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From Atapuerca to Europe: Tracing the earliest peopling of Europe

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ABSTRACT

The Sierra de Atapuerca sites (Spain) have yielded excellent data and they represent the longest chronological sequence discovered in Europe to date, covering the late Early Pleistocene to the late Middle Pleistocene. In view of these exceptional characteristics, this work aims to meet three objectives: to characterise the technological features of various key European sites in relation to the significant factors observed through the Atapuerca sequence; to evaluate whether technological evolution in Europe during the Early and the Middle Pleistocene is consistent with that of Atapuerca; and finally, to consider the possibility of extrapolating population inferences from Atapuerca to the rest of the continent.

The conclusions suggest that the earliest peopling of western Europe occurred not long before 1 Ma and was accompanied by a relatively homogeneous Mode 1 technology. Between 800 and 600 ka, the European framework is limited to a few assemblages, most of them derived from European Mode 1, and even probably belonging to the earliest European Acheulean. Interestingly, at Atapuerca there is a gap between *c.* 900 ka and *c.* 500 ka with no hominin presence; in other words, approximately 400,000 years passed between the late Mode 1 of *Homo antecessor* and the first Mode 2 represented there with *Homo heidelbergensis*. Significantly, this hominin gap has been observed in three consecutive levels of the Gran Dolina site (about 4 m thickness), all of them extremely rich in faunal remains.

This paper poses the hypothesis that this gap at Atapuerca represents a non-local, continental phenomenon, leading to consideration of several different points. Firstly, *H. antecessor* and its possible ascendants, who had formerly peopled Europe, might have been in the process of extinction around 800 ka. Secondly, before 650 ka new but light waves of hominins may have arrived in Europe carrying the new Acheulean technology. These waves did not reach most of the continent, and surely they were not successful in demographic terms until (thirdly) the arrival of the full Acheulean groups at 500 ka. Between 500 ka and 300 ka this full Acheulean appeared at several European sites, and *H. heidelbergensis*, whatever its origin, is strongly associated with this technology on this subcontinent. Fourthly, if the Mode 1 populations eventually disappeared before 650 ka then the later Clactonian/Tayacian sites of northern Europe cannot be derived from this legacy, but must come from the Acheulean line, and are therefore a variant. Finally, the data suggest that the Acheulean may have technically developed into the European Middle Palaeolithic, as *H. heidelbergensis* evolved into Neanderthals.

1. Introduction: the data from Atapuerca

Four sites in Sierra de Atapuerca – Sima del Elefante, Gran Dolina, Galería and Sima de los Huesos – have been used to build the longest sequence of hominin occupations in Europe from the late Early Pleistocene to the late Middle Pleistocene. As the specific features of each of these sites can be consulted elsewhere (Carbonell et al., 1995, 1999, 2001, 2005, 2008; Arsuaga et al., 1997; Mosquera, 1998; Bermúdez de Castro et al., 1999, 2004, 2008; Rosas, 2001, 2006; Rodríguez, 2004; Molines et al., 2005; Ollé et al., 2005; Carbonell and Mosquera, 2006; Rodríguez et al., 2011), this paper will only focus on the data significant to this purpose. These data concern sites, levels, and dates associated with the presence of hominins as indicated by either fossil or cultural remains (Table 1).

As Table 1 shows, there is a general continuity concerning hominin occupations in the Atapuerca landscape, with the exception of a gap between 900 and 500 ka, represented by three levels of the Gran Dolina site (TD7, TD8 and TD8-9), from which neither hominin nor cultural remains have been recovered with the exception of one small quartz flake (8*11*3 mm) appearing in level TD7. These levels are, however, very rich in faunal remains.

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Table 1
Dates, sites, levels, associated technologies and hominins from some Atapuerca sites.

Date	Site/Level	Technology	Hominins
1.2 Ma	Sima del Elefante-TE9	Early Mode 1	*Homo* sp. (Bermúdez de Castro et al., 2011) (previously *H. antecessor*, Carbonell et al., 2008)
c. 1 Ma	Gran Dolina-TD3-4	Early Mode 1	
c. 900 ka	Gran Dolina-TD6	Late Mode 1	*H. antecessor* (Bermúdez de Castro et al., 1997) See Berger et al. (2008) for dating.
Hiatus 500–400	Galería-Sima de los Huesos-Gran Dolina-TD10.3 and TD10.4[a]	Full Mode 2-Acheulean type	*H. heidelbergensis* (Arsuaga et al., 1997)
c. 300	Gran Dolina-TD10.1 and TD10.2, and top of Galería	Late Mode 2 and transition to Mode 3	

[a] TD10.3 and TD10.4 have only been sampled and the surface excavation of these levels is in progress.

