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Review

Uranium series dating reveals a long sequence of rock art at Altamira Cave (Santillana del Mar, Cantabria)

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ABSTRACT

The rock art in Altamira Cave was the first ensemble of Palaeolithic parietal art to be identified scientifically (Sautuola, 1880). Due to the great thematic, technical and stylistic variety of the art in the cave, which constitutes one of the most complete Palaeolithic art ensembles, Altamira was listed as World Heritage by UNESCO in 1985. Uranium-series dating has recently been applied to figures on the decorated ceiling in the cave. Several motifs are partly covered by thin layers of calcite precipitates, whose formation process is datable by this method. The results provide the date when the calcite formed, which gives a minimum age for the underlying depictions. These results confirm that the parietal art at Altamira was produced during a prolonged period of time, at least 20,000 years (between 35,000 and 15,200 years ago), and that part of the ensemble corresponds to the Aurignacian period.

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1. Introduction

Rock art was originally dated by making stylistic comparisons with the depictions on portable objects recovered from datable archaeological levels and by studying the order of superimposed figures (Lorblanchet, 1995: 241–280). The first method provided evidence of the synchronicity of the figures, whereas the second revealed diachronic differences. Later, accelerator mass spectrometry radiocarbon dating (Valladas et al., 2005) opened new perspectives as a way to obtain radiometric dates and determine the diachronic development and synchronic and spatial variability of Palaeolithic art. This method has specific limitations in procedure (size of the samples, problems of contamination) and interpretation of the results (e.g. the possible use of charcoal some time after the fuel – either wood or bone – was burnt) (Clottes and Valladas, 2003; Pettit and Bahn, 2003; Valladas, 2003). Additionally, as this method could only be applied to black paintings made with organic matter (charcoal), it meant that few depictions painted in the first half of the Upper Palaeolithic could be dated, as most black figures were produced in the middle and late phases of the Magdalenian period (Valladas et al., 2005; Alcolea and Balbín, 2007; Pettitt and Pike, 2007; Ochoa, 2011). Due to these problems, Uranium series dating of carbonates directly associated with the parietal art is an indispensable procedure to obtain high-quality chronological information for engravings and paintings made with inorganic colouring matter (Aubert et al., 2007; Taçon et al., 2012).

Precise chronological determinations of cave art are essential to be able to understand and study the social and symbolic structure of human groups, and advance beyond the inferences made from generic considerations. For instance, it is necessary to determine which figures are synchronic or diachronic, the relationship between the human occupations in the caves and the production of parietal art, and the number of times the same places were used for symbolic acts. It is therefore necessary to apply high-resolution chronological procedures to obtain precise information about the

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dates of Palaeolithic rock art ensembles and approach the symbolic structure of Palaeolithic human groups with greater precision.

In an attempt to provide greater chronological constraints on cave art in northern Iberia, Pike et al. (2012) reported 50 U-series determinations on calcite deposits overlying, and occasionally underlying cave paintings and engravings from 11 caves in Spain. Here we report in greater detail on the dates Pike et al. (2012) obtained from Altamira Cave and integrate them with site's broader archeological context.

2. Altamira Cave: archaeological context and palaeolithic cave art

Altamira Cave, listed as World Heritage by UNESCO in 1985, is located in the north of the Iberian Peninsula, in Santillana del Mar (Cantabria, Spain) (Fig. 1). It was the first cave where Palaeolithic cave art was identified, as the discoverer, Marcelino Sanz de Sautuola, affirmed in 1880 that the engravings and paintings were Palaeolithic in age (Sautuola, 1880). This claim, which implied that "Prehistoric Men" were capable of producing Art, was widely dismissed, and the controversy about the age of the paintings lasted until 1902 (Barandiarán, 1995). Since then, archaeological research has concentrated on studying the human occupations and parietal art in the cave.

The entrance hall of the cave preserves an important archaeological deposit. The first excavations documented two Palaeolithic levels: one of the late Solutrean and the other of the early Magdalenian. Since 2003, The Altamira National Museum and Research Centre has been working on several scientific projects aimed at understanding the occupations and artwork in the cave and in its immediate surroundings (Lasheras et al., 2005–2006, 2012; Heras et al., 2008; Rasines et al., 2009).

The latest work studying the stratigraphy of the deposit has documented a sequence of human occupation with eight levels (Fig. 2), from the Late Gravettian to the Middle Magdalenian. Levels 1 to 5 correspond to the Magdalenian. Level 6, whose upper surface in contact with Level 5 is eroded, contains Late Solutrean materials. Level 7 is also Solutrean in age. Finally, the oldest occupation to be documented is Level 8, which is Late Gravettian. These levels overlie blocks of stone collapsed from the roof of the cave before the Gravettian occupation, and indeed the possibility of older archaeological levels underneath these blocks cannot be ruled out. In short,

