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RADIOCARBON EVIDENCE OF THE MIDDLE TO UPPER PALAEOLITHIC TRANSITION IN SOUTHWESTERN EUROPE

LA TRANSICIÓN DEL PALEOLÍTICO MEDIO AL SUPERIOR EN EL SUROESTE DE EUROPA EN BASE A LAS DATACIONES RADIOCARBÓNICAS

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ABSTRACT

In the present paper we systematically evaluate the radiometric database underlying the Middle to Upper Palaeolithc transition in southwestern Europe.The different models which attempt to explain the demographical processes underlying this transition rely to a large degree on radiocarbon chronology. We observe that: 1) with increasing age, dates on bone samples show large offsets against those on charcoal, often underestimating these for several thousand years BP and; 2) there is no proof for a persistence of Middle Palaeolithic industries into the time of the earliest Aurignacian in SW Europe. These data contradict the "*Ebro- Frontier*" model that distinguishes Late Middle Palaeolithic industries in the SW of the Iberian Peninsula from early Aurignacian ones in the NE. On the contrary, our data 3) imply a model of interregional shifts of populations contracting during severe cold and arid phases and expanding under warmer, interstadial conditions, raising ideas on a regional *in situ* development of the SW European Aurignacian out of Latest Middle Palaeolithic industries made by Neanderthals some 40.0 kyr cal BC.

RESUMEN

Se presenta un estudio sistemático sobre la información radiometrica disponible para la transición Paleolítico Medio-Paleolítico Superior en el Suroeste de Europa. Los diferentes modelos para explicar el proceso demográfico que subyace en esta transición dependen en gran medida de la cronología radiocarbónica. Se observa que: 1) a mayor antiguedad las fechas sobre hueso muestran una mayor desvisación frente a las muestras sobre carbón, a menudo infravalorando estas varios miles de años BP y 2) que no hay pruebas de perduración de industrias de Paleolítico Medio durante las fases tempranas del Auriñaciense en el SW de Europa. Estos datos contradicen el modelo de "frontera del Ebro" que distingue industrias de Paleolítico Medio Tardío en el SW de la Península Ibérica de las industrias del Auriñaciense temprano en el NE. Por el contrario, 3) nuestros datos implican un modelo de cambios de población interregional que se contrae durante las fases aridas y de frío severo y que se expande durante las fases más calidas de los interestadios, surgiendo la idea de un desarrollo regional del Auriñaciense del SW europeo a partir de las industrias del Paleolítico Medio Tardío realizadas por los Neanderthales hace 40 kyr cal BC.

Key words: Middle to Upper Palaeolithic transition. Colonization model. "*Ebro-Frontier*". Radiometric dates. Radiocarbon calibration. Palaeoclimate change. Population dynamics.

Palabras clave: *Transición. Paleolítico Medio-Superior. Modelo de colonización. "Frontera del Ebro". Datación. Calibración. Cambio paleoclimático. Dinámica de población.*

1. INTRODUCTION

The disappearance of Neanderthals is one of the most controversial questions in the study of homi-

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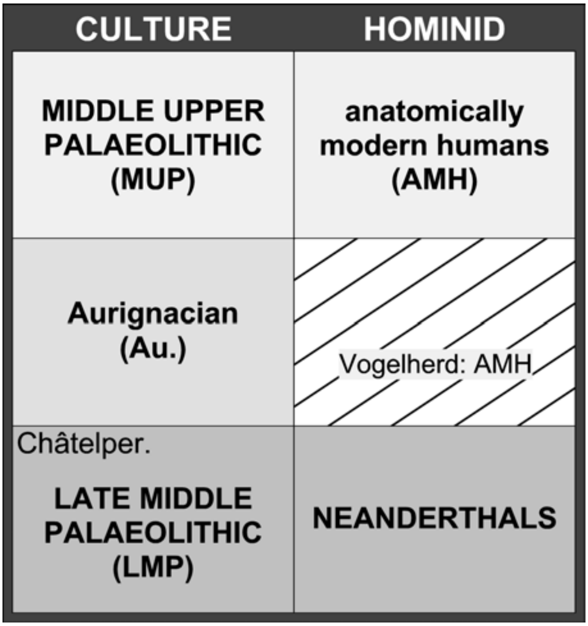

Fig. 1. Cultural sequence of Late Middle Palaeolithic to Middle Upper Palaeolithic technocomplexes in SW Europe compared with the hominid record.