In the analysis of the technical features of the Atapuerca assemblages (see Ollé et al., this volume), several factors emerge that seem to determine the type of technology of each level-site. When these data are examined as a whole, various significant trends become apparent in the Atapuerca assemblages (Table 2). First of all, there is a clear trend towards diversified knapping methods over time. Also, small retouched tools are absent or very scarce in the older levels, but they tend to increase in abundance over time and become increasingly standardised, diversified and finely shaped. Choppers and chopping tools are present in all levels, but they decrease in number throughout the Middle Pleistocene. Handaxes and cleavers appear at around 500 ka.

Before 900 ka, there is evidence of an Early European Mode 1 at Sima del Elefante-TE9 and Gran Dolina-TD3-4, characterised by the existence of a single knapping method (unipolar longitudinal, where flakes are removed parallel to one another, from a single striking platform) and the scarcity or absence of small retouched tools. Choppers and chopping tools are represented, but large cutting tools are completely absent. This Early Mode 1 technically may have evolved into the Late Mode 1 of Gran Dolina-TD6, which differs from the older technology in its higher representation of small retouched tools and the diversification of knapping methods. With regard to the hominin progression, the *Homo* sp. of Sima del Elefante-TE9 (Bermúdez de Castro et al., 2011) is followed by the *Homo antecessor* of Gran Dolina-TD6 (Carbonell et al., 1995). This *Homo* (previously classified as *H. antecessor* in Carbonell et al., 2008) is likely to be phylogenetically related to the *H. antecessor* of TD6.

Between *c.* 900 ka and *c.* 500 ka, the abovementioned archaeological gap occurs. This time span is represented by levels TD7, TD8 and TD9–10 of Gran Dolina, all very rich in micro and macrofaunal remains, but lacking any trace of hominins or hominin activities. Not a single tool or piece of flaking waste has been found in these levels (except the abovementioned quartz spall from TD7). In contrast, they are extremely rich in herbivore (*Dama vallonnetensis*, *Cervidae* indet., *Equus altidens*, *Bison* cf. *voigtsedtensis*, *Sus scrofa*, *Stephanorhinus etruscus*, *Eucladoceros giulii*, *Cervus elaphus* cf. *acoronatus*, and *Hippopotamus* sp.), and carnivore (*Ursus* sp., *Canis mosbachensis, Vulpes* sp., *Crocuta crocuta, Hyaena* sp., *Lynx* sp. and *Panthera gombaszoegensis)* remains, as well as some remains of the genus *Macaca* and *Meles* sp. Mustelidae and Hystricidae are also well represented (Blasco et al., in press; Rodríguez et al., 2011). This 400,000-year gap in the presence of hominins may mean that the Late Mode 1 technology of TD6 did not evolve towards the full Mode 2-Acheulean-type of Gran Dolina-TD10, Galería and Sima de los Huesos. Furthermore, this same discontinuity is seen in the hominin species present at the sites, since TD6 was represented by *H. antecessor* and the Acheulean levels of Galería and Sima de los Huesos are represented by *Homo heidelbergensis*. The absence of an Early Mode 2 technology at Atapuerca (see below) also supports this break.

Finally, between 500 and 300–250 ka there seems to be a continuity from the full Mode 2-Acheulean type to the Late Mode 2-Acheulean and eventually to the Mode 3 throughout the upper levels of both Gran Dolina and Galería. Interestingly, no human fossils have been recovered from the younger levels of either site.

