

Radiocarbon Dates for Las Chimeneas (Cantabria, Spain) Palaeolithic Cave Art: Quality of Radiocarbon and Relevance to Parietal Art

MARCOS GARCÍA-DIEZ¹ , ÁLVARO IBERO¹ , BLANCA OCHOA¹ ,
PAULA LÓPEZ-CALLE¹  AND DANIEL GARRIDO² 

¹*Department of Prehistory, Ancient History and Archaeology, Complutense University of Madrid, Madrid, Spain*

²*Prehistoric Caves of Cantabria, Puente Viesgo, Spain*

AMS radiocarbon dating has been widely applied in Palaeolithic art research and its value has been proven over the past three decades. Yet it still suffers from issues that need to be discussed and analysed to improve future sampling strategies and strengthen the interpretation of the results. This study presents new AMS dates for the parietal art in Cueva de Las Chimeneas in northern Spain, describes the quality of the samples, and discusses their reliability. The joint assessment of the dates and its comparison with previously obtained dates as well as stratified and dated portable art makes it possible to put forward a hypothesis about the time of creation of the cave's parietal art and the degree of synchrony or diachrony in its production. Consequently, it is proposed that the cave art at Las Chimeneas was created in the lower Magdalenian, between 19,000 and 17,500 cal BP.

Keywords: AMS ¹⁴C dating, radiocarbon, chronology, rock art, Magdalenian, Upper Palaeolithic

INTRODUCTION

In the early twentieth century, the first scholars working in prehistoric cave art considered chronology to be a key part of their research. Their main proposals for the development of prehistoric art envisaged a linear evolution (Breuil, 1952; Leroi-Gourhan, 1965). Those theories were widely accepted by researchers until new methods for the direct dating of paintings appeared in the 1990s. The data acquired for the chronology of the European

Palaeolithic representations modified and/or nuanced the proposed sequences (Pettitt & Pike, 2007; Hoffmann et al., 2018; Ochoa et al., 2020).

Our understanding of the development of Palaeolithic cave art is currently disparate. Most parietal art radiocarbon dates and the contextualized portable evidence are concentrated in the later stages of the Upper Palaeolithic (middle Magdalenian and upper-final Magdalenian). For earlier times, the available information is significantly limited. This has important

implications for the dating of cave art, which has been based principally on comparison between dated portable and parietal series. Consequently, the development of art in more recent periods of the Upper Palaeolithic is known in detail, while previous periods, such as the pre-Magdalenian and the initial phases of the Magdalenian, are much less well known. In the past few decades, however, AMS radiocarbon dating and other techniques like U-series dating have made it possible to address these key aspects of research with scientific data.

The application of AMS radiocarbon dating to cave art involves working with small samples that have been subjected to largely unknown micro-environmental conditions. This might impose limits on the results due to natural contamination and anthropic impact (Hedges et al., 1998; Valladas et al., 1999, 2006; Fortea, 2002; Scharebreyter-Gurtner et al., 2002; Clottes & Valladas, 2003; Valladas, 2003; Alcolea & Balbín-Behrmann, 2007; Pettitt & Pike, 2007; Hoffmann et al., 2016; Bonneau et al., 2017; Pike et al., 2017; David et al., 2019; Ochoa et al., 2020). To avoid or minimize the effect of contamination on the results, pre-treatment protocols are applied to the samples. Nonetheless, the incoherence of widely-accepted archaeological assumptions or of other scientific results has led some researchers to question the reliability of certain results. This includes interpretive problems linked to the origin of the carbon used, in particular the relation between the time of death of the wood being dated and the graphic event being targeted, which generate archaeological uncertainties and raise new questions. Advancing in our knowledge will involve obtaining new dates, assessing the quality of the results, and discussing their relevance in our interpretations. The results obtained for cave art should thus be assessed critically.

This study presents new radiocarbon dates for Palaeolithic art at Cueva de Las Chimeneas. Their reliability is discussed, and the results are compared with other dates obtained in the 1990s. Their archaeological significance is assessed and working hypotheses are proposed in order to better understand the graphic development of Upper Palaeolithic hunter-gatherer societies before the middle Magdalenian.

CUEVA DE LAS CHIMENEAS IN SUMMARY

The cave of Las Chimeneas is located in Monte Castillo, in the municipal district of Puente Viesgo in Cantabria, northern Spain (Figure 1). It was discovered in 1953. Monte Castillo contains other caves with prehistoric art: El Castillo, Pasioga, Las Monedas, and Cantera I. This concentration of caves emphasizes the symbolic value of the cone-shaped hill, which has been called the 'Sacred Mountain' (García-Diez et al., 2018) because of the density of motifs and the repeated and continuous decoration and occupation of the sites. UNESCO listed Las Chimeneas as a World Heritage site in 2008 (García-Diez, 2009).

The cave (Figure 1) consists of two levels connected by a shaft or 'chimney' 15 m deep (González Echeagaray, 1974; García-Diez & Garrido, 2014). The upper level, with its modern, artificially made entrance, is a passage with many large speleothems. No anthropic evidence has been found on this level, all the cave art being located in the 160 m-long lower level. The cave's original entrance is now blocked, but it connected with a straight passage that led to the most densely decorated area and a circular chamber called the *Hall of the Paintings*. From there, the cave continues along smaller and, in some cases, difficult passages. The sedimentary deposits in the old entrance have not yielded

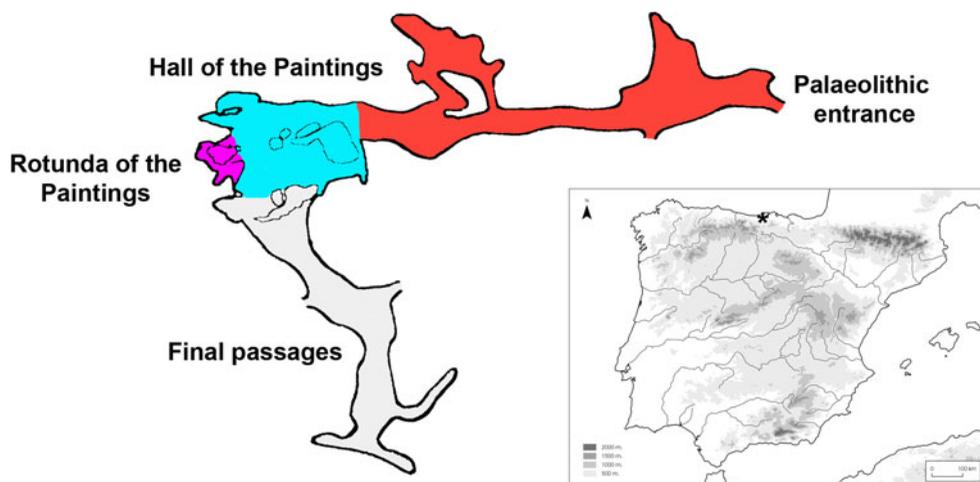


Figure 1. Location of the cave of Las Chimeneas and topography of the lower level.

any evidence of occupation within the inner cave.