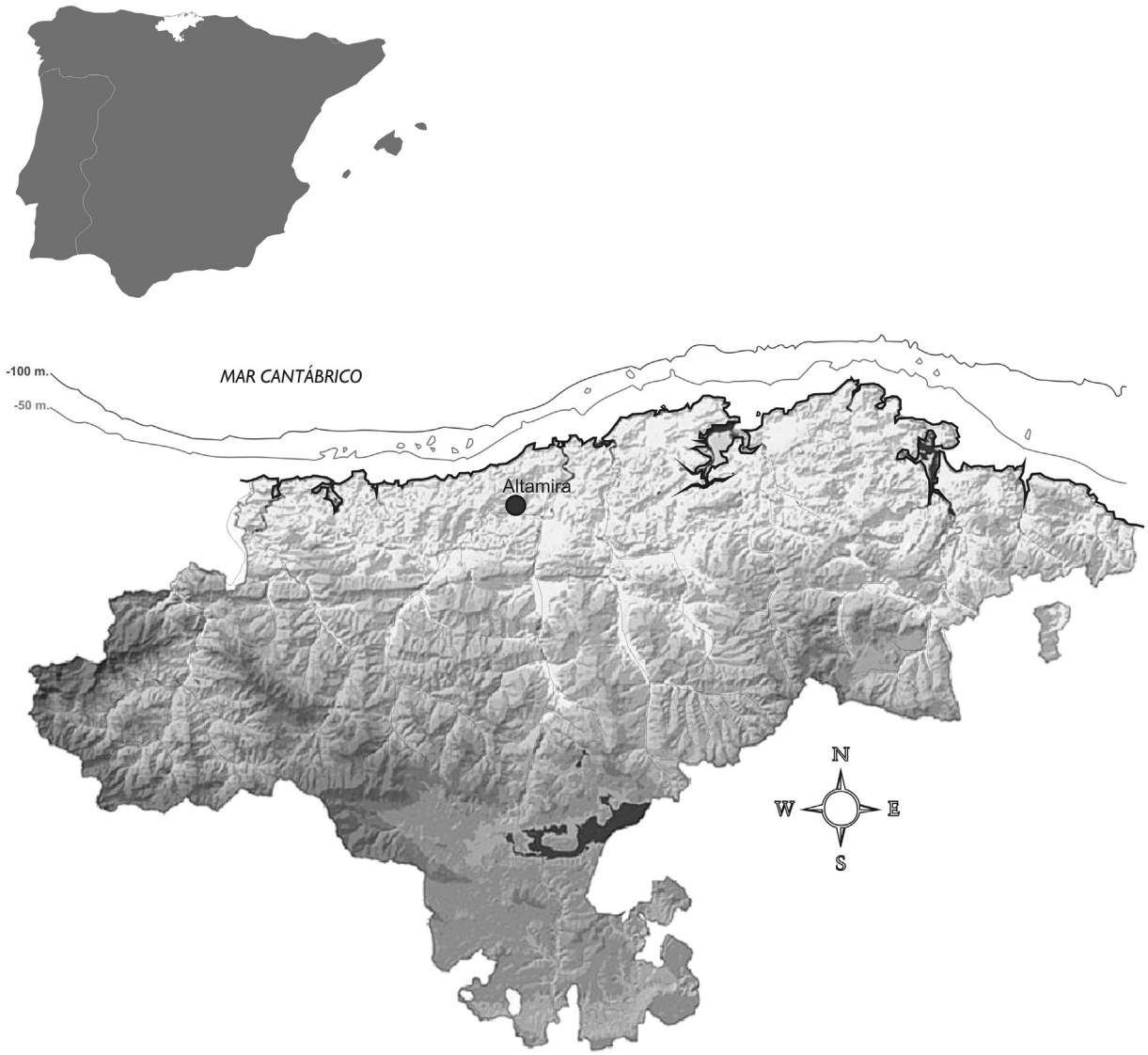


Fig. 1. Geographical location of Altamira Cave.

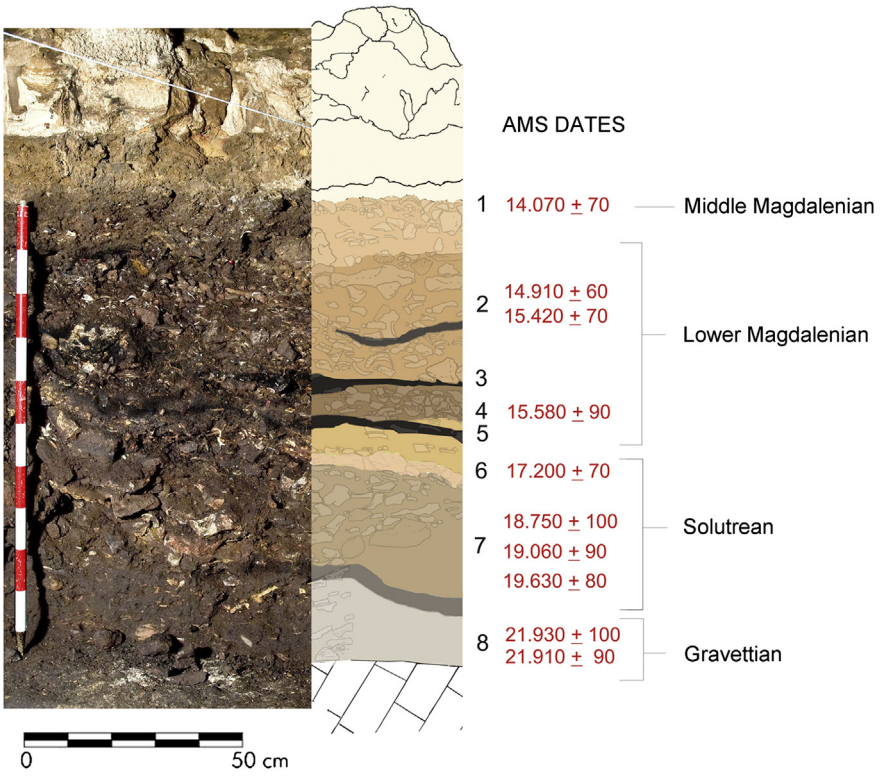


Fig. 2. Stratigraphy and AMS chronology (AMS) of human occupation of Altamira Cave.

the entrance hall at Altamira contains an archaeological deposit where evidence of protracted human occupation has been documented and dated by AMS ^{14}C to between 26,784 and 16,866 cal BP.