2. Other European sites

The technical traits of the Atapuerca assemblages were compared with other European records (Table 3, Fig. 1). To do so, the technical features of these records were extracted both through

Table 2
Technological features of the Atapuerca levels and sites. Q2

Atapuerca	Sima del Elefante-TE9 Gran Dolina-TD3–4	Gran Dolina-TD6	Galería-Sima de los Huesos[a] – Gran Dolina-TD10.3 and TD10.4	Gran Dolina-TD10.1 and TD10.2 and top of Galería
Model A. Existence of one simple production method, often unipolar longitudinal	Yes			
Model B. Diversification of production methods: centripetal, unipolar, orthogonal, multidirectional, bipolar		Yes		
Model C. Diversification of production methods, but dominance of centripetal			Yes	
Model D. Centripetal method + development of preferential flakes' methods (Levallois)				Yes
Small retouched flakes	No	Yes	Yes	Yes
Small tools diversity, standardisation, continuity of retouch, intense configuration	No	No	Yes	Yes
Choppers, chopping tools	Yes	Yes	No (Few)	No (Few)
Large cutting tools	No	No	Yes	Yes
European Mode	Early Mode 1	Late Mode 1	Full Mode 2 – Acheulean	Late Mode 2 and transition to Mode 3

[a] Assemblage composed of only one handaxe.

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Table 3

* Sites without sufficient information. ** Bipolar on anvil. In Western Europe this knapping method may be related to raw material conditionings. @ Bilzingsleben shows large tools on bone, but most of them are unifacial. + Boxgrove is a special case, since very few cores have been identified, beside the handaxes that were also used to detached flakes. Mode 2 without LCT: Mode 2 without Large Cutting Tools. [c] Information confirmed through our own analyses. TG: Galería (Atapuerca). SH: Sima de los Huesos (Atapuerca). As shown in Table 2, Model A: Existence of one simple production method, often unipolar longitudinal. Model B: Diversification of production methods: centripetal, unipolar, orthogonal, multidirectional, bipolar. Model C: Diversification of production methods, but dominance of centripetal. Model D: Centripetal method + development of preferential flakes' methods (Levallois). Dating methods: PM = Paleomagnetism, BS = Biostratigraphy, ESR = Electron Spin Resonance, TL: termoluminescence, U = Uranium Series, K (Ar)/Ar = Potassium (Argon)/Argon, CN = Cosmogenic nuclides. Q3 Q4

