,000 BP. These deposits may lay buried under the current beach deposits or even have been eroded, though some evidences were found in the base of the sequence of Arnela. On the eastern mountains some stratified scouring dated around ca. 40,000 BP is related to this event (PÉREZ ALBERTI *et al.* 2009a, PÉREZ ALBERTI 2011)

In this sense, the OSL datings of the colluvial layers at As Lamas Test Pit-II of 39,866±3554 BP (Layer IIIb-MAD-5601rBIN) and 38,947±3150 BP (Layer II-MAD-5600rBIN) seem to complete the sequence achieved in the coastal deposits by providing these older events (FÁBREGAS VALCARCE *et al.* 2010) (Fig. 11). The layer IIIb reflects the erosion phase that dismantled the Middle Pleistocene deposits containing Mode 2 lithic industries. In the upper layer, somewhat younger, the lithic assemblage adscribed to the Mode 3, coherent with the absolute dating, there is also evidence of a second erosive period shortly after the previous one. These layers represent two successive erosive and accumulative episodes, showing an instability period and morphogenetic dynamics in the Monforte de Lemos basin around ca. 39,000 BP. This could be related to the H4 event, whose incidence was higher in Atlantic Iberia (SEPHULCRE *et al.* 2007).

Finally, the OSL dating of 69,446±5472 BP (MAD-5608rBIN) at the colluvial layer of O Regueiral could be an evidence of erosive processes during MIS 4, possibly related to H6 (?), but further analysis must be carried out in order to check this hypothesis.

Thus, we can observe that the erosive episodes linked to the effects of the Heinrich events were recorded both in coastal and continental deposits, providing us a good framework for the knowledge of the morphogenetic and post-depositional processes that affected the archaeological assemblages during the Upper Pleistocene. The incidence of erosive and scouring processes related to cold episodes may have been higher in the coastal deposits due to direct oceanic influence, while in the mountainous regions the glacial and periglacial processes may have been enhanced by the combination of altitude and cold conditions. These processes not only affected the landscape morphology and Pleistocene surfaces, but also the depositional context of the archaeological sites.

Table 1. Radiocarbon and OSL datings of the coastal deposits and archaeological sites in relation to the stability and erosion periods.

	Archaeological Site	Layer	Method	Laboratory Reference	Chronology BP	Biblio. Reference
Erosion phase Heinrich 6 (?)	O Regueiral Layer IV	Alluvial fan	OSL	MAD-5608rBIN	69,446±5472 BP	FÁBREGAS <i>et al.</i> 2010
Erosion phase Heinrich 4	As Lamas Layer IIIB	Colluvium	OSL	MAD-5601rBIN	39,866±3554 BP	FÁBREGAS <i>et al.</i> 2010
	As Lamas Layer II	Colluvium	OSL	MAD-5600rBIN	38,947±3150 BP	FÁBREGAS <i>et al.</i> 2010
First stability period	Sanxián IV_Ib	Alluvial fan Organic layer	C ₁₄	–	38,830±2200 BP	CANO <i>et al.</i> 1997b
	Arnela	Organic layer	C ₁₄	–	37,550±690 BP	PÉREZ ALBERTI <i>et al.</i> 1999
	Caamaño	Organic layer	C ₁₄	GrN-20506	36,050+1430-1210 BP	TRENHAILE <i>et al.</i> 1999
	Oia Layer I	Organic layer	C ₁₄	–	32,980±530 BP	CANO <i>et al.</i> 1997b
	Caamaño	Organic layer	C ₁₄	GrN-21591	32,340+2400-1800 BP	TRENHAILE <i>et al.</i> 1999
Erosion phase Heinrich 3 (?)	A Chaira Layer III (basal colluvium)	Colluvium	ESTIMATED	–	32,000-30,000 BP	VILLAR QUINTEIRO 1999
Second stability period	Caamaño	Organic layer	C ₁₄	GrN-20507	30,120+670-620 BP	TRENHAILE <i>et al.</i> 1999
	Sanxián I-1	Alluvial fan. Organic layer	C ₁₄	–	28,000±230 BP	CANO <i>et al.</i> 1997b
Erosion phase Heinrich 2 (?)	Gándaras de Budiño Lower colluvium	Colluvium	C ₁₄	I-2174	26,700+3600/-2500 BP	AGUIRRE & BUTZER 1967
	A Chaira Layer III (Upper colluvium)	Colluvium	ESTIMATED	–	<20,000 BP	VILLAR QUINTEIRO 1999
Third stability period	Caamaño	Organic layer	C ₁₄	GrN-20508	20,160±270 BP	TRENHAILE <i>et al.</i> 1999
	Moreira	Organic layer	C ₁₄	–	18,980±110 BP	PÉREZ ALBERTI <i>et al.</i> 1999
Erosion phase	Gándaras de Budiño Lower colluvium	Colluvium	C ₁₄	I-2175	18,000±300 BP	AGUIRRE & BUTZER 1967

