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The Solutrean–Magdalenian transition: A view from Iberia

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ABSTRACT

The paper examines the Upper Solutrean–Archaic Magdalenian/Badegoulian succession on the base of lithic and bone tool production, chrono-stratigraphic data and radiocarbon dates from the Cantabrian and Mediterranean regions of Iberia, mainly the areas of Asturias and Valencia (Spain). The discussion considers a reduced number of variables (characteristic stone tools, bone points and decoration techniques) and highlights the elements in common. The analysis concerning the transformation of lithic production at Cova del Parpalló provides new data for the Upper Solutrean–Archaic Magdalenian/Badegoulian transition.

1. Introduction

The techniques used for the manufacture of Solutrean stone points changed during the Last Glacial Maximum (hereafter LGM), ca. 23–19 ka cal BP). For more than two millennia, human groups in France and the Iberian Peninsula had shared these techniques, but with progressively more marked regional diversification (Jordá Cerdá, 1955; Smith, 1966; Fullola, 1979; Straus, 1983; Rasilla Vives, 1989, 1994; Villaverde and Fullola, 1990; Zilhão, 1997; Tiffagom, 2006; Banks et al., 2009). Changes in lithic production along with a shift towards an increase in the use of bone points allow differentiation of a new archaeological techno complex known as Archaic Magdalenian or Badegoulian (Cretin, 2007). As implied by the continued use of these two terms, something which is still a matter of debate, a complex relationship exists between the Upper Solutrean and the succeeding Archaic Magdalenian/Badegoulian. The term Magdalenian was widely accepted on the basis of the six phases recognized by Breuil (1912). However, almost all the diagnostic elements of the early Magdalenian horizon originate from Badegoulian type sites. There is flake and raclette production at Badegoule, antler debitage by percussion at Abri Fritsch, bone points with single basal bevel with bracket-sign incised marks (Le Placard type), and the pseudo-excise carving technique (short continuous incisions) at Badegoule and Le Placard. Nonetheless, all these elements are still characterized as Magdalenian.

The transition is not only defined by the shift from stone points to ones made of bone. In the Cantabrian region, the continuity between the archaeological cultures referred to as Solutrean and Magdalenian is widely accepted in the literature (Corchón, 1981, 1994: 134; Straus and Clark, 1986: 375; Rasilla Vives, 1994: 73; Rasilla Vives and Straus, 2006). Moreover, the convergence of certain artifacts types, raw material use and decoration techniques and patterns indicates that exchange processes between regional groups were taking place (Barandiarán, 1973; Sacchi, 1986; Utrilla, 1986; Fortea, 1989; González Morales and Straus, 2009). For the Mediterranean region, a change in lithic and bone tool industries is suggested, pointing to contacts with southeast France and the Cantabrian-Pyrenees region (Villaverde, 1994; Aura Tortosa, 1995, 2007; Villaverde et al., 1998).

Another view of the transition goes beyond the succession of characteristic tool types and suggests the existence of a dynamic relationship between with palaeoclimatic change and interaction between regional groups. It is likely that two factors played a decisive role in this transformation. New demographic dynamics during the LGM (Straus and Clark, 1986) and new relationships between groups that may be inferred from the distribution of shared patterns and conventions in Palaeolithic art in southwest Europe (Sauvet et al., 2008). Barton et al. (2011) have recently suggested that for a better understanding of the complexity of cultural transmission mechanisms, multidimensional models that

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combine biological, cultural and environmental data are required. Banks et al. (2011), in their study of the French Badegoulian, applied an eco-cultural niche model geared towards examining the relationship between ecological and cultural systems. Data concerning lithic raw material circulation and production systems allowed them to identify distinct social territories within a single ecological niche. The present study assesses the presence and association of certain descriptors of the lithic and bone/antler industries.

2. LGM industries in Iberia: antecedents and regional data

Iberia is located at the southwest of Europe and is characterized by concentrations of sites in coastal areas, the Cantabrian region to the north, the Atlantic front of Portugal to the west and the Mediterranean to the east and southeast (Fig. 1). Connections with the Pyrenees-Aquitaine region were identified during early work at Altamira Cave and Castillo, and the presence of mutual influence has been accepted. Relations with Africa have also been suggested repeatedly during the past 100 or so years of research. However, apart from some typological similarities between some tools (Tiffagom, 2006b), the evidence from North Africa is insufficient for an in-depth discussion of the issue. In the southernmost regions of Iberia, located closer to Africa, rock art appears during the Gravettian (Fortea Pérez, 2005).

The Upper Palaeolithic sequence of Iberia was based on a small number of sites, mainly excavated between 1910 and 1930. They include the Atlantic sites of Cueto de la Mina (Asturias), and Cueva del Castillo (Cantabria), and then Cova del Parpalló in the Mediterranean region of Valencia. The characteristics in common in these two areas may be summarized as follows:

a) Data from cave and rockshelter sites reveal dynamic geological processes related to unstable palaeoclimates (Fumanal, 1986; Jordá Pardo, 1992; Hoyos, 1994; Bergadá, 1998) and complex taphonomic problems (trampling, etc). At some sites, these processes may have been responsible for the mixing of Upper Solutrean and Magdalenain–Badegoulian artifacts, as has been noted at some French sites (cf. Aubry et al., 2007).
b) Blade blanks, Solutrean retouch, bifacial working and the production of shouldered points are essential elements of the Solutrean technique (Rasilla Vives, 1994). Another characteristic is the thermal treatment of flint (Tiffagom, 1998), together with regional diversity in certain types of Solutrean points (Straus, 1990; Rasilla Vives and Santamaria, 2006; Tiffagom, 2006).
c) The end of the Solutrean is followed by changes in lithic production. The generally accepted characteristics, that nevertheless need to be further refined, include the use of local raw materials and the abandonment of blade blanks for points, replaced by more expedient production of short blades and flakes (tools with an "archaic" appearance). In parallel with these changes in lithic production was an increase in bone industries.
d) The longer duration of the Solutrean in Iberia compared to the French regions (Jordá Cerdá, 1955; Fortea and Jordá Cerdá, 1976; Utrilla, 1981, 1989; Straus, 1983; Villaverde and Fullola, 1990; Rasilla Vives and Llana, 1994; Corchón, 1999), resulted in a somewhat late chronology for the Archaic

Fig. 1. Location of the main Cantabrian and Mediterranean sites mentioned in the text. The two reference areas are indicated, Asturias for the Cantabrian region and Valencia for the Mediterranean.

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Magdalenian/Badegoulian (Utrilla, 1981, 2006; Utrilla and González Sainz, 2003; Aura Tortosa, 1995, 2007). Further discussion and analysis of the chronological framework established by the available radiocarbon dates may provide a better understanding of the overall transition process.