Western Europe	Dates	Dating methods	References	Model A	Model B	Model C	Model D	Small ret. flakes	Small tools diversity, standardization, etc	Choppers, chop. tools	Large cut. tools	European Mode	Hominins
Lézignan le Cèbe *	1,57	Ar/Ar, BS	(Crochet et al., 2009)	?				No	No	Few	No	Early Mode 1 > 800 ka	
Pirro Nord	1,6–1,3	BS	(Arzarello and Peretto, 2010)		X?			No	No	No	No		
Barranco León [c]	1,3	PM, BS	(Toro et al., 2009)		X			Yes	No	Yes	No		
Fuente Nueva [c]	1,2	PM, BS	(Toro et al., 2009)		X			No	No	Yes	No		
Ata-TE9	1,2	PM, CN, BS	(Carbonell et al., 2008; Bermúdez de Castro et al., 2011)	X				Few	No	Few	No		*H. antecessor* (now *Homo* sp.)
Pont de Lavaud [c]	1,1	ESR	(Despriée et al., 2010)	X **				No	No	No	No		
Lune.Rosiers Unit 3	1,1/930	ESR	(Despriée et al., 2010)	X				Few	No	No	No		
Ata-TD3–4	*c.* 1	U/ESR, PM, BS	(Carbonell et al., 2001)	X				No	No	Yes	No		
Le Vallonnet [c]	1	ESR, PM, BS	(Lumley et al., 1988)	X				Few	No	Yes	No		
Monte Poggiolo [c]	*c.* 850	ESR, PM	(Arzarello and Peretto, 2010; Muttoni et al., 2011)	X				No	No	No	No		
Happisburgh *	990–780	PM, BS	(Parfitt et al., 2010)	?				Few	Low	No	No	Late Mode 1 900—780 ka	
Ata-TD6	*c.*900	U/ESR, TL, PM, BS	(Carbonell et al., 1999; Berger et al., 2008)		X			Several	Low	Few	No		*H. antecessor*
Vallparadis [c]	900? –800	PM, ESR, BS	(Martínez et al., 2010; Duval et al., 2011)	X **				Yes	Low	Yes	No		
Pakefield	*c.*700	PM, BS	(Parfitt et al., 2005)	X				Few	Low	No	No		
Quípar	900	PM	(Scott and Gibert, 2009)		~~X~~ ?~~?~~			Several	High	Yes	Yes	Early Mode 2-Acheulean	
S. Zamborino	760	PM	(Scott and Gibert, 2009)		?			Several	High	No	Abundant	(before 500 ka)	
Boella	*c.* 700	PM, BS	(Vallverdú et al., 2009)	X				Several	Low	No	Few		
Notarchirico	650	ESR, TL, BS	(Piperno and Tagliacozzo, 2001)		?			Yes	?	Yes	Yes		
La Noira	680–630	ESR	(Despriée et al., 2010)		X			Few	Low	No	Abundant		
L'Arago P [c]	570	ESR, BS	(Barsky and de Lumley, 2010)			X		Few	Low	Few	Abundant		
Isernia La Pineta	616–606	U/ESR, Ar/Ar	(Coltorti et al., 2005; Peretto, 2006)	X **				Few	Low	No	No	Late Mode 1 < 700 ky	
Boxgrove	500	BS	(Roberts and Parfitt, 1999)			X +		Few	Low	No	Abundant	~~Developed~~ Mode	*H. heidelbergensis*
Ata-TG-SH-TD10.3 & TD10.4	500–400	ESR, TL, U	(Carbonell et al., 2001)			X		Abundant	High	No	Several	2-Acheulean < 500 ka	*H. heidelbergensis*
L'Aragó G [c]	455	ESR, BS	(Lumley and Barsky, 2004)		X?	X?		Abundant	High	Yes	Yes		*H. heidelbergensis*
Schöningen *	400	TL, BS	(Thieme, 1997; Thieme, 2005)	?				Abundant	~~,?~~	No	No	Mode 2 without LCT	
Bilizingsleben @	370	U, BS	(Mania et al., 1999; Mania and Mania, 2005)			X		Abundant	High	Several	Several @		*H. erectus*
Ata- TD10.1, TD10.2 & top of TG	*c.* 300	ESR, TL, U	(Rodríguez et al., 2011)				X	Abundant	High	Few	Few	Late Mode 2-Acheulean and Transit. Mode 3 *c.* 300 ka	