The drawings and engravings are distributed in the different areas of the lower level, mostly at the end of the main passage. The first figure, an incompletely engraved caprid, is found halfway along the main passage, near the shaft that connects the two levels of the cave. Continuing along the main passage, numerous finger tracings stand out because of their cameo chromatic effect on the wall. Above them, two possible bovids face one another, and a possible incomplete hind is depicted below them. A little further on, on the opposite wall, a finger-drawn sign and a stag with large antlers in twisted perspective are located next to a reticulated sign. ‘Macaroni’ designs drawn with fingers, incised with a pointed object, and scraped are visible in the sector just before the *Hall of the Paintings*. Beneath an overhang, the first black drawing is an incomplete ibex.

At the end of the passage and inside the *Hall of the Paintings*, black drawings represent at least two simple rectangles, two simple trapezoidal shapes, two rectangles with a double zigzag on their upper side,

two large rectangles with different interior patterns, and convergent lines that together with the shape of the wall might depict a zoomorph. To the right, some black lines might correspond to an unfinished rectangle, while a partial figure of a horse may be integrated with the shape of the rock. Above them, in the roof, several engraved lines include a simple rectangle and a dashed line. To the left, in the roof, a large rectangle was drawn with fingers; a smaller rectangle with small parallel lines in the middle is drawn inside the larger rectangle.

Behind this panel (Figure 2), a small passage called the *Rotunda of the Paintings* can be reached in two ways. Entering on the left, a horse’s head is associated with the edge of the rock and a stag’s head. Following the narrow and low passage, a small chamber is reached: it features five stags, together with black lines, a simple rectangle, and macaroni. The stags, four of them complete and one partial, are characterized by the simplicity of the drawings and the absence of the nasal-frontal region. Their accumulation in a small chamber, their arrangement in two pairs of stags, and the variation in their orientation suggest that they form a composition.



Figure 2. General view of the stags of the Rotunda of the Paintings.

Back in the *Hall of the Paintings*, to the right, a sector with a low irregular roof contains more figures on the different faces of the ribs of rock in the roof. The surface is soft; some motifs were drawn with fingers and others with blunt or sharp implements. Four panels have been distinguished: among numerous lines, a large number of zoomorphs can be identified (eight or nine aurochs, four stags, two hinds, one or two ibex, a chamois, a horse, and two indeterminate animals). They are all incomplete, drawn with a simple outline, and have few internal details.

MATERIALS, METHODS, AND RESULTS

Four new radiocarbon dates for the parietal art in Las Chimeneas (samples CH-1, CH-2, CH-4a, and CH-5) are presented here (Figure 3). The samples were processed by the Oxford Radiocarbon Accelerator Unit (ORAU). Another two dates (Samples 1

and 2) had been published in the past (Moure et al., 1996). They were processed in the Laboratoire mixte CNRS-CEA of the Centre des faibles Radioactives in Gif-sur-Yvette and are included here for discussion and analysis.

- Sample 1 (Figure 3 top left). Stag no. 20, located in the *Rotunda of the Paintings*. This figure, drawn in charcoal, has a simple outline and rounded anatomical connections. It is formed by part of the maxillary line, frontal line, antlers (brow tines and main beams), neck, cervical-dorsal line, croup (top of rump), rump, hind legs, belly, forelegs, chest, and eye, with indication of the tear duct. Radiocarbon measurement (GifA-95194): $15,070 \pm 140$ BP, corresponding to 18,715–18,167 cal BP at 95.4% confidence (Table 1 and Figure 4).
- Sample 2 (Figure 3 top right). Black lines to the right of Group 14, in the *Hall of the Paintings*, drawn in charcoal. Radiocarbon measurement (GifA-

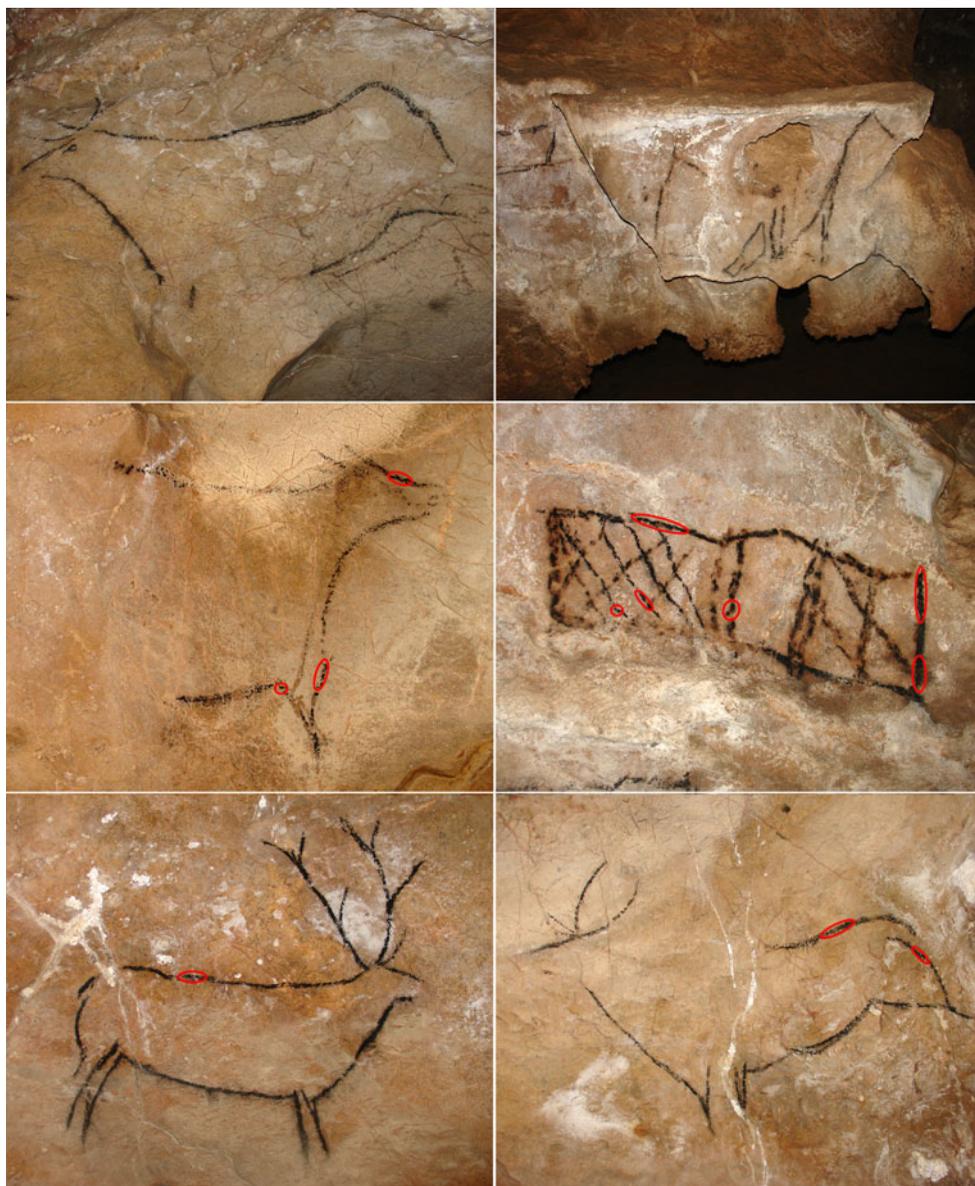


Figure 3. The AMS-dated figures from Las Chimeneas with sample locations marked in red. Top left: Sample 1, stag no. 20; top right: Sample 2, black lines; centre left: Sample CH-1, ibex no. 13; centre right: Sample CH-2, rectangular shape; bottom left: Sample CH-4a, stag no. 19; bottom right: Sample CH-5, stag no. 21.