2.1. Data from the Cantabrian region

The "transition" in the Cantabrian sites coincides with erosion (Hoyos, 1994) and taphonomic processes. The use of the terms Archaic Magdalenian (AM) and Badegoulian (BA), which may be confusing, is closely related to the historical roots of the research in different regions. In Iberia, the former (AM) is mostly preferred in the Cantabrian region, while the latter (BA) has been used for Cova del Parpalló in the Mediterranean region. This is one of the type-sites used by A. Cheynier (1939, 1951) to define the "Proto-Magdalenian" (the initial phases of the Magdalenian) that was finally named Badegoulian by Vignard (1965).

In relation to the Archaic Magdalenian (AM), Utrilla (1981, 2006) suggests that after the Cantabrian Upper Solutrean (US) assemblages dated to between 22 and 19.5 ka cal BP may be grouped into three partly contemporary facies (Fig. 2):

- A "transitional" group identified at Caldas 3 (chamber I) and XIVc (chamber II) and at La Riera (8–15), both in Asturias, amongst other sites. This group corresponds to what has been termed Final Solutrean or "de-solutreanized" (Straus, 1975; Corchón, 1981; Rasilla Vives, 1994). At La Riera, Straus and Clark (1986) highlighted the use of local raw materials for the production of an "archaic" toolkit, some raclettes and the variable presence of bladelets which are more abundant in the recently excavated sites (Straus and González, 2007).
- A second group is characterized by raclettes and the pseudo-excise decoration technique described by Barandiarán (1973, pp. 258), and associated with Archaic Magdalenian–Badegoulian contexts (Utrilla, 1986; Seronie Vivien, 2005). This facies is identified at Aitzbitarte IV (Basque Country).

These two groups would fall within the so-called Cantabrian Badegoulian as has been described by Bosselin and Djindjian (1999).

- A third group termed archaic Magdalenian of Rascaño –5 type includes a few raclettes and flat section sagaie antler points with large single basal bevel, with a concave profile that ends in a small tongue and bears a Le Placard type bracket-sign decoration (Utrilla, 1981). The dates for Castillo –8 and Rascaño –5, both in Cantabria, are bracketed between 21 and 20 ka cal BP.

After 19.5 ka cal BP, the Cantabrian Lower Magdalenian (LM) sites with blade/bladelets and square section sagaie multiply. This horizon is characterized by greater technological stability (Utrilla, 2006; Cazals and Bracco, 2007).

The relationship among the three AM facies is still debated. The analysis of their lithic industries will possibly allow connections with other regions to be identified (Corchón, 2005; Straus et al.,


		DATES BP	CANTABRIAN REGION	Local raw use 'Archaich toolkit'	Raclettes	La Placard type	Pseudo- excise technique	MEDITERRANEAN REGION	DATES BP	
ARCHAIC MAGDALENIAN	Rascaño -5 facies	16430	Rascaño -5	■	■	●	●			
		16850	Castillo -8	■	■	●				
			Lloseta / Rio	■	■	●				
			Cova Rosa	■		●	●			
			Cueto de la Mina	■		●	●			
			Llonín III	■	■	●	●			
		17050 17400	El Mirón 117 313	■						
	"Raclette" facies	17210	La Riera 10- 12	■	■	●				
		17950	Aitzbitarte IV-3		■		●			
		17380 18250	Caldas XIVc 6-3	■	■					
				■	■			Maltravieso	17840 17930	BADEGOULIAN
				■	■		●	Volcán del Faro		
				■	■	●	●	Parpalló	18510	
						●		Gato -2	17700 18600	

Fig. 2. Presence of the lithic and bone industry descriptors mentioned in the text in the main AM and BA sites of the Cantabrian and the Mediterranean regions respectively.

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2008). Common elements may be encountered in all three groups, but it is only at Llonín III (Galeria) where all of the three facies are found in association. This particular context at Llonin (Asturias) is strongly affected by fire related activities and points to the predominant use of local quartzite and radiolarite raw materials (Fortea et al., 1995, 2004, 2007).

Discoidal–facial–Levallois type percussion was employed at Llonín to obtain large quartzite flake blanks for the manufacture of most retouched tools including notches, denticulates, side-scrapers and splintered pieces. Radiolarite was abundant and was mainly used for the production of blade and bladelet blanks for end-scrapers and retouched blades. In contrast to local raw materials, better quality exotic flint reached the site as blanks or finished tools. Burins, composite tools, scrapers on small flakes and raclettes were produced with these flint types. Bone tools are abundant and among them two pieces with pseudo-excise decoration and another two bone points with Le Placard type bracket-sign decoration are exceptional (Fig. 3: 2 and 11).

It has recently been suggested that these facies parallel the French Badegoulian both in chronology (22.5–20 ka cal BP) and lithic and bone/antler production (Sauvet et al., 2008).

2.2. Data from the Mediterranean region

Sites with long stratigraphic sequences in this region (Bajondillo, Pirulejo, Nerja, and Ambrosio are in Andalusia, while Beneito, Cendres and Malladetes are in Valencia) are frequently characterized by an erosional discontinuity during the interval 22–20 ka cal BP (Aura Tortosa, 1995, 2007). The sequence from Cova del Parpalló (Valencia) is the basic reference for the Solutrean – Magdalenian/Badegoulian transition in the Mediterranean (Pericot, 1942; Fullola, 1979; Fortea et al., 1983; Villaverde et al., 1998; Aura Tortosa, 2007). Although there are other nearby sites with horizons similar to those defined at Parpalló as Badegoulian (BA), they originate from poorly defined contexts. The evidence from Volcán del Faro (Valencia) (Aparicio, 2003) points to a similar sequence to that from Parpalló from the end of the Solutrean to the classic Magdalenian with harpoons (Aura Tortosa, 1995). However, problems of taphonomy have frustrated attempts to radiocarbon date the sequence.

