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Contextual, technological and chronometric data from Cova Gran: Their contribution to discussion of the Middle-to-Upper Paleolithic transition in northeastern Iberia

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A B S T R A C T

The Middle to Upper Palaeolithic transition in Western Europe is a central topic in current paleoanthropological research. Recently, Neanderthal survival during MIS 3 and the emergence of anatomically modern humans have been the focus of much discussion in Iberia.

Here, we analyse the stratigraphic and contextual resolution of the S1B/497D archaeological levels from Cova Gran, in which a techno-typological discontinuity has been identified affecting raw material, knapping systems, blanks and retouched tools. Attributes such as radial reduction systems to obtain flakes for subsequent preferential modification into notches and denticulates place level S1B within the Mousterian tradition. However, in 497D, attributed to the Early Upper Palaeolithic, laminar production intermingles the extraction of blades, bladelets and flakes. Blades were transformed into burins, end scrapers and retouched blades, and bladelets into microlithic tools such as backed points and backed bladelets. These artefacts are associated with a significant assemblage of notches, denticulates and scrapers on flakes. Radiometric data places the end of the Mousterian tradition *ca.* 42 ka cal BP and the appearance of the Early Upper Palaeolithic *ca.* 39–38 ka cal BP.

The geographic and temporal ascription of levels S1B and 497D stimulate discussion on Neanderthal survival at the end of MIS 3 in northeastern Iberia. Likewise, the 497D lithic assemblage is compared to other techno-complexes assigned to this chronological range: the Chatelperronian tradition assigned to Neanderthals and Protoaurignacian linked to the appearance of anatomically modern humans. The archaeological resolution and techno-typological discontinuity documented in Cova Gran are useful points of reference in analysis of the Middle-to-Upper Palaeolithic transition in northeastern Iberia, and have implications affecting the characterization of this process across Western Europe.

1. Introduction: Middle-to-Upper Palaeolithic “transition” narratives in Iberia

The 1980s witnessed renewed interest in a classical discussion in Palaeoanthropology, the Middle/Upper Palaeolithic transition (MUPT). The discussion addresses the causes of the Neanderthal demise and appearance of anatomically modern humans (AMH), a process related to radical transformations in the technical, organizational and cognitive spheres (e.g. Mellars and Stringer, 1989; Farizy, 1990). Uncertainties around these issues continue to fuel the current debate (Hublin, 2015 and references therein).

Discussion of the MUPT in Iberia is structured within this framework. Radiometric dates from Abric Romaní, l'Arbreda and Castillo (Bischoff et al., 1988, 1989; Cabrera and Bischoff, 1989) focused attention on the new ^{14}C AMS and U/Th techniques delimiting the temporal sequence of the process, and describing anomalies specific to the MUPT transition in Iberia that differed from the rest of Western Europe. Two key points were raised in the

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conference *El Origen del Hombre Moderno en el Suroeste de Europa* (Cabrera, 1993):

a) Neanderthal survival at the end of MIS 3 – which lasts into MIS 2–, a scenario that confirms some of the predictions proposed by the Ebro Frontier model, that was formally presented at this workshop by Zilhão (1993);
b) The “continuity vs. population replacement” debate presents opposing models to explain the origin of the Upper Palaeolithic and, in general, the appearance of “modern” behaviour in Iberia, illustrated at Castillo (Cabrera and Bischoff, 1989; Cabrera et al., 1993) and l'Arbreda (Bischoff et al., 1989; Soler and Maroto, 1990).

It is beyond the scope of this paper to look at these issues in detail; instead, we focus on the taphonomic, chronometric and techno-typological review of key sites discussed in Zilhão's (2006) controversial synthesis, although not all his implications are fully accepted and have been the subject of several critiques (among others Vaquero, 2006; Bernaldo de Quirós et al., 2008; Soler Subils et al., 2008).

Twenty five years after the meeting organised by V. Cabrera, it is time for an up-to-date review of the MUPT question in north-eastern Iberia integrating issues originally not included in this debate. We consider that the archaeostratigraphic, techno-typological and chronometric context of Cova Gran de Santa Linya is relevant in assessing whether the appearance of the Upper Palaeolithic is a local process developed by Neanderthals in the Iberian Pyrenees; or alternatively, whether it is due to the appearance of *Homo sapiens*, a new previously unidentified human population in the area. The location of Cova Gran in the contact zone between the Ebro Basin and the southern Pyrenees is significant (Fig. 1), as it is an area where prolonged Neanderthal survival is proposed (Garcia Garriga et al., 2012), while an early and sudden appearance of AMH is assumed (Bischoff et al., 1989; Wood et al., 2014). These, not necessarily opposing hypotheses, make Cova Gran key in analysis of the MUPT in Iberia and the Western Mediterranean.

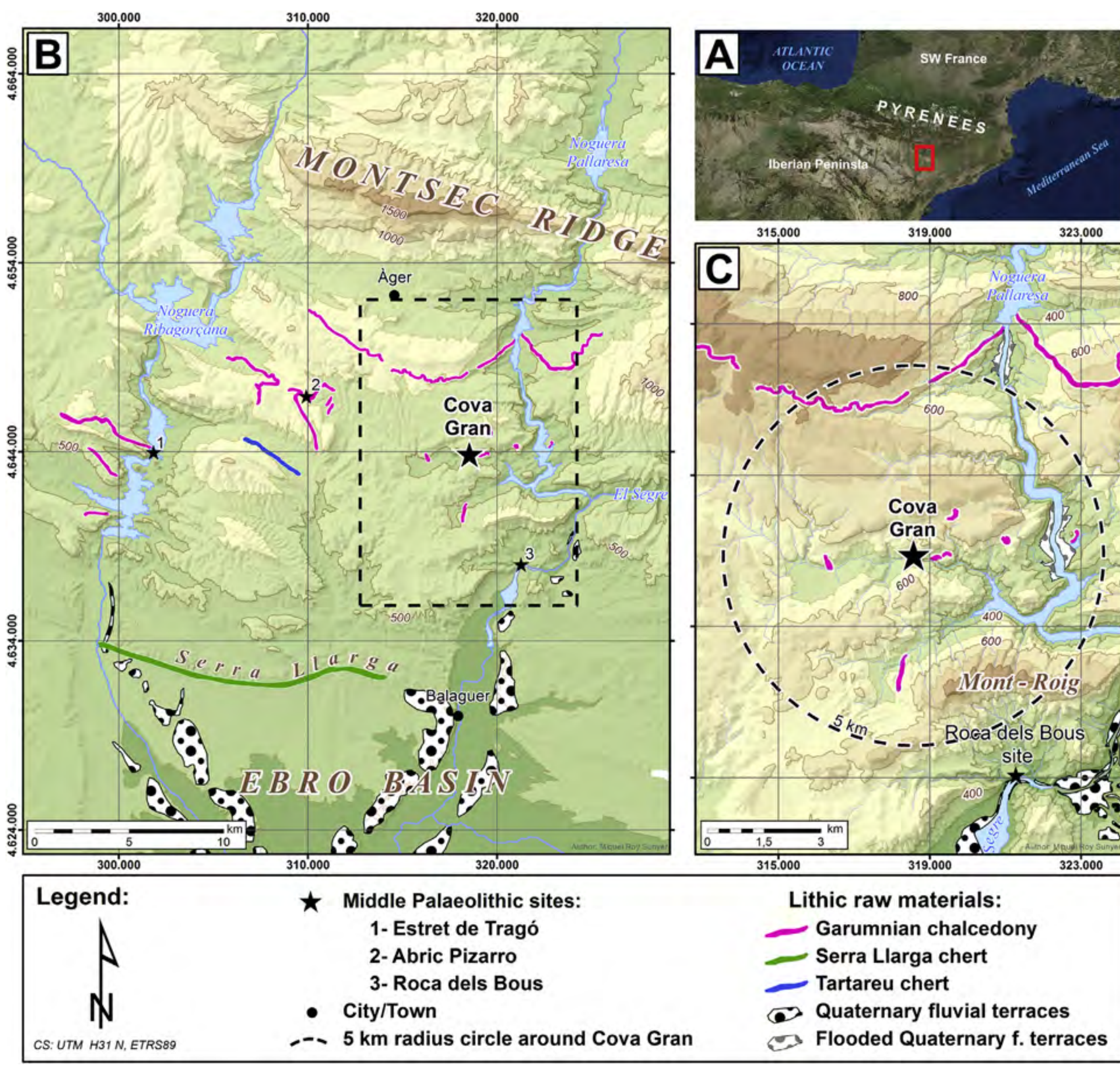

Fig. 1. A) Location of Cova Gran between northern Iberia and SW France. B and C) Geographic setting in the Sierras Marginales Exteriores of the southeastern Prepyrenees. Regional Middle Palaeolithic sites and outcrops of chalcedony, flint and quartzite are indicated.