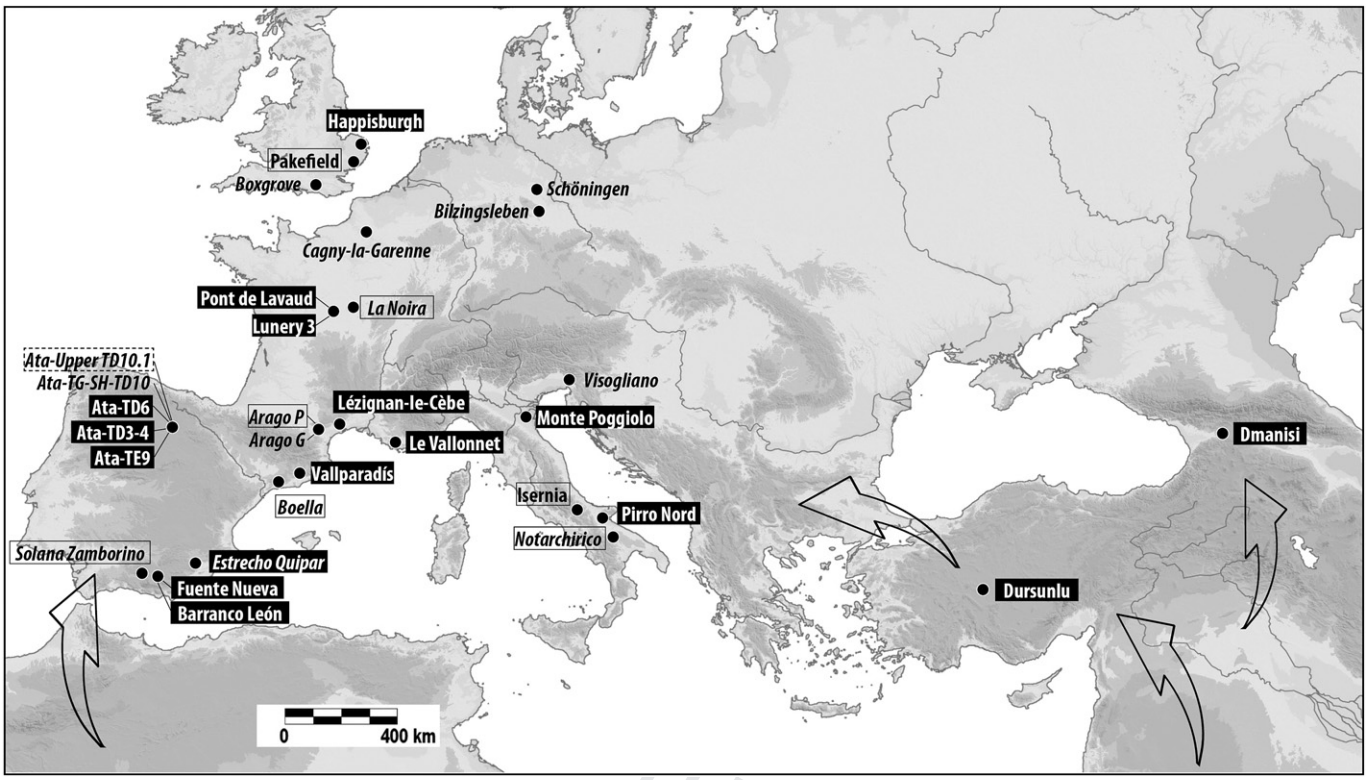

Fig. 1. The most significant European sites. Regular type on black background: Mode 1 sites older than 800 ka. Italics on black background: Early Acheulean sites older than 800 ka (debatable dates). Regular type in transparent box: Late Mode 1 sites between 800 and 500 Ky. Italics in transparent box: Early Acheulean sites between 800 and 500 ka. Italics without box: Mode 2 sites both without large cutting tools and Acheulean type. Ata-Upper TD10.1: Late Acheulean and transition to Mode 3.

analyses and major publications on these sites. As Table 3 shows, the assemblages generally share common technical features with others of the same chronology, although not enough data was available for some records to make a comparison (i.e. Lézignan le Cèbe, Pirro Nord and Happisburgh; See Table 3 for bibliography.).

The earliest occupation of western Europe unquestionably occurred before 1 Ma with a quite simple and homogeneous Early Mode 1 technology. The sudden presence and good representation of European sites of this chronology suggests that the first settlement may not have occurred much earlier than that, as other researchers have pointed out (Muttoni et al., 2010). Therefore, this chronology for the earliest peopling does not seem to be due to methodological or taphonomical biases. However, the origin – African or Asian – of this early settlement is currently under debate (Bermúdez de Castro et al., 2010). Unfortunately, here technology cannot help palaeoanthropology, as nothing in Europe's oldest Mode 1 lithic assemblages would allow their possible African or Asian origin to be distinguished. The earliest European assemblages are singular and non-standardised, which makes comparisons difficult. The exceptions are the lithic records of Fuente Nueva and Barranco León (Toro et al., 2009), which are much more diversified and standardised, and the only ones in Europe that include spheroids. Unfortunately, spheroids appear both in Africa and Asia, so they cannot be used as markers of any technological "tradition".

Around 800 ka, the European technological framework is limited to very few assemblages with Late Mode 1 technology, derived from Early European Mode 1. The difference between Early and Late European Mode 1, besides their chronologies, seems to be limited to the small retouched tools: they are not unheard of in Early Mode 1, but when they appear they lack diversity, standardisation and intensity of shaping. In contrast, these tools are always present in Late Mode 1, and they are comparatively more standardised and diversified. The Late European Mode 1 assemblages compared are TD6 (Spain), and Pakefield and Happisburgh (England).

New lithic assemblages with Early Acheulean features also seem to appear in Europe for the first time at the end of the Lower Pleistocene. Although the dates (900 ka) of the Spanish Acheulean sites of Quípar and Solana de Zamborino (see Table 3 for references) are debatable (Jiménez-Arenas et al., 2011), new evidence from the site of La Boella (Spain) (Saladié et al., 2008; Vallverdú et al., 2009) situates the entrance of this Early Acheulean as early as around 700 ka. Other old European Acheulean sites known to date are La Noira (France) (680–630 ka), Notarchiricco (Italy) (650 ka), and L'Arago-Level P (France) (570 ka). Interestingly, there is only one other site as old as these: Isernia La Pineta (Italy) dated at around 600 ka. Despite the strong conditioning of raw materials at this site, the Isernia assemblage seems to exhibit Mode 1 technology. Recent ESR/U-series data on this site offered an age of 435 ka, which is considered biased and too young (Shao et al., 2011).