The Cantabrian facies for the US – AM succession have not been recognized in the Mediterranean region. Here the sequence consists of three cultural units:

- An Upper Solutrean (the so-called “Solutreo-Gravettian”), characterized by rare foliates and numerous Mediterranean shouldered points. At Parpalló the first short single basal bevel sagaie and a Le Placard type single bevel point appear (Pericot, 1942; pp. 70).
- A “Parpalló type” Badegoulian horizon is characterized by flake and short blade blanks and also includes a “low-investment toolkit” (notches, denticulates or side-scrapers made on flakes) and raclettes in its upper phases. Bone/antler industries include sagaie with large single basal bevel and bi-points of

Fig. 3. AM–BA antler and bone sagaies, rods and thick pieces from Asturian and Valencian sites. Variants of the pseudo-excise technique: juxtaposed short incisions (1, 2, 4 and ¿3?); sets of deep incisions (5) and incisions associated with a line (7 and 8). Le Placard type sagaie (9–11). 1: Cova Rosa; 2: Llonín III (Galeria); 3: Parpalló (CO 4,25-4,00); 4–6: Cueto de la Mina (Conde de la Vega del Sella, 1916: Lám XXV–XXVI); 7: Volcán del Faro (layer 26); 8: Parpalló (P 3,75-3,50); 9 Parpalló (CO 3,75-3,50); 10. Parpalló (CO 4,25-4,00); 11: Llonín III (Vestíbulo).

Table 1
List of selected radiocarbon dates from the Spanish Solutrean–Magdalenian Transition (GI 2 and GS 2).

Site and level	Lab Nr	Date	SD	Method	Material	CalAge BP (95%) {0 = AD1950}	Phase	Phase this paper	Reference
Cantabrian Region									
Altamira sup	GifA-90047	14520	260	AMS	Bone	18,140–17,060	LM	LM	González Echegaray, 1996
La Paloma –6	OxA-974	14600	160	AMS	Antler	18,740–17,195	LM	LM	Barandiarán, 1988
Entrefoces	Ly-2937	14690	200	14C		18,520–17,990	LM	LM	Gionzález Morales, 1990
Pendo II	OxA-977	14830	130	AMS	Antler	18,510–18,040	LM	LM	Barandiarán, 1988
El Mirón 108	GX-27114	14850	60	AMS	Charcoal	18,020–17,820	MM/LM	LM	Straus and Gonzalez Morales 2007
El Mirón 15	GX-23392	15010	260	14C	Bone/collagen	18,780–17,660	LM	LM	Straus and Gonzalez Morales 2007
Las Caldas II -XIII	Ua-4301	15165	160	AMS	Bone	18,760–17,800	LM	LM	Corchón, 1994
Rascaño 3	BM-1452	15173	160	14C		18,770–17,810	LM	LM	Glez. Echegaray and Barandiarán, 1981
El Mirón 16	GX- 23415	15180	100	AMS	Bone/collagen	18,750–17,830	LM	LM	Straus and Gonzalez Morales 2007
La Riera 19	Q-2116	15230	300	14C	Charcoal	18,930–17,730	LM	LM	Straus and Clark, 1986
Ekain VIId (18–19)	I-12266	15400	240	14C	Bone	19,030–17,790	LM	LM	Altuna and Merino 1984
El Mirón 17	GX-25853	15700	190	14C	Charcoal	19,210–18,530	LM	LM	Straus and Gonzalez Morales 2007
Erralla V	I- 12868	15740	240	14C	Bone	19,420–18,460	LM	LM	Altuna et al., 1985
Abauntz E	Ly 1965	15800	350	14C	Bone	19,835–19,050	LM	LM	Utrilla, 1989
Praile Aitz	GrA-24685	15530	100	AMS	Bone	19,130–18,690	LM	LM	Peñalver and Mujika, 2003
Altamira	I-12012	15910	230	14C		19,620–18,580	LM	LM	González Sainz, 1989
Ekain, VIIc 16/17	I-12225	15970	240	14C	Bone	19,750–18,590	LM	LM	Altuna and Merino 1984
Rascaño 4	BM-1453	15988	195	14C		19,650–18,650	LM	LM	Glez. Echegaray and Barandiarán, 1981
Ekain VIIb 14/15	I-12224	16030	240	14C	Bone	19,850–18,610	LM	LM	Altuna and Merino 1984
Erralla Va	I-12540	16030	240	14C		19,850–18,610	LM	LM	Altuna et al., 1985
El Mirón 110	GX-23396	16130	250	14C	Bone/collagen	20,020–18,660	LM	LM	Straus and Gonzalez Morales 2007
Erralla Va	I-12551	16270	240	14C	B	20,200–18,800	LM	LM	Altuna et al., 1985
El Mirón 111	GX-23395	16370	190	14C	Bone/collagen	20,190–19,070	LM	LM	Straus and Gonzalez Morales 2007
Rascaño 5	BM-1455	16433	130	14C		20140–19300	AM	AM	Glez. Echegaray and Barandiarán, 1981
El Mirón 114	GX-28209	16460	50	AMS	Bone/collagen	19,980–19,580	AM	AM	Straus and Gonzalez Morales 2007
Ekain VIIb	I-12020	16510	270	14C	Bone	20,530–19,050	LM	LM	Altuna and Merino 1984
Castillo –8	OxA-971	16850	220	AMS	Antler	20,770–19,690	AM	AM	Barandiarán, 1988
La Riera 17	GAK-6445	16900	200	14C	Charcoal	20,780–19,820	US	AM	Straus and Clark, 1986
El Mirón 117	GX-25857	17050	60	AMS	Charcoal	20,640–20,320	MA	AM	Straus and Gonzalez Morales 2007
Las Caldas Pasillo 4	Ly-2422	17050	290	14C	Bone	21,170–19,810	US	AM	Corchón, 1999
Urtiaga F -inf	GrN-5817	17050	140	14C	Bone	20,820–20,180	MA	AM	Altuna, 1972
La Riera 12	Gak-6446	17210	350	14C	Bone	21,480–19,880	US	AM	Straus and Clark, 1986
Las Caldas II -XIVc	Ua-4302	17380	215	AMS	Bone	21,390–20,350	US	AM	Corchón, 1994
El Mirón 313	GX-31194	17400	270	14C	Bone/collagen	21,510–20,270	LM/US	AM	Straus et al., 2008
Aitzbitarte IV–III	GrN-5993	17950	150	14C	Bone	21,880–21,160	US / AM	AM	Altuna, 1972
Las Caldas Pasillo 3	Ly-2421	18250	300	AMS	Bone	22,730–21,270	US	AM	Jordá et al., 1992
Las Caldas I- 11	Ua-15316	18305	295	AMS	Bone	22,760–21,240	US	US	Corchón, 1999
Las Caldas Pasillo 7	Ly-2423	18310	260	14C	Bone	22,720–21,280	US	US	Jordá et al., 1992
Cueto de la Mina V (1981–86)	Ua-3586	19110	205	AMS	Bone	23,440–22,520	US	US	Rasilla and Llana, 1994
Antoliñako Koba Lmc	GrN-23785	19280	120	14C	Bone	23,450–22,850	US	US	Aguirre, 1999
Llonín-IV	OxA-22700	19300	110	AMS	Bone	23,460–22,900	US	US	This paper
Llonín-IV	OxA-22699	19330	100	AMS	Bone	23,460–22,980	US	US	This paper
Las Caldas Pasillo-9	Ly-2424	19390	260	14C	Bone	23,790–22,670	US	US	Jordá et al., 1992
Llonín-IV	OxA-22698	19480	110	AMS	Bone	23,550–23,190	US	US	This paper
Mediterranean Region									
Estebanvela VI	Beta-228871	14450	80	AMS		17,840–17,520	LM	LM	Cacho et al., 2010
El Monte	Beta-245814	14660	80	AMS	Charcoal	17,900–17,740	LM	LM	Cacho et al., 2010
Buendía 1C	Beta-212777	14840	50	AMS	Charcoal	17,960–17,840	LM	LM	Cacho et al., 2010
Alonsé	GrA-21537	14840	90	AMS	Charcoal	18,620–17,620	LM	LM	Utrilla and Montes, 2007
Cendres XIIA	BETA-118023	14850	100	AMS	Charcoal	18,650–17,610	LM	LM	Villaverde et al., 1999
Alonsé m	GrA-21536	15069	90	AMS	Charcoal	18,700–17,780	LM	LM	Montes, 2005
Alexandre IIIb	GrN-23448	15370	110	14C	Charcoal	18,930–17,850	LM	LM	Utrilla and Montes, 2007
Montlleó sect B	OxA-9017	15440	80	AMS	Charcoal	18,750–18,550	LM	LM	Mangado et al., 2009
Cendres XII	Ly-5586	15820	150	14C	Charcoal	19,270–18,630	LM	LM	Villaverde et al., 1999
Montlleó sect B	OaX-X-2234-52	16900	110	AMS	Bone	20,560–20,080	LM	LM	Mangado et al., 2009
Cendres XIIbase	Beta 118024	17230	130	AMS	Charcoal	21,010–20,370	US	US	Villaverde et al., 1999
L'Arbreda sup-A	Gif-6418	17320	290	14C	Charcoal	21,470–20,150	US	US	Delibrias et al., 1987
Ratlla del Bubo II	Ly-5219	17360	180	14C	Charcoal	21,310–20,390	US	US	Soler et al., 1990
Gato 2	GrA-42226	17700	70	AMS	B	21,440–21,040	AM	AM /BA	Blasco and Rodanés, in press
L'Arbreda sup-B	Gif-6420	17720	290	14C	Charcoal	21,920–20,560	US	US	Delibrias et al., 1987
Maltravieso A	Poz-30469	17840	90	AMS	Charcoal	21,550–21,190	BA	BA	Canals et al., 2010
Parpalló 4-4.25m	Birm-521	17896	340	14C	Bone	22,570–20,570	US	US	Bofinger and Davidson, 1977
Maltravieso A	Poz-30469	17930	100	AMS	Charcoal	21,630–21,270	BA	BA	Canals et al., 2010
Nerja 8c	UBAR 98	17940	200	14C	Charcoal	22,190–20,990	US	US	Jordá Pardo and Aura, 2009
Gorham's Cave III	Beta-184042	18440	160	AMS	Charcoal	22,370–22,120	US	US	Finlayson et al., 2006
Parpalló T-11	OxA-22629	18510	100	AMS	Bone	22,700–21,780	BA	BA	This paper
Gato 2	GrA-22505	18650	140	AMS	Charcoal	22,800–22,160	AM	AM /BA	Blasco and Rodanés, in press