95230): $13,940 \pm 140$ BP (also published as $13,949 \pm 140$ BP in Moure *et al.*, 1996), corresponding to 17,346–16,520 cal BP at 95.4% confidence (Table 1 and Figure 4).

- Sample CH-1 (Figure 3 centre left). Ibex no. 13 (caprid), located in the *Hall of the Paintings*. It is a partial figure (forequarters) represented only by the outline, drawn with charcoal. It consists

Table 1. AMS dates obtained for Las Chimeneas. The results were calibrated with the IntCal20 curve (Reimer et al., 2020) using the OxCal 4.4 program (Bronk Ramsey et al., 2009).

Sample	Laboratory ref.	Motif	Pre-treatment	$\delta^{13}\text{C}$ (‰)	Date BP	cal BP date at 95.4% confidence
Sample 1	GifA-95194	Stag no. 20	n/a	n/a	15,070 \pm 140	18,715–18,167
Sample 2	GifA-95230	Lines no. 14	n/a	n/a	13,940 \pm 140	17,346–16,520
CH-1	OxA-X-2386-21	Ibex no. 13	Non-routine	-26.27	16,850 \pm 270	20,951–19,610
CH-2	OxA-X-2386-22	Rectangle no. 14	Non-routine	-26.13	14,610 \pm 130	18,200–17,446
CH-4a	OxA-X-2377-7	Stag no. 19	Only acid	-23.86	15,540 \pm 70	18,946–18,710
CH-5	OxA-X-2377-8	Stag no. 21	Only acid	-25.54	14,730 \pm 100	18,252–17,771

of the frontal and maxillary lines, nostril, one ear, two small horns, a longitudinal dividing line on the face, chest, forelimb and front part of the belly, front half of the cervical-dorsal line, and the neck. The lines and anatomical connections are mostly rounded but the connection between the forelimb and belly is angular. The sample was collected from three anatomical regions (frontal line, lower part of the chest, and the back of the forelimb) and from different lines (frontal line, chest, and foreleg). Radiocarbon measurement (OxA-X-2386-21): 16,850 \pm 270 BP, corresponding to 20,951–19,610 cal BP at 95.4% confidence; $\delta^{13}\text{C}$ (‰): -26.27‰. Laboratory comment: ‘this sample was “OxA-X-ed” to reflect very small starting weights of carbon and non-routine chemical preparation applied to preserve a dateable fraction’; ‘OxA-X-ed’ refers to the laboratory number assigned by ORAU; the OxA-X-xxx (where xxx is a number) refers to the dates that are ‘research measurements using non-standard or experimental methods’ (Oxford Radiocarbon Accelerator Unit, n.d.).

- Sample CH-2 (Figure 3 centre right). Rectangular shape to the left of Group 14, in the *Hall of the Paintings*, drawn with charcoal. This rectangle is divided internally into three parts separated by two vertical lines. The left sector, the

largest, is filled by a lattice pattern; the centre is empty and smaller, while the right sector is divided by a cross. The sample was taken from six lines in four areas (upper side, right side, vertical separating line, and oblique lines in the left sector). Radiocarbon measurement (OxA-X-2386-22): 14,610 \pm 130 BP, corresponding to 18,200–17,446 cal BP at 95.4% confidence; $\delta^{13}\text{C}$ (‰): -26.13‰. Laboratory comment: ‘this sample was OxA-X-ed to reflect very small starting weights of carbon and non-routine chemical preparation applied to preserve a dateable fraction’ (Table 1 and Figure 4).

- Sample CH-4a (Figure 3 bottom left). Stag no. 19 in the *Rotunda of the Paintings*. This outline figure, drawn with simple lines using charcoal, is composed of the maxillary and frontal lines, large antlers (main beams, brow tines, bay tines, royal antlers, and crown), neck, cervical-dorsal line, croup, rump, tail, hind legs, belly, forelegs, and chest. The lines and anatomical connections are mostly rounded except for the connections between the limbs and belly. The sample was collected from a single line in one anatomical region (the back). Radiocarbon measurement (OxA-X-2377-7): 15,540 \pm 70 BP, corresponding to 18,946–18,710 cal BP at 95.4% confidence; $\delta^{13}\text{C}$ (‰): -23.86‰. Laboratory

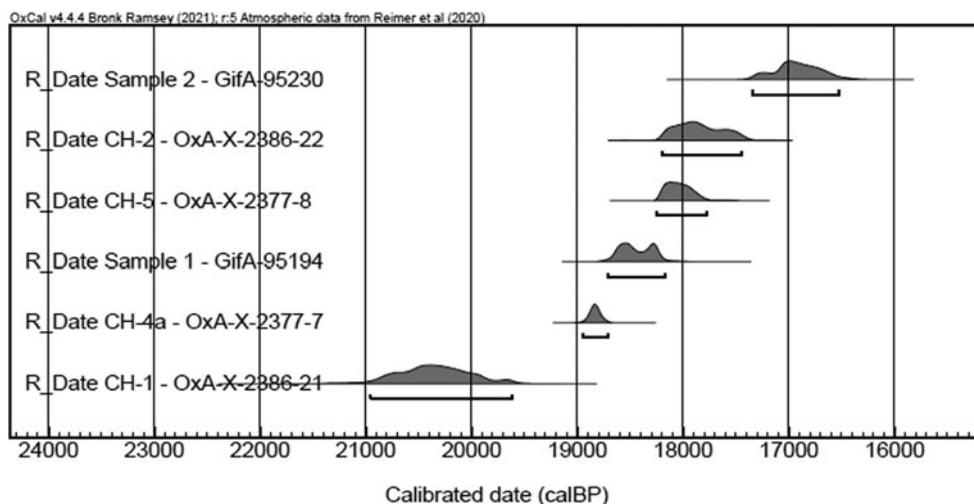


Figure 4. AMS dating of the Las Chimeneas images.

comments: ‘this sample was treated using only an acid preparation step, which is not the full treatment for this type of sample. This was due to extremely small starting weights and to the fact that many other samples of a similar size from the same site had failed. This date should therefore be viewed with a health warning. It is possible that unremoved contaminants might remain to influence the age. For this reason, the sample was OxA-X-ed’ (Table 1 and Figure 4).

