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The Contribution of Open-Air Sites to the Environmental Reconstruction of the Gravettian at the "Basque Crossroads" (North Iberia)

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Abstract
The reconstruction of the Cantabrian Gravettian and its palaeoenvironmental sequence is based on cave stratigraphies, which generally indicate a very rigorous climate (intense cold, occasionally dry and other times attenuated by the humidity). However, as open-air deposits are increasingly studied (Ametzagaina, Irikaitz and Mugarduia South), other situations are being detected in the Gravettian, with much milder conditions. We can now criticise the simplistic view of the Gravettian as a period governed solely by intensely cold conditions and look through the window of opportunity offered by the open-air camps to observe completely different landscapes and environments. Consequently, in the cold Heinrich events caves would have been inhabited, while in more temperate times (such as the Dansgaard-Oeschger cycles) the habitat would have been preferentially in the open-air. The historiographic and methodological over-emphasis on cave sites has created a mirage that is reinforced by every new study in such locations. The difficulties of all kind involved in locating, excavating and dating open-air sites adequately has led us to believe they did not exist or their contribution was unnecessary to draw a global picture of the period. The most extreme case is the flint workshop of Mugarduia South (Navarre) at over 900 m above sea level, nearly 60 km from the modern coast and in a palaeobotanic environment dominated by deciduous species.

1. Introduction

Owing to historiographic circumstances too lengthy to explain in detail, the Middle and Upper Palaeolithic in northern Iberia have been reconstructed almost exclusively from stratigraphic sequences in caves. This has created an imbalance (Arrizabalaga and Iriarte-Chiapusso, 2009) as the main regional sequences in the rest of Europe have been developed with a much more equal contribution of open-air sites of different functions (camps, hunting stations, workshops, etc.). We recently reflected (Arrizabalaga *et al.*, 2015) on the archaeological consequences of all kind deriving from this imbalance in the sources of information. The present paper will focus on one of the aspects in which the contribution of some of these open-air sites might prove to be most decisive in the near future. The practical absence of open-air Upper Palaeolithic sites in the region results in an even greater scarcity of palaeoenvironmental studies at such sites. In our opinion, a palaeoclimate sequence constructed solely from cave deposits implies the risk of a significant bias. In regions like northern Iberia, with a large range of potential habitats, both in caves and in the open-air, the choice of one or other location would depend on the interests of the group and the benefits derived from that choice, according to the reigning environmental conditions.
Our initial hypothesis is that, during the Cantabrian Upper Palaeolithic, caves would be

chosen for the shelter they provided from other groups, dangerous animals or inclement weather. Open-air sites would attest that, under certain conditions and specific needs (as a clear example of resources distributed at random, the procurement of lithic raw materials) such shelter was not necessary. Although highly localised geographically (the eastern sector of the northern Iberian coast) and with few known deposits, archaeobotanic research at some of the Gravettian sites studied in recent decades appears to support this hypothesis provisionally. This would alter our monochrome view of the Gravettian as a technocomplex that developed exclusively in a very rigorous climate stage.

2. The Gravettian in the east of northern Iberia. Reappraising the traditional view.

For the reappraisal exercise, a relatively recent monograph is available (De las Heras *et al*., 2013) for northern Iberia as a whole. The new aspects introduced in the Gravettian in the eastern sector by the open-air sites were presented in three previous papers (Arrizabalaga and Iriarte-Chiapusso, 2010a, 2010b, 2011a). Although the increasing information and consequent change of perspective apply to all northern Iberia, this paper stresses the eastern sector (known as the “Basque Crossroads”) because the main open-air sites that originated this reflection are located in that area.

A major change has taken place in the distribution map of Gravettian deposits in the Basque Country in the last twenty-five years (Figure 1). This change has been important from the quantitative point of view, but even more striking from the qualitative viewpoint. The open-air sites (flint workshops and camps) that were poorly known south of the Pyrenees have appeared in greater abundance than for other Upper Palaeolithic periods. Additionally, a prediction based on the finds at coastal sites of flint from high altitude outcrops (an average of about 900 masl) in the Ebro valley has been confirmed, and Navarre and above all Álava have ceased to lie outside the human oecumene. The expansion of the Gravettian world towards surrounding regions (Ebro valley and therefore the Mediterranean side of the watershed) makes us wonder whether the model of occupation of the terrain in the Basque Country was different from the situation in more western sectors, where the coast-inland contrast (or rather, the contrast between lowlands and highlands) is much more marked. Thus the mountain passes communicating Gipuzkoa and Biscay with Álava and Navarre are rarely higher than 600 m altitude and were easily passed even in the coldest climates, to access resources at average altitudes of 500-600 m (such as prey) and maximum heights of 900 m (lithic resources). This differs from the situation in the western half of Cantabria, Asturias and Galicia where the passes across the Cantabrian Mountains are often higher than 1,200 m altitude, to reach resources in the northern Iberian Plateau with average altitudes of 900 m. The numerous finds of flint from outcrops at Urbasa and Treviño in Biscayan (e.g. Antoliñako Koba and Bolinkoba) and Guipuzcoan (Irikaitz and Amalda) Gravettian levels attest the frequency of expeditions across the mountains. The need to obtain flint and the occurrence of long periods of a benign climate would allow the higher terrain (with its lower temperatures and fewer caves than in the coastal area) to be occupied in a more stable way.

In addition, since the 1990s two circumstances have forced a modification in the geochronological framework; the widespread use of the AMS radiocarbon method and the systematic dating of transition levels between the Middle and Upper Palaeolithic. These have recently culminated in the use of more exhaustive pre-treatment of the samples. The result of this is a larger number of reliable dates for Aurignacian (and also late Mousterian) series and a notable movement towards older chronologies for levels considered Aurignacian (Wood *et al*., 2014). While awaiting a more precise definition of the evolved or full Aurignacian in the south of the Pyrenees, the period separating the Aurignacian and Gravettian is now restricted to a time between 29,000 and 28,000 uncalibrated BP. At a more recent time, another poorly defined period (few dates, which are not linked with abundant materials) exists between 20,000 and 19,000 uncalibrated BP, which would correspond to the time of the middle Solutrean in Cantabrian Spain, according to De la Rasilla (1989).

Most of the available dates were obtained at the site of Aitzbitarte III (Altuna *et al.*, 2011) with two clearly differentiated areas; the inner area (with some problems for the conservation of the sequence) and the outer area (in which the conditions appear to be optimal). The period from 28,000 to 21,000 is covered by a series of dates with their corresponding material culture, about which there are no serious doubts. The presence of occupations with a Gravettian material culture during those seven millennia can be confirmed. It should be noted that most of the dates in the table were obtained after 1990 and many of them with the AMS method. The circumstances of the upper and lower range of the period are different. Five determinations date the period from 29,000 to 28,000, after the date corresponding to the top of Level C3b at Isturitz (29,400 ± 370), clearly Aurignacian (Barandiarán, 1999). Two of them (28,950 ± 655 and 28,320 ± 605) belong to Level IV in the outer series at Aitzbitarte III, above the Aurignacian Level V, whose dates put back the base of the sequence to about 31,000. The other three dates are a TL determination from Mugarduia South (Barandiaran *et al.*, 2007), one from Level IIbam at Zatoya (generically attributed to the first third of the Upper Palaeolithic: Barandiarán and Cava, 2001) and another date from the top of the same Unit C3b at Isturitz. These five dates may be questioned, with objections made to the treatment of some of the samples. No information is available about the context of outer Level IV at Aitzbitarte III, which is known to have yielded very few Noailles burins, contrasting with their over-representation in the sequence inside the cave. Additionally, a Level V underlies this unit and dates attribute this unit to the Aurignacian (probably the ancient phase). The date from Zatoya corresponds to a very interesting but scarcely diagnostic series which might just as easily be attributed to a late Aurignacian phase (Barandiarán and Cava, 2001). The result from Isturitz can be omitted as it contradicts the original date. Finally the result from Mugarduia South covers a long period (3,616 years), it is not pertinent to compare TL dates with uncalibrated radiocarbon results and the authors note the difficulty of accurately measuring the TL signal from burnt flint in the context of this workshop. In short, if the reference of 28,000 BP for the first Basque Gravettian dates appears very precise, the same cannot be said for this first poorly defined millennium.

It is even more difficult, with the data currently available, to define the final phase of the Gravettian, from about 20,000 BP onwards or even 21,000. The results within the period between the two dates for Level V at Amalda (19,000 ± 340 and 17.880 ± 390 BP) are very hard to contextualise and would square better with a middle or upper Solutrean phase (as the base of the Solutrean at Aitzbitarte IV was designated) than with the Perigordian VII proposed for Level V at Amalda (Altuna *et al.*, 1990). Certain objections may equally be made to the use of dates from Ekain (20,900 ± 450) (Altuna and Merino, 1984), where that determination practically lacks any archaeological context; Mugarduia South (20,240 ± 2597), because it is a TL determination; Grotte du Phare (19,900 ± 350) (Chauchat, 1994), again without any context; and Lezetxiki (19,340 ± 780), scarcely compatible with the material characterisation of the Level IIIa the sample came from (Falguères *et al.*, 2006).