(continued on next page)

Table 1 (*continued*)

Site and level	Lab Nr	Date	SD	Method	Material	CalAge BP (95%) {0 = AD1950}	Phase	Phase this paper	Reference
Cendres XIII	Beta-118027	18750	130	AMS	Charcoal	22,860–22,380	US	US	Villaverde et al., 1999
Cendres XIII	Beta-118026	18920	180	AMS	Charcoal	23,250–22,410	US	US	Villaverde et al., 1999
B. de la Xemeneia	Beta-191695	18950	90	AMS	Bone	23,080–22,560	US	US	Mangado et al., 2010
Parpalló T-16	OxA-22651	19020	100	AMS	Bone	23,230–22,590	US	US	This paper
Ambrosio II.2	Gif-A-II.2	19170	190	AMS	Charcoal	23,630–22,310	US	US	Ripoll et al., 2006
Ambrosio II g	GifA 9883	19250	70	AMS	Charcoal	23,570–22,490	US	US	Ripoll et al., 2006
Ambrosio II.6	Gif-A-II.6	19300	190	AMS	Charcoal	23,680–22,440	US	US	Ripoll et al., 2006
Other dates mentioned									
Ambrosio VI	Gif-7277	16590	1400	14C	Charcoal		MS		Ripoll López, 1988
Beneito B2	Ly-3596	16560	480	14C	B		US		Iturbe and Cortell, 1987
Malladetes III	KN-I/918	16300	1500	14C	Charcoal		US		Fortea and Jordá, 1976

mostly circular or oval section. During the earliest part of this horizon the majority of the Le Placard type points appear, as well as motifs made with a technique that closely resembles the pseudo-excise. Therefore, in the Badegoulian levels of Parpalló all the characteristics of the Cantabrian AM may be recognized (Figs. 2 and 3: 9–10).

Utrilla has recently suggested, based on the material and dates from Cueva del Gato (Aragón, Ebro valley), that Le Placard type bone points appear earlier in the Ebro valley (Gato −2: 18.6 and 17.7 ka ^{14}C BP) and the Mediterranean region (*cf.* Parpalló 4-4,25m: 17.9 ka ^{14}C BP), compared to Cantabria (Castillo −8: 16.8 ka ^{14}C BP and Rascaño −5: 16.4 ka ^{14}C BP) (Table 1). The Ebro valley forms a natural passage for communication between the Cantabrian and Mediterranean regions (Utrilla et al., 2010).

- A Lower Magdalenian (LM) horizon with an important blade and bladelet component, similar to the Cantabrian LM. Up until now this facies has been better recorded in Meseta, Catalonia and the Ebro valley.

3. Analysis of the radiocarbon series

The original set of dates ranging from 19.5 to 14.5 ka ^{14}C BP (23,690–17,620 cal BP) was critically reviewed in relation to their stratigraphic and archaeological contexts. Those which contradicted their stratigraphic position were rejected. This was the case with a large number of dates due to the fact that the Solutrean–Magdalenian “transition” coincides with a period during which there was extensive erosion. Similarly, dates from poorly defined archaeological contexts or those with only preliminary data were also excluded. Two dates from each level were selected and in those cases where more were available, the most recent and oldest and those with the least standard deviation were preferred. In general, only those dates with a standard deviation of less than 350 years were included, amounting to 44 in the Cantabrian region and 29 in the Mediterranean. The dates were calibrated using CalPal (Weninger and Jöris, 2004).