- Sample CH-5 (Figure 3 bottom right). Stag no. 21 in the *Rotunda of the Paintings*. It is an outline figure, drawn with simple lines using charcoal, consisting of the maxillary line, part of the frontal line, antlers (brow tines and main beams), neck possibly suggested by the shape of the wall, back part of the cervical-dorsal line, croup, rump, tail, hind leg, belly, forelimbs, and chest. The lines and anatomical connections are mostly rounded except for the connections between the limbs and the belly. The sample was taken from lines in two anatomical regions, the back and the rump. Radiocarbon measurement (OxA-X-

2377-8): $14,730 \pm 100$ BP, corresponding to 18,252–17,771 cal BP at 95.4% confidence; $\delta^{13}\text{C}$ (‰): -25.54 ‰. Laboratory comments: ‘this sample was treated using only an acid preparation step, which is not the full treatment for this type of sample. This was due to extremely small starting weights and to the fact that many other samples of a similar size from the same site had failed. This date should therefore be viewed with a health warning. It is possible that unremoved contaminants might remain to influence the age. For this reason the sample was OxA-X-ed’ (Table 1 and Figure 4).

DISCUSSION

Quality of the results

The cave of Las Chimeneas is in an optimal state of conservation because the works carried out in the lower passage were minimal (lowering and levelling the floors in some areas and barriers in front of the panels, which have been removed), barely affecting or altering the areas where

the dated drawings are located (García-Diez et al., 2013). In addition, the number of visits has been, and still is, limited, being normally restricted to small groups and of a short duration. There is no graffiti on the walls. This suggests that any potential anthropic contamination after the discovery of the cave has had very little or no impact on the pigment used for the parietal depictions.

We do not know the quantity of the datable charcoal samples analysed by ORAU, but it must have been small in the case of the samples CH-1, CH-2, CH-4a, and CH-5 because the laboratory informed us that the original weight of the samples was very small (CH-1 and CH-2) or extremely small (CH-4a and CH-5), i.e. the weight of the datable charcoal was probably less than 0.5 mcg. The same lack of information affects Samples 1 and 2.

Given the initially very low weight of samples CH-1 and CH-2, they were dated following a non-routine chemical preparation (Brock et al., 2010). ORAU reports that samples CH-4a and CH-5 were prepared 'using only an acid preparation step, which is not the full treatment for this type of sample' (normally an acid-base-acid treatment, ABA), which implies that some contaminants may not have been removed (such as carbonates, humic and fulvic acids, and other unknown pollutants). This might influence the result obtained.

No specific information is available about the preparation treatment for Samples 1 and 2. It probably followed the usual protocol for dating cave art at the Gif-sur-Yvette laboratory, which stipulates the need to halt the pre-treatment before completion to avoid the disappearance of all the dateable carbon. Details of the pre-treatment were not published.

Of the four new determinations, three (CH-1, CH-2, and CH-5) correspond to multiple samples; these were formed by combining small samples of charcoal from

different anatomical parts or regions of the same figure, or of different traces (the amount collected in a single movement of the hand) from the same anatomical part or region. The other new determination, CH-4a, corresponds to a single sample. Although it was not specified, Samples 1 and 2 were probably taken by multiple sampling as that was the usual procedure in the early 1990s.

We can therefore be sure that the material dated in CH-4 comes from a single temporal event. In contrast, in the case of CH-1, CH-2, and CH-5 (and probably Samples 1 and 2) we cannot be certain that the different lines that were sampled were all produced at the same time or whether they accumulated in different episodes of artistic production.

This information about the quality of the samples from Las Chimeneas that have been dated means that the results cannot be accepted directly; they must be treated with caution rather than considered indisputable archaeological data. The small weight of the carbon and, especially, the consequent lack of complete pre-treatment and/or application of a non-routine pre-treatment require us to bear in mind the potential limitations of the results. Moreover, it cannot be ascertained beyond doubt that five of the six results are representative of a particular time of production. Therefore, any considerations based on these results must be regarded as working hypotheses to be confirmed by new data in future studies.

Cueva de Las Chimeneas in the context of dated Iberian Palaeolithic portable and parietal art

By considering portable art found in reliable archaeological contexts, the art in Las Chimeneas can be compared within its northern Spanish setting and the Iberian

Peninsula in general (Figure 5). In northern Spain, portable art animal figures are, however, few for the upper Solutrean and the first phases of the Magdalenian (Barandiarán, 1972, 1994; Corchón, 1986, 2004). Comparisons cannot be made in most cases either because the representations are very simple (at Ermitia, Lumentxa, El Buxu, and Las Caldas) or stylistically dissimilar from those of Las Chimeneas (at Bolinkoba and Altamira), or because the use of different artistic techniques (sculpture in El Buxu and El Pendo) cannot be readily compared. The only points of reference are with a bovid found in an early Magdalenian level in Balmori (Figure 5A), related to Las Chimeneas by its very simple outline and the formal treatment of some limbs, and some striated figures from the lower Magdalenian level at the cave of El Castillo (Figure 5B and 5C), where the ends of the limbs are similar to those of Las Chimeneas. Another point of resemblance may be a preference for rectangular or pseudo-rectangular shapes (traditionally referred to as tectiforms) in lower Magdalenian portable art in the region. Even so, the comparison of the Las Chimeneas rectangular motif with portable examples from El Cierro (Figure 5D), Altamira (Figure 5E), and Rascaño (Figure 5F) is limited to basic geometric traits and the presence of internal lines (which are more complex at Las Chimeneas).

In Mediterranean Spain, the collection of portable art from El Parpalló (Villaverde, 1994) allows comparisons with Las Chimeneas, as regards both upper Solutrean and Solutrean-Gravettian art and the early Magdalenian A figures. The appearance of elongated triangular limbs and open parallel legs, the greater size of the heads, an occasional tendency to represent large hind quarters, linear V-shaped horns, and simple outlines would

suggest that Las Chimeneas imagery is attributable to the evolved Solutrean by analogy with El Parpalló. In terms of continuity of the subject matter represented, the early Magdalenian represents a 'step backwards'; it is characterized by an increase in the number of cervids compared with caprids and a simplification of the anatomical structure which departs from their analytical figurative representation. On the other hand, the quadrangular signs (Figure 5G, 5H, and 5I), most of which are simple rectangular shapes without complex internal divisions, are attributed to the upper and evolved Solutrean at El Parpalló (Villaverde & Cantó, 2020).

In the Cantabrian rock art repertoire, there are hardly any figures comparable to those of Las Chimeneas for which reliable dating is available. At Altamira, a painted tectiform-type quadrangular sign (Breuil & Obermaier, 1935: no. 57a) from the Final Gallery (Figure 5J) yielded a result of 19,110–18,270 cal BP at 95.4% confidence (GifA-91185; Moure *et al.*, 1996: 308); this sign has a complex pattern of linear infill, similar to that of other signs next to it. In another space in the same cave, a rather simple doe head, known as the 'La Hoya Hind' (Figure 5K) has been dated to 18,767–17,996 cal BP at 95.4% confidence (GifA-96062; Moure *et al.*, 1996: 303); this figure's incompleteness, its contours, its use of twisted perspective, and its position right on the edge of the parietal support shares traits with some of the Las Chimeneas figures. Finally, in the cave of El Castillo, an ibex (Alcalde del Río *et al.*, 1911: no. 56–57) (Figure 5L), dated to 18,272–17,522 cal BP at 95.4% confidence (GifA-98156; Moure & González-Sainz, 2000: table 1), shares with some of the dated figures in Las Chimeneas its rounded contour, the opening of the snout area, and the general morphology of the forelimb.