Other important Basque Gravettian sequences have not contributed dates to this reconstruction. Some of them will be hard to date precisely, as at Irikaitz, where part of the sedimentary matrix and its contents appear to correspond to the Holstein interglacial period. Others are susceptible to sampling and will provide data during their excavation (e.g. Bolinkoba). The new open-air sites (Pelbarte, Prado and Ametzagaina) are more difficult to date as their primary context is unknown and they therefore lack elements to correct the TL signal, as occurred when dating burnt flint at Mugarduia South. We are missing some dates for the northern side of the Pyrenees, particularly for the sites of Isturitz, Lezia and Gatzarria, which would complete the regional picture with important data (although they should be obtained, at least for Isturitz, in the course of new excavations in the deposit).

In conclusion, whilst acknowledging the significant over-reliance on the dates from Amalda (Altuna *et al*., 1990) and above all from Aitzbitarte III (Altuna *et al*., 2011) in the design of this geochronological framework, a new time span for the Gravettian on the Basque Crossroads appears to be established from at least 21,000 to 28,000 uncalibrated BP. Future data for a further three millennia (29,000-28,000 and 21,000-19,000) will need to be considered carefully. It seems prudent to assess Level V at Amalda in a different context, whether the reference to a presumed Perigordian VII (or proto-Magdalenian) is taken as valid or an attribution to a Solutrean without the diagnostic artefacts is accepted. This latter hypothesis would allow the start of the Basque Solutrean sequence to be set at about 19,000 uncalibrated BP, which would be quite coherent with the wider regional panorama. The resulting framework includes some 15 dates obtained by three different methods (conventional C14, AMS and TL) for different materials, which trace a relatively continuous series though seven millennia, giving the Basque Gravettian geochronology certain consistency.

The situation of the climate data for the Gravettian is not any better. Once Level II at Lezetxiki is excluded from the list of sites attributable to the Gravettian, the amount of palaeoenvironmental information becomes even more restricted. Detailed analyses of Level VI at Amalda (the doubts about Level V, attributed to the proto-Magdalenian or Perigordian VII, have been expressed above) have been published in full (Altuna *et al*., 1990). Reports on Aitzbitarte III and Mugarduia South have also been published recently in great detail (Barandiarán *et al*., 2013). The Biscayan caves of Askondo and Arlanpe include Gravettian levels and their reports have recently been published (Garate and Ríos-Garaizar, 2012; Ríos-Garaizar *et al*., 2013); but no archaeobotanic information is given for the former site and the levels were archaeologically barren at the latter. Some isolated citations to palaeoenvironmental information (interpretation of palaeontological or sedimentological proxies) are made for the sequences at Aldatxarren, Antoliñako Koba and Bolinkoba (old excavations) in the corresponding research projects. Both the publication of these reports and the ongoing excavations at Bolinkoba (Iriarte and Arrizabalaga, 2013) and Aldatxarren, and the analysis of the basal levels at Ekain and levels with few remains (like Usategi) should provide a firmer foundation of palaeoenvironmental data than is available at the present time. However, it is not exaggerated to state that the current situation is still poor and we cannot go beyond a description of the limited indicators that are known. In quantitative terms, 29 series are susceptible of being analysed (three units in Aitzbitarte III, two in Isturitz, Bolinkoba, Antoliñako Koba and Amalda, and one each in Askondo, Arlanpe, Usategi, Gatzarria, Polvorín, Pelbarte, Prado, Ermittia, Ekain, Irikaitz, Ametzagaina, Aldatxarren, Jaizkibel, Mugarduia South, Alkerdi, Zatoya, Lezia and Azkonzilo) but only five of them provide detailed archaeobotanic information. These are two cave deposits (Amalda and Aitzbitarte III) and three open-air sites (Irikaitz, Ametzagaina and Mugarduia South).

3. Case Studies: caves, camps and workshops

This section will describe the five sites that have provided most archaeobotanic information for the chronological and geographical areas of study. The data will compared with information from other sites in the surrounding area or analyses of lesser resolution in the discussion section.

Cave of Amalda (Gipuzkoa, 205 masl)

Despite only being about six kilometres from the modern coastline, the cave of Amalda is located at a medium altitude (over 200m) on a steep hillside 110m above the River Alzolarats. This small valley on a practically W-E line must have provided quite sheltered environmental conditions during the Pleistocene, judging from the high density of Palaeolithic sites in the valley. The cave was excavated under the supervision of J. Altuna between 1979 and 1984. The monograph with the main results of the archaeological work was published some years later (Altuna *et al*., 1990). As explained above, Level VI is considered fully Gravettian, whereas in our opinion Level V, which was quite poor and published as proto-Magdalenian in the original report, would correspond to a Solutrean level lacking the characteristic leaf-shaped points.

The palynological study at Amalda (Dupré 1988, 1990) situates Level VI in the second pollen zone in the deposit (samples 18 to 16), cold and humid at first and drier at its end. The curve shows a low arboreal percentage, represented almost totally by pine, together with some hazel, birch, oak and Cupressaceae. The complementary dynamics of herbaceous taxa (Gramineae and composites) and Filicales reflect the environmental humidity. Ferns, very abundant at the start of this level, are gradually replaced by a herbaceous cover. The samples corresponding to Level V (third pollen zone) reveal an initial rise in temperature and humidity and are attributed by the author to the Laugèrie-Lascaux amelioration. Both variables steadily decline towards the top of the level, which records the coldest moment in the whole sequence in the cave. The interpretation of the diagram reveals some ambiguous aspects, which may be attributed to the low taxonomical diversity of the analysis and the position of the cave in a relatively sheltered place near the coast. As at so many other Palaeolithic sites in northern Iberian, the high humidity and the proximity of the sea attenuate the climate conditions considerably during many of the stadials. The rigorous conditions reigning during the formation of Level VI and V at Amalda are, however, unquestionable.

Cave of Aitzbitarte III (Gipuzkoa, 220 masl)

The location of the cave of Aitzbitarte is similar to that of Amalda, in a relatively sheltered valley, at a medium altitude and near the modern coast (although the most likely estimates situate the coastline 15km further out to sea during the stadials in the Upper Palaeolithic). The Landarbaso valley is open to the NNW, unlike the Alzolarats valley, and therefore the Pleistocene environmental conditions must have been more extreme in the Aitzbitarte caves as this direction coincides with the dominant winds in the “cul-de-sac” of the Bay of Biscay. It should also be added that the modern distance from the coast is slightly larger and the bathymetric depth contours indicate that the inter-tidal line would have been even further away when the sea level dropped.

The modern archaeological excavations at Aitzbitarte III were conducted in two phases between 1985 and 2002, under the supervision of J. Altuna. At first, a large surface area ($42m^2$) was excavated inside the cave, from 1985 to 1994. In the latter year, the work moved to a small area ($14m^2$) in the entrance of the cave. The detailed results were made known in a recent report (Altuna *et al*., 2011). The archaeological levels attributed to the Gravettian in this report are Upper Vb, Va and IV (ancient Gravettian) and III (recent Gravettian).

The pollen study at Aitzbitarte III (Iriarte-Chiapusso, 2011a) produced results that are somewhat conditioned by the preservation of the palynomorphs and the small sedimentary content of the stratigraphic units, so that several levels are represented by a single sample (Figure 2). The first of these factors resulted in no representative information for Level III. However, the coherence in the diagrams of the Gravettian levels that have been studied give the environmental observations inferred from the analysis great consistency. Basically, the situation was one of a very rigorous climate, with an open landscape (mean arboreal pollen values of 3%) with pine, juniper and birch representing the few trees. Diachronic variations reflect a certain increase in humidity at the start of the Gravettian series, with the consequent increase in fern spores, a relative recovery of Poaceae, Leguminosae, Rosaceae and Umbelliferae, and a parallel decline in composites (*Centaurea*). In contrast, the sequence ends in Level IV with a new climate deterioration in which tree pollen increases slightly because of an expansion of *Juniperus*, and the tendencies for the Filicales and herbaceous taxa in the previous sub-phase are inverted. In short, the open vegetation observed through the analysis of the Gravettian levels at Aitzbitarte III is an indicator of a cold climate in which the beneficial effect usually exercised by the Bay of Biscay on deposits near the coast is hardly perceived.

The open-air camp of Ametzagaina (Gipuzkoa, 120 masl)

The Gravettian camp at Ametzagaina was discovered some time ago, but the first reports had no impact because of the deteriorated nature of the surroundings of the site. In this century, a number of soundings and excavations were carried out in the area under the direction of J. Tapia. Lithic materials were found on the surface over a large area, but hardly any of the soundings revealed undisturbed portions of the stratigraphy. In 2007, a test excavation was opened in an area with an irregular surface, which turned out to be an area of trenches dug when the city of Donostia (San Sebastián) was besieged in the Carlist Wars (Tapia *et al*., 2009; Calvo *et al*., 2013). The rampart built with the sediment dug out of the trenches protected a few square metres of the archaeological deposit in the conditions in which it had reached the mid-nineteenth century. These remains have been studied in an attempt to recover an archaeo-botanic and sedimentological sequence of the occupation. The density of lithic finds at Ametzagaina is considerable, so that the assemblages found in the East and West Hills include over 400 tools. The lithic industry is coherent with a series of occupations in the Gravettian (Arrizabalaga *et al*., 2014).