2. Cova Gran de Santa Linya: general setting and stratigraphic context

The Cova Gran de Santa Linya rockshelter (318541, 4643877, UTM H31N ETRS89, 385 masl) is located on the first foothills of the southeastern Prepyrenees, in a valley cut by the Sant Miquel river through limestone of the Bona Formation (Upper Cretaceous). The valley links the main channels of the Segre river basin, giving access to the Ebro Basin and the inner Pyrenean valleys (Fig. 1). Excavation conducted in the *Ramp* (R), *Transition* (T) and *Platform* (P) sectors documented human occupations assigned to Late Prehistory, Magdalenian, Early Upper Palaeolithic and Middle Palaeolithic, yielding over 40 ^{14}C AMS and Thermoluminescence (Tl) dates. The broad chrono-cultural sequence revealed in the deposits indicates extensive occupation of the rock-shelter, making Cova Gran a key site in Western Mediterranean prehistory (Mora et al., 2011, 2014).

The deposit comprises two platforms. The first covers a horizontal surface of 1800 m^2 inside the shelter, below the rock wall. The second, outside and west of the rockshelter, is 200 m^2 and slopes at 15° until it converges the main surface. This morphology is related to intense palaeoflooding events of the Sant Miquel channel – currently inactive – during the Upper Pleistocene, identified in other incised valleys in the same geographical area (Rico, 2004). The flooding process led to preservation of the oldest archaeological sequence in Cova Gran in the Ramp (R) sector, a deposit located 3 m above the rockshelter surface and comprising the MUPT levels (Martínez-Moreno et al., 2010; Mora et al., 2011, 2014).

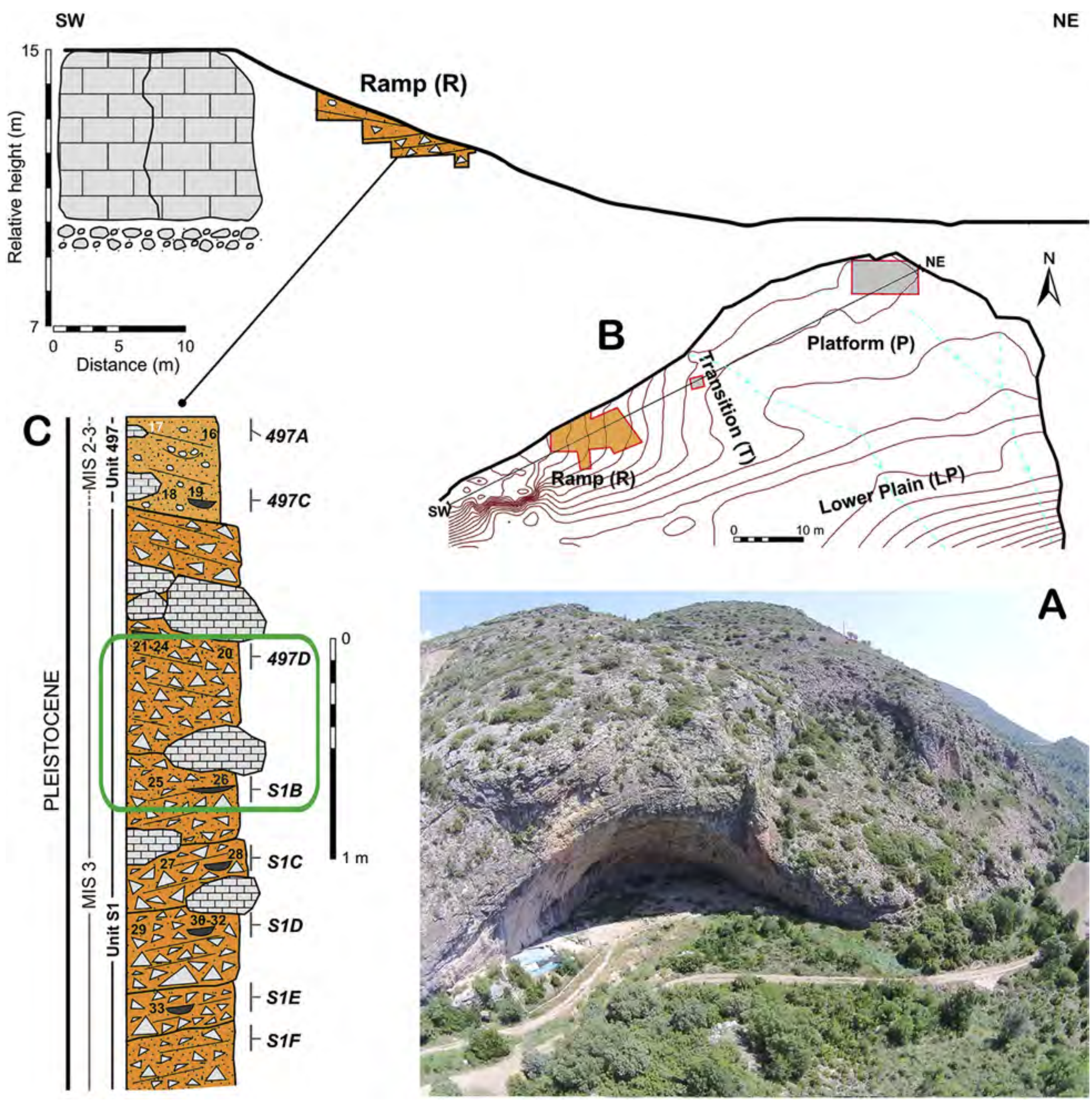

Fig. 2. A) Aerial view of Cova Gran. The blue protective fabric in the west corner indicates the excavated area in the R sector. B) General map of the excavated sectors. The profile indicates location of R sector in within the deposit (contour lines: 0.5 m). C) S1/497 sedimentary units (for details see Martínez-Moreno et al., 2010; Mora et al., 2011). Note the stratigraphic position of 497D, S1B, S1C and S1D in the sequence and compare with the chronometric framework (Fig. 6). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

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Two lithostratigraphic units were identified in the R sector: 497 and S1. The upper unit – 497 – is 0.5 m thick with a slope 12°N–70°E and rests on unit S1. Unit 497 consists of autochthonous materials washed downslope with fine and very fine, rounded and sub-rounded gravels in an abundant matrix of lutitic sands (40%.). Granular sediments affected by water flow indicate relatively milder environmental conditions. The basal unit – S1 is a 2 m-thick complex of medium and coarse gravels, sandy–clayey matrix and angular debris of gravitational origin. S1 consists of autochthonous rock fall deposits, in beds in which contact is either gradual or separated by collapsed boulders >1 m in size, and angular to very angular, poorly classified sediments with medium and coarse gravels, and a limited matrix (<20%) of silty/clayey sands. The fine fraction, composed primarily of calcite and dolomite, decreases towards the rockshelter roof, and coincides with an increase in siliceous minerals and gypsum. The basal layers excavated in the east of the ramp form a depositional slope towards the W–SW which gradually flattens out, while the upper layers in the western area slope E–NE (Benito Calvo et al., 2009). Micromorphological analysis has provided further insights into the formation processes and the stratigraphic integrity of this part of the sequence (Polo-Díaz et al., 2016) (Fig. 2).

3. The archaeostratigraphical resolution of the Ramp sector

The formation processes of sector R are related to weathering and gravitational processes, creating irregular beds of homogeneous sediments but lacking sedimentary references. Because of the low stratigraphic visibility, establishment of archaeological units was based on contextual information provided by the systematic plotting of lithic and bone remains and their spatial relationship with hearths (Martínez-Moreno et al., 2016). N–S and E–W vertical plots show occupation surfaces to be on a slight slope extending towards the central platform of the rockshelter. Activity of the Sant Miquel river demolished part of the deposit which should be more extensive. Large collapsed boulders seal and separate occupation events and sterile layers separate archaeological materials and hearths (Fig. 3).

Levels 497A and 497C of the sedimentary unit 497 were excavated and assigned to the Early Upper Palaeolithic (EUP). Bedrock has not yet been reached in unit S1, but level 497D corresponds to the EUP, and levels S1B, S1B1, S1C, S1D and S1E are attributed to the Middle Palaeolithic. Slope erosion, particularly in 497D, caused irregularity of surfaces. These occupations have a mean thickness of 5–10 cm, and include hearths, bone remains and abundant lithic artefacts, which allow chrono-cultural attributions to be made and inferences drawn regarding technical behaviour, subsistence strategies and intrasite spatial settlement patterns (Table 1). Although vertical density based on coordinates is a relative indicator, the Middle Palaeolithic levels seem denser than the EUP, and seem to correspond to discrete occupations.