The parietal ensemble is large and varied (Breuil and Obermaier, 1935; Freeman and González Echegaray, 2001; Lasheras, 2003). It contains practically all known Palaeolithic themes (animals, anthropomorphs and signs), techniques (painting, drawing, different types of engravings and use of natural rock forms), and styles. The figures are distributed throughout the cave, whilst being concentrated in two sectors (Fig. 3): the *Techo de los Polícromos*, the Ceiling in the hall of the polychrome paintings; and the *Cola de Caballo* or "Horse's Tail", the final passage. The Ceiling has the famous naturalistic bison, engraved and painted in red and black, and adapted to the natural shape and fissures in the rock. When these polychrome figures were painted, superimposition shows many representations of signs and animals (mainly horses) in different styles had already been produced on the Ceiling.

3. Method

The decay of radioactive ^{238}U to radiogenic and radioactive ^{234}U and ^{230}Th can be used to date the formation of calcite precipitates such as stalactites and stalagmites (e.g. Ivanovich and Harmon, 1992; Richards and Dorale, 2003). Where these precipitates have formed directly on cave paintings or engravings, the date of precipitation can provide a minimum age for the underlying art, or where previously precipitated calcite has been painted a maximum age can be provided. The sample removal, preparation and dating procedure is summarized in the following.

Each potential location was inspected carefully with a hand lens and locations were sampled only where the painting was clearly covered with calcite, or where the underlying calcite was accessible close to the painting. Calcite overlying a painting was carefully scraped with a scalpel, catching the scrapings in a plastic tray, until the brightness of the underlying pigment indicated the boundary between the two was approaching. For thick (>2 mm) layers of calcite it was sometimes possible to collect two or more samples which should give dates in sequential order. Where painting or engraving was directly onto stalagmite or flowstone, a sample from the layers beneath the painting was obtained using a hand drill, from as close as possible to the painting, but without causing damage. The samples collected ranged in mass from 10 to 100 mg.

Samples were initially inspected under a low power microscope and, where possible, any obvious particles of detritus were removed. At this stage some samples that were visibly contaminated with significant quantities of detritus were rejected as unsuitable for dating. The sample was weighed in a Teflon beaker. A few drops of milliQ 18 MΩ water were added, and the sample was dissolved by further stepwise addition of 7 M HNO_3. A mixed $^{229}Th/^{236}U$ spike was added and the solution left for a few hours to equilibrate. The sample solution was dried by placing the beaker on a hotplate. When nearly dry the sample was treated with 100 μl 6 M HCl and 55 μl H_2O_2 and left until dry. Finally, the sample was redissolved in 600 μl 6 M HCl ready for the ion exchange columns. Where appropriate, any insoluble residue was removed by centrifuge prior to ion exchange chemistry.

U and Th were separated from the sample matrix using ion exchange chromatography and a two column procedure based on Hoffmann (2008). The first column separates U from Th and the second purifies the two fractions. We use 600 μl of pre-cleaned Bio Rad AG1x8 resin. The sample is introduced into the fist column in 6 M HCl. The Th fraction is collected immediately as it passes directly through the column. U is then eluted using 1 M HBr followed by 18 MΩ water. After drying down the two fractions were redissolved in 7 M HNO_3 and separately passed down the column for purification. Th is eluted with 6 M HCl and U is eluted with 1 M HBr. The elutants were dried then redissolved in 0.6 M HCl ready for analysis.

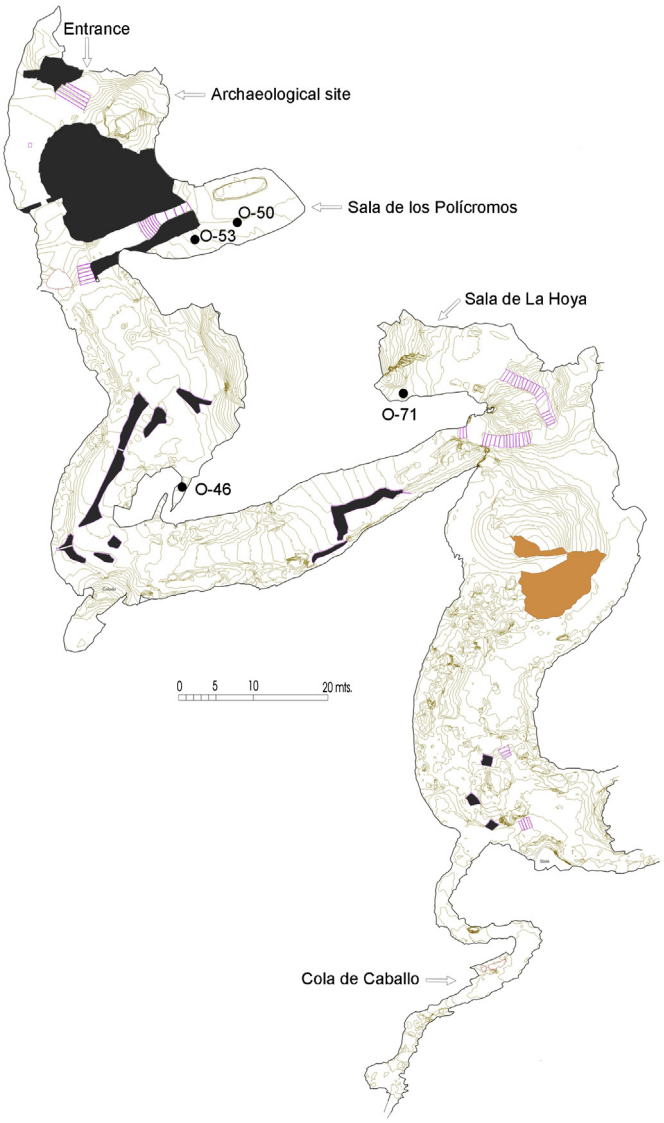


Fig. 3. Plan of Altamira Cave showing the location of decorated passages.