At Ametzagaina, as at Irikaitz and many other open-air sites, soil acidity, the thinness of the sediment, heavy rainfall and successive changes in land use have not allowed the preservation of organic materials like bone, or even charcoal. This circumstance impedes radiocarbon dating and hinders other forms of absolute dating, such as those based on luminescence. In contrast, the conservation of the pollen record seems to be even better than in cave deposits (Figure 3). The tree cover was dominated by deciduous species (alder, birch, hazel and oak) rather than pine. During the Gravettian occupations at Ametzagaina, the climate conditions were milder as regards temperature and humidity, in relation with an interstadial before the last glacial maximum. In this mild phase of the Upper Pleistocene, the presence of colonising plant species seems to suggest that a significantly colder phase was not long in the past, as the arboreal vegetation is in the recovery stage. Under these conditions, open vegetation developed, with a predominance of heaths and Gramineae, which together with the dynamic of ferns reveal the high level of environmental humidity, However, the humidity is seen to decrease gradually towards the top of the sequence, with a decline in such taxa as ferns, heathers, alder, hazel and oak. As noted in other parts of northern Iberia, even in Upper Pleistocene stadials, the high systemic environmental humidity is reflected in a significant presence of heaths and Gramineae in the herbaceous-shrub layer (Gómez-Orellana, 2002; Ramil-Rego *et al*., 2006).

To sum up, the palynological sequence at Ametzagaina is evidence of a relatively long chronological series, which developed during a milder phase between two cold periods. The humidity is greatest at the start, with certain vigour of pioneer tree species, and the series continues until the humidity decreases significantly and colder conditions probably return, to the detriment of more thermophilous ferns and deciduous trees. Both the quantitative and the qualitative circumstances of the series can guarantee the coetaneity of the sedimentary deposit and the Gravettian occupation.

The open-air camp of Irikaitz (Gipuzkoa, 55 masl)

The site of Irikaitz was not found by systematic surveying, but by members of a local group of researchers in 1995. The deposit gradually grew in size whenever a trial sounding on the edge of the area revealed prehistoric remains, and now covers at least eight hectares. In 1998, as a substantial part of the site was about to be affected by the building of a sports centre, the first excavations were carried out to assess the importance of the site, and these were followed by others, almost uninterruptedly, until 2013, under the supervision of A. Arrizabalaga (Arrizabalaga and Iriarte-Chiapusso, 2003, 2005, 2011b). From 1998 to 2003, the excavation concentrated on the first sector (Geltoki), where a total of six levels were found (Arrizabalaga and Iriarte 2011b), two of them with Gravettian materials (G.II and G.III). From 2002 to 2013, the fieldwork concentrated on a second sector (Luebaki), with a much more problematic stratigraphy, but a high density of finds, in which the Levels G.II and G.III merged approximately in L.II. The low altitude of the site and its proximity to both the River Urola and the modern coastline may have influenced the sedimentary process at Irikaitz significantly.

Preliminary information on Irikaitz referred to a deposit with Upper Palaeolithic remains in a secondary position. However, in the first excavation season Lower Palaeolithic lithic artefacts were found in a primary position, as well as more altered Gravettian remains. This circumstance, impossible to detect without fieldwork of certain extension, completely changed the assessment of the site and meant that building work in the area had to be re-designed. An additional problem was that the methodological tools developed until that time were directly connected with cave excavations: geo-archaeology, geo-chronology, bio-archaeology and the study of industries were clearly orientated towards the reconstruction of cave environments. Even the logistics of excavations in a region with such heavy rainfall caused problems which seemed unsolvable. These difficulties, in the case of Irikaitz, have resulted in a considerable investment in energy over the years to adapt these methodologies to open-air environments. From the stratigraphic viewpoint, Irikaitz is challenging as continuous vertical interbedded layers are found between levels, generally in the interfacies and often in deeper parts of each unit. These phenomena rarely reach such an intensity or extent in cave environments. In a similar way, when geo-chronology fails, chronology in cave deposits is supported by bio-stratigraphic sequences, especially of large fauna. At Irikaitz, geo-chronology has not been successful to date Gravettian layers, as no precise dates have been obtained either by radiocarbon or by OSL, and the support of fauna is lacking as it has not been conserved. Archaeo-botany has succeeded better, as pollen and anthracological and carpological remains are preserved (Arrizabalaga *et al*., 2003; Ruiz-Alonso *et al*., 2013), but it is not easy to give a clear meaning, in palaeo-environmental terms, to a partially undated sequence.

As a consequence of the conservation of the sequence, as explained above, the archaeobotanic studies have focused on the Geltoki sector. The anthracological and carpological results (Ruiz-Alonso *et al*., 2013) and preliminary palynological analyses

(Arrizabalaga *et al*., 2003) have been published. The levels G.II and G.III yielded little pollen information, apart from a significant presence of deciduous trees, particularly oak and alder. The anthracological analysis, with lesser environmental resolution due to the characteristic bias in the sample, indicates a predominance of deciduous *Quercus* species, followed by alder, hazel and beech. Species like ash and birch were also present in the Gravettian vegetation. Therefore deciduous and riparian species are well represented, reflecting the interstadial conditions in which this Gravettian occupation took place. The presence of hornbeam, a species absent from the regional Holocene record, is a guarantee of the consistency between the samples taken and the Palaeolithic occupations at the site.

The lithic workshop of Mugarduia South (Navarre, 905 masl)

On the Urbasa Plateau, to the south of the Atlantic-Mediterranean watershed (but very near to it), the flint workshop of Mugarduia South is emplaced directly on an outcrop of the high-quality Urbasa raw material. Despite its location in the Ebro valley, an area with a lower density of Palaeolithic sites, in the open air and at a high altitude, the test soundings (1982) and subsequent excavation (1987) at this flint workshop revealed a repeated occupation during the Gravettian. The excavation, supervised by I. Barandiarán, culminated with the publication of a full report with the results (Barandiarán *et al*., 2013). In this, the chapter on the pollen study (Figure 4) was written by one of the present authors (Iriarte-Chiapusso, 2013).

Despite its location on high land, the site yielded a pollen spectrum attesting a quite benign climate. The first fertile samples reach 65% arboreal pollen, again dominated by pioneer species (birch and hazel). Other taxa (pine, oak, beech, lime, Cupressaceae and *Sambucus*) did not reach very significant values. Ferns reached high percentages, indicating humid conditions, while Poaceae, Ranunculaceae and *Plantago* are the main representatives of the herbaceous layer. In the middle of the sequence, the tendencies change and the percentages of birch decrease in the benefit of hazel, pine, beech, oak and Cupressaceae, with the occasional appearance of alder, yew and lime. Although the total arboreal pollen declines, the circumstances of its representation suggest that the colonisation phase had been completed and mixed deciduous woodland expanded in a period with a mild climate. Humidity must have increased, judging by the still significant presence of ferns. Thus, in a situation reminiscent of the series at Ametzagaina, the pollen series displays certain change over time, from a colonisation phase with birch and hazel woodland in the area to the establishment of a mixed broadleaf forest in a context of the stable climate conditions.

At Mugarduia South, as at Ametzagaina and Irikaitz, a method has been developed to certify the consistency of the pollen spectrum obtained in the archaeological sequence. Although the site is today surrounded by beech and several associated species, we know that this vegetation has been favoured by humans in the recent Holocene. To obtain a modern or near-modern picture of the pollen rain, several samples of moss in the surroundings of the site were collected and analysed. They revealed a period in which the woodland was co-dominated by beech and pine, with low values of oak and ash, and a minimal presence of birch and hazel. Consequently, in addition to the Gravettian lithic assemblage and the care taken in the sampling, the vegetation recorded in the archaeological sediment is quite different from both the modern plant cover and the woodland recorded in the moss traps, which belongs to a recent historical period but before the systematic human interference in the development of the forest.

4. Discussion. An environmental reappraisal of the regional Gravettian.

In addition to the five sequences described above, other supplementary archaeobotanic data is of less resolution or refers to a wider geographical area. Palaeobotanic proxies are preferred, since the diversity of situations created if all palaeoenvironmental indicators were included would result in an inoperative number of nuances.

In the municipality of Deba, Cueva de Ekain (90 masl) does not contain a clear Gravettian record in its stratigraphic sequence, although one level (Level VIII) is dated to 20,900 ± 450 BP in the end of the Gravettian (Arrizabalaga, 1995). The palynological study of is level was carried out after M. Dupré's study (Dupré, 1984), and only a brief reference to it exists. This identifies thermophilous taxa (deciduous oak, holm oak, hazel and elm) in relatively high percentages (although the amounts are not given), together with pine. The composition of this quite well-developed arboreal layer induces the researcher to imagine a time with a temperate humid climate (Sánchez-Goñi, 1989).