The S1B and 497D archaeological levels, in which techno-typological changes associated with the MUPT were detected, are in the upper part of the S1 unit (Martínez-Moreno et al., 2010, 2012; Mora et al., 2012) (Fig. 2). The 497D/S1B superposition was excavated over an area of 50 m^2, with a linear overlap along 10 m. Vertical plots established two archaeostratigraphic units separated by a sterile level, with no traces of bioturbation or cryoturbation to suggest vertical migration of artefacts. This stratigraphic integrity has implications for the homogeneity of the archaeological assemblages. Soil micromorphology shows no sedimentary breaks or syn/post-depositional unconformities indicating stratigraphic discontinuity. 497D and S1B are cultural aggregations formed in the same sedimentary cycle during an undefined temporal range that does not seem to be related to severe climatic or environmental changes (Polo-Díaz et al., 2016).

4. Lithic assemblages: visualizing a systemic techno-typological discontinuity

While the Middle-to-Upper transition is a phenomenon affecting all components of the archaeological record, the techno-typological change is always the focus of discussion. The lack of techno-typological coherence between the S1B and 497D lithic assemblages is striking and indicates different techno-typological traditions, even though they are stratigraphically successive levels. The S1B assemblage is indicative of the technical variability identified in Mousterian levels (de la Torre et al., 2013), while the 497D assemblage refers to EUP levels in Cova Gran (Martínez-Moreno et al., 2010). As indicated above, we underline a key argument in the interpretation of these assemblages is that they are from archaeological contexts separated by a sterile sedimentary layer, in which no severe syn/post-depositional processes were identified (Benito Calvo et al., 2011; Polo-Díaz et al., 2016). More than 3500 artefacts have been recovered from each level, comprising cores, blanks and retouched tools, suggesting transport of over 20 kg of raw material. Characteristics of the S1B and 497D technical systems are described below, and their quantitative and qualitative parameters have been discussed elsewhere (Martínez-Moreno et al., 2010, 2012; Mora et al., 2012; de la Torre et al., 2013).

4.1. Carrying rocks: changes in raw material

The assemblages are of two different lithologies: quartzites from the river network and siliceous rocks from nearby hills. There are many outcrops of Garumnian chalcedonies (Upper Cretaceous/Lower Palaeocene) in hills to the north of, and near the site, but although the material is abundant, it is poorly suited for knapping activities. Better quality flint outcrops are found in the Serra Llarga (Lower Oligocene) in the contact area with the Ebro Basin 20 km south of Cova Gran (Fig. 1). Thus, raw material sources are within a 20 km radius of the site. Other good quality siliceous formations are located over 80 km away (Roy et al., 2013).

S1B and 497D indicate management of resources that are essentially local (Table 2); among the more than 8200 artefacts from both levels, only one flint flake from 497D is not from a local context. The Garumnian chalcedonies comprises 90% of all lithics in S1B and 86% in 497D, indicating acquisition focused on an abundant, tough, but low quality material with multiple cracks and impurities that hamper knapping. Nevertheless, some changes are evident among secondary rocks. Quartzite forms 12% of retouched tools in S1B and 35% of the total assemblage weight, an increase related to selection of large-sized blanks transported to the site from about 5 km away. In contrast, while quartzite is scarce in 497D, a significant increase in Serra Llarga flint is noted and forms 20% of all artefacts, although only two cores are recorded, suggesting transport of selected blanks to the site.

These changes in raw materials from more distant locations indicate differences related to the selection of artefacts for transport to the site. In S1B and 497D transport of preforms and isolated blanks from the Garumnian outcrops is documented, although this is more evident when focusing on secondary raw materials. In S1B large and morphologically standardized quartzite flakes are more commonly brought to the site, while in 497D the focus is on small artefacts and/or retouched tools on Serra Llarga flint. Although these observations do not involve quantitative variations, they indicate changes in selection criteria for artefacts related to different functional requirements (Roy et al., 2013).

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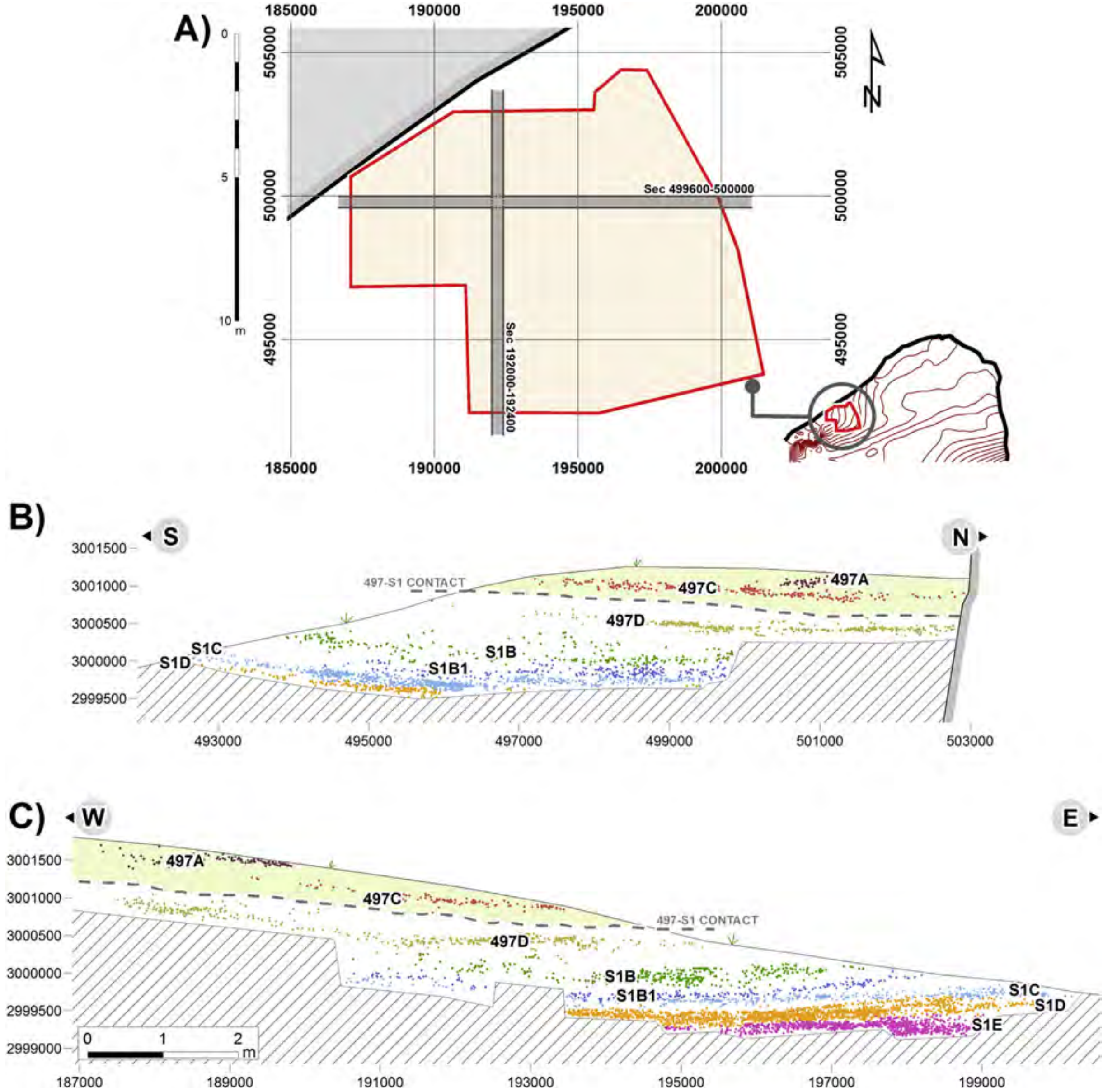

Fig. 3. Archaeostratigraphy of R sector. A) Excavated area and location of NS and E–W vertical plots B) N–S vertical plot in Y axis = 192,000–192,400 (plot width 40 cm). C) E–W vertical plot in X axis = 499,600–500,000 plot width 40 cm). The contact between S1 and 497 sedimentary units is noted.

4.2. Knapping system: different concepts, different solutions

Differences in reduction methods and blanks produced are central in defining the systemic rupture between S1B/497D (Martínez-Moreno et al., 2010, 2012). S1B cores and blanks are technologically Middle Palaeolithic with knapping systems aimed essentially at flake production (97% of complete blanks) and, to a lesser extent, a few points and blades. Two different reduction methods are identified, each having different aims (de la Torre et al., 2013). The first comprises single platform, unifacial expedient systems, usually in fragmented form. There is no volumetric control of cores during knapping, which hampers recurrent

Table 1
Contextual parameters (excavated surface and thickness), and number of lithic artefacts, bone remains, hearths and presence of marine ornaments from levels excavated in the R sector. EUP = Early Upper Palaeolithic, MP = Middle Palaeolithic.