U and Th isotope measurements were undertaken using a ThermoFinnigan Neptune Multi-Collector (MC) Inductively Coupled Plasma Mass Spectrometer (ICPMS). Instrumental biases are assessed and corrected by adopting a standard–sample bracketing procedure to derive correction factors e.g. for mass fractionation effects. U and Th solutions are measured separately, NBL-112a is used for U isotope measurements as the bracketing U-standard and an in-house ^{229}Th–^{230}Th–^{232}Th standard solution for Th measurements. Further details of our MC-ICPMS procedures can be found in Hoffmann et al. (2007) and Hoffmann (2008). U-series dating of speleothems is described in more detail in Scholz and Hoffmann (2008).

Detrital contamination was monitored by measurement of common thorium ^{232}Th. Where possible, a correction was applied using an assumed detrital activity ratio of ^{232}Th/^{238}U = 1.250 ± 0.625, typical of upper crustal silicates (Wedepohl, 1995) and assuming ^{230}Th and U isotopes are in equilibrium (i.e. ^{230}Th/^{238}U = 1.0; ^{234}U/^{238}U = 1.0). Note the conservative nature of these assumptions. The detrital correction has mainly two effects, namely a decrease of the calculated age and an increase of the relative uncertainty on the calculated age. Where detrital contamination is dominant, this effect on the error renders the corrected age too imprecise to be useful. In these cases, no date, either corrected or uncorrected, has been reported.

Minimum ages are given at 95% confidence (i.e. the mean age minus 2σ). Note that the ages are reported in a (years) or ka (thousands of years) before date of chemical separation of U and Th, and are therefore not directly comparable with uncalibrated radiocarbon dates. All ratios are given as activity ratios. Unless otherwise stated, all errors are at 95%.

4. Sampling and results

A total of eight calcite samples associated with the rock art were taken and analysed by the Uranium series method. Four samples were either taken for a minimum age determination but not dated because of detrital contamination detected at an early stage of the analysis, or taken for a maximum age determination and their age turned out to be too old for them to be of any significance. The representations associated with the relevant samples are (Table 1):

- BIG-UTh-O-71 (a and b; Table 1 and Fig. 4A): male ibex drawn as a simple outline in black (charcoal) in Sector IV (area of the cave known as *La Hoya* or "The Pit"). The calcite samples provide a minimum age for the figure. Samples a and b were friable crystalline calcite directly overlying black pigment and therefore would provide a minimum age; as they were too small to date individually, we combined them for a single measurement. The low ^{230}Th/^{232}Th indicates considerable contamination with detritus, and therefore this date cannot be considered reliable. The result of the corrected age is 2850 ± 350 a.
- BIG-UTh-O-46 (Table 1 and Fig. 4B): large rectangular sign in red drawn as a series of ladder-shaped bands, in the "Red Side-Passage" in Sector III. The small 'cauliflower' stalagtite provides a minimum age for the figure. The sample was free from significant detrital contamination. The result of the corrected age is 5860 ± 70 a.
- BIG-UTh-O-53 (Table 1 and Fig. 4C): large red horse, painted in red with a mostly dotted outline, in Sector I (Polychrome Ceiling) overlain by a small cauliflower stalactite, providing a minimum age. This sample is not contaminated with significant detritus, providing a minimum age. The result of the corrected age is 22,110 ± 130 a.
- BIG-UTh-O-50 (Table 1 and Fig. 4D): red linear sign, consisting of a wide, sinuous line coming to a triangular-shaped point in its middle part. Located in the central sector of the Polychrome Ceiling. Thin calcite encrustation, providing a minimum age. This sample has only moderate detrital contamination. The result of the corrected age is 36,160 ± 610 a.

5. Discussion

Detrital contamination was a problem for many of the samples taken at Altamira Cave. However, three (BIG-UTh-O-46, 50 and 53) of the samples contained acceptable levels of contamination and yielded meaningful dates. This proportion justifies the application of the method as a way to obtain valuable chronological information for Palaeolithic parietal art. In addition, Uranium series dating is a vital tool in discussions about the authenticity of figures, as the dates of even Holocene carbonates covering figures can be used to dismiss the possibility that they are modern falsifications (as at Arcy – Liger, 1995, Covalanas – Bischoff et al., 2003, Creswell Crags – Pike et al., 2005). Equally, carbonates situated below figures and whose dates are not of Pleistocene age (as at the cave of El Becerral – García-Diez and Eguizabal, 2007–2008 in Cantabria) or which are later than the

Table 1
Results of U-series disequilibrium dating for Altamira samples. All isotopic ratios are activity ratios; errors are at 2σ. Ages are corrected for detritus by using an assumed $^{232}Th/^{238}U$ activity of 1.250 ± 0.625 and $^{230}Th/^{238}U$ and $^{234}U/^{238}U$ at equilibrium.