The recent examples of Askondo and Arlanpe (Biscay), which have still not provided valid information for this period, have been cited above. Also in Biscay, the site of Antoliñako koba (300 masl) contains two levels attributed to the Gravettian and dated between 27,700 and 25,800 BP (in the lower level, Lmbk) and between 23,500 and 22,100 BP (in the upper level, Lab) (Aguirre, 2000). The deficient sporopollenin preservation in this cave site does not allow any palaeobotanic information to be obtained for its Gravettian levels.

The palaeontological level (Level Arg-o) which starts the stratigraphic sequence in Cueva de Santimamiñe (Biscay, 150 masl) is dated to a similar age (20,530 ± 110 BP). The palynological information comes from a single sample, which gives a very isolated picture of the conditions in this level. The pollen spectrum corresponds to open vegetation corresponding to a cold but relatively humid climate, with an arboreal portion (23%) consisting solely of *Pinus* (dominant taxon) and *Juniperus*. In the predominant herbaceous-shrub layer, Gramineae are the main taxa, accompanied mostly by Umbelliferae, Labiatae, heathers, Leguminosae, Compositae and *Plantago*. Ferns reach a representation of 15% (Iriarte-Chiapusso, 2011b).

Further from the modern coastline, the Gravettian level in Cueva de El Mirón (Cantabria, 250 masl) forms part of a long archaeological sequence covering practically the whole of the Upper Palaeolithic. The first results of the Gravettian samples (Straus et al. 2013) seem to confirm increasing humidity from the bottom to the top of the level. The values of tree pollen are higher than in the previous deposits, but the taxonomical diversity is lower; only pine is recorded, except for a scarce and discontinuous presence of birch. Also in Cantabria, no information is available for the Gravettian Levels V and Va at Cueva de El Pendo (25 masl) as they were excluded from the palynological study carried out (Leroi-Gourhan, 1980).

In the case of the classic palynological study at Cueva Morín (Cantabria, 65 masl) several pollen samples contained fewer than 150 remains, and therefore have been excluded from this study. In consequence, an intermittent picture is formed by the Levels Upper 5 (20,124 ± 340 BP) and 4 in the sequence. In the three most representative samples (8, 7 and 5), the arboreal vegetation (with values of about 10%) is dominated by pine, together with birch and hazel. However, in the other Gravettian samples, deciduous taxa like *Alnus*, *Quercus* and *Ulmus* are present discontinuously. Once again, the composites and Gramineae are the main taxa in the herbaceous layer (Leroi-Gourhan, 1971). Whilst bearing in mind the limitations explained, the climate seems to deteriorate towards the top of Level 4.

In northern Iberian, no non-anthropic sequences are currently known within the period of the Gravettian. In Mendía Bay (Rivadedeva, Asturias) a Quaternary deposit with a series of peat palaeo-soils has been the subject of several pollen studies (Mary *et al*., 1975, 1977; Gómez-Orellana, 2002). Although a level dated to 20,330 ± 270 BP was found in one of them (La Franca 3), owing to the characteristics of the limnetic level and its pollen record, the author of the study considered the date was not valid (Gómez-Orellana, 2002).

The trait common to all the pollen records described above is the predominance of open vegetation, although the values of deciduous trees sometimes suggest less rigorous conditions (Iriarte and Murelaga, 2013). According to the chronological series in these studies, without ignoring the nuances due to the comparison of absolute dates obtained by different dating methods, in the time span between 33,000 and 29,000 cal BP, open vegetation was associated with cold climate conditions. In this vegetation, with small forest cover, pine was the most abundant element, usually accompanied by smaller percentages of *Juniperus* and/or *Betula* (Aitzbitarte III and El Mirón). However, there are exceptions, such as the Gravettian levels in Cueva de Amalda, where in an environmental context equally characterised by a landscape with little forest cover, the discontinuous presence of a few deciduous taxa was detected *(Corylus* and *Quercus* pendunculate tp.).

The chronostratigraphic discontinuity of the other cave deposits restricts the palynological information for the late and final Gravettian. In the period 24,956 – 24,170 cal BP, the environmental context of the palaeontological level Arg-o at Cueva de Santimamiñe was cold and relatively humid, with little forest cover (*Pinus* and *Juniperus*). Although at Cueva Morín (24,975 – 23,275 cal BP) some deciduous trees were present in that open landscape (*Corylus*, *Alnus*, *Quercus* and *Ulmus*), the tendency in these Gravettian levels is towards a harsher climate.

The gradual accumulation of palaeoenvironmental data for the northern coast and the north-west of the Iberian Peninsula is revealing that the differences seen in the studies are related to variations in biogeographical conditions in the areas, rather than to taphonomic problems (Iriarte and Murelaga, 2013). Thus, the different geographic location of Mugarduia South compared with that of the other pollen records is an important factor to be taken into account in their contextualisation. Most of the regional sites where pollen studies have been performed are less than 10km from the modern coastline (Cueva Morín, Santimamiñe, Antoliñako koba, Amalda, Ekain, Ametzagaina and Aitzbitarte III), while their altitudes vary from 65 masl. at Cueva Morín to 300 masl at Cueva de Antoliñako koba. In contrast, Mugarduia South is at an average altitude of 905 masl, and over 50 km in a straight line from the modern coast. Additionally, only Ametzagaina is like Mugarduia South, an open-air site with precise information. However, the lack of numerical dates is a serious limitation to the correlation of the two sequences; the exact ages of Zones 1 and 2 at Mugarduia South and the ensemble at Ametzagaina are unknown. However, the two records, which differ substantially from the other cave deposits, agree in several aspects:

- They reflect mild environmental conditions.
- The forest cover was more extensive.
- Deciduous taxa dominate the forest cover.
- Gramineae and heathers are important in the herbaceous-shrub layer.
- The degree of humidity was high (particularly at Mugarduia South).

The comparison of the two records also reveals some differences. At Ametzagaina the values of fern spores and tree pollen are lower (AP: 20-25%) and hazel, alder and, to a lesser extent, birch are the main species. In the interpretation of these dissimilarities, the different location and altitude of the deposits, and the lack of absolute dates, should not be forgotten. However, in accordance with the characteristics of Zones 1 and 2 at Mugarduia South, the record at Ametzagaina appears to correlate better with the first, where the higher altitude would favour the spread of birch over hazel, while the proximity of Ametzagaina to the River Urumea would favour alder, which is absent at Urbasa because of the geological factor of the rapid drainage in the underlying karst. The main differences between these two open-air records can thus be explained by the circumstances of their locations (altitude and distance from the sea).

Owing to the discontinuities, due to chrono-stratigraphic factors and sporopollenin preservation, the records cannot easily by correlated with the succession of Dansgaard-Oeschger cycles and Heinrich events (Bond and Lotti, 1995; Meese *et al.*, 1997; Rahmstorf, 2003; Hemming, 2004; Rasmussen *et al.*, 2006). However, it can be seen that a diversity of environmental situations existed during the Gravettian. In some of those situations, the amelioration of the climate allowed the expansion of forest cover and a predominance of deciduous species. It is not only a coincidence that the only two palynological studies for open-air sites, in very different geographical areas (Ametzagaina and Mugarduia South), attest this climate amelioration. The TL dates for the base of the sequence at Mugarduia South indicate that the environmental conditions would be situated in a Dansgaard-Oeschger event, beginning with Event 4. Unfortunately, the brevity of the reference to Level VIII at Cueva de Ekain (26,207-23,880 cal BP), where the environmental conditions may have been similar to those at Ametzagaina and Mugarduia South, does not allow a more precise correlation between these sequences. The same can be said of those sites where the sporopollenin record has not been preserved, despite studies being attempted (e.g. Antoliñako koba). At other sites, no samples have yet been obtained for their Gravettian sequence (e.g. Prado in Álava, Bolinkoba and Askondo in Biscay, and Usategi and Aldatxarren in Gipuzkoa).

Once the radiocarbon dates of the regional Gravettian sequence have been calibrated (Figure 5), the start of the period can be associated with rapid cooling which culminated in the Heinrich H3 event. The central part of the period includes two milder cycles (DO4 and DO3). After a time of gradual cooling, the end of the Gravettian would coincide approximately with another Heinrich event, H2, followed, in the transition to the Solutrean, by a new amelioration, DO2 (Iriarte-Chiapusso and Murelaga, 2013). As the chronological span of the regional Gravettian has been greatly enlarged and the resolution of the analyses has improved, it should be possible to attribute each of the levels to a point on the climate curve relatively easily. However, several factors make this task more difficult than might be thought, as a recent study as shown (Arrizabalaga and De la Peña, 2013: 383). First, many of the cave sites do not possess a long series of dates, or these display unfortunate inversions and overlapping, and practically no geochronological frameworks are available for open-air sites. Additionally, the accumulation of dates obtained since they first became possible, using different methodologies, probably generates more noise than true information. Finally, the curves resulting from the calibrated dates in neighbouring regions (in this case, central or western sectors of northern Iberia, the Basque-Navarre area and the Pyrenees) differ greatly, which suggests that regional factors affect the conservation of radiocarbon or the availability of samples. Whereas most of the calibrated dates in central-western sectors of northern Iberia are associated with the middle Gravettian (28-24 ka cal BP), in the Basque Country three peaks are seen in an almost Gaussian distribution curve (around 33, 29.5 and 25 ka cal BP), and in the Pyrenees the dates are concentrated in the early phases, with peaks at 31.5, 30.5 and 28.5 ka cal BP.