Unit	Level	Surface (m^2)	Thick (cm)	Number lithics	Number bones	Number hearths	Marine ornaments	Cultural attribution
497	497A	19	5–10	1752	107	1	Yes	EUP
	497C	37	5–10	2046	51	4	Yes	EUP
S1	497D	63	10–15	4489	695	14	Yes	EUP
	S1B	69	15–20	3780	925	6	No	MP
	S1B1	55	5–10	3105	1174	4	No	MP
	S1C	61	5–10	8548	2193	14	No	MP
	S1D	36	10–15	7988	2693	10	No	MP

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Table 2
Raw material distribution of lithic categories in S1B and 497D (greater than 2 cm in length). Number of fragments (N) and weight percentages (total column indicates weight in kg for each category).

		S1B				497D			
		Chalcedony	Serra LLarga	Quartzite	Total	Chalcedony	Serra Llarga	Quartzite	Total
Core	N	28	1	2	31	46	2	–	48
	% weight	90,3	3,2	6,5	2,6	95,8	4,2	–	6,8
Flakes	N	472	5	43	520	483	55	3	541
	% weight	90,8	1	8,3	5,7	96,5	3,4	0,1	2,9
Fragments	N	2140	23	219	2382	2624	432	16	3074
	% weight	89,8	1	9,2	10,3	91,3	7,2	1,4	6,9
Retouched	N	172	9	24	205	227	67	1	295
	% weight	83,9	4,4	11,7	5,8	76,9	22,7	0,3	2,2

exploitation and results in the extraction of a short series of blanks (Casanova et al., 2009, 2014; Mora et al., 2012). The second knapping system is characterized by the bifacial volumetric shaping of cores, enabling recurrent sequences of blank production indicating preferential Levallois and other recurrent centripetal Levallois methods (Böeda, 1993; Mora et al., 2012) (Fig. 4A). These methods generate short, wide flakes with a mean length of 4 cm associated with stereotypical morphologies such as, *eclats debordants*, pseudolevallois flakes, pseudopoints, and kombewa flakes. Dorsal faces are formed by radial extractions, and the negative of previous extractions on some artefacts indicates preferential blanks. Butts tend to be large, flat and broad, with some multifaceted platforms also documented, usually with marked impact points and bulbs suggesting the exclusive application of direct, hard hammer percussion (Roussel et al., 2009) (Fig. 5A).

497D is associated with laminar knapping methods aimed at extracting morphologically varied and elongated blanks. Cores are pyramidal and truncated pyramidal volumes, with one or two opposed orthogonal platforms from which blanks with straight profiles were produced. The denticulated and sinuous shape of knapping platforms indicate little preparation and maintenance, and use of direct hard hammer percussion, possibly combining tough and soft hammer percussion (Roussel et al., 2009), causes multiple knapping accidents (Fig. 4B). Platform rejuvenation tablets and distal semi-crests aimed at shaping blank extractions were identified, although no central crested blades were documented. Although these technical elements are associated with laminar knapping, attributes such as the inclusion of bladelets, blades and laminar flakes in the same reduction sequence are not common (CREP, 1984; Inizan et al., 1995; Böeda, 2013). Usually, the abundance of flakes in laminar *debitage* systems has been considered as a by-product connected with volumetric shaping of the core, although in some cases it has been suggested that exhausted laminar cores were recycled for the extraction of flakes (Bon and Bodu, 2002). Recently, core reduction specifically directed towards flake production has been identified in several Upper Palaeolithic assemblages (Pastoors et al., 2012 and references therein).

In recent years, two reduction systems have been identified in the first techno-complexes of the Upper Palaeolithic in Western Europe. The first is the application of the same knapping method from dissociated volumes to obtain blades and bladelets. Alternatively, in the second system, bladelets were obtained from carinated shapes such as end scrapers or burins. Such methods enable the production of morphometrically regular blanks (Bon, 2002; Le Brun-Ricalens, 2005). Although alternating extraction of blades and bladelets from the same core has been mentioned (Bordes, 2006), it does not seem to be commonplace.

Nonetheless, these schemes do not explain attributes of the 497D assemblage. Different knapping methods applied to cores for the exclusive extraction of flakes have not been detected. This system of alternating blades, bladelets and flakes produces irregular blanks without any visible evidence in metrical attributes of a distinct rupture between blades and bladelets. Usually, blades do not have parallel ridges or triangular/trapezoidal sections, but have ridges that are offset from the knapping axis. Nevertheless, the method enables the recurrent manufacture of pieces from bladelets to large blades (more than 12 cm), although the range of unbroken artefacts and negatives on cores is 4–6 cm (Martínez-Moreno et al., 2012). Many blanks broke during knapping due to the type of percussion applied to a raw material with many cracks and impurities, resulting in an apparent scarcity of blades. In fact, flakes form 80% of the assemblage, but their morphotechnical attributes indicate a knapping system from platforms, which is different from the radial pattern identified in S1B. The abundance of flakes and low morphological standardization of elongated blanks, gives an archaic appearance to the 497D assemblage (Martínez-Moreno et al., 2010, 2012).

4.3. Retouched pieces: changes in assemblage tool types

The retouched component is key for the chrono-cultural assignation of assemblages. It is assumed that Middle Palaeolithic assemblages are characterized by their low typological range in contrast to the higher typological diversity observed in Upper Palaeolithic traditions.

As such, S1B is clearly attributable to the Mousterian. Among the 191 retouched flint and quartzite tools, notches (69) and denticulate (58) are more abundant than artefacts with continuous retouch (62). Side scrapers are more common than transversal and bilateral scrapers (9). Edge modification is achieved by simple and/or abrupt retouch; Quina retouch was not identified. This assemblage also includes end scrapers (2), points (3), scaled pieces (1) and pieces with bifacial retouch (2) (Mora et al., 2012). The preferential selection of large blanks to be retouched suggests they were handheld, although intentional reduction on some artefacts might be related to hafting (Bernard-Guelle and Porraz, 2001; Mora et al., 2012) (Fig. 5A). The large size of artefacts indicates the abundance of local raw material and its transport seems to be related to particular functional purposes, in contrast to other assemblages in the area such as Roca dels Bous (Mora et al., 2012; de la Torre et al., 2013). Due to their limited typological diversity, assemblages structured around notches and denticulates have usually been underestimated; this assumption is currently under review and it has been suggested that such assemblages might indicate technomorphological and functional versatility is greater than has traditionally been considered (Delagnes et al., 2007; Delagnes and Rendu, 2011).

The 280 retouched tools identified in 497D indicate the appearance of new morphotypes. The assemblage comprises blades with transversal truncation or associated with notches (16), blades with lateral truncation, some pointed and with a curved or very