From 500 ka onwards, the Acheulean develops throughout Europe and is represented from the north (Boxgorve, England, see Table 1 for references; Cagny la Garenne, France, Bahain et al., 2001; Lamotte and Tuffreau, 2001) to the south (Atapuerca-Galería, Spain. See Table 1 for references; Visogliano, Italy, Abbazzi et al., 2000) of the subcontinent (see Santonja and Villa, 2006, for Acheulean sites in Europe). Simultaneously, lithic industries without large cutting tools are well represented across Europe, particularly in its northern latitudes (e.g. Schöningen), giving rise to the so-called Clactonian/Tayacian technology of the second half of the Middle Pleistocene.

Early European Mode 1 technology is characterised by the use of a single knapping method, usually the unipolar longitudinal technique. However, the sites of Fuente Nueva and Barranco León show

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a wider variety of flaking techniques, which seems to be an African trait that becomes more common in Europe in younger assemblages. Small retouched tools are often absent from Early Mode 1 records, but when they are present they lack diversity and standardised shaping. In contrast, Late Mode 1 assemblages show wider diversity in the knapping methods used. Also, small retouched tools are always represented, and they are comparatively more standardised, diversified and better shaped.

European Mode 2-Acheulean type technology is characterised by the diversification of knapping methods, with the centripetal technique becoming dominant in full Mode 2-Acheulean. Furthermore, all the sites belonging to this type exhibit several small retouched tools, and they are highly diversified, standardised and finely shaped compared to earlier records. These sites have also yielded large cutting tools, whereas such tools are absent in Mode 1 sites. Here, the difference between Early and full Mode 2-Acheulean types is rather limited to the chronology, although roughly shaped picks and trihedral morphologies seem to be slightly overrepresented among the large cutting tools in the oldest Acheulean assemblages. Similarly, small retouched tools become more diversified over time and their retouch becomes increasingly refined and standardised.

The transition from the European Acheulean to Mode 3 can also be distinguished by the decreasing number of large cutting tools and increasing presence of the Levallois method. Finally, the case of choppers and chopping tools deserves special attention. At the Atapuerca sites they were represented in the oldest assemblages but they disappeared during the Middle Pleistocene. However, they are present or absent at other European sites regardless of the lithic record or chronology, suggesting that they lack a specific meaning in technological terms.

3. Discussion: from Atapuerca to Europe

As described at the beginning of this paper, the Atapuerca records can be linked together to provide an overall view of the hominin occupations of the area over a period of about a million years; from 1.2 Ma at Sima del Elefante-TE9 to around 300 ka at Gran Dolina-TD10.1 and TD10.2, or even 250 ka at the upper levels of Galería. This chain seems to break for 400,000 years, from around 900 until 500 ka, a time span represented by levels TD7, TD8 and TD8–9 of Gran Dolina, where neither hominins nor hominin activities (with the exception of the small flake) have been identified. In contrast, these levels are extremely rich in faunal remains, particularly herbivores. Although small-mammal analyses have indicated a gradually opening landscape from these levels towards the mid Middle Pleistocene (Cuenca-Bescós et al., 2011), other studies have concluded that no correlations can be drawn at Atapuerca between climatic changes, faunal turnovers and cultural/hominin changes (Rodríguez et al., 2011). Actually, this gradually opening landscape is detected from level TD8–9 onwards. Meanwhile, levels below TD8–9 including TD6 reflect landscapes featuring warm and humid conditions. If this gradual transition to cold and dry conditions influenced hominin settling then the gap in hominin occupations should be located in TD8–9 and not below it (TD7 and TD8).

The 900-500-ka gap at Atapuerca may not be simply a local occurrence, but is actually a continental phenomenon. In other words, the discontinuity between the Late Mode 1 of *H. antecessor* and the full Mode 2 of *H. heidelbergensis* did not occur at a local scale, but was instead a Europe-wide event. If this is so, further hypotheses linked to this idea must also be considered.