If we wished to complete the geochronological curve that is apparently the fullest (the one on the “Basque Crossroads” studied here), dates are missing from times that roughly coincide with the two consecutive milder Dansgaard-Oeschger cycles (DO4 and DO3) in the middle and late Gravettian. Owing to the great difficulty in dating open-air deposits, as explained above, the radiocarbon determinations with which this series has been constructed come from cave sites. Although this does not signify that the trough between the peaks at 29.5 and 25 ka cal BP necessarily corresponds to the open-air sites (as well as to Cueva de Ekain), the hypothesis is suggestive and may be supported by the sequences of certain diachronicity recorded at Ametzagaina and Mugarduia South. The confirmation of the hypothesis will be achieved with the discovery, excavation and precise dating of other open-air sites.

5. Conclusions

Interesting terrain remains to be explored in the palaeoenvironmental contextualisation of the Gravettian period, whose length has recently been practically doubled (Arrizabalaga and Iriarte 2010a, 2010b). The palaeobotanic characterisation of a number of open-air sites has shown that these were occupied in mild conditions, noticeably better than those prevailing at the times of most cave occupations. This is observed also at a high-altitude site, Mugarduia South (905 masl) so the factor of height above sea level can be ruled out as an explanation for this phenomenon. Some diachronic environmental change is also seen in the series from Ametzagaina and Mugarduia South, in long stratigraphic sequences with a high density of finds, so these were not ephemeral camps during short seasonal expeditions, but places repeatedly visited during quite long periods of time.

While the Heinrich cold events correlate with some of the cave stratigraphies that have been studied (the clearest example is Aitzbitarte III), the milder Dansgaard-Oeschger cycles do not. In our opinion, these cycles, which occurred three times during the regional Gravettian, should be correlated at least with the open-air sites described here. A more precise ascription of each site would require numerical dating that is not yet available, as well as the location and study of new open-air Gravettian deposits. However, all the current data support the hypothesis proposed in the Introduction.

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References

Aguirre, M. 2000. El paleolítico de Antoliñako koba (Gautegiz-Arteaga, Bizkaia): secuencia estratigráfica y dinámica industrial. Avance de las campañas de excavación 1995-2000. Illunzar 4: 39-81.

Altuna, J., Baldeón, A., Mariezkurrena, K. (dirs). 1990. La cueva de Amalda (Zestoa, País Vasco). Ocupaciones paleolíticas y postpaleolíticas. Eusko Ikaskuntza, Donostia.

Altuna, J., Marriezkurrena, K., Rios-Garaizar, J. (eds). 2011. Ocupaciones Humanas en Aitzbitarte III (País Vasco) 33.600-18.400 BP (Zona de entrada a la cueva). Colección de Patrimonio Cultural Vasco 5. Servicio Central de Publicaciones del Gobierno Vasco, Vitoria-Gasteiz.

Altuna, J., Merino, J.M. (dirs.). 1984. El yacimiento prehistórico de la cueva de Ekain (Deba, Guipúzcoa). 351 pp. Eusko Ikaskuntza. San Sebastián.

Arrizabalaga, A. 1995. La industria lítica del Paleolítico Superior Inicial en el oriente cantábrico. Ph.D. Thesis, Universidad del País Vasco UPV-EHU, Vitoria-Gasteiz, Spain.

Arrizabalaga, A., Calvo, A., Elorrieta, I., Tapia, J., Tarriño, A. 2014. Where to and what for? Mobility patterns and lithic resources management among Gravettian hunter-gatherers in the Western Pyrenees. Journal of Anthropological Research 70, 233-261.

Arrizabalaga, A., De la Peña, P. 2013. El registro de la industria lítica como base para una organización del Gravetiense cantábrico. In: De Las Heras, C., Lasheras, J.A., Arrizabalaga, A., De la Rasilla, M. (coors.). Pensando el Gravetiense: nuevos datos para la Región Cantábrica, en su contexto peninsular y pirenaico, Monografías del Museo y Centro de Investigación de Altamira, 23, Madrid, pp. 367-388.

Arrizabalaga, A., Iriarte-Chiapusso, M.J. 2005. Irikaitz (Zestoa, País Vasco). Estudio preliminar del Paleolítico inferior en el sondeo "Geltoki". In: Bicho, N., Corchón, M.S. (coors). O Paleolítico: actas do IV Congresso de Arqueologia Peninsular (Faro, 14 a 19 de Setembro de 2004). Centro de Estudos de Patrimonio, Departamento de Historia, Arqueologia e Patrimonio, Universidade do Algarve, Faro, pp. 267-275.

Arrizabalaga, A., Iriarte-Chiapusso, M.J. 2009. Through the Looking-Glass. The Most Recent Years of Cantabrian Research in the Middle to Upper PalaeolithicTransition. In: Camps, M., Chauhan, P. (eds.), Sourcebook of Paleolithic Transitions. Methods, Theories, and Interpretations. Springer, New York, pp. 333-340.

Arrizabalaga, A., Iriarte-Chiapusso, M.J. 2010a. El Gravetiense en la encrucijada. Actualización de la información y propuesta de relectura para el caso vasco. In: Mata, E. (coord.). Cuaternario y arqueología. Homenaje a Francisco Giles Pachecho. Diputación Provincial de Cádiz, Servicio de Publicaciones: Asociación Profesional del Patrimonio Histórico-Arqueológico de Cádiz, Cádiz, pp. 133-145

Arrizabalaga, A., Iriarte-Chiapusso, M.J. 2010b. El Paleolítico superior inicial en el siglo XXI. Dos décadas de avances en la encrucijada vasca. In: Mangado, X. (eds.), El Paleolítico superior peninsular: novedades del siglo XXI. Homenaje al Profesor Javier Fortea. SERP (Seminari d'Etudis i Recerques Prehistòriques). Universitat de Barcelona, Barcelona, pp. 311-335.

Arrizabalaga, A., Iriarte-Chiapusso, M.J. 2011a. Les gisements archéologiques gravettiens de plein air dans le Pays Basque péninsulaire: un phénomène émergent. In : Goutas, N., Klaric,L., Pessese, D., Guillermin, P. (eds.), À la recherche des identités gravettiens: actualités, questionnements et perspectives: actes de la table ronde sur le Gravettien en France et dans les pays limitrophes, Aix-en-Provence, 6-8 octobre 2008. Société Préhistorique Française, Paris, pp.197-206.

Arrizabalaga, A., Iriarte-Chiapusso, M.J. 2011b. Lower and Upper Palaeolithic settlements in Irikaitz (Zestoa, Basque Country, Spain). Deconstruction of a Pleistocene archaeological site in the eastern Cantabrian range. Cuaternario y Geomorfología 25, 105-119.

Arrizabalaga, A., Iriarte-Chiapusso, M.J., Ruiz-Alonso, M. 2003. El yacimiento arqueológico de Irikaitz (Zestoa, País Vasco). Contextualización arqueobotánica y en el marco del Paleolítico inferior vasco. In: Flor, G. (ed.). Actas de la XI Reunión Nacional de Cuaternario. AEQUA, Oviedo, pp. 211-217.

Arrizabalaga, A., Iriarte-Chiapusso, M.J., Ruiz-Alonso, M. 2003. El yacimiento arqueológico de Irikaitz (Zestoa, País Vasco). Contextualización arqueobotánica y en el marco del Paleolítico inferior vasco. In: Flor, G. (ed.). Actas de la XI Reunión Nacional de Cuaternario. AEQUA, Oviedo, pp. 211-217.

Arrizabalaga, A., Rios-Garaizar, J., Álvarez-Alonso, D. 2015. The Past is Out There: Open air Palaeolithic sites and new research strategies in the Cantabrian region (northern Iberia). Quternary International 364, 181-187.

Barandiarán, I. 1999. La cueva de Isturitz (Pyrénées Atlantiques). Memoria de la campaña arqueológica de la campaña de excavaciones en la Sala de Saint-Martin, del 1 al 30 de julio de 1999. D.F.S. de fouilles programmées. S.R.A. Aquitaine.

Barandiarán, I., Benéitez, P., Cava, A., Millán, M.A. 2007. El taller gravetiense de Mugarduia sur (Navarra): identificación y cronología. Zephyrus 60, 85-96.

Barandiarán, I., Cava, A. 2001. El Paleolítico superior de la cueva de Zatoya (Navarra): actualización de los datos en 1997. Trabajos de Arqueología Navarra 15, 5-99.