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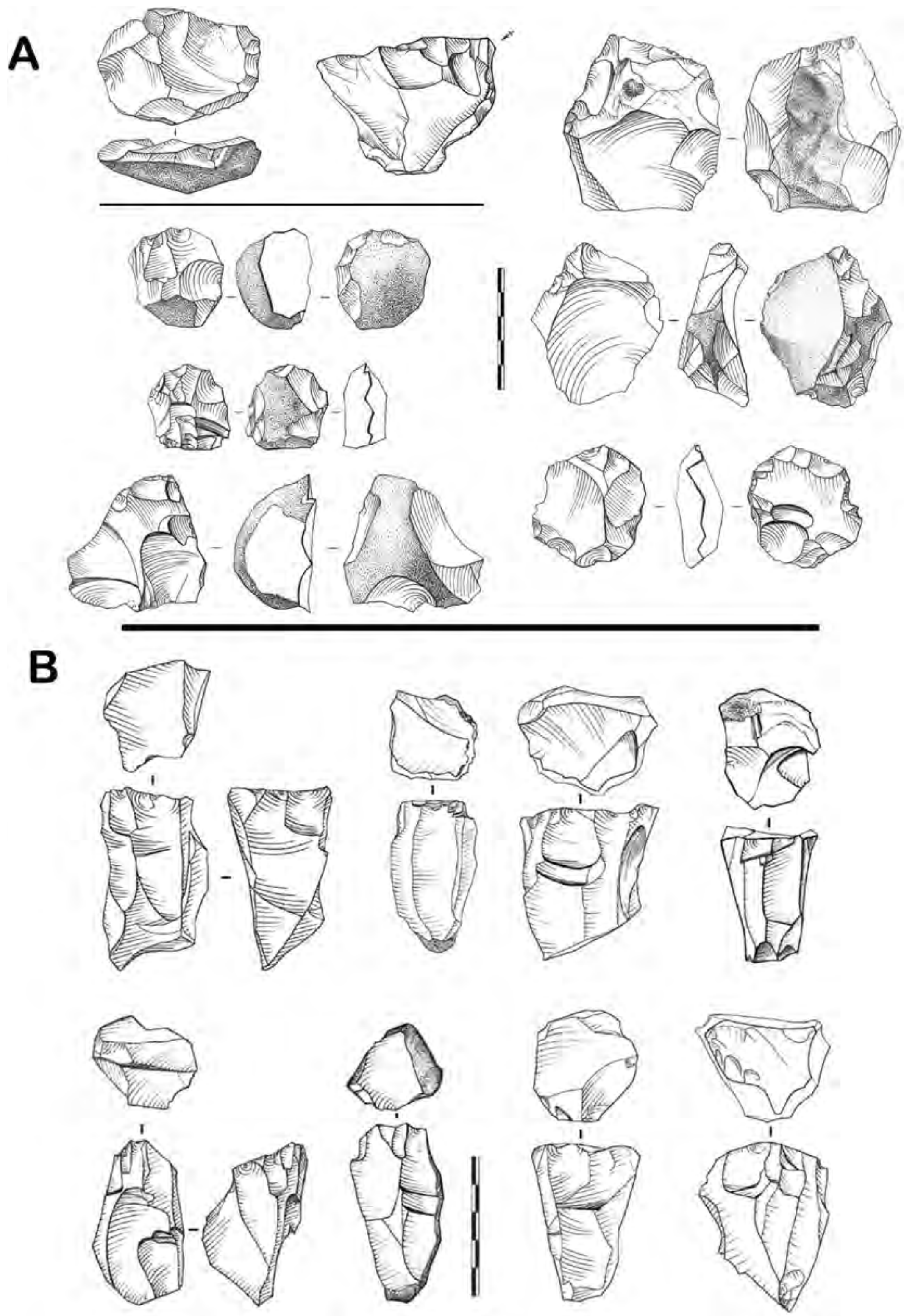

Fig. 4. A) Examples of the S1B structured cores assigned to recurrent preferential and recurrent centripetal Levallois methods. Expedient cores (upper corner left) are unifacial centripetal and a core-flake with extractions on the dorsal surface (see Martínez-Moreno et al., 2010; Mora et al., 2012). B) 497D cores showing laminar knapping (see Martínez-Moreno et al., 2010, 2012). Graphic scale 5 cm.

oblique back (11) which cannot be considered typologically as Aurignacian blades. There are also end scrapers (7) and burins (6) on blades and flakes. Elongated blanks include bladelet fragments (25) with summary lateral retouch, and in some cases alternating retouch. Nevertheless, the main components of the retouched assemblage (58%) are notches (52), denticulates (66) and scrapers (25), although they are different to those recovered from S1B. Notches are shaped by isolated retouch primarily on small artefacts, distinct from the clactonian notches on thick blanks in S1B. Side scrapers are partially retouched in contrast to the invasive

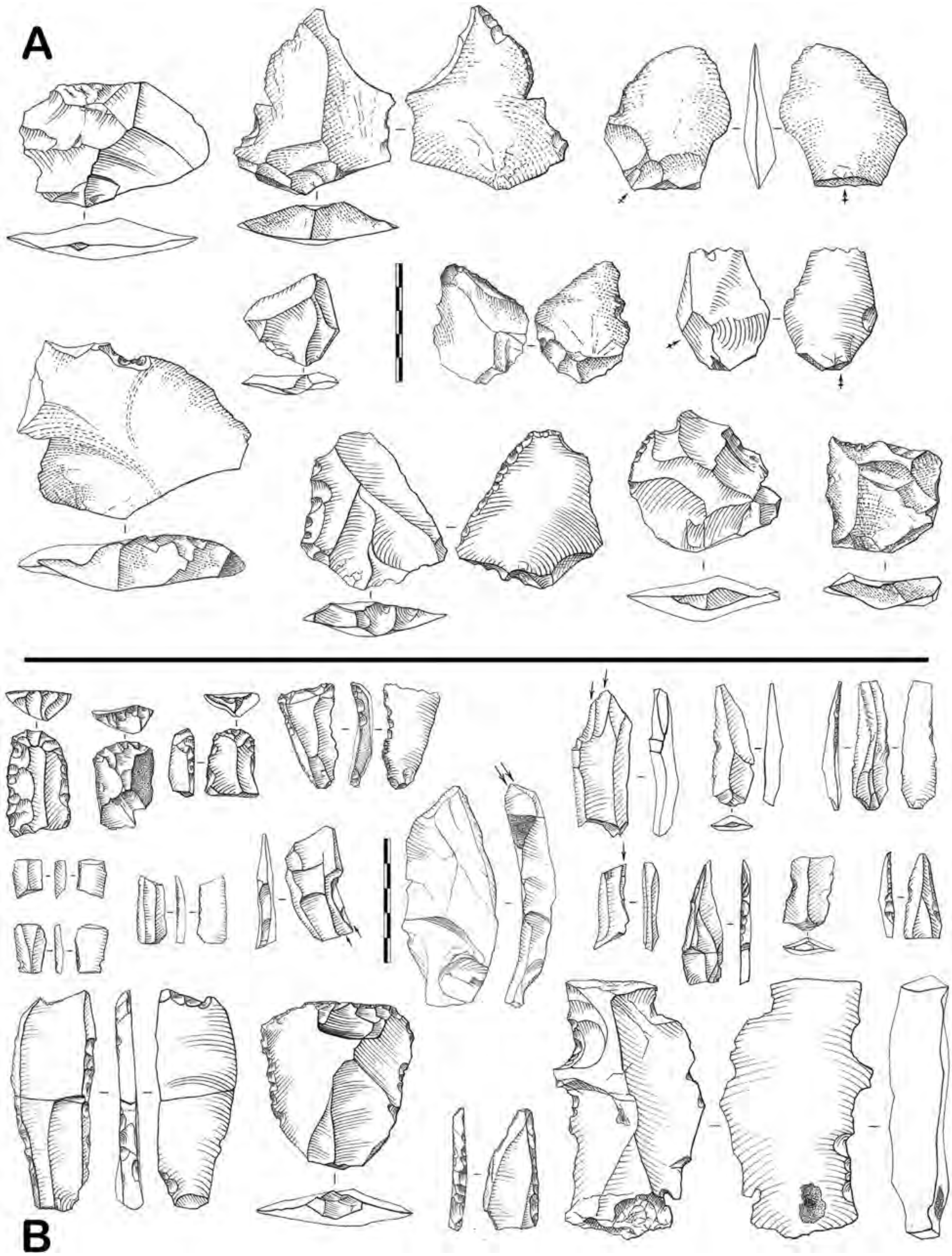

Fig. 5. A) Notches, denticulates and side scrapers on Levallois, pseudolevallois and *kombewa* flakes from S1B (see Martínez-Moreno et al., 2010; Mora et al., 2012). B) Retouched pieces on blades and bladelets comprising points, retouched blades, fragmented bladelets, end scrapers and burins from 497D (see Martínez-Moreno et al., 2010, 2012). Graphic scale 5 cm.

modification of S1B pieces. These differences suggest design shifts related to use. The quantitative importance of the basic component seems to be a particularity of 497D, and is not commonly mentioned in Upper Palaeolithic assemblages in which such tools are often very scarce (Fig. 5B).

The differences in raw material management, knapping systems and retouched tools support the notion of a systemic discontinuity. The S1B assemblage relates to other Mousterian levels in Cova Gran as well as other sites from the same region such as Tragó and Roca dels Bous (see Fig. 1), and shows no trends heralding the changes observed in 497D (Mora et al., 2012; de la Torre et al., 2013). Conversely, the 497D assemblage reflects a previously unknown technical tradition, suggesting a rupture with systems developed over thousands of years in this area of the southeastern Prepyrenees (Martínez-Moreno et al., 2010; Mora et al., 2014).

5. An uncertain chronometric frame?

Definition of the temporal framework of this systemic discontinuity is based on the application of radiometric methods on unequivocal archaeological contexts in order to overcome uncertainties surrounding the characteristics of the 45–30 ka interval. This chronometric analysis of the R sector incorporated all dates from the 497 and S1 sedimentary units; radiocarbon AMS dates from 10 charcoal and 3 marine shells were calibrated using IntCal13 at 2δ p(95%) (Reimer et al., 2013), and 6 Tl dates were also included. Chronometric intervals and graphic representation were obtained with OxCal v.4.2 (Bronk Ramsey, 2009) (Table 3). (Fig. 6).