Table 1 lists the 73 selected dates together with relevant information. Given that there is not always agreement on the attribution of a dated context to a particular chrono-cultural phase, the table includes two columns. The first lists the attribution suggested by the original investigators of the site, while the second is based on a revised synthesis of the evidence.

A total of 39 dates were obtained using AMS and further 34 by conventional ^{14}C. The proportion of the two methods changes in relation to geographic regions and chrono-cultural phases. More than 60% of the selected dates from the Cantabrian region were obtained using conventional ^{14}C, compared to only 24% of those from the Mediterranean region. Comparison of the different cultural facies points to the LM as having more dates available (34, 43.8%), followed by the US (22, 38.5%) and finally the AM (17, 23.3%). Moreover, most of the conventional ^{14}C dates correspond to the US in the Mediterranean region and to the LM in the Cantabrian. Such differences reflect the variable pace of research in different regions as well as regional research “traditions”.

The selected dates place the palaeoclimatic context of the Solutrean–Magdalenian transition between Heinrich Events 2 and 1 and during the climate phases GI 2 and GS 2. The chronological data were correlated with high resolution proxies, the ^{18}O GISP2 Hulu Age Model (Grootes et al., 1993; Meese et al., 1994; Wang et al., 2001) and the SST MD95-2043 from the Alboran Sea (Cacho et al., 2001).

The 73 selected dates may be grouped into three broad chrono-cultural units, the Upper Solutrean (US), the Archaic Magdalenian (AM) or Badegoulian (BA) and the Lower Magdalenian (LM). Besides calibration using CalPal 2007 Hulu (Weninger et al., 2012 online), one curve was obtained for each region and different curves for each one of the three facies (Fig. 4).

The regional curves show the succession of archaeological phases as described above (US–AM/BA–LM). In the Cantabrian region there is more of an overlap while in the Mediterranean there is a hiatus of approximately 700 years between the AM/BA and the LM. The “transitional” phases unfortunately correspond with episodes of instability in the calibration curves, probably related to a general fluctuation in atmospheric ^{14}C. In addition there are the erosion processes discussed previously (Hoyos, 1994; Rasilla Vives, 1994; Aura Tortosa, 1995; Aura et al., 2006).

Table 2 summarizes the data which point to regional differences, mostly for the end of the US and the central horizon (AM/BA). Probability curves for the LM are practically coincident despite the fact that this phase is poorly documented in the Mediterranean region.

The data suggest that the US ended earlier in Cantabria than in the Mediterranean region. This is because various assemblages from the former region, listed as Solutrean in the literature, have been attributed to the AM, thus widening the probability curve for this phase by up to 2700 cal years. The contexts which make up this phase are characterized by local raw material use, the production of flakes, an increase in backed bladelets, tools of archaic appearance and a few raclettes, and the virtual *absence* (<3%) of Solutrean tool types (Straus, 1975; Straus and Clark, 1986; Corchón, 1994, 1999; Rasilla Vives, 1994). The phase is also characterized by the presence of bone points of rounded or flat section and long basal bevel, and the use of the pseudo-excise decoration technique. Finally, in the Cantabrian region there is an overlap of approximately 600 calibrated years between the AM and LM curves (Fig. 4).

In the Mediterranean region, the probability curve for US dates is a millennium longer than in Cantabria. There are dates that could potentially extend the end of the US until approximately 21 ka cal

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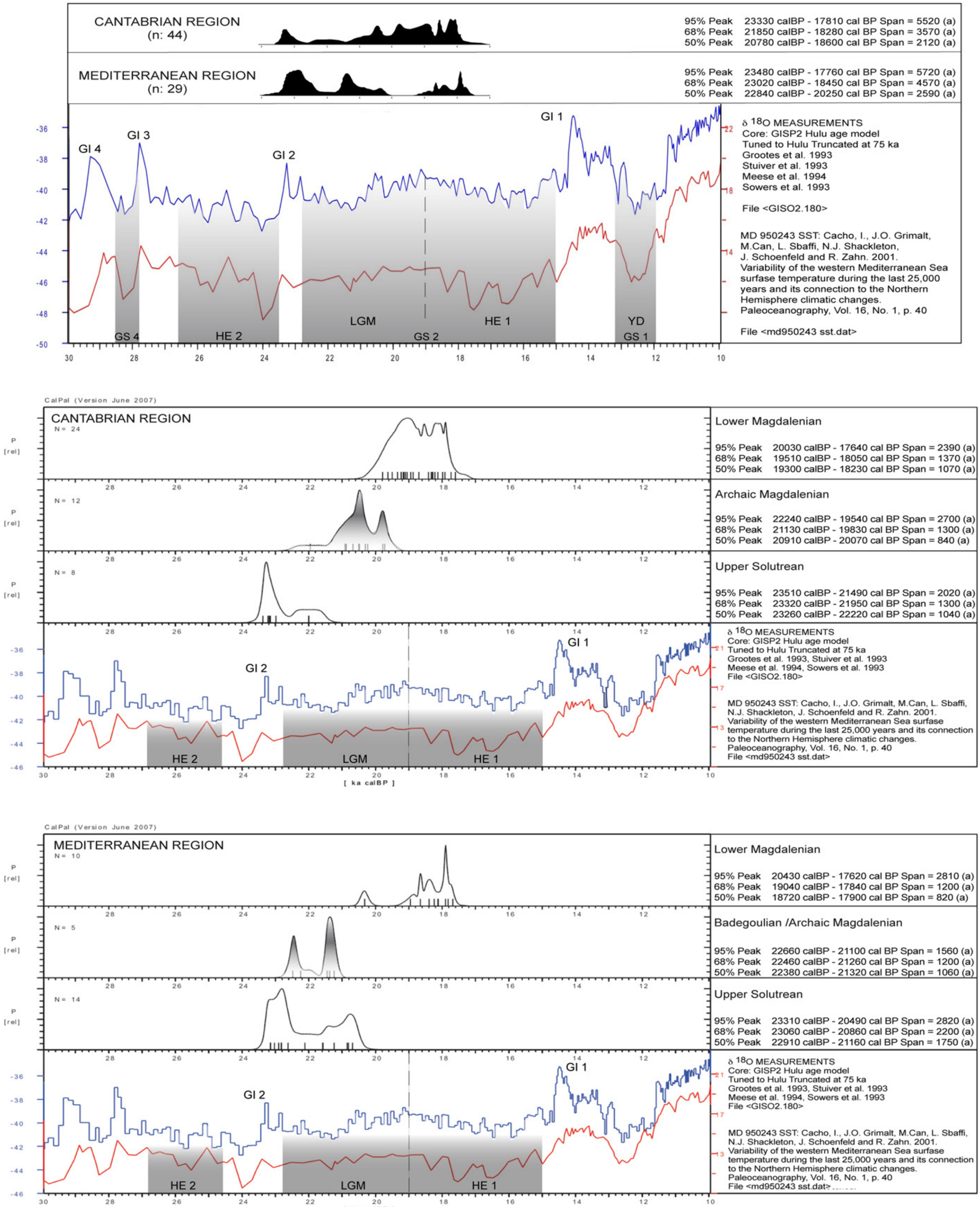