Barandiarán, I., Cava, A., Aguirre, M. (dirs.). 2013. El taller de sílex de Mugarduia sur. Una ocupación de Urbasa (Navarra) durante el Gravetiense. Servicio Editorial de la Universidad del País Vasco, Bilbao.

Bond, G.C., Lotty, R. 1995. Iceberg Discharges into the North Atlantic on Millennial Time Scales During the Last Glaciation. Science 267, 1005-1010.

Calvo, A., Tapia, J., Arrizabalaga, A., Iriarte-Chiapusso, M.J. 2013. El yacimiento de Ametzagaina (Donostia, País Vasco). Un campamento gravetiense al aire libre en el Cantábrico. In: De Las Heras, C., Lasheras, J.A., Arrizabalaga, A., De la Rasilla, M. (coors.). Pensando el Gravetiense: nuevos datos para la Región Cantábrica, en su contexto peninsular y pirenaico, Monografías del Museo y Centro de Investigación de Altamira, 23, Madrid, pp. 243-254.

Chauchat, C. 1994. La station prehistorique de Lestaulan, quartier de Maignon, à Bayonne (Pyrénées Atlantiques). Munibe Antropologia-Arkeologia 46, 3-22.

De la Rasilla, M. 1989. Secuencia y crono-estratigrafía del Solutrense Cantábrico. Trabajos de Prehistoria 46, 35-46.

De Las Heras, C., Lasheras, J.A., Arrizabalaga, A., De la Rasilla, M. (coors.). 2013. Pensando el Gravetiense: nuevos datos para la Región Cantábrica, en su contexto peninsular y pirenaico, Monografías del Museo y Centro de Investigación de Altamira, 23, Madrid.

Dupré, M. 1984. Palinología de los niveles VII a II del yacimiento de Ekain, in Altuna, J. and Merino, J.M. (dirs.). El yacimiento prehistórico de la cueva de Ekain (Deba, Guipúzcoa). Eusko Ikaskuntza, San Sebastián, pp 61-63.

Dupré, M. 1988. Palinología y Paleoambiente. Nuevos datos españoles. Referencias. Serie Trabajos Varios, 84, Servicio de Investigación Prehistórica, Diputación Provincial de Valencia, Valencia.

Dupré, M. 1990. Análisis polínico de la cueva de Amalda. In: Altuna, A., Baldeón, A., Mariezkurrena, K. (dir). La cueva de Amalda (Zestoa, País Vasco). Ocupaciones paleolíticas y postpaleolíticas. Eusko Ikaskuntza, Donostia, pp. 49-51.

Falguères, Ch., Yokoyama, Y., Arrizabalaga, A. 2006. La geocronología del yacimiento pleistocénico de Lezetxiki (Arrasate, País Vasco). Crítica de las dataciones existentes y algunas nuevas aportaciones. Munibe 57, 93-106.

Garate, D., Rios-Garaizar, J., 2012. La cueva de Askondo (Mañaria): Arte parietal y ocupación humana durante la Prehistoria. Bizkaiko Arkeologi Indusketak (BAI) 2. Diputación Foral de Bizkaia, Bilbao.

Gómez-Orellana, L., 2002. El último Ciclo Glaciar-Interglaciar en el litoral del NW ibérico: Dinámica climática y paisajística. Ph.D. Thesis, Universidad de Santiago de Compostela, Lugo, Spain.

Hemming, S. R. 2004. Heinrich events: Massive late Pleistocene detritus layers of the North Atlantic and their global climate imprint. Review of Geophysics 42, RG1005.

Iriarte-Chiapusso, M.J. 2011a. El medio vegetal del yacimiento de Aitzbitarte III (Rentería, País Vasco), a partir de su análisis palinológico. In: Altuna, A., Marriezkurrena, K., Rios-Garaizar, J. (eds). Ocupaciones Humanas en Aitzbitarte III (País Vasco) 33.600-18.400 BP (Zona de entrada a la cueva). Colección de Patrimonio Cultural Vasco 5. Servicio Central de Publicaciones del Gobierno Vasco, Vitoria-Gasteiz, pp. 57-78.

Iriarte-Chiapusso, M.J. 2011b. Polen y vegetación en la secuencia estratigráfica de Santimamiñe (Kortezubi, Bizkaia). In: López Quintana, J.C (dir). La cueva de Santimamiñe: revisión y actualización (2004-2006). Bizkaiko Arkeologi Indusketak (BAI) 1. Diputación Foral de Bizkaia, Bilbao, pp. 321-342.

Iriarte-Chiapusso, M.J. 2013. La secuencia paleoambiental del taller gravetiense al aire libre de Mugarduia Sur (Sierra de Urbasa, Navarra). La contribución de la Palinologia. In: Barandiarán, I., Cava, A., Aguirre, M. El taller de sílex de Mugarduia sur. Una ocupación de Urbasa (Navarra) durante el Gravetiense. Servicio Editorial de la Universidad del País Vasco, Bilbao, pp. 87-100.

Iriarte-Chiapusso, M.J., Arrizabalaga, A. 2013. El Gravetiense de Bolinkoba a la luz de las excavaciones antiguas y recientes. In: De Las Heras, C., Lasheras, J.A., Arrizabalaga, A., De la Rasilla, M. (coors.). Pensando el Gravetiense: nuevos datos para la Región Cantábrica, en su contexto peninsular y pirenaico, Monografías del Museo y Centro de Investigación de Altamira, 23, Madrid, pp. 217-227.

Iriarte-Chiapusso, M.J., Murelaga, X., 2013. El registro microfaunístico y paleobotánico en la región cantábrica durante el Gravetiense. Reconstrucción paleoambiental. In: De

Las Heras, C., Lasheras, J.A., Arrizabalaga, A., De la Rasilla, M. (coors.). Pensando el Gravetiense: nuevos datos para la Región Cantábrica, en su contexto peninsular y pirenaico, Monografías del Museo y Centro de Investigación de Altamira, 23, Madrid, pp. 302-312.

Leroi-Gourhan, A. 1971. Análisis polínico de la cueva Morín. In: González-Echegaray, J., Freeman, L.G. (eds). Cueva Morín: excavaciones 1966-1968. Publicaciones del Patronato de las cuevas de la Provincia de Santander, Santander, pp. 359-365.

Leroi-Gourhan, A. 1980. Análisis polínico de El Pendo. In: González-Echegaray, J. (dir). El yacimiento de la cueva de “El Pendo” (excavaciones 1953-57). Biblioteca Praehistórica Hispana, Madrid, pp. 265-266.

Mary, G., Medus, J., Delibrias, G. 1975. Le Quaternaire de la cote Asturienne (Espagne). Bulletin de l’Association française pour l’Etude du Quaternaire 1, 13-23.

Mary, G., Medus, J., Delibrias, G. 1977. Documents sur l’évolution de la flore du Littoral Nord Espagnol au Würm. Recherches Françaisses sur le Quaternaire. INQUA 1977. Supplément au Bulletin de l’Association française pour l’Etude du Quaternaire 1 (50), 23-31.

Meese, D.A., Gow, A.J., Alley, R.B., Zielinski, G.A., Grootes, P.M., Ram, M., Taylor, K.C., Mayewski, P.A. and Bolzan, J.F. 1997. The Greenland Ice Sheet Project 2 depth-age scale: Methods and results. Journal of Geophysical Research 102, 26411–26423.

Rahmstorf, S., 2003. Timing of abrupt climate change: a precise clock. Research Letters 30, 1510.

Ramil-Rego, P., Iriarte-Chiapusso, M. J.; Muñiz-Sobrino, C., Gómez-Orellana, L. 2006. Cambio climático y dinámica temporal del paisaje y de los hábitats en las ecorregiones del NW de la península ibérica durante el Pleistoceno superior. Munibe 57 (1), Homenaje a J. Altuna, 537-551.

Rasmussen, S.O., Andersen, K.K., Bigler, M., Clausen, H.B., Dahl-Jensen, D., Fischer, H., Goto-Azuma, K., Hansson, M., Johnsen, S.J., Jouzel, J., Masson-Delmotte, V., Popp, T., Röthlisberger, R., Ruth, U., Stauffer, B., Siggaard-Andersen, M.L., Steffensen, J.P., Sveinbjörnsdóttir, A.E., Svensson, A., White, J.W.C. 2008. Dynamics of abrupt climate change as inferred from the NGRIP ice core record. Geophysical Research Abstracts 10.

Rios-Garaizar, J., Garate, D., Gómez-Olivencia, A., 2013. La cueva de Arlanpe (Lemoa): Ocupaciones humanas desde el Paleolítico Medio Antíguo hasta la Prehistoria, Bizkaiko Arkeologi Indusketak (BAI) 3. Diputación Foral de Bizkaia, Bilbao.

Ruiz-Alonso, M., Zapata, L., Arrizabalaga, A. 2013. Lower Palaeolithic charcoal from Irikaitz-Geltoki (Basque Country, Spain). In: Damblon, F. (ed.) Proceedings of the Fourth International Meeting of Anthracology, B.A.R. International Series S2486, Oxford, pp. 233-240.