^{14}C AMS and Tl yielded different chronometric dates for the EUP and MP levels. As Tl dates are imprecise due to high δ values leading to temporal ranges <10 ka, we use the μ parameter calculated by OxCal as a guide. ^{14}C dates yielded a more accurate calendric framework (<1.5 ka). Although ^{14}C and Tl dates show a temporal order that conforms with the stratigraphic sequence, some anomalies can be detected.

The μ value of the Tl series shows that the archaeological levels in the 497 sedimentary unit are more recent than S1, and indicates a temporal gap between 497 and S1 of more than 5 ka (12 ka when the μ value between 497C and 497D is taken into consideration). The upper part of the S1 unit would be older than 37.5 ka, and the base of the excavated Mousterian sequence, yielded a minimum date of >43 ka. Although the μ value for the Tl dates serves as a temporal indicator, as those intervals are wider, the intervals define a vector that matches the temporal order of the archaeological sequence well.

Some chronometric anomalies observed between the S1D/S1C and 497D levels, record a phenomenon we define as *radiometric synchrony*, in which the stratigraphically older levels assigned to the Middle Palaeolithic yielded temporal ranges similar to or more recent than 497D (Martínez-Moreno et al., 2010). This apparent radiometric synchrony challenges the stratigraphic position of the dates obtained from the S1B and 497D levels. However, the assumption that the S1D and S1C dates were obtained from charcoals that had migrated from the upper levels can be rejected on the basis of the vertical geometry of the archaeological levels (Fig. 3). Furthermore, microstratigraphic analysis of the S1B sedimentary context indicates formation processes related to the accumulation of “in situ” overlapping combustion structures, thus further supporting the stratigraphic integrity of the archaeological record overlying the S1D and S1C levels, and rendering the potential intrusion of materials from above the 497D sequence unlikely (Polo-Díaz et al., 2016).

Conversely, the AA 68834 charcoal sample from a hearth in 497D provides a more probable explanation. The sample processed with the more aggressive protocol ABOX, produced older chronometric ranges in the order of 1–2 ka (see Table 3). This suggests that treatments used in ^{14}C laboratories affect the radiometric signal and that the commonly applied AAA and ABA protocols are not always effective (Pigati et al., 2007). Such problems are not exclusive to charcoal and have been detected in shell and bone samples too (Higham et al., 2009; Wood et al., 2010). A marine shell from 497D (OxA-19250) tested by the experimental protocol CarDS (Douka et al., 2010) yielded a date 6 ka younger than dates derived from charcoal, suggesting the shell carbonate had not been completely purified, much the same as has been proposed for some shell ornaments from Franchthi Cave (Douka et al., 2011). A similar process affected the dates of other marine shells from 497A to 497C treated with A protocol, and therefore these dates should be considered as minimum ages.

The increasing technical complexity related to the acquisition of reliable dates should not overshadow the stratigraphic resolution of samples whose stratigraphic position and contextual provenance is known, as the close association between date and context is key to this discussion. Thus, if the S1D and S1C dates are considered minimum ages, the apparent radiometric synchrony with 497D disappears. Based on these indications, we propose some chronometric ranges relating to change in the bio-cultural process identified in Cova Gran. We suggest the demise of the Mousterian tradition seen in the Cova Gran sequence occurred during the temporal range provided by the Beta-224299 sample from S1B, suggesting a minimum age of 42 ka cal BP. Similarly, we assign the emergence of the EUP to the temporal range provided by AA 68834 from 497D, treated with ABOX protocol, indicating a date *ca.* 39–38 ka cal BP, while samples treated with AAA and ABA protocols indicate a minimum age *ca.* 37.5–36 ka cal BP (Fig. 6).

6. Discussion: Cova Gran and the MUPT debate in northeastern Iberia

Contextual and chronometric data are essential in assessing the significance of the discontinuity in lithic assemblages detected in Cova Gran. Those radiometric intervals directly affect the MUPT discussion; for example, the continued presence of Neanderthals in the southern Pyrenees during MIS 3 and the origin of the Upper Palaeolithic in northeastern Iberia, both key issues in the palaeogeographic development of the Iberian Peninsula between 45 and 30 ka (Zilhão, 2006).

6.1. Cova Gran and Neanderthal resilience at the end of MIS 3

A prolonged presence of Neanderthal populations in a large area of Iberia at the end of MIS 3 forms the basis of the *Ebro frontier* model (Zilhão, 1993, 2000, 2006, 2009). This model proposes that the Ebro Basin could have formed a biogeographic barrier segregating Neanderthal populations north of the boundary from those in the Central Meseta, the Mediterranean coast and Andalucia, with groups surviving in Andalucia until their final demise during MIS 2 (Finlayson et al., 2006, 2008). In contrast to the static scenario proposed by the Ebro frontier model, another proposal suggests that late Neanderthal populations were not restricted to the south of the frontier; the early presence of AMH groups detected in Cantabria and northeastern Iberia occurred while these areas were still populated by Neanderthals. In this case, Iberia would have witnessed a significant and complex diversity of paleobiogeographic scenarios forming a mosaic landscape, without dismissing a prolonged coexistence of Neanderthals and *Homo sapiens* (Straus, 2005).

This premise has been used to explain the persistence of Neanderthal populations after the arrival of *Homo sapiens* in

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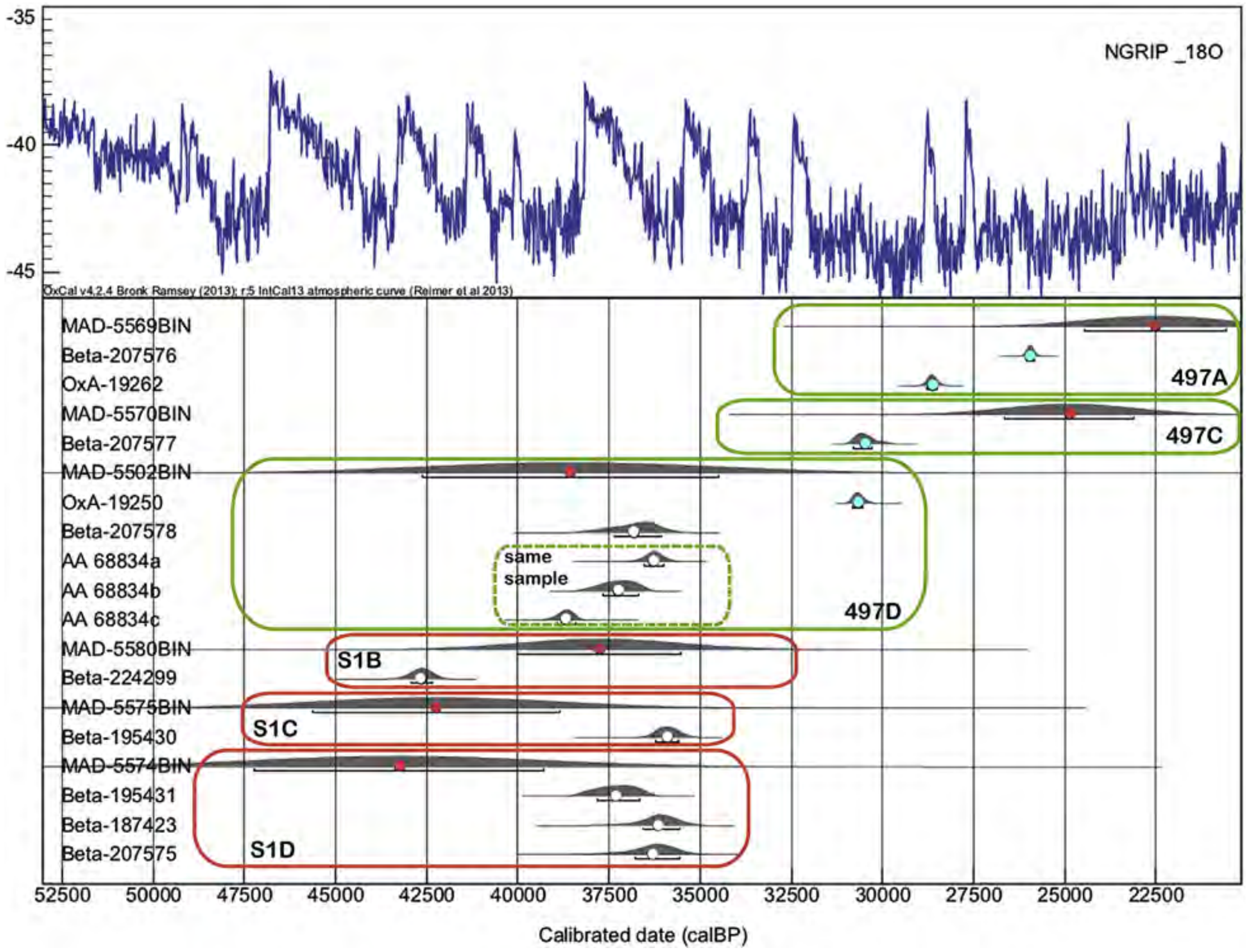