Sample BIG-UTh	$^{230}Th/^{238}U$	$^{234/238}U$	$^{230}Th/^{232}Th$	Uncorrected age (ka)	Corrected age (ka)	Lower age limit (ka) (minimum age)	Upper age limit (ka)
O-46	0.07980 ± 0.00047	1.4959 ± 0.0026	40.29 ± 0.35	5.969 ± 0.038	5.86 ± 0.07	5.79	5.94
O-50	0.4933 ± 0.0024	1.6594 ± 0.0030	17.473 ± 0.068	37.60 ± 0.23	36.16 ± 0.61	35.55	36.77
O-53	0.2884 ± 0.0013	1.5471 ± 0.0026	107.07 ± 0.20	22.26 ± 0.11	22.11 ± 0.13	21.98	22.24
O-71	0.05320 ± 0.00081	1.6567 ± 0.0030	3.964 ± 0.058	3.557 ± 0.055	2.85 ± 0.35	2.5	3.2

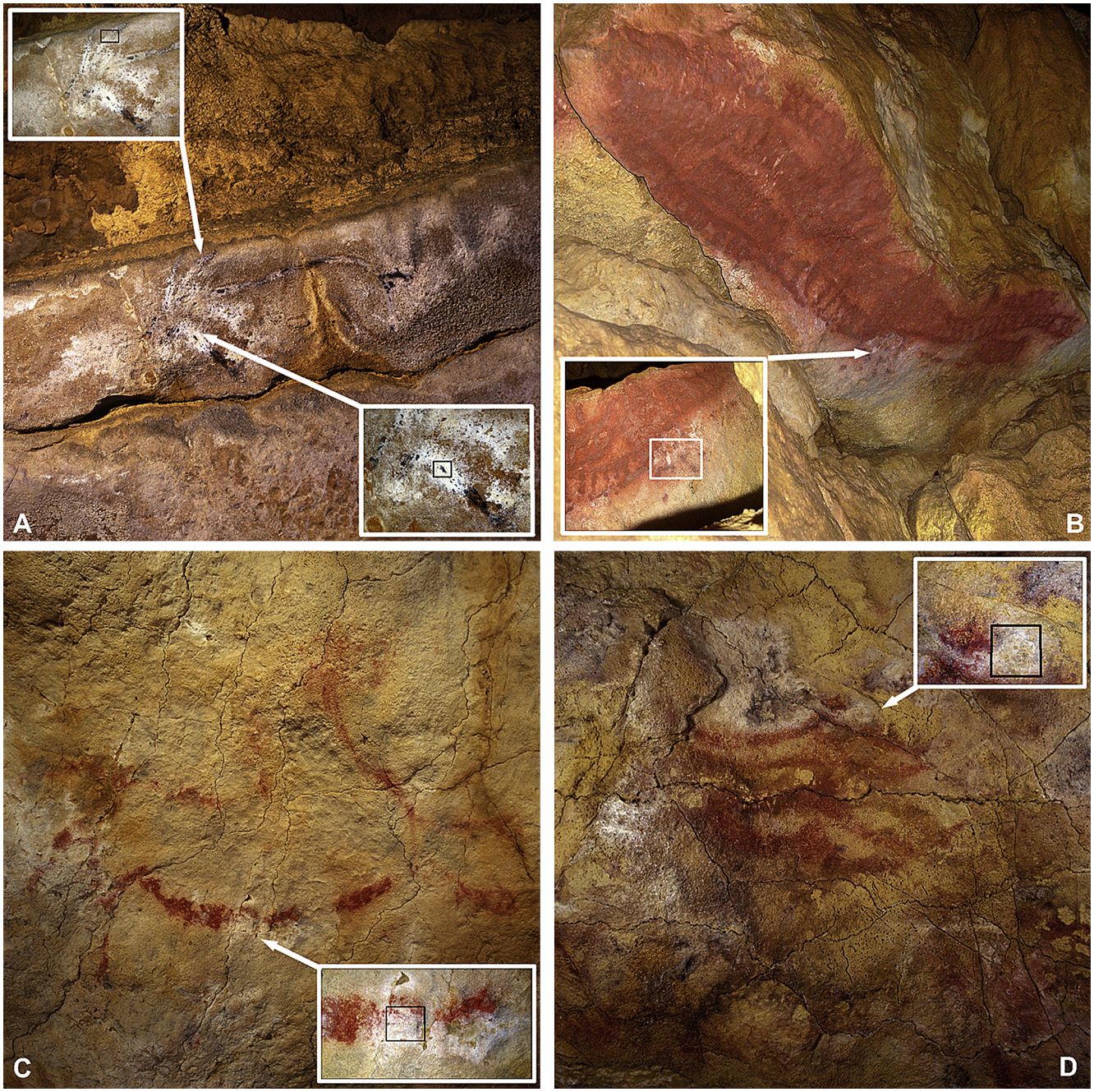


Fig. 4. Details of samples of Altamira Cave: A: BIG-UTh-O-71 (male ibex); B: BIG-UTh-O-46 (rectangular sign); C: BIG-UTh-O-53 (red horse); D: BIG-UTh-O-53 (sinuous triangular-shaped sign). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

time of the first discoveries of Palaeolithic art (about 1875) imply the figures are modern. In the present study, Sample BIG-UTh-O-46 gave a minimum age of 5790 a for the large red ladder-shaped sign. Although this is consistent with the known antiquity of some paintings of this form, it is not chronologically diagnostic to demonstrate the Palaeolithic age of this art.