Sánchez-Goñi, M. F. 1989. Análisis palinológico de los nivles VIII y IX de la cueva de Ekain. Memoria 1987-1988, 156, Sociedad de Estudios Vascos, San Sebastián.

Straus, L.G., González-Morales, M., Marín, A.B., Iriarte-Chiapusso, M.J. 2013. Las ocupaciones humanas de la cueva del Mirón (Ramales de la Victoria, Cantabria, España) durante el Último Máximo Glaciar y el periodo Solutrense. In: Ripoll, S., Avezuela, B., Jordá, J., Muñoz, F. (eds.) De punta a punta. El Solutrense en los albores del siglo XXI. UNED. Madrid, pp. 413-426.

Tapia, J., Arrizabalaga, A., Iriarte-Chiapusso, M.J., Calvo, A. 2009. El campamento gravetiense de Ametzagaina (Donostia, País Vasco). Un avance a su estudio arqueológico. Munibe 60, 99–115.

Wood, R.E., Arrizabalaga, A., Camps, M., Fallon, S., Iriarte-Chiapusso, M.J., Jones, R., Maroto, J. de la Rasilla, M., Santamaría, D., Soler, J., Soler, N., Villaluenga, A., Higham, T.F.G. 2014. The chronology of the earliest Upper Palaeolithic in northern Iberia:New insights from L'Arbreda, Labeko Koba and La Viña. Journal of Human Evolution 69, 91-109.

CAPTIONS FOR FIGURES

Figure 1. Main sites cited through the text: 1. Cueva Morín; 2. El Mirón; 3. Antoliñako Koba and Santimamiñe; 4. Arlanpe; 5. Askondo; 6. Bolinkoba; 7. Prado; 8. Pelbarte; 9. Mugarduia South; 10. Usategi; 11. Aldatxarren; 12. Ekain; 13. Irikaitz; 14. Amalda; 15. Ametzagaina; 16. Aitzbitarte III and Aitzbitarte IV; 17. Alkerdi; 18. Isturitz; 19. Gatzarria; 20. Zatoya.

Figure 2: Palynological diagram from Aitzbitarte III

Figure 3: Palynological diagram from Ametzagaina

Figure 4: Palynological diagram from Mugarduia South

Figure 5: Accumulated curve of calibrated radiocarbon dates obtained in the sites of western-central Cantabrian region, Pyrenean area and Basque Crossroads which lithics are adscribed to Gravettian (from Arrizabalaga and De la Peña, 2013).

Figure

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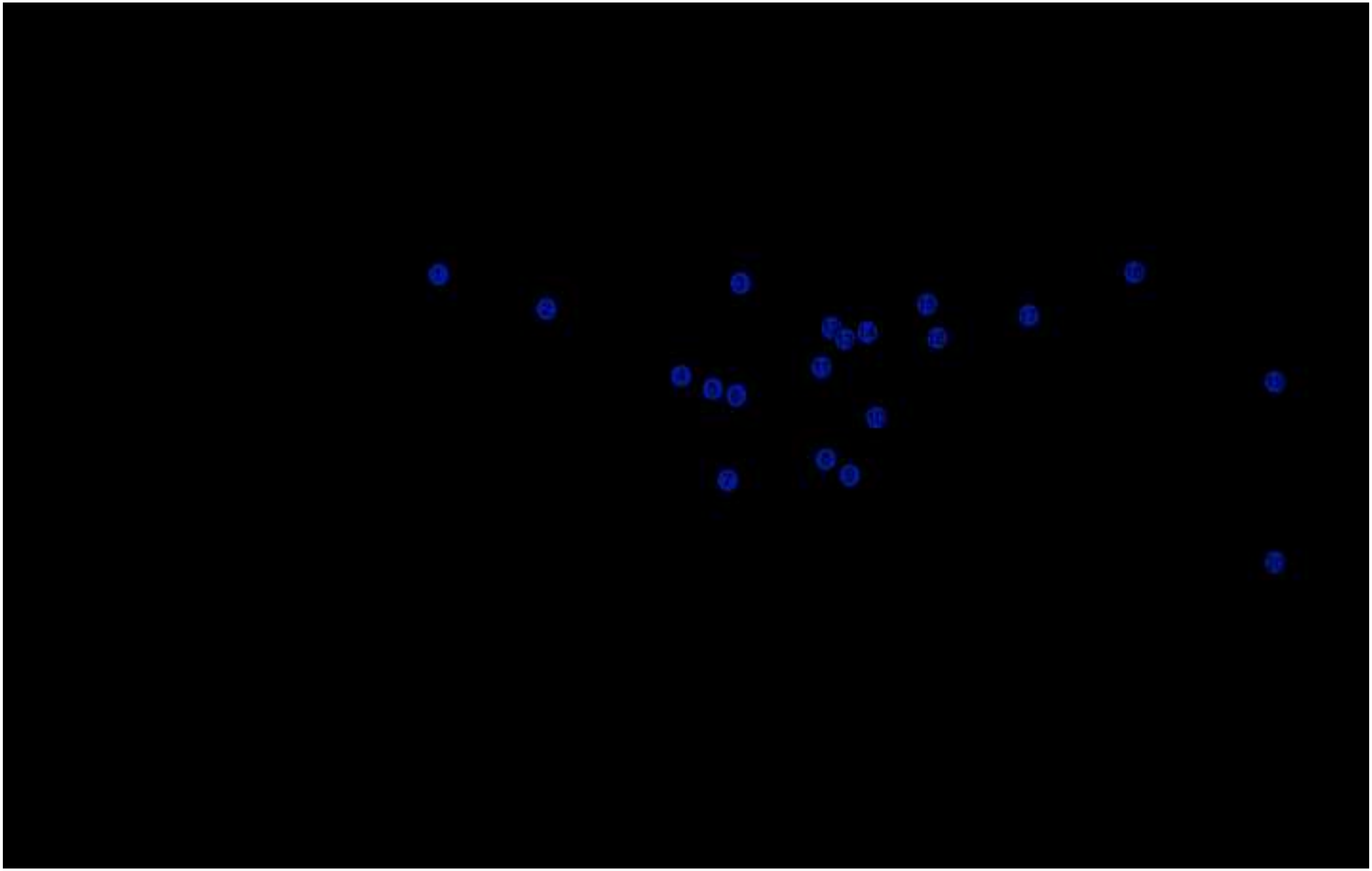

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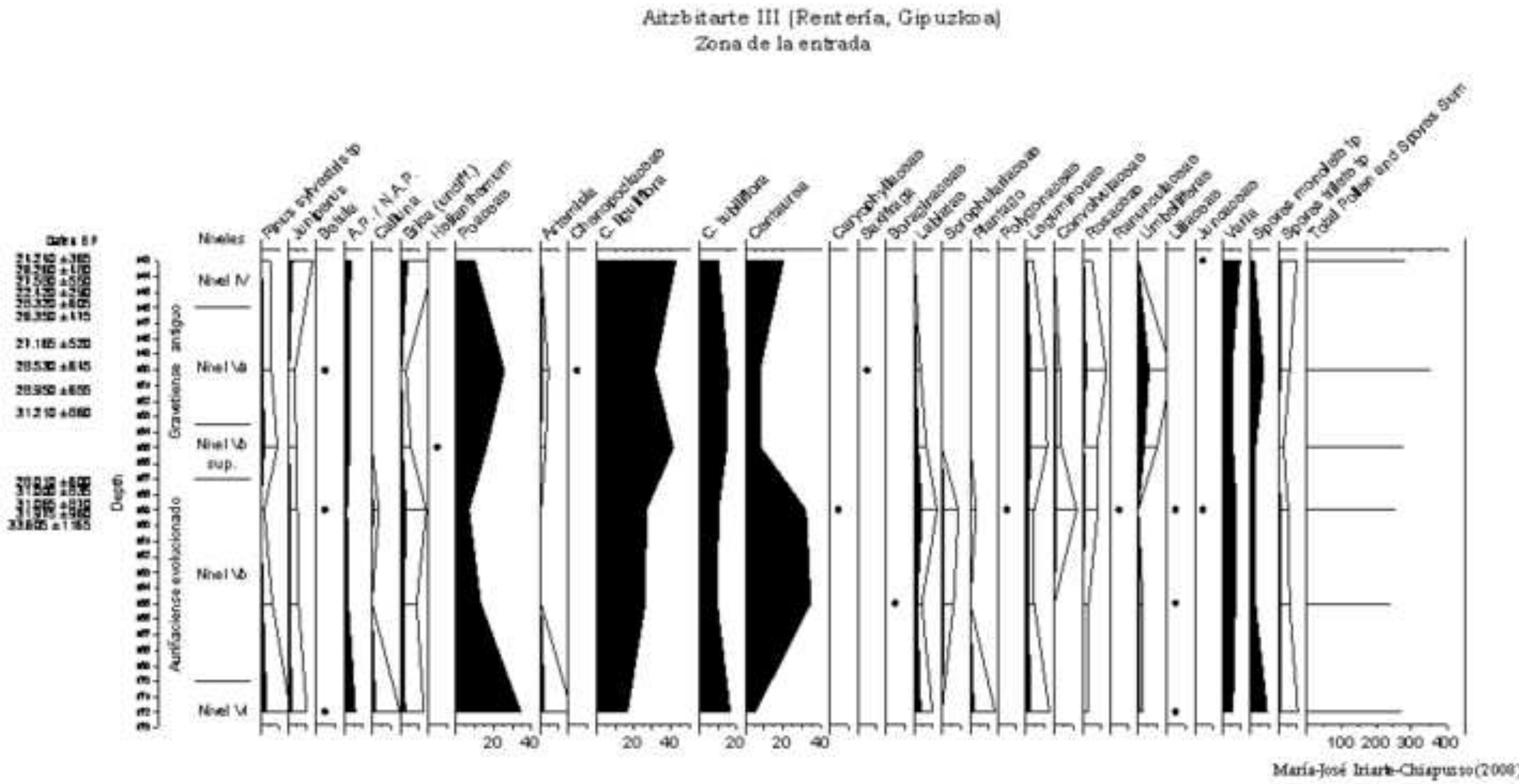