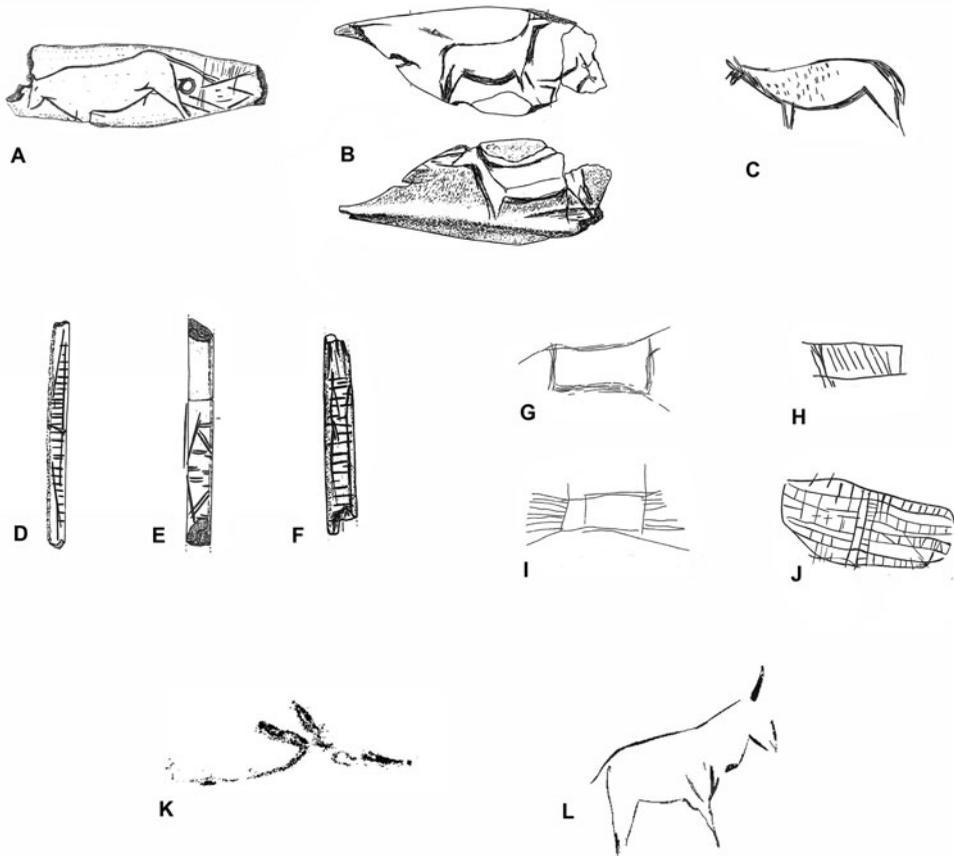


Figure 5. Contextualized portable evidence and dated rock art which show graphic affinities with the figures dated at Las Chimeneas. (A–F after Corchón, 1986; G–I after Villaverde & Cantó, 2020; J after Breuil & Obermaier, 1935; K after Rogerio-Candelera & Élez Villar, 2009; L after Alcalde del Río et al., 1911).

In sum, stylistic and thematic comparisons suggest that the cave art in Las Chimeneas can be attributed generically to a time in the upper Solutrean or initial Magdalenian. Comparison with the Mediterranean evidence would indicate that the zoomorphic representations belong to this entire timespan, whereas the signs would be restricted to the Solutrean period. Contextualized portable art and dated rock art in the nearest contexts in northern Spain would also indicate that the Las Chimeneas cave art belongs to the lower Magdalenian (approximately between 19,000 and 17,500 cal BP).

An internal comparison: synchrony or diachrony?

Based on the style of the motifs in Las Chimeneas, various researchers have proposed several hypotheses for their age. The application of Leroi-Gourhan's (1965) morpho-stylistic sequence would suggest that it belongs to his Style III (c. 19,000–15,000 BP). Leroi-Gourhan maintained that proposal in his general study of Palaeolithic art, and González Echegaray (1974, 1992) took up this attribution in his monograph on Las Chimeneas, where he restricted the age to

about 17,000–16,500 BP in the transition from the Solutrean to the Magdalenian. Later, other authors, or the same authors nuancing their conclusions, have accepted that chronology. The publication of the first AMS radiocarbon dates (Samples 1 and 2) generated an internal debate about the validity of the results among the researchers who published them (Moure et al., 1996: 316–19): the synchrony of the ensemble was generally accepted, although some (González-Sainz) attributed it to the first half (before 17,000 BP) and others (Moure, Bernaldo de Quirós, and Cabrera Valdés) to the second half (after 17,000 BP) of Leroi-Gourhan's Style III.

The presence and absence of overlaps between the different radiocarbon results and the spatial relationships between the motifs leave room for a debate about whether the black drawings in the cave of Las Chimeneas are chronologically and/or culturally synchronic or diachronic.

Our results (Figure 4) show that CH-1 (caprid, ibex no. 13) and Sample 2 (lines no. 14) are the oldest and most recent dates, respectively, and do not overlap with any other sample. They bracket an extended and discontinuous period between 20,951 and 16,520 cal BP for the production of the black parietal art in Las Chimeneas. The other samples (CH-2, CH-4a, CH-5, and Sample 1) overlap chronologically to different degrees (see below and Table 1).

In the *Rotunda of the Paintings*, Sample 1 (18,715–18,167 cal BP) overlaps with the other two stags that have been dated, i.e. CH-5 (18,252–18,167 cal BP) and CH-4a (18,715–18,710 cal BP), the latter two dates not overlapping each other. This would imply that the group of stags was painted intermittently between 18,715 and 18,167 cal BP.

The timespan between the production of the stags in the *Rotunda of the Paintings* and the ibex no. 13 (CH-1) in the *Hall of*

the Paintings would range from a minimum of 895 years (between 19,610 and 18,715 cal BP) to a maximum of 2784 years (between 20,951 and 18,167 cal BP). Therefore, the results clearly suggest a temporal difference.

The two non-figurative motifs (the linear Sample 2, 17,346–16,520 cal BP, and the geometric CH-2, 18,200–17,446 cal BP) in the *Hall of the Paintings* (in the sector just before the access to the *Rotunda of the Paintings*, and 10 m from the ibex no. 13 in the same chamber) do not overlap with one another; a gap of at least 100 years (between 17,446 and 17,346 cal BP) suggests that they were created at different times between 18,200 and 16,520 cal BP. On the other hand, the date for the rectangle (CH-2) overlaps with two of the stags: with CH-5 by 429 years (between 18,200 [CH-2] and 17,771 cal BP [CH-5]) and with Sample 1 by 33 years (between 18,200 [CH-2] and 18,167 cal BP [Sample 1]).