The minimum ages of samples BIG-UTh-O-53 (21,980 a) and BIG-UTh-O-50 (35,550 a) are significant to be able to constrain the time when the art was produced and certify the existence of graphic activity in the Early Upper Palaeolithic (Fig. 5), in pre-Magdalenian times (Cabrera et al., 2004; Rasilla and Straus, 2004; Straus, 2005; Zilhão, 2006; Maroto et al., 2012). The result of BIG-UTh-O-53 indicates a time in the Late Solutrean, while BIG-UTh-O-50 corresponds at least to the Aurignacian. Both dates have archaeological implications for Altamira and for Palaeolithic art in general.

5.1. The archaeological significance of sample BIG-UTh-O-50

Sample BIG-UTh-O-50 was taken from a deposit of calcite that formed over a wide, sinuous red line with a triangular-shaped point in its middle part. This line is together with and parallel to three similar lines, forming a large group (60 × 60 cm). This sign has traditionally been described as a "claviform" (Breuil and Obermaier, 1935; Freeman and González Echegaray, 2001), a category that includes many variations. While true claviform signs (club-like signs formed by an approximately straight line with a pointed central appendix) exist at Altamira, the painting associated with sample BIG-UTh-O-50 does not share the same morphological or chromatic characteristics as these signs.

Different ages have been proposed for the large diversity of signs classed as claviforms at Altamira; from middle or late phases of the Aurignacian (now Gravettian – Breuil and Obermaier, 1935) to the Early-Middle Magdalenian (Leroi-Gourhan, 1965; González Sainz, 1993; Freeman and González Echegaray, 2001). In this cave, the study of superimpositions involving claviforms is inconclusive as in some cases they are situated beneath black figures (a horse) and polychrome paintings (bison), and in other occasions they are above polychrome figures (a hind). These stratigraphic relationships suggest that such claviform figures were painted in more than one period.

The geographic distribution of the classic Altamira-type claviforms is very small, which hinders the study of their chronology, thematic associations and archaeological context. They have been documented in the caves of La Pasiega (Galleries B and C) (González Sainz and Balbín, 2010), Las Aguas (Lasheras et al., 2010) and La Garma (González Sainz and Moure, 2010) in Cantabria, and the cave of Tito Bustillo (Balbín and Alcolea, 2003) in Asturias. The large triangular signs at El Tebellín (González Morales, 1982) in Asturias have also been associated with these claviforms.

The minimum age of 35,550 a obtained for sample BIG-UTh-O-50 shows that the sign was produced at least during the Aurignacian although no archaeological remains of that period have yet been found in the cave. This double-curved sign is associated with three similar motifs and is surrounded by red stains and two partial and faded large red horses in an early style (similar to the horse associated with sample ALT-9). In addition, Breuil (1935: lám. VI) identified a stencilled hand painting and a representation of a foot in violet that are now indiscernible. In short, this sign is in association with a group of motifs regarded as belonging to an early chronology.

This U-series date raises certain points about the chronological framework:

- It confirms that Palaeolithic parietal artistic expression began at least in the Aurignacian. This motif was one of the first to be painted in Altamira Cave and in the Iberian Peninsula as a whole. Very few representations can be attributed to such an early time with any degree of certitude (Pike et al., 2012).
- A debate is still on-going as to whether the first art in Iberia was figurative or non-figurative, or whether both styles co-existed. This result demonstrates that at least some non-figurative representations were produced in the Early Upper Palaeolithic. Given the absence of figurative art among the earliest motifs dated by Pike et al. (2012), non-figurative art may predate figurative styles.
- It shows that signs included within the category of claviforms were produced in the Aurignacian. Considered in conjunction

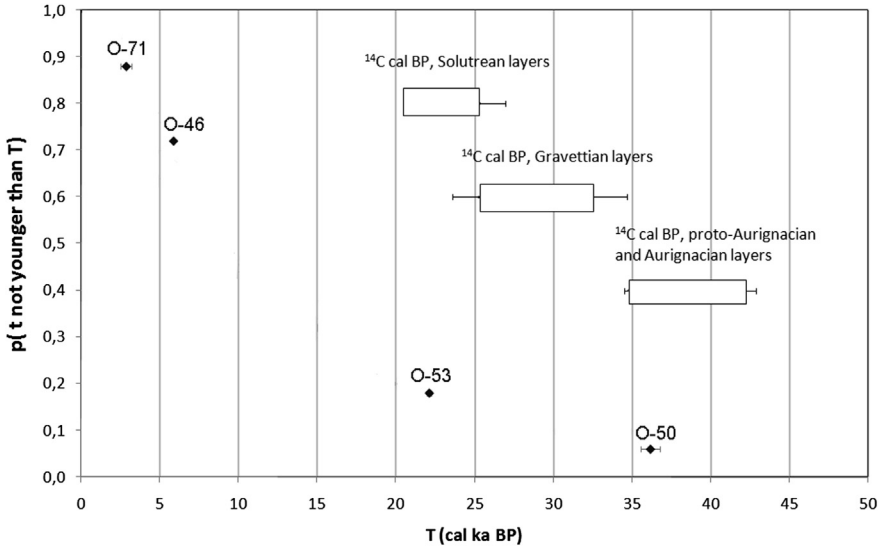


Fig. 5. BIG-UTh-O-46, 50, 53 and 71 represent minimum ages for the cave art of Altamira. Also shown is the pre-Magdalenian radiocarbon chronology from excavated cultural horizons in northern Spain (with arbitrary *y*-axis offsets for clarity).

with the superimpositions of figures and claviforms in Altamira, this indicates that approximately similar signs were produced at different times and consequently the great morphological variability within this category may reflect chronological and semiotic differences.