Fig. 4. Cumulative probability curve of the valid radiocarbon dates from the Cantabrian and Mediterranean regions of Iberia. For calibration CalPal 2007 Hulu (Weninger et al., 2012) was used. Top: Curves for the Cantabrian and the Mediterranean regions showing the erosional discontinuities mentioned in the text. Center: The curves for the Cantabrian region arranged in each one of the chrono-cultural phases (US, AM and LM). Bottom: Curves for the Mediterranean region arranged in each one of the three chrono-cultural phases (US, BA and LM). Palaeoclimate proxies: ^{18}O GISP2 Hulu Age Model (Grootes et al., 1993; Meese et al., 1994; Wang et al., 2001) and SST MD95-2043 obtained in the Alboran Sea (Cacho et al., 2001).

Table 2
Calibrated chronology of the three major chrono-cultural phases.

	Cantabrian region	Mediterranean region
Lower Magdalenian	(95%) 20,030–17,640 cal BP	(95%) 20,430–17,620 cal BP
Archaic Magdalenian/Badegoulian	(95%) 22,240–19,540 cal BP	(95%) 22,660–21,100 cal BP
Upper Solutrean	(95%) 23,510–21,490 cal BP	(95%) 23,310–20,490 cal BP

BP. However, these were not included in this synthesis as they include bulk bone samples dated to around 16 500 ka ^{14}C BP with standard deviation values greater than 350 years (Malladetes, Beneito or Ambrosio). Half of the US dates were obtained by conventional ^{14}C and these are the most recent, while new AMS dates place the end of the US at approximately 20.5 ka cal BP (Table 1).

The BA in the Mediterranean region is poorly-dated. However, new dates have recently become available, including one so far unpublished, that places the basal levels of the Badegoulian at Parpalló at 22.7 and 21.8 ka cal BP. This date (OxA-22629), is being cross-checked at present with further samples. At Gato –2, an AM/BA context with a point with Le Placard decoration was dated to between 22.8 and 21 ka cal BP. At Maltravieso (Extremadura), a site near Portugal and thus located closer to the Atlantic than to the Mediterranean coastal region, two dates (21.6 and 21.2 ka cal BP) were obtained for an poorly-defined assemblage characterized by the use of local raw materials, flakes and one raclette (Canals et al., 2010).

4. The US–BA transition at Parpalló: analysis of the lithic and bone toolkit

Parpalló is a reference sequence for the Palaeolithic of SW Europe. Excavated by L. Pericot between 1928 and 1931, the site contains evidence for successive human occupation from the Gravettian to the Magdalenian with harpoons. The Solutrean – Magdalenian succession was established by Pericot (1942) at approximately 4 m from the top in a 9.5 m deep trench. Even at that time it was clear that there were difficulties in differentiating the layers with US material from those with Magdalenian/Badegoulian artifacts. The analysis of the graphic documents and artefacts from the “talus” sector confirmed these difficulties, but has allowed the US – BA succession to be placed at approximately 3.50 m (Aura Tortosa, 1995, 2007).

Data for lithic production within levels directly related to the US – BA succession are now available, allowing comparison with levels bracketed to between 4.25 and 4.00 m, 4.00–3.75 m and 3.75–3.50 m. The review of the AM/BA lithic assemblage is part of a wider project comparing processes at Cantabrian and Mediterranean sites. However, it has recently been claimed by Banks et al. (2011, pp. 361) that there is no convincing evidence for a Badegoulian presence in the Iberian Peninsula. The first results of the analysis of lithic production during the transition period and in relation to changes observed in the bone industries are presented below.

4.1. Lithic production

The lithic industries of the part of the Parpalló sequence included in this analysis comprise approximately 30,000 pieces, of which 14,598 have been studied. The rest of the materials do not provide well defined technological or typological information (decortication flakes, atypical flakes, debris, fragments, altered pieces and others). There is an extensive list of descriptors for the analysis of transitional lithic industries. These may be organized in 6 broad categories in which cores, blanks and retouched pieces are grouped:

A) Blade production for blanks to produce Mediterranean shouldered points and the few foliate points. Most of the evidence for thermal (fire) treatment of blanks and cores is related to these artifacts.
B) Blade blank production for end-scrapers, burins, truncations and backed blades. The identification of this production may be related in part to the use of different raw materials from those employed in group A.
C) Bladelet production for the manufacture of Mediterranean shouldered points, backed bladelets and points.
D) Short, broad blades for the manufacture of domestic tools (short end-scrapers, side-scrapers, pieces with simple and semi-abrupt retouch).
E) Production from indeterminate and multifaceted cores. This undifferentiated flake production using soft hammer direct percussion may have had various aims, classic blade percussion, production of blanks with a laminar tendency and also flake production. Simple retouched pieces often have use wear traces, while there are also some notches and some splintered pieces.
F) Production termed “Badegoulian” that groups together discoidal-facial-Levallois percussion (Bracco et al., 2003; Cretin et al., 2007), core-scrapers (Bodu, 2005), dorsal front cores (Ducasse and Langlais, 2007) and core-burins (Le Brun-Ricalens and Brou, 2003). Discoidal–facial–Levallois cores, described by Bracco et al. (2003) and Crétin et al. (2007) provided blanks for short end-scrapers, retouched micro-tools, retouched flakes and the first raclettes (Fig. 5). All the other core types have preserved but a few bladelets, possibly as a result of the recovery techniques used during the 1928–1932 excavation campaigns at Parpalló (Zilhão, 1997; Straus et al., 2008).

The changes recorded in these six groups provide evidence for the transformation of technoeconomic structures of the US. The shaping of new strategies in lithic production is more obvious when comparing the lower and upper levels of the part of the Parpalló sequence presented here. Analysis points to a continual decline in blade production and the increase of undifferentiated, Badegoulian and short-wide blade blanks. These comprise 40% of lithic production in level 3.75–3.50 m, compared to 11% in level 4.25–4.00 m. This tendency becomes more marked in overlying levels (Fig. 6).