Consequently, if all the dates obtained by AMS radiocarbon dating are considered reliable, we should conclude that the series of black drawings in Las Chimeneas was produced in at least three chrono-cultural phases between 20,951 and 16,520 cal BP. These are: Phase 1) the upper Solutrean or initial Magdalenian (20,951 to 19,610 cal BP), when ibex no. 13 was drawn in the *Hall of the Paintings*; Phase 2) the lower Magdalenian, in a maximum timespan ranging from 18,715 to 18,167 cal BP, when several stag motifs were produced in the *Rotunda of the Paintings* (stags nos. 19, 20, and 21) and a geometric form (rectangle no. 14) was drawn in the *Hall of the Paintings*; Phase 3) the middle Magdalenian (17,346 to 16,520 cal BP), when linear forms were drawn in the *Hall of the Paintings* (lines no. 14). The stylistic comparisons made above would support the identification of Phases 1 and 2, but not that of Phase 3.

Alternatively, the limitations of the quality of the results discussed earlier may require this hypothesis of gradual and discontinuous iconographic activity to be reconsidered. The synchronicity of the Las Chimeneas ensemble would be justified if the greatest importance were ascribed to the result obtained for a single sample (CH-4a, 18,946–18,710 cal BP) and this would agree with the comparisons with portable art in Cantabrian Spain. This timespan coincides with the different overlaps between the parietal figures (CH-2, CH-4a, CH-5, and Sample 1), which gives an overall span bracketed between 18,946 (earliest date for CH-4) and 17,446 cal BP (latest date for CH-2) and a chronological agreement between 18,715 and 18,167 cal BP among the dates obtained.

Given the information currently available and based on the arguments presented here, we consider that the most plausible hypothesis is that the painted depictions at Las Chimeneas were culturally synchronic (but not evidence of synchronicity *sensu stricto*), although this must be tested with further dates. The potential links between figures in terms of time, as well as technique (black charcoal drawings) and style (simple outline figures with no special attention to secondary anatomy, twisted and semi-twisted perspectives of the antlers, enlarged forequarters, and absence of the nasal-frontal line) suggest that the black drawings in the cave of Las Chimeneas were created in the lower Magdalenian.

The imagery at Las Chimeneas includes other engraved animal figures. Their morpho-stylistic analysis makes it possible to document close graphic links (rounded contour figures, twisted and semi-twisted perspectives, and anatomical simplicity) with those painted in black. The only documented differences between these two 'technical' groups consist of the treatment of the snout, which tends to be closed in

the engravings and open in the drawings, and a slightly greater thematic diversity in the engravings (which includes bovinds). Consequently, it is possible to sustain the argument that the execution of all the art at Las Chimeneas is potentially synchronous.

CONCLUSION

Clearly, we must date cave art to advance our understanding of the origin of the graphic and symbolic expression of prehistoric hunter-gatherer groups. For this reason, new high-precision dates are needed, and the quality of the samples and the reliability of the results should be discussed. This implies that the full results (including their limitations) must be published.

The application of AMS radiocarbon dating to the Palaeolithic parietal art at the cave of Las Chimeneas has allowed us to discuss the quality of the radiocarbon analysis and its results, including the full or partial decontamination protocols in the pre-treatment of the samples, the weight of dateable carbon, and the type of sampling (single spot or multiple). In the case of Las Chimeneas, the results should be treated with caution and assessed in a wider perspective.

The formal and stylistic assessment of the dated parietal figures in the context of Iberian portable art supports a generic attribution of the Las Chimeneas depictions to the upper Solutrean or early Magdalenian. Within the narrower context of Cantabrian Spain, we suggest that their production can be bracketed between about 19,000 and 17,500 cal BP. The analysis of the quality of the dating results, the chronological overlap of the dates, the morpho-stylistic contextualization, and the consideration of the spatial relationships suggest that the cave art in Las Chimeneas is most probably culturally synchronic and was created in the

first stages of the Magdalenian. It is, however, currently impossible to establish whether the figures were drawn in a single graphic event or in more than one episode.

Even if our results are regarded as a hypothesis to be tested with new, better-quality data, it remains that the publication of all the information related to the process of obtaining AMS radiocarbon dates is essential. It is only by considering the quality and reliability of information that archaeological debates can progress and advances in our knowledge of the past can be made.

ACKNOWLEDGEMENTS

This work was supported by the Ministry of Science and Research of the Government of Spain under Grant PID2020-115347GB-I00.

REFERENCES

- Alcalde del Río, H., Breuil, H. & Sierra, L. 1911. *Les cavernes de la région cantabrique*. Monaco: Chêne.
- Alcolea González, J. & Balbín-Behrmann, R. 2007. C¹⁴ et style. La chronologie de l'art pariétal à l'heure actuelle. *L'Anthropologie*, 111: 435–66. <https://doi.org/10.1016/j.anthro.2007.07.001>
- Barandiarán, I. 1972. *Arte mueble del paleolítico cantábrico* (Monografías Arqueológicas de la Universidad de Zaragoza 14). Zaragoza: Universidad de Zaragoza.
- Barandiarán, I. 1994. Arte mueble del paleolítico cantábrico: una visión de síntesis. *Complutum*, 5: 45–79.
- Bonneau, A., Staff, R.A., Highman, T., Brock, F., Pearce, D.G. & Mitchell, P.J. 2017. Successfully Dating Rock Art in Southern Africa Using Improved Sampling Methods and New Characterization and Pretreatment Protocols. *Radiocarbon*, 59: 659–77. <https://doi.org/10.1017/RDC.2016.69>
- Breuil, H. 1952. *Quatre cents siècles d'art pariétal*. Montignac: Centre d'Études de la Documentation Préhistorique.
- Breuil, H. & Obermaier, H. 1935. *The Cave of Altamira at Santillana del Mar*. Madrid: Tipografía de Archivos.
- Brock, F., Higham, T., Ditchfield, P. & Bronk Ramsey, C. 2010. Current Pretreatment Methods for AMS Radiocarbon Dating at the Oxford Radiocarbon Accelerator Unit (ORAU). *Radiocarbon*, 52: 103–12. <https://doi.org/10.1017/S0033822200045069>
- Bronk Ramsey, C. 2009. Bayesian Analysis of Radiocarbon Dates. *Radiocarbon*, 51: 337–60. <https://doi.org/10.1017/S0033822200033865>
- Bronk Ramsey, C. 2021. OxCal version 4.4 [online] [accessed 22 September 2022]. Available at: <https://c14.arch.ox.ac.uk/oxcal/OxCal.html>
- Clottes, J. & Valladas, H. 2003. Style, Chauvet and Radiocarbon. *Antiquity*, 77: 142–45. <https://doi.org/10.1017/S0003598X00061433>
- Corchón, M.S. 1986. *El arte mueble paleolítico cantábrico. Contexto y análisis interno* (Centro de Investigación y Museo de Altamira, Monografía 16). Madrid: Ministerio de Cultura, Dirección General de Bellas Artes y Archivos.
- Corchón, M.S. 2004. El arte mueble paleolítico en la Cornisa Cantábrica y su prolongación en el Epipaleolítico. *Kobie (Serie Anejos)*, 8: 425–74.
- David, B., Delannoy, J.J., Petchey, F., Gunn, R., Huntley, J., Veth, P., et al. 2019. Dating Painting Events through By-Products of Ochre Processing: Borologa 1 Rockshelter, Kimberley, Australia. *Australian Archaeology*, 85: 5–94. <https://doi.org/10.1080/03122417.2019.1603263>
- Fortea, F.J. 2002. Trente-neuf dates C14-SMA pour l'art pariétal paléolithique des Asturies. *Bulletin de la Société Préhistorique Ariège-Pyrénées*, 57: 7–28.
- García-Díez, M. 2009. Palaeolithic Caves of Northern Spain: World Heritage Site. *Rock Art Research*, 26: 99–101.
- García-Díez, M. & Garrido, D. 2014. Cueva de Las Chimeneas (Puente Viesgo, Cantabria). In: R. Sala; E. Carbonell, J.M. Bermúdez de Castro & J.L. Arsuaga, eds. *Los cazadores recolectores del Pleistoceno y del Holoceno en Iberia y el estrecho de Gibraltar: estado actual del conocimiento del registro arqueológico*. Burgos: Universidad de Burgos, Fundación Atapuerca, pp. 651–55.
- García-Díez, M., Garrido, D. & Ceballos, J. M. 2013. La puesta en valor de cavidades: Monte Castillo (Puente Viesgo) a través