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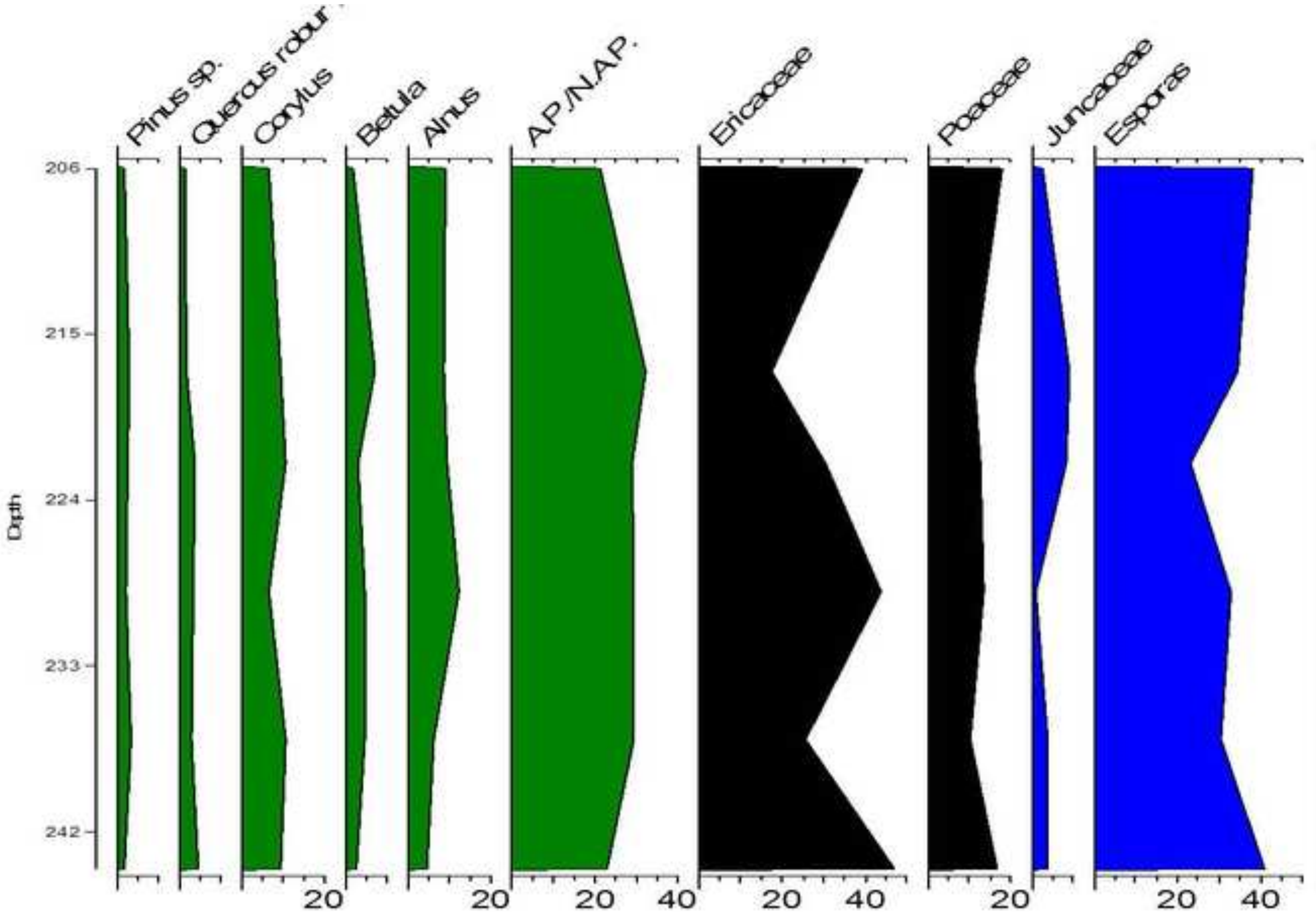

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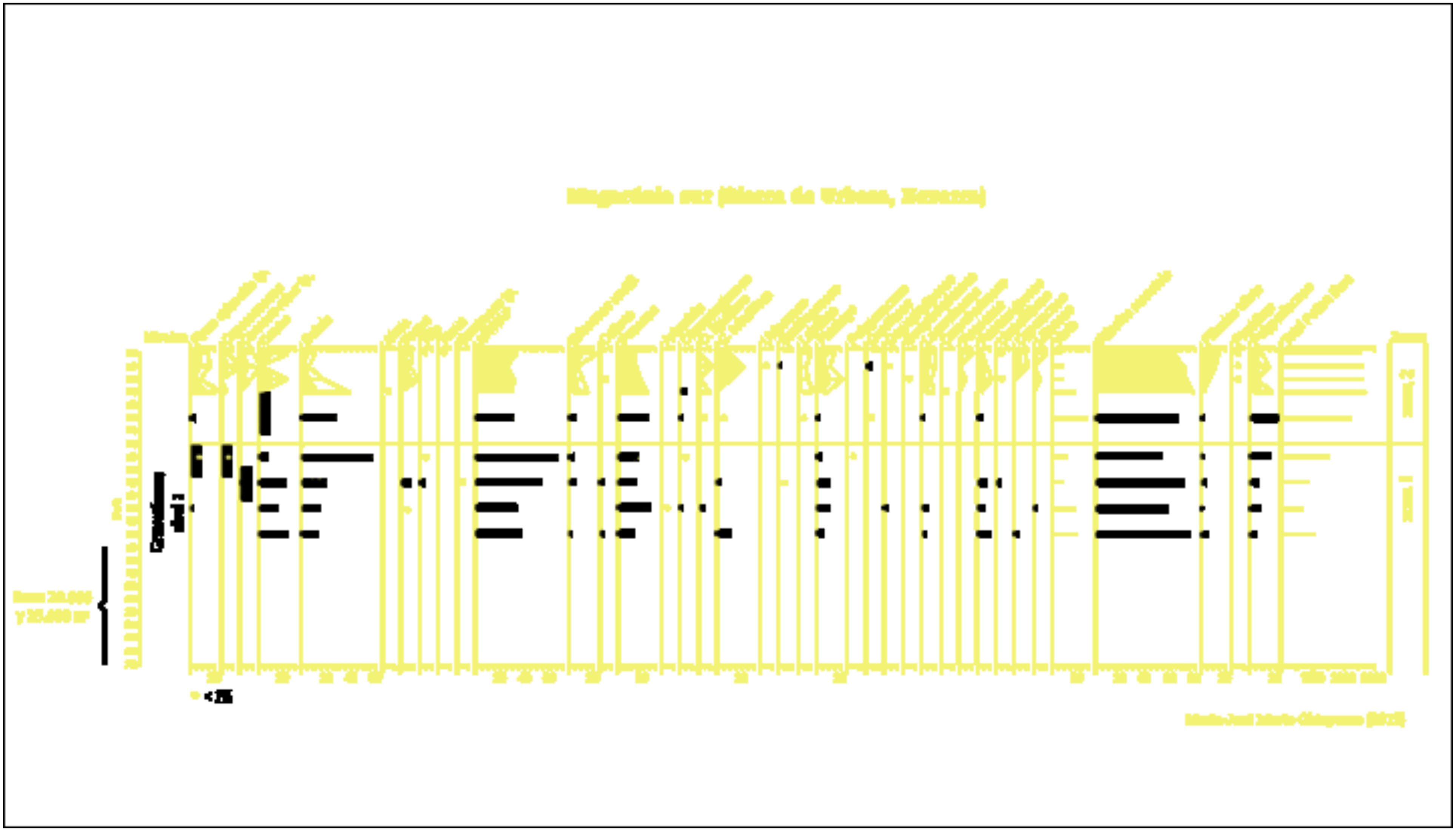

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