4.2. Bone and antler production

Bone and antler industries increase in parallel with the changes in lithic production. However, there are no data concerning the techniques that were used to prepare the blanks (grooving *vs.* debitage by percussion) (Allain et al., 1974; Adán Àlvarez, 1994; Averbouh and Pétillon, 2011).

At Parpalló, the bone industry of levels between 4.25 and 3.75 m is dominated by round and flat cross-section pieces of two main types, bi-pointed and single basal bevel points (Pericot, 1942). Bi-pointed pieces with polygonal cross-sectional bases, the first points with single bevel and two Le Placard sagaies derive from US level (4.25–4.00 m). Points with single basal bevel, with oblique marked incisions appear frequently in the overlying part of the

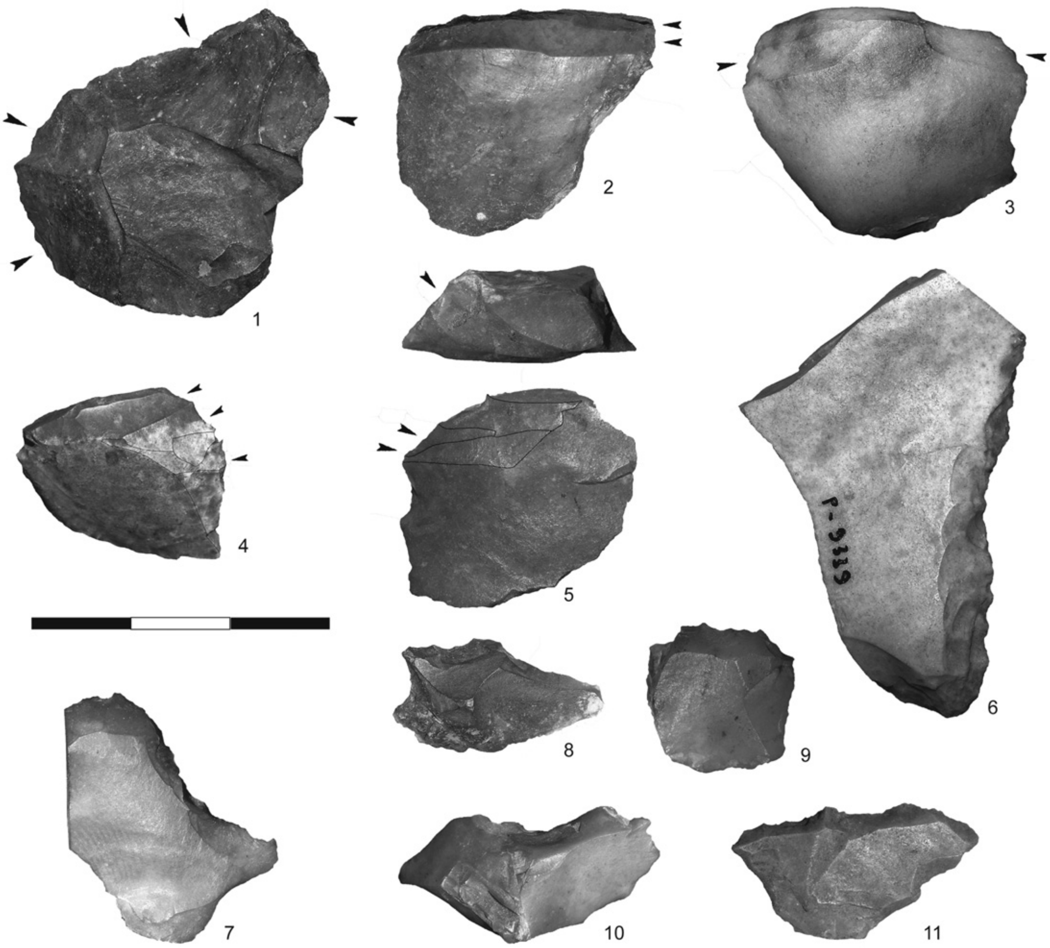

Fig. 5. The "Badegoulian Production" of Parpalló. 1: discoidal-Levallois core; 2, 3: transversal-burin; 4, 5: dorsal front cores; 6–11: retouched pieces. (1: 3.75–3.50; 2, 9 and 11: sector L 3.75–3.50; 3: sector CE 4.25–4.00; 5: sector CE 4.00–3.75; 4, 6, 7, 8 and 10: sector CE 3.75–3.50).

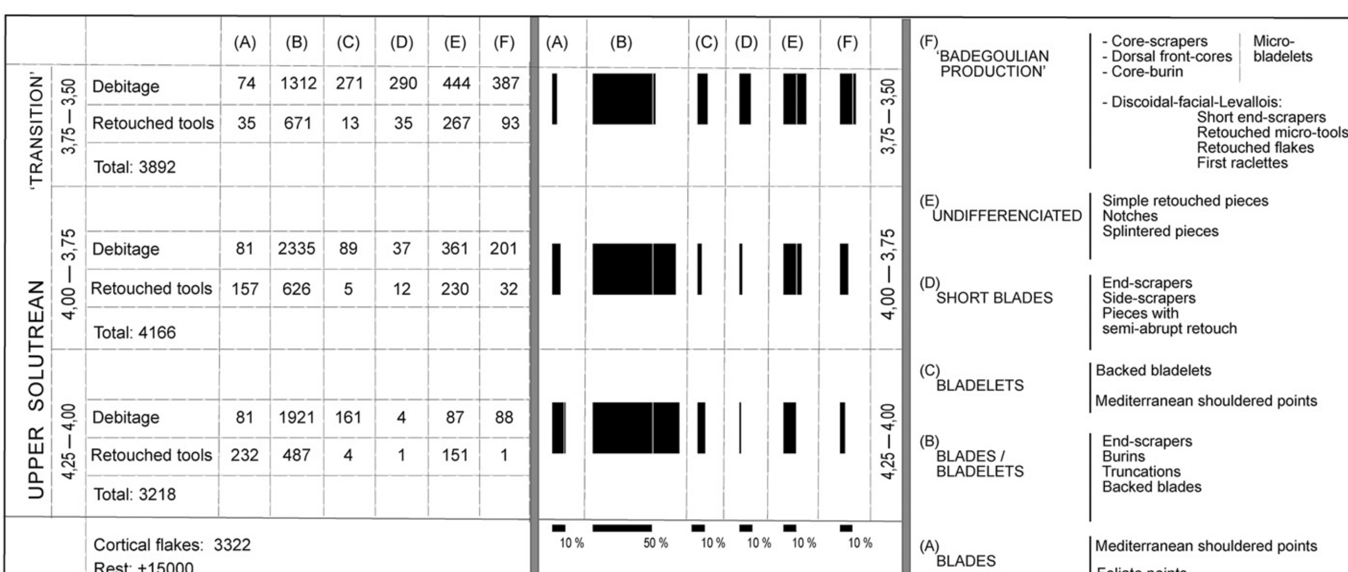

Fig. 6. Distribution of the lithic productions that correspond to the US–BA 'transition' at Parpalló. The column to the right includes retouched artifacts associated to each one of the lithic productions.