- de su historia moderna (1903–1971). *Sautuola*, 16, 485–96.
- García-Diez, M., Garrido, D., Angulo, J. & Fernández-Vega, P.A. 2018. *Monte Castillo, la montaña sagrada: más de 65000 años de arte rupestre paleolítico en Cantabria, patrimonio mundial*. Santander: Gobierno de Cantabria.
- González Echegaray, J. 1974. *Las pinturas y grabados de la Cueva de las Chimeneas* (Monografías de Arte Rupestre, Arte Paleolítico 2). Barcelona: Diputación provincial.
- González Echegaray, J. 1992. Paleoambientes de la Cornisa Cantábrica y su relación con el desarrollo del arte del Paleolítico Superior. *Espacio, tiempo y forma, Serie I, Prehistoria y Arqueología*, 5: 73–86.
- Hedges, R.E.M., Bronk Ramsey, C., Van Klinken, G., Pettitt, P., Nielsen, C., Etchegoyen, A., et al. 1998. Methodological Issues in the ^{14}C Dating of Rock Paintings. *Radiocarbon*, 40: 35–44. <https://doi.org/10.1017/S0033822200017859>
- Hoffmann, D.L., Pike, A.W.G., García-Diez, M., Pettitt, P. & Zilhão, J. 2016. Methods for U-Series Dating of CaCO_3 Crusts Associated with Palaeolithic Cave Art and Application to Iberian Sites. *Quaternary Geochronology*, 36: 104–19. <https://doi.org/10.1016/j.quageo.2016.07.004>
- Hoffmann, D.L., Standish, C.D., García-Diez, M., Pettitt, P., Milton, J.A., Zilhão, J., et al. 2018. U-Th Dating of Carbonate Crusts Reveals Neandertal Origin of Iberian Cave Art. *Science*, 359: 912–15. <https://doi.org/10.1126/science.aap777>
- Leroi-Gourhan, A. 1965. *Préhistoire de l'art occidental*. Paris: Mazonod.
- Moure, A. & González-Sainz, C. 2000. Cronología del arte paleolítico cantábrico: últimas aportaciones y estado actual de la cuestión. In: J.V. Oliveira, ed. *III Congreso de Arqueología peninsular (UTAD, Vila Real 1999) vol. 2*. Porto: Associação para o Desenvolvimento da Cooperaçao em Arqueologia Peninsular, pp. 461–74.
- Moure, A., González-Sainz, C., Bernaldo de Quirós, F. & Cabrera, V. 1996. Dataciones absolutas de pigmentos en cuevas cantábricas: Altamira, El Castillo, Chimeneas y Las Monedas. In: A. Moure, ed. *El hombre fósil 80 años después: Volumen conmemorativo del 80 aniversario de la muerte de Hugo Obermaier*. Santander: Universidad de Cantabria, pp. 295–324.
- Ochoa, B., M. García-Diez, M., Domingo, I. & Martins, A. 2020. Dating Iberian Prehistoric Art: Methods, Sampling, Data, Limits and Interpretations. *Quaternary International*, 572: 88–105. <https://doi.org/10.1016/j.quaint.2020.08.048>
- Oxford Radiocarbon Accelerator Unit n.d. *OxA numbers*. Retrieved 13 October 2021 from https://c14.arch.ox.ac.uk/oxa_ref.php
- Pettitt, P. & Pike A.W.G. 2007. Dating European Paleolithic Cave Art: Progress, Prospects, and Problems. *Journal of Archaeological Method and Theory*, 14: 27–47. <https://doi.org/10.1007/s10816-007-9026-4>
- Pike, A.W.G., Hoffmann, D.L., Pettitt, P., García-Diez, M. & Zilhão, J. 2017. Dating Palaeolithic Cave Art: Why U–Th is the Way to Go. *Quaternary International*, 432: 41–49. <https://doi.org/10.1016/j.quaint.2015.12.013>
- Reimer, P.J., Austin, W.E.N., Bard, E., Bayliss, A., Blackwell, P.G., Bronk Ramsey, C., et al. 2020. The IntCal20 Northern Hemisphere Radiocarbon Age Calibration Curve (0–55 cal kBP). *Radiocarbon*, 62: 725–57. <https://doi.org/10.1017/RDC.2020.41>
- Rogerio-Candelera, M.A. & Élez Villar, J. 2009. Un nuevo calco del cáprido de la Sala de La Hoya (Cueva de Altamira) mediante técnicas de análisis de la imagen. In: M.E. Saiz Carrasco, R. López Romero, M.A. Cano Díaz-Tendero & J.C. Calvo García, eds. *VIII Congreso de Arqueometría*. Teruel: Seminario de Arqueología y Etnología Turolense, pp. 409–18.
- Scharebereiter-Gurtner, C., Saiz-Jimenez, C., Piñar, G., Lubitz, W. & Rolleke, S. 2002. Altamira Cave Paleolithic Paintings Harbor Partly Unknown Bacterial Communities. *FEMS Microbiology Letters*, 211: 7–11. <https://doi.org/10.1111/j.1574-6968.2002.tb11195.x>
- Valladas, H. 2003. Direct Radiocarbon Dating of Prehistoric Cave Paintings by Accelerator Mass Spectrometry. *Measurement Science & Technology*, 14: 1487–92. <https://doi.org/10.1088/0957-0233/14/9/301>
- Valladas, H., Tisnérat, N., Cachier, H. & Arnold, M. 1999. Datation directe des peintures préhistoriques par la méthode du carbone 14 en spectrométrie de masse par accélérateur. *Mémoires de la Société Préhistorique Française*, 26 & *Supplément 1999 de la Revue d'Archéométrie*: 39–44.