This fact could explain why most of the Galician Lower and Middle Paleolithic open-air archaeological sites are in a secondary position, showing the importance of post-depositional processes in the archaeological record linked to harsh conditions (vg. VILLAR QUINTEIRO 2009). On the granitic peneplains of Ourense province, the lithic assemblages of A Veiga and Campo da Mama (Fig. 1) are linked to a coarse-grained facies (gravels, blocks, etc.) related to accumulative processes induced by the deforestation of the nearby territory or a worsening of environmental conditions (COSTA CASAIS *et al.* 1998; LÓPEZ CORDEIRO 2001). At the site of A Chaira (Ourense) (Fig. 1) the Acheulian lithic assemblage appears in the lower colluvium, probably formed under humid

periglacial conditions, and buried by an upper colluvium related to a drier period of periglacial influence (VILLAR QUINTEIRO 1999). The author, based on a previous research carried out in the region by M. Costa Casais (1995), attributes an age of ca. 32,000-30,000 BP to the humid conditions of the lower colluvium, while the second is thought to be younger than 20,000 BP (VILLAR QUINTEIRO 1999: 13). Though no absolute datings are available, this interpretation might suggest an adscription to the H3 event (Table 1).

These are some examples of harsh environmental conditions under which the previous deposits were dismantled. The technological studies of the lithic assemblages, supported by taphonomic studies, point

to their homogeneity, meaning that erosion acted on previous deposits containing single or coeval occupations. But in some cases erosion and re-deposition may have resulted in the mixing of the remains of several and diachronical assemblages, as shown by the technological analysis of the lithic industry of A Piteira (Toén, Ourense), where Acheulian and Mousonian industries were found in the same layer (DE LOMBERA 2005).

Finally, in the site of As Gándaras de Budío (Fig. 1) the lithic artefacts were found in the lower and upper colluvia (AGUIRRE 1964). The analysis of the lithic assemblages and the geomorphological reinterpretation of the stratigraphy have led to the identification of only one in situ lithic assemblage, related to the +24 m Terrace (GRACIA *et al.* 2004; RAMIL REGO *et al.* 1993), being the lithic industries of the lower and upper colluvia remains of this previous occupation (DE LOMBERA 2006; MÉNDEZ QUINTAS 2007, 2008; VIDAL ENCINAS 1982). As stated before, there are two radiocarbon datings available for the lower colluvium ($26,700 \pm 3600$ -2500 BP, I-2174; and $18,000 \pm 300$ BP, I-2175) (AGUIRRE & BUTZER 1967) that could date the erosive and accumulation episodes of the late Upper Pleistocene, but we must be cautious due to the high divergence of the results, given that the samples belongs to the same Colluvium and were located just few centimeters from one another.

The scarce geo-archaeological works carried out in NW Iberia show the high incidence of the erosion phases on site formation processes. Though scarce information regarding technological and spatial features (refittings, chaîne opératoire, etc.) can be achieved from those lithic assemblages in secondary position, the dating of those deposits has been shown to be of great interest for the paleoenvironmental studies. The new data obtained in Monforte de Lemos basin, as well as the available data from other archaeological sites, have shown the widespread incidence of morphogenetic processes, specially related to Heinrich events, coeval to those identified in coastal deposits. Thus, it is necessary to increase the use of those dating methods suitable for our region (OSL, TL, ISRL, etc.) in order to achieve a better understanding of the Pleistocene dynamics and site formation processes in NW Iberia.

6. CONCLUSION

The geoarchaeological research carried out in the Monforte de Lemos basin shows the high influence of the Upper Pleistocene erosion phases, some probably belonging to Heinrich events, on the archaeological

record by dismantling and removing the lithic artefacts from their original depositional contexts and mixing different occupational layers.

The OSL datings obtained in the sites of As Lamas and O Regueiral and their sedimentological features allow the establishment of a correlation with the coastal, glacial and periglacial deposits of NW Iberia. This enabled the identification of the H4 and H6 events in the colluvial layers of As Lamas and O Regueiral, respectively, both events scarcely represented in the Galician landscape.

The post-depositional processes have commonly affected the Galician Lower and Middle Paleolithic open-air archaeological sites, especially those located on reliefs with enhanced slope dynamics and scouring such as those found on granitic substrata, but also acting on fluvial terraces of the main river valleys or on the Tertiary depressions.

ACKNOWLEDGMENTS

This work was carried out under the research project “Ocupaciones humanas durante el Pleistoceno de la Cuenca media del Miño” (HUM/2007-63662 and HAR2010-21786/HIST) funded by the Ministerio de Ciencia e Innovación. ALH has been supported by a pre-doctoral grant from Fundación Atapuerca. We also want to thank the referees for their helpful commentaries.

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