Fig. 6. Plot of the radiometric series from the R sector. μ value for charcoals (white), marine shells (blue) and burnt flint (red). AA 68834 sample-chronometric variations according to the type of pre-treatment are noted. Note the "radiometric synchrony" among S1D/S1C and 497D ^{14}C dates. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

northeastern Iberia. It shown that sites such as Ermitons and Fuentes de San Cristóbal anchor the continuity of Neanderthal populations in the southeastern Pyrenees, an area where an early appearance of the Protoaurignacian has been attested at the Reclau Viver sites — near Ermitons cave — (Maroto et al., 1996). Following the hypothesis of the competitive exclusion of Neanderthals proposed by Banks et al. (2008), it has been suggested recently that increasing pressure by the arrival of AMH groups resulted in the

Table 3
^{14}C and Tl series from the R sector. Cal BP 2δ and μ ranges were obtained with OxCal v.4.2. ^{14}C dates include the type of pre-treatment applied. AAA and ABA protocols are comparable. ABOX protocol is explained in Pigati et al. (2007).

Stratigraphic unit	Archaeological level	# Laboratory	Sample	Method & protocol	BP	δ	cal BP p (95%)	μ	Attribution
497	497A	MAD-5569BIN	burnt flint	Tl	20,555	1940	26,376–18,635	22,506	EUP
497	497A	Beta-207576	marine shell	^{14}C AMS-A	21,690	120	26,159–25,730	25,946	EUP
497	497A	OxA-19262	marine shell	^{14}C AMS-CarDS	24,600	110	28,891–28,365	28,635	EUP
497	497C	MAD-5570BIN	burnt flint	Tl	22,922	1777	28,420–21,326	24,873	EUP
497	497C	Beta-207577	marine shell	^{14}C AMS-A	26,220	220	30,941–29,875	30,468	EUP
S1	497D	MAD-5502BIN	burnt flint	Tl	36,610	4056	46,655–30,467	38,561	EUP
S1	497D	OxA-19250	marine shell	^{14}C AMS-CarDS	26,340	130	30,945–30,340	30,654	EUP
S1	497D	Beta-207578	charcoal charred	^{14}C AMS-ABA	32,630	450	38,155–35,684	36,804	EUP
S1	497D	AA 68834a	charcoal hearth	^{14}C AMS-A	32,368	241	36,891–35,685	36,287	EUP
S1	497D	AA 68834b	charcoal hearth	^{14}C AMS-AAA	33,068	261	38,167–36,431	37,256	EUP
S1	497D	AA 68834c	charcoal hearth	^{14}C AMS-ABOX	34,179	247	39,337–38,184	38,705	EUP
S1	S1B	MAD-5580BIN	burnt flint	Tl	35,820	2237	42,234–33,307	37,771	MP
S1	S1B	Beta-224299	charcoal hearth	^{14}C AMS-ABA	38,640	440	43,281–42,047	42,656	MP
S1	S1C	MAD-5575BIN	burnt flint	Tl	40,288	3389	49,002–35,476	42,239	MP
S1	S1C	Beta-195430	charcoal hearth	^{14}C AMS-ABA	32,000	300	36,521–35,198	35,893	MP
S1	S1D	MAD-5574BIN	burnt flint	Tl	41,308	3979	51,199–35,319	43,259	MP
S1	S1D	Beta-195431	charcoal hearth	^{14}C AMS-ABA	33,090	350	38,327–36,362	37,308	MP
S1	S1D	Beta-187423	charcoal hearth	^{14}C AMS-ABA	32,180	430	37,415–35,105	36,169	MP
S1	S1D	Beta-207575	charcoal hearth	^{14}C AMS-ABA	32,260	490	37,774–35,110	36,325	MP

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restructuring of Neanderthal lifestyle towards the management of mountain resources. With this in mind, the ^{14}C series from Cova Gran, might support Neanderthal continuity in the southeastern Prepyrenees and indicate a shift in exploitation of natural resources by local Neanderthal populations (Garcia Garriga et al., 2012).

We agree that the imprecise contextual resolution of San Cristóbal and Ermitons cannot validate Neanderthal continuity at the end of MIS 3 (Zilhão, 2006, 2009). The use of crude BP dates as chronometric markers is a methodological error that weakens the discussion. We will not discuss Garcia Garriga et al.'s (2012) unjustified assignment of 497D as Mousterian, as it does not take into account our results (Martínez-Moreno et al., 2010). While possible Neanderthal resilience at the end of MIS 3 and beginning of MIS 2 is a scenario that cannot be excluded, we suggest that justification of this proposal based exclusively on dating is unfeasible. Likewise, alternative explanations contradict the radiometric synchrony indicated for the 497D and S1C–S1D ^{14}C dates. One option is to accept that the temporal range suggests rapid sedimentation rates, such as 1.5 m in 2.5–3 ka (Fig. 6), but elevated sedimentary rates are not sustained by the archaeostratigraphy of the deposit (see Fig. 3) or by micromorphological studies (Polo-Díaz et al., 2016). It seems more likely that the chronometric results are affected by ^{14}C protocols used in samples dated close to the limit of the ^{14}C method, as demonstrated by sample AA 68834. Following the reasoning of this argument, S1C and S1D should be considered minimum ages that underestimate the temporal range of those levels which therefore are not synchronic with 497D. This proposal reconciles chronometry and stratigraphic order (Martínez-Moreno et al., 2010).

Radiocarbon dates, then, should be analysed critically. Their interpretation is affected by multiple factors including issues from the context from which the date was taken to sample processing procedures. It is wrong to use dates taken out of context without noting their stratigraphic position and yet consider them as absolute data as proposed by Garcia Garriga et al. (2012). Likewise, several dates associated with the MUPT debate in Iberia have similar problems to those described for the Mousterian levels S1D and S1C of Cova Gran (Zilhão, 2006; Santamaría and de la Rasilla, 2013). New dating programmes, applying more rigorous protocols, might yield more reliable chronometric indicators (Higham et al., 2014); moreover, in order to analyse the biogeography of human populations in Iberia at the end of MIS 3, these "accurate" dates should be associated with contextualized archaeological assemblages.

6.2. *Cova Gran and the appearance of the Upper Palaeolithic in northeastern Iberia*

The emergence of the Upper Palaeolithic in Iberia transcends the techno-typological realm as it is considered a proxy for the appearance of a new species. Transformations identified in S1B/497D affect this discussion. A new assemblage of artefacts was identified in 497D, comprising truncations, points, backed points, retouched bladelets, burins and end scrapers, associated with notches, denticulates and side scrapers (58% of retouched tools). Although some of these attributes give an archaic aspect to the assemblage, the techno-complex falls within an Upper Palaeolithic tradition. Significant differences in raw material procurement, knapping methods, blanks and retouched tools indicate S1B to be part of the Mousterian tradition, rooted in this region from MIS 5e to MIS 3 (Mora et al., 2012; de la Torre et al., 2013). Such technical continuity was not identified in 497D whose archaic attributes fit within a new technical system. Thus, we suggest that this systemic discontinuity indicates the emergence of an innovative techno-cultural tradition previously unknown in this part of the southeastern Prepyrenees.

Nevertheless, the ascription of 497D to early Upper Palaeolithic techno-complexes is not apparent. Chronometric dating of 497D yielded a minimum age of 37.5–36 ka cal BP, and an ABOX date suggests 39–38 ka cal BP. This temporal framework suggests the Aurignacian *phylum*, traditionally considered the first indication of the Upper Palaeolithic in Western Europe. Recent study confirms Laplace's (1966) proposal distinguishing two different techno-complexes: the Protoaurignacian and Early Aurignacian (Bon, 2002, 2006).