5.2. The archaeological significance of sample BIG-UTh-O-53

Sample BIG-UTh-O-53 was taken from calcite deposited over the belly of a large red horse. This 182-cm long figure was produced mainly with red dots to form the outline of its body while its head is filled with red colour-wash. Its outstretched legs give the animal great dynamism, suggesting movement and possibly jumping. Other similar figures in their thematic conceptions, technique, size and style have been identified on the Polychrome Ceiling at Altamira.

Animal figures with continuous or discontinuous dotted outlines, made by dabbing the pigment on with a finger or a pad of some kind, are quite common in the central part of Cantabrian Spain (García-Diez, 2002; García-Diez and Eguizabal, 2003) and were defined by J.M. Apellániz (1982) as belonging to the "Ramales School", after the town of Ramales de la Victoria where the classic examples of this kind of technique were found in Cueva de Covalanas. They are figures with a simple outline where little attention is paid to secondary anatomy. They tend towards anatomical disproportion, mainly between the area of the body and the head. Breuil and other scholars (1935, 1952) placed them in the Aurignacian-Perigordian artistic cycle, whereas others, such as Jordá (1964, 1978), Leroi-Gourhan (1965) and Moure et al. (1991), regarded these figures as Solutrean. Recently, stylistic studies (González Sainz, 1999; González-Sainz and San Miguel, 2001; Montes and Sanguino, 2001; García-Diez and Eguizabal, 2003; Garate Maidagan, 2010) and thermoluminescence dating of calcite samples associated with this type of figure in Cueva de Pondra (González-Sainz and San Miguel, 2001) have not succeeded in determining either their age with any precision (apart from a generic chronology in the Aurignacian, Gravettian, Solutrean and/or early Magdalenian) or the duration of this artistic cycle.

Although the dotted horses in Altamira have traditionally been ascribed to the style of the "Ramales School" (Apellániz, 1982), differences exist that allow the group of figures in Altamira to be dissociated from the other ensembles. These include the size of the dots (larger in Altamira), main theme (horse in Altamira, rather than hinds as at most sites), size of the figures (over 150 cm in Altamira, compared with generally smaller figures in other caves) and a tendency towards more dynamic figures in Altamira compared with a predominant static rigidity elsewhere. These characteristics give the Altamira figures great internal homogeneity and reveal significant differences with other dotted outline ensembles; therefore it cannot be said that the red figures in Altamira correspond to the archetype of the "Ramales School". The closest technical, thematic and stylistic affinities exist in Gallery B at La Pasiega (Breuil et al., 1913; González Sainz and Balbín, 2010) and possibly in the recently discovered group at Cueva de Askondo (Basque Country) (Gárate and Ríos Garaizar, 2011).

The minimum age of 21,980 a represented by BIG-UTh-O-53 means that the large red horses at Altamira belong to the Solutrean period at the latest. These horses are associated spatially with archaic figures; one of them with two red stencilled hands. In North Spain and France, these hand motifs were mostly painted from the Aurignacian to the Late Gravettian. Thus, the possibility that the red dotted figures also belong to pre-Solutrean times, that is, to the Gravettian or Aurignacian, cannot be ruled out.

5.3. The graphic cycle at Altamira Cave

The numerous superimpositions on the Polychrome Ceiling in Altamira Cave have been used by several scholars to establish the development and chronology of European Palaeolithic art. For Breuil (Breuil and Obermaier, 1935), they were evidence of a long graphic tradition that began in the Aurignacian with animals painted with broad red lines or colour-wash, hands, anthropomorphs with animal features, "hut-type" signs, claviforms and tectiforms. It continued during the Solutrean and Early Magdalenian with black outlined figures with internal details and engravings with multiple outlines and/or striated interiors. Finally, it concluded in the Late Magdalenian with naturalistic engravings and black outlined figures, and with the polychrome paintings. This model was based on a linear conception of evolution in form and style, from the most simple to the most complex, in which greater naturalism and technical perfection was gradually achieved. In the 1960s, Leroi-Gourhan (1965) modified the perception of a protracted accumulation of depictions to a more simplified model which included all the representations within his Styles III and IV. Thus, the first art in Altamira would have been produced in the Solutrean. This short chronology, and other later proposals (Bernaldo de Quirós, 1994; Lasheras, 2003), matched the production of the art with the periods of human occupation in the entrance hall, divided into Late Solutrean and Early Magdalenian phases. It should be noted that at that time the existence of earlier occupations in the Gravettian was unknown, as this was a recent discovery.

Radiocarbon and other geo-chronological procedures have succeeded in determining the duration of the graphic cycle at Altamira. The application of AMS dating to black paintings (Valladas et al., 1992; Moure and González Sainz, 2000; Moure et al., 1996 – Table 2) established that some of them were produced in the Magdalenian, between 19,258 and 15,204 cal BP. U-series dating now shows that another part of the graphic ensemble was produced in the Early Upper Palaeolithic, in the Aurignacian (BIG-UTh-O-50) and Solutrean (BIG-UTh-O-53) at the latest. This implies: firstly, a return to the long chronology proposed by Breuil, putting an end to a debate that has occupied researchers for nearly a century; secondly, that artistic creation began at a very early date; and thirdly, that the different phases of graphic production must have taken place over a protracted period of time, between at least 35,559 a and 15,204 cal BP. This accumulation (Fig. 6) confirms the changing and prolonged symbolic significance the cave held, from the time of the first artistic phases in the Early Upper Palaeolithic to the Middle Magdalenian.