Firstly, that the *Homo* species that inhabited Europe at around 1.2 Ma and was likely similar to or an ascendant of *H. antecessor*, may have been undergoing extinction *c.* 800 ka. There are several archaeological sites in Europe before 800 ka and after 500 ka, but very few between the two dates (Table 3), which seems to reinforce the significance of the Atapuerca gap. Although abundant enough to be represented in several parts of Europe, *H. antecessor* and ascendant populations probably never achieved p[illegible]ular success in demographic terms until the end of the Early Pleistocene. Before this time, the Atapuerca data from Sima del Elefante-TE9 (1.2 Ma) and Gran Dolina TD3–TD4 (*c.* 1 Ma) point to minor opportunistic occupations consisting of few individuals. At *c.* 900 ka, base camps, hunting, carcass transport, social cooperation and food sharing appear for the first time in level TD6 of Gran Dolina (Saladié et al., 2011), which reflects the complex social organisation of those hominins. The marked impact of these occupations seems to point to the better adaptation and growing demography of *H. antecessor*. However, these strategies may not have prevented their extinction. Although it is not known why *H. antecessor* went extinct, certainly cannibalism (Fernández-Jalvo et al., 1996, 1999; Carbonell et al., 2010), if a traditional practice, did not help these populations toward demographic success.

Secondly, Acheulean technology arrived in Europe around or before 650 ka. This arrival would be related to the Gesher-Benot-Ya'aqov Acheulean tradition (Goren-Inbar et al., 2000), closer in time to the European sites, instead of the older Ubeidiya tradition (1.4 Ma) (Bar-Yosef and Goren-Inbar, 1993; Bar-Yosef and Belfer-Cohen, 2001), which would imply a huge delay. However, Sharon (2011) has highlighted the similarity between the *entame* flaking tradition to obtain large flakes as blanks for handaxes and cleavers in northern Africa and the techniques used on the Iberian Peninsula during the Middle Pleistocene. If so, it is also reasonable to suggest that this tradition may be older, with roots at the end of the Early Pleistocene. In this case, the Strait of Gibraltar would have been the natural link between northern Africa and southern Europe (Santonja and Perez-Gonzalez, 2010) as far back as 650 ka.

None of the few European sites represented at this stage (Quípar, Solana de Zamborino, La Noira, La Boella and Notarchirico) have yielded hominin fossils, so the hominin responsible for the arrival of the Early Acheulean cannot be identified. One possibility is that the last *H. antecessor* groups adopted the new technology, but based on the number of European sites of this chronology it is highly improbable that there were enough individuals to facilitate this adoption and its transmission over any distance. It is more likely that the Early Acheulean was brought to Europe by some new hominin group. Although there is no theoretical need to link technological changes and hominin dispersals, the Atapuerca data actually support this relationship regardless of chronology (Rodríguez et al., 2011). Therefore, it is suggested that the Early Acheulean was introduced by hominins other than *H. antecessor*. However, given the limited dispersal of these arriv[illegible]and the scarcity of sites (Acheulean technology did not really develop in Europe until 500 ka), these new settlers were few and not particularly successful, and ~~that~~ the continent become almost depopulated between around 800 and 500 ka, after the last Late Mode 1 and the earliest Mode 2 groups disappeared.

Thirdly, a great change occurred at around 500 ka with the arrival of the full Acheulean and its high impact on the landscape, as evidenced by the increasing number of sites and intense occupations that characterise this technology. At 300 ka this full Acheulean is present virtually all across Europe. As *H. heidelbergensis* is always associated with this technology, this species may have also been responsible for introducing and dispersing the Acheulean throughout the subcontinent. Interestingly, this huge dispersal did not need fire to succeed, no matter what the climate or latitude. Not a single sign of hearths or the use of fire has been identified at Atapuerca, even in the youngest levels belonging to the mid Middle Pleistocene. The same can be said of the other European sites. The