The Protoaurignacian, tradition spread from the Western Mediterranean to Cantabria, and key sites include l'Arbreda and nearby sites such as Reclau Viver and Mollet III (Maroto et al., 1996). ^{14}C AMS dates from carbon collected in the 1980s revealed the prominent role of l'Arbreda in the discussion of the Iberian MUPT, justifying a sudden and early emergence of AMH. The average of four dates from L'Arbreda Level I established a final Mousterian presence at 39,900 ± 600 BP, while the average of seven dates from level H placed the first Protoaurignacian at 38,300 ± 500 BP (Bischoff et al., 1989). This interpretation which was criticized for the limited stratigraphic resolution of the sequence and questionable correlation between dates and contexts (Zilhão, 2006), was subsequently addressed by Soler Subils et al. (2008). Recent results of micromorphological analysis provided evidence for local reworking at this boundary, while other observations suggest a gradual transition rather than a sudden sedimentary change between levels I to H (Kehl et al., 2014). New ^{14}C dates from bone samples treated with ultrafiltration and which have been subject to Bayesian modeling, suggests a boundary for the final Mousterian (level I) at 43–41.1 ka cal BP, and the initial Protoaurignacian (level H) at 42.3–40.3 ka cal BP. Although these ranges do not replicate dates from the 1980s, this chronometric interval indicates an early irruption of the Protoaurignacian in Western Europe at l'Arbreda (Wood et al., 2014).

The techno-typological attributes of the more than 2300 artefacts from level H are consistent with a Protoaurignacian assignation (Bischoff et al., 1989; Soler and Maroto, 1990; Maroto et al., 1996). The assemblage is primarily on flint (70%) from a source in southeastern France, over 100 km away. Some flint artefacts were transported as finished blanks, although local raw materials such as quartz and quartzite were also used. Knapping methods are split between large pyramidal cores for the production of blades, and bladelets cores, but carinated end scrapers are common too. Maintenance of core platforms, core edges and use of soft percussion created regular blanks. Elongated, straight Dufour bladelets with marginal retouch are very common although Roc de Combe-subtype bladelets are also documented. A significant laminar component is evident among the 204 retouched tools which include two Font-Yves points and 92 Dufour bladelets – 40% of the formal tools – along with retouched blades, burins and truncations, although end scrapers are considered to be cores. Side scrapers, denticulates and notches, representing 18% of the assemblage, are on local rocks. However, it should be noted that carinated scrapers and Roc de Combe bladelets are more characteristic of the Early Aurignacian, but the lithic assemblage of level H at l'Arbreda has been attributed exclusively to the Protoaurignacian (Ortega et al., 2005; Soler Subils et al., 2008). In any event, raw material provisioning, knapping methods, blank standardization and the predominance of bladelets characteristic of l'Arbreda level H, have not been identified in level 497D at Cova Gran. These marked differences prevent the inclusion of the 497D assemblage in any of those phases related to the appearance of Early Upper Paleolithic, whether it be Protoaurignacian or Early Aurignacian.

The chronometric range of 497D enables us to assess whether this assemblage is a "transitional industry". The Chatelperronian, a Neanderthal technical tradition identified throughout southeastern France and Cantabria, is a techno-complex that shares similarities with the Upper Palaeolithic. It is characterized by a laminar knapping system for the production of elongated blades, subsequently modified into points/knives, that are very abundant in some key French sites such as Grotte du Renne (Arcy-sur-Cure), Quincay, Saint Cesaire, Les Cottés (Connet, 2002; Bordes and Teyssandier, 2011; Soressi and Roussel, 2014).

Zilhão (2006, 2009) suggests that the Chatelperronian techno-complex is found only in northern Iberia – from Morin in the West to l'Arbreda in the East – and temporally dated at ca. 42 ka cal BP–, at a time which coincides with the appearance in Western Europe of *Homo sapiens* associated with the Protoaurignacian that replaced the Chatelperronian tradition. But we can see this scenario is difficult to assess. According to Zilhão (2006) Chatelperronian sites in Cantabria are assigned on the basis of a few *fossil directors* (Chatelperron points), but these assemblages yielded few artefacts recovered from dubious archaeological contexts, even at Morin X which has the only relevant lithic assemblage (Maíllo Fernández, 2007). Similarly in northeastern Iberia the Chatelperronian is based on isolated Chatelperron points recovered from the Mousterian levels of Reclau Viver, Arbreda, Ermitons and Bellvis (the latter on the northern slopes of the Pyrenees). These artefacts were knapped following Levallois/discoid methods on local materials, although in l'Arbreda level I two points on laminar blanks of non-local flint, different from the rest of the assemblage, were documented. Instead of using these artefacts to define the presence of the Chatelperronian, in northeastern Iberia they should have been considered as a component of some Late Mousterian assemblages (Maroto et al., 2002). Sintomatically, similar problems have also been identified in southwestern France where Chatelperron points are often scarce and usually found in dubious contexts, but paradoxically these artefacts are associated with Aurignacian assemblages (Connet, 2002).

Such uncertainties highlight the need to overcome the "*fossil director*" phase when analysing techno-typological trends used to determine the Chatelperronian, and assess whether they correspond to the current definition of this techno-complex (Bachellerie et al., 2007; Roussel, 2013; Soressi and Roussel, 2014). In this respect, we suggest that there is no evidence of transformations indicating 'transitional industries' in S1B or any level within the Mousterian sequence in Cova Gran. Likewise, the 497D assemblage does not correspond on either a chronological or techno-typological level with Zilhão's (2006) proposal for the characterization of the Chaltperronian in the north of Iberia. In sum, we consider that the chronocultural assignation of 497D assemblage from Cova Gran requires and deserves further and detailed observations (Martínez-Moreno et al., 2010, 2012).

7. Conclusion

The Middle to Upper Palaeolithic transition is a complex process. In recent years, Iberia has been the focus of much research relating to issues such as the continuity of Neanderthals at the end of MIS 3 or the early and sudden emergence of AMH. Nevertheless, a central remaining problem is the disparity among explanations of the process and supporting data. One example is the scenario proposed by Zilhão (2006) to characterize the Chatelperronian phase in northern Iberia that he considers to be associated with Neanderthals which was subsequently replaced by the emergence of the Protoaurignacian associated with the emergence of AMH. The main conclusion of Zilhão's proposal is that it is difficult to assess. Several uncertainties surround some sites; complex formation processes, low stratigraphic resolution and even inadequate documentation of those assemblages (Zilhão, 2006). This imbalance between *scenarios* and data leads to inflation of the inferential value of ^{14}C when arguing for the protracted endurance of Neanderthals in the southeastern Pyrenees (Garcia Garriga et al., 2012), or assigning assemblages to the Chatelperronian based on the presence of a few *fossil directors*. The pragmatic use of decontextualized indicators does not provide solutions, but conversely generates more problems.

To overcome these limitations, which are not exclusive to the Iberian MUPT, it has been suggested that the use of ^{14}C dates treated with more accurate protocols will create a reliable chronometric framework (Higham et al., 2009; Wood et al., 2010; Higham, 2011), and substantially modify the recent 'state-of-the-art' proposed for the MUPT in Iberia (Jöris et al., 2003; Maroto et al., 2005; Vaquero et al., 2006; Jöris and Street, 2008). The new temporal framework relocates the so-called "late" Neanderthals in older chronologies and suggests a more viable temporal framework for the irruption of AMH in northern Iberia (Maroto et al., 2012; Wood et al., 2013, 2014).

The present review was included in a wider project covering 40 sites in Western Europe, with 11 in Iberia, which proposed that the Neanderthal demise occurred around the time range 40.8–39.2 ka cal BP (Higham et al., 2014). The project included, almost exclusively, ^{14}C dates from the ORAU laboratory treated with ultrafiltration and Abox-SC, although dates from other laboratories were integrated. BP dates were converted into calibrated ranges of 2δ to which Bayesian statistics were applied. OxCal software was used to introduce conditions to create numeric ranges modelled by Bayesian statistics. The process defined a temporal order independent of indicators such as the relationship between date and context or the stratigraphic position of the sample within the series, which affects interpretation of dates. The subsidiary role of contextual information created a sensation of temporal organization in which numeric intervals follow each other harmoniously, but without precise archaeological correlation, as can be seen in the recent debate about the MUPT in Abric Romani (Camps and Higham, 2012; Vaquero and Carbonell, 2012). It is incorrect to separate site chronometry from contextual information as proposed by Higham et al. (2014), because dates lack relevance if not associated to contexts.

Cova Gran is important not only for the MUPT temporal range it contributes to the chronometric discussion, but in addition its stratigraphic resolution confirms the integrity of the archaeological record at the MUPT boundary (Benito Calvo et al., 2011; Polo-Díaz et al., 2016). The techno-typological discontinuity between S1B/497D is not the result of syn/post-depositional processes or inaccurate recovery methods. The argument presented in this paper considers changes affecting the entire archaeological record from a holistic perspective, not just the technical sphere. Future studies should explore the implications of the discontinuity in subsistence strategies, site organization or the appearance of indicators related to the cognitive sphere (Martínez-Moreno et al., 2010), These issues show that Cova Gran is a key site in the MUPT discussion in Iberia, and implications arising from the data obtained from this site affect discussion of the paleobiogeography of human populations in Western Europe around 45–30 ka.

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