5.4. Parietal art and archaeological context

The Polychrome Ceiling in Altamira is located some 15 m from the cave entrance, in a space to the side of the entrance hall and

Table 2
AMS dating of black paintings of Altamira Cave.

	Lab sample	Fraction	AMS BP	cal BP (95,45)
Bison XLIV	GifA-96067	Carbon	13,130 ± 120	16,576–15204
Bison XLIV	GifA-91178	Carbon	13,570 ± 190	17,114–16634
Bison XXXVI	GifA-91179	Carbon	13,940 ± 170	17,518–16740
Bison XLIV	GifA-91249	Humic	14,410 ± 200	18,021–16978
Bison XXXIII	GifA-91330	Humic	14,250 ± 180	17,849–16920
Bison XXXIII	GifA-91181	Carbon	14,330 ± 190	17,926–16960
Line under red deer	GifA-96059	Carbon	14,650 ± 140	18,485–17255
Bison XXXVI	GifA-91254	Humic	14,710 ± 200	18,534–17259
Bison XXXVI	GifA-96060	Carbon	14,800 ± 150	18,526–17631
Bison XXXIII	GifA-96071	Carbon	14,820 ± 130	18,529–17678
Red deer	GifA-96062	Carbon	15,050 ± 180	18,657–17860
Quadrangular	GifA-91185	Carbon	15,440 ± 200	19,258–18040

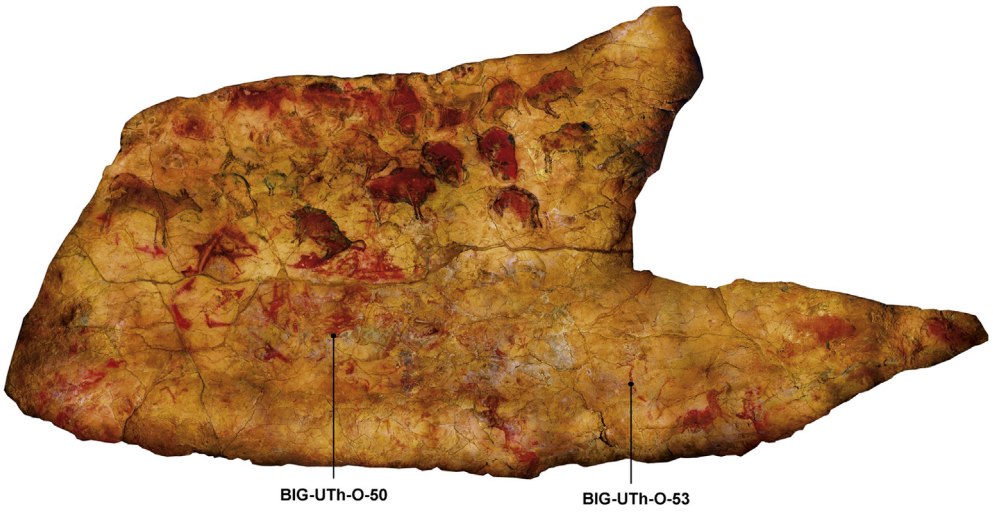


Fig. 6. The accumulation of figures in the Polychrome Ceiling of Altamira Cave with the U-series samples and results.

about 6 m below the level of the entrance. The excavation of the archaeological levels and taphonomic studies have clearly defined the entrance hall as a domestic area and habitat (Freeman and González Echegaray, 2001; Lasheras et al., 2005–2006; Heras et al., 2008; Rasines et al., 2009). In contrast, the chamber with the Ceiling is an area of graphic symbolism, where the archaeological materials found correspond to occasional visits, probably connected with the graphic activity, and to geological processes that have moved them from their original positions. This different spatial distribution of remains should not necessarily be understood as representing a differential use of the two areas. The close spatial connection between them, in terms of cave topography and of distance, together with evidence of poorly-conserved graphic production in the entrance hall (Lasheras, 2003: 67), is an indication of the links and interaction between domestic and symbolic activities.

In addition, gravitational processes have changed the morphology of the entrance hall since prehistoric times (Hoyos, 1993). The relationship between the geological processes causing the collapse of the cave roof and the human occupations mean that the entrance hall received natural light and was affected directly by any inclement weather. In contrast, the chamber with the painted ceiling was essentially an inner dark area, although it is possible that its westernmost sector (with the lowest density of figures) was originally in an area of penumbra. Consequently, the traditional hypothesis that early, pre-Solutrean art was produced in outer parts of the cave (Laming-Emperaire, 1962) should be definitively abandoned (Clottes, 1997), as the archaic graphic cycle at Altamira is distributed across much of the Polychrome Ceiling, in a clearly inner area.

6. Conclusion

Uranium-series dating is a geo-chronological procedure enabling the determination of a minimum age for Palaeolithic parietal art. The results obtained by sampling calcite deposits at Altamira Cave show that part of the non-figurative graphic ensemble belongs at least to the Aurignacian period, during the first expansion of *Homo sapiens* in the Iberian Peninsula. The thematic and stylistic similarities between the motifs associated with the dated samples and other representations on the Polychrome Ceiling indicate that intense graphic and symbolic activity took place in the cave during pre-Magdalenian times.

The spatial distribution of the parietal art and its relationship with a domestic context demonstrate the close cultural link between a symbolic area (in an area with little or no natural light) and the habitat (within daylight).

The parietal art in Altamira Cave corresponds to a protracted span of time, and was produced during a period of at least 20,000 years (between 35,559 a and 15,204 cal BP), which indicates the great symbolic importance Altamira held for Palaeolithic groups and the re-use and integration of previous motifs in each of the new phases in the development of the symbolic space.

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