- Valladas, H., Tisnérat, N., Kaltnecker, E., Cachier, H., Arnold, M. & Clottes, J. 2006. La datation de l'art pariétal par la méthode du carbone 14: apports et perspectives. *Bulletin de la Société Préhistorique de l'Ariège*, 61: 51–60.
- Villaverde, V. 1994. *Arte paleolítico de la Cova del Parpalló. Estudio de la colección de plaquetas y cantos con grabados y pinturas*. Valencia: Diputación Provincial de Valencia.
- Villaverde, V. & Cantó, A. 2020. Les signes quadrangulaires dans la collection d'art mobilier du Parpalló. In: E. Paillet, P. Paillet & E. Robert, eds. *Voyages dans une forêt de symboles*. Treignes: Centre d'Etudes et de Documentation Archéologique, pp. 295–302.

BIOGRAPHICAL NOTES

Marcos García-Díez is a lecturer and researcher in prehistoric archaeology at the Complutense University of Madrid (UCM), Spain. His specialist interests are prehistoric art, the origins of symbolic behaviour, chronometric studies in rock art, territoriality and mobility of prehistoric hunter-gatherers, and conservation and management of cultural heritage.

Address: Department of Prehistory, Ancient History and Archaeology, Complutense University of Madrid, c/ Profesor Aranguren s/n, 28040 Madrid, Spain. [email: marcos.garcia.diez@ucm.es]. ORCID: 0000-0001-7923-5280.

Álvaro Ibero is a pre-doctoral fellow at Complutense University of Madrid. His main research interests include the study of social and cultural identity of prehistoric communities through their symbolic behaviour and their construction of the landscape.

Address: Department of Prehistory, Ancient History and Archaeology, Complutense University of Madrid, c/ Profesor Aranguren s/n, 28040 Madrid,

Spain. [email: a.iber@ucm.es]. ORCID: 0000-0002-4079-180X.

Blanca Ochoa obtained her PhD in quaternary sciences (prehistory) in 2016 from the University of the Basque Country (UPV/EHU). Currently she is a postdoctoral fellow at Universidad Complutense of Madrid. She is a Palaeolithic art specialist, her main interests being rock art and portable art recording, and the chronology of Palaeolithic art in northern Spain.

Address: Department of Prehistory, Ancient History and Archaeology, Complutense University of Madrid, c/ Profesor Aranguren s/n, 28040 Madrid, Spain. [email: blanca.ochoafraille@gmail.com]. ORCID: 0000-0002-8180-0135.

Paula López-Calle is an archaeology graduate of the Complutense University of Madrid who recently began research in archaeology. Her subject interests include Palaeolithic archaeology, rock and portable art, *chaînes opératoires*, and cognitive processes.

Address: Department of Prehistory, Ancient History and Archaeology, Complutense University of Madrid, c/ Profesor Aranguren s/n, 28040 Madrid, Spain. [email: paulop11@ucm.es]. ORCID: 0000-0002-7645-870X.

Daniel Garrido obtained his PhD in quaternary sciences (prehistory) in 2015 from the University of Salamanca. His specialist interests are cave and portable art, bone industry, and management of cave art heritage.

Address: Prehistoric Cave of Cantabria, Puente Viesgo, 39670 Cantabria, Spain. [email: daniel.garrido@srcd.es]. ORCID: 0000-0002-4931-3548

Nouvelles dates radiocarbone obtenues à Las Chimeneas (Cantabrie, Espagne) : qualité des dates et leur pertinence pour l'art pariétal paléolithique

La datation au radiocarbone par spectrométrie de masse par accélérateur (SMA) a largement été utilisée en recherche dédiée à l'art paléolithique et sa valeur a été démontrée au cours des trois dernières décennies. Elle se heurte cependant encore à des problèmes méthodologiques qui doivent être analysés et discutés afin d'améliorer nos stratégies d'échantillonnage et d'améliorer l'interprétation des résultats. Les auteurs de cette étude présentent quelques nouvelles dates SMA concernant l'art pariétal de Las Chimeneas en Espagne du nord, décrivent la qualité des échantillons et en examinent leur fiabilité. L'évaluation conjointe de ces dates et la comparaison avec d'autres dates obtenues antérieurement ainsi qu'avec des objets d'art mobilier bien datés et stratifiés permettent de proposer une hypothèse sur la date de création de l'art pariétal de la grotte et sur le degré de synchronie ou de diachronie de leur production. Les auteurs concluent que l'art pariétal de Las Chimeneas date du Magdalénien ancien, soit entre 19'000 et 17'500 cal BP. Translation by Madeleine Hummler

Mots-clés: datation SMA, radiocarbone, chronologie, art pariétal, Magdalénien, Paléolithique supérieur

Neue Radiokarbonbestimmungen in der Höhle von Las Chimeneas (Kantabrien, Spanien): ihre Qualität und Bedeutung für die paläolithische Felskunst

Man hat die AMS-Radiokarbonatierung in der Forschung der paläolithischen Kunst weitgehend angewendet und ihr Wert wurde in den letzten drei Jahrzehnten mehrfach nachgewiesen. Sie leidet jedoch immer noch an Problemen, welche analysiert und diskutiert werden müssen, um das Probenahmeverfahren zu verbessern. Dieser Artikel betrifft neue AMS Bestimmungen für die Felskunst der Höhle von Las Chimeneas in Nordspanien und die Qualität und Zuverlässigkeit der Proben werden bewertet. Die Auswertung der Daten und der Vergleich mit anderen, früher erhaltenen Radiokarbonbestimmungen sowie mit gut datierten und stratifizierten tragbaren Kunstgegenständen ermöglicht es, eine Hypothese über die Chronologie und Synchronie (oder nicht) der Erzeugung der Felskunst in der Höhle aufzustellen. Die Verfasser sind der Meinung, dass die Felskunst in Las Chimeneas im unteren Magdalénien, also zwischen 19,000 und 17,500 cal BP, entstand. Translation by Madeleine Hummler

Stichworte: AMS-Datierung, Radiokarbon, Chronologie, Felskunst, Magdalénien, Jungpaläolithikum

Nuevas dataciones de radiocarbono para el arte paleolítico de la Cueva de Las Chimeneas (Cantabria, España) : calidad de los resultados y relevancia para el arte parietal

La datación por radiocarbono AMS ha sido ampliamente aplicada en el estudio del arte paleolítico, y su importancia ha quedado demostrada en las últimas tres décadas. No obstante, siguen existiendo problemas que deben ser discutidos y analizados para mejorar futuras estrategias de muestreo y reforzar la interpretación de los resultados. Este trabajo presenta nuevas fechas AMS para el arte parietal de la Cueva de Las Chimeneas en el norte de España, describiendo la calidad de las muestras y discutiendo su fiabilidad. La puesta en común de las fechas y su comparación con dataciones previas, así como con el arte mueble datado y contextualizado, permite formular hipótesis sobre el periodo de creación del arte parietal de la cueva y el grado de sincronía o diacronía de su producción. En consecuencia, se propone que el arte de Las Chimeneas fue creado durante el Magdaleniense inferior, entre 19,000 y 17,500 cal BP. Translation by the authors

Palabras clave: datación AMS ^{14}C , radiocarbono, cronología, arte rupestre, Magdaleniense, Paleolítico superior