sequence (4.00–3.75 m). Most of Le Placard sagaies together with bone points with wide, convex single bevels covering more than a third of their length (Pericot, 1942), were concentrated in the upper level (3.75–3.50 m) although they are also present in the overlying layers (3.50–3.25 m). The engraved representation of an ibex, *Capra pyrenaica*, using a technique similar to pseudo-excise decoration, was recovered in the upper part of the sequence (Pericot, 1942, fig 76.6). The same technique was documented at Volcán del Faro on a thick piece of round section and with a rounded base, which was also associated with raclettes (Fig. 3: 7).

5. Discussion

The archaeological record in the two regions of Iberia discussed here is essentially known from stratified caves and rock shelters. The understanding of lithic production strategies in the Cantabrian region is insufficient to allow a discussion of the degree of continuity and transformation of technoeconomic strategies between the US and the AM. This is even more so for the so-called transitional facies that appear better represented in Asturias (Las Caldas, La Riera, possibly Cueto de la Mina and El Cierro). In these assemblages there are certain characteristics, including local raw material use and the presence of tools with archaic features, which show similarities with Parpalló (with low frequencies of limestone and quartzite) and the French Badegoulian (Bodu et al., 2007a).

The presence of Solutrean points in AM assemblages is not exclusive to the Cantabrian region sites; it is also described at other sites such as Abri Fritsch, Laugerie Haute, Badegoule and Parpalló. The presence of these objects may be related to sedimentary processes, in which case separate taphonomic analysis at each site is required. Nonetheless, continuity of occupation may also be implied by their presence.

The data from Parpalló permit a preliminary evaluation of changes in lithic production between the US and BA, without however implying a single model of technoeconomic transformation. A few Solutrean pieces (shouldered points and bifacial solutrean flakes) are still recorded in level 3.75–3.50 m representing 0.9% of 3433 retouched pieces and 2.8% of all debitage. Moreover, a significant decline in laminar production is recognized, followed by an increase in undifferentiated production of short flakes and elements grouped as “Badegoulian” (flake production, microbladelet and microflake production from carinated cores, core-burins and transversal burins).

The data indicate that the evolutionary inertia of the lithic production categories (A, B and C) lasts longer than the actual tool types (Mediterranean solutrean points and foliate points) (Fig. 6), a characteristic also observed in other periods (Tiffagom, 2006b, pp. 72). This transformation process suggests the following two hypotheses:

1) The changes observed in the frequency of lithic elements between 4.25 and 3.50 m at Parpalló may have resulted from post-depositional processes. Analysis of possible inter- and intra-stratigraphic refitting would be useful for the evaluation of this hypothesis. However, no data is yet available.
2) The co-existence of various traits may indicate the presence of a formative Badegoulain phase with US–BA elements that in turn would suggest a transition rather than a simple substitution process. Antecedents of such a model could be suggested for describing the transformation that took place in lithic production during the Mediterranean US (Tiffagom, 2006).

These changes observed in lithic production may also be related to the intensity of the activities performed with chipped stone artifacts. The description of tools with an “archaic” appearance and the presence of evidence for rejuvenation and recycling is commented upon with reference to the BA industries (Aura Tortosa, 1995). Correlation of these characteristics with the duration of occupation and settlement systems should be assessed (Barton, 1991; Bamforth and Bleed, 1997; Straus et al., 2008). Moreover, these characteristics are documented in both regions despite their significant ecological differences. This suggests that the observed convergence in lithic and bone/antler production may be explained by regional scale connections between groups.

Finally, in the light of the new radiocarbon data, the beginning of the AM/BA in the Mediterranean region appears to be dated as early as the Badegoulian in France (Crétin et al., 2007; Ducasse, 2010). In this case the duration of the Upper Solutrean would be shorter and the dates after ca. 20 cal BP for the LM of the Spanish Mediterranean region would be compatible with the new data. However, these should be treated with caution (Aura Tortosa and Jordà Pardo, in preparation).

6. Conclusions

The diagnostic artifacts types repeatedly used in this paper are invasively retouched Solutrean points, Mediterranean backed shouldered points, “archaic” tools, raclettes, sagaies with circular section, single basal bevels, Le Placard type decoration and pseudo-excise decoration. In Iberia the association and stratigraphic location of these elements provide regional links with areas to the north of the Pyrenees (Bodu et al., 2007b). In the Cantabrian region, Le Placard bone points appeared until recently, to be associated with the AM facies at Rascaño −5 (Utrilla, 2006). However, at Llonín these elements are associated with other diagnostics such as the use of local raw materials, raclettes and the pseudo-excise technique (Fortea et al., 2004). Some of these elements are also present at La Riera, Cueto de la Mina (Fig. 3: 4–6). In the Mediterranean area, such bone points may be found at the base of the BA, but with possible intrusion from US levels at Parpalló. In the Ebro valley the dates from Gato −2 antedate the data from the Cantabrian region (Utrilla et al., 2010). Therefore, when the US–AM/BA succession is assessed on the basis of artifact “substitution” patterns, it is characterized by regional variability although with some shared elements.

These changes coincided with significant increases in bone points that should not be considered a Magdalenian feature, but rather a Badegoulian one. The distribution of bi-points and thick pieces, Breuil’s “gros ciseaux et lissoirs ornés” (1912, Figs. 21 and 22), the generalization of single basal bevel points of round and oval section, Le Placard types, and the pseudo-excise technique provide additional evidence for contact between groups in the Cantabrian region, the Ebro Valley and the Mediterranean region. It is improbable that with so many characteristics in common, contacts between different regions did not exist (Sauvet et al., 2008, pp. 39). The simplest explanation for these similarities is that after 22.5–22 ka cal BP, transformation processes took place in much of the previous “Solutrean territory” in these regions.

In Iberia there is no agreement concerning the naming of the technoeconomic process that took place during the GS 2. However, the AM assemblages of the Cantabrian region and the BA of the Mediterranean region share many key attributes.

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