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oldest European hearths documented to date are at the sites of Terra Amata (France) (Lumley, 2006), Beeches Pit (England) (Gowlett, 2006), Schöningen (Germany) (Thieme, 2005) and Bilzingsleben (Germany) (Mania and Mania, 2005), all of them around 400 ka (perhaps 370 ka for Bilzingsleben), and were possibly lit by *H. heidelbergensis* populations. Hearths may have been in use in Europe before this date, but the practice was not generalised until around 250 ka, as noted by Roebroeks and Villa (2011). This absence is not related to a supposed lack of complex behaviour on the part of *H. heidelbergensis* (Menéndez, 2009), but rather because it was unnecessary, even to successfully inhabit the northern European latitudes. The generalisation of fire seems to have been more related to the reorganisation of domestic activities, including feeding, as the analysis of several Neanderthal sites indicates (Vaquero and Pastó, 2001; Vaquero, 2008; Roebroeks and Villa, 2011). In any case, the absence of hearths at Atapuerca may be significant for the potential extrapolation of the Atapuerca sequence to the rest of Europe.

Fourthly, another hypothesis can be formulated: if Late Mode 1 eventually disappeared after Pakefield (700 ka) or even Isernia (600 ka), then the younger Clactonian/Tayacian sites of northern Europe dating to around 300 ka cannot come from this legacy, but rather are descended from an Acheulean background. That is, the Clactonian would be a variant of the Acheulean (Ashton et al., 1998; White, 2000; McNabb, 2007; Lycett and Cramon-Taubadel, 2008).

Finally, the data support the hypothesis that the Late Acheulean technically evolved into the European Mode 3, without the need for external input, as Neanderthals descended from *H. heidelbergensis* (Moncel et al., 2011; White et al., 2011).

4. Conclusions

In summary, when organising the European sites in their chronological frameworks it is clear that the archaeological record is extremely poor between *c.* 800 and 500 ka. Few sites have been dated within this time span, and although none of them have yielded hominin remains, primarily Early Acheulean assemblages have been recovered from them. This gap makes it difficult to establish technological or paleoanthropological evolutionary trends along this time span. However, both technology and hominins before and after this gap are notably different: at a technological level, there is a more or less developed Mode 1 until 800 ka and then an already technically and morphologically homogeneous Mode 2 from 500 ka onwards, which suggests the direct arrival and fast dispersal of the full Acheulean in Europe.

At a biological level, *Homo* sp. and *H. antecessor* were present before 800 ka versus *H. heidelbergensis* from 500 ka onwards. In contrast to this 900–500 ka gap, after 500 ka several sites have been discovered in Europe, and when hominin remains appear at these sites they are assigned to *H. heidelbergensis* (e.g. Mauer, Sima de los Huesos, Boxgrove, Galería, L'Arago).

Therefore, neither does the European Late Mode 1 of *c.* 800 ka seem to have evolved towards the Acheulean of *c.* 500 ka, nor is the evolutionary relationship between *H. antecessor* and *H. heidelbergensis* as clear and direct as previously thought. The model of "source and sink" recently proposed to explain European Middle Pleistocene peopling (Dennell et al., 2011) may coincide with the proposed gap, in which the Atapuerca record reflects a continent-scale event, and the human occupations of Galería, Sima de los Huesos and Gran Dolina may represent a new stage of European peopling during the Middle Pleistocene, different both in technology and biology.

Based on this hypothesis, a scenario is suggested in which an unknown *Homo* sp. entered Europe from Asia or Africa before 1 Ma, assisted by an Early Mode 1 technology. This hominin likely evolved into *H. antecessor* before 800 ka, who developed Late Mode 1 technology derived from ancestral technology.

H. antecessor may have gone extinct at the end of the Early Pleistocene, possibly around the same time that the new Acheulean technology entered Europe for the first time. This Early Acheulean reached primarily the Mediterranean area. The hominin populations that introduced the Early Acheulean may not have been strong enough in demographic terms to continue peopling the continent, leading Europe to become nearly uninhabited from 800 until 500 ka, when new waves of populations (this time *H. heidelbergensis* populations) dispersed the full Acheulean quickly and intensively and throughout the continent. This full Acheulean shows clear African traits from the time of its dispersal across Europe. Furthermore, it may have developed into a variant for those sites without large cutting tools, the so-called Clactonian/Tayacian sites, and eventually into the Late Acheulean and Mode 3, just as the *H. heidelbergensis* populations may have evolved into Neanderthals.

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