nid evolution. Neanderthal fossil remains throughout Europe are exclusively known from pre-Aurignacian sites (Fig. 1), while early anatomically modern humans are exclusively tied to Upper Palaeolithic (UP) and younger technocomplexes (Churchill and Smith 2000; cf. Gambier 1997). Churchill and Smith evaluate the evidence for "*the makers of the Early Aurignacian in Europe*" and assert modern human presence in Europe "*almost certainly*" by ca. 32.0 kyr BP, and – based on Rieks 1931 discovery of a modern human skull ("Stetten 1") from the base of the Aurignacian layer V of the southern German Vogelherd cave (Riek 1932; 1934) – they see a "*strong possibility*" that modern humans "*were there by ca. 36 ka BP*". Although the new radiocarbon dates from the same stratum vary by several thousand years BP, they confirm the antiquity of the Aurignacian deposits at Vogelherd cave (Conard and Bolus 2003). But stratigraphic attribution of hominid fossils can rarely be established with certainty since skeletal remains may have been reworked in into older layers, a problem especially relevant for old excavations, which are often less well-documented. A good example is the recent dating of a perforated shell (*Littorina* sp.), found as a grave-good in a Cro-Magnon burial at the famous eponymous rock-shelter of the Gravettian period, which had formerly been attributed to an Aurignacian horizon at this site (Henry-Gambier 2002; cf. Djindjan *et al.* 1999). Being aware of such difficulties Cabrera Valdés *et al.* (2000: 91) state that the "*only well-known human evidence for the time range 40-35 ka is either of Neanderthal or undiagnostic type* [...], *while the presence of modern human types is not certainly recognized in Europe until about 30 ka*".

Nevertheless, the majority of models that today undertake efforts to explain the origin of anatomically modern humans is based on the "*Out of Africa*" hypothesis (Stringer and Andrews 1988; Stringer 2003), postulating colonization of Europe by early *Homo sapiens* with a simultaneous contraction of Neanderthal dispersal as expressed in the geographical spread of Middle Palaeolithic (MP) sites (Bocquet-Appel and Demars 2000). Recent studies in molecular genetics of fossil Neanderthal remains (Krings *et al.* 1997; 1999; Ovchinnikov *et al.* 2000) and new finds of early *Homo sapiens* in Ethiopia (White *et al.* 2003; cf. Clark *et al.* 2003) have provided substantial support for the "*Out of Africa*" hypothesis, whereby anatomically modern humans immigrated from Africa through the Near East into Europe replacing indigenous Neanderthal populations (Stringer 2003). This process – roughly placed between 40.0 and 30.0 kyr ago – is generally assumed to be unidirectional, with modern humans spreading rapidly through Central Europe, finally arriving on the Iberian Peninsula (Zilhão and d'Errico 1999).

2. THE "EBRO-FRONTIER" AND RECENT CONTROVERSIES

According to the European colonization scenario, anatomically modern humans reached the Iberian Peninsula last. Consequently, most authors today believe that modern humans – following the arrival of the Aurignacian north of the Ebro basin (as represented by the antiquity of early Aurignacian radiocarbon dates from the North of the Iberian Peninsula) – and Neanderthals in the southwestern part of the peninsula coexisted for many thousands of years: i.e. between 40.0 and 30.0 kyr ago (Fig. 2; Zilhão 2000a; 2000b; Zilhão and d'Errico 1999). In view of this "*Ebro-Frontier*"-model the Iberian Peninsula represents the major Neanderthal refugium (Vega Toscano 1993; vgl. Zilhão 1993) before their final replacement during the later Aurig-

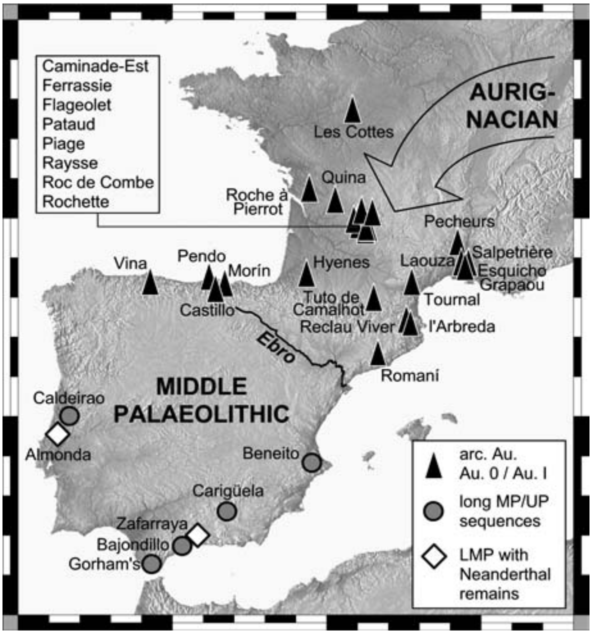

Fig. 2. J. Zihão's "*Ebro-Frontier*", seperating earliest anatomically modern human populations in Europe (as likely to be represented by 'archaic Aurignacian', 'Aurignacian 0' and 'Aurignacian I' inventories) from latest Middle Palaeolithic ones in the southwest of the Iberian Peninsula (modified after: Zilhão 2000a; 2000b; with addition from the "*Stage Three Project database*" of last interpleniglacial radiometric dates for European archaeological sites: Davies 2000, online; cf. annotation 1).
(arc.) Au. – (archaic) Aurignacian; MP – Middle Palaeolithic; UP – Upper Palaeolithic; LMP – Latest Middle Palaeolithic.

nacian, following *ca.* 33,500 ^{14}C BP (Vega Toscano 1990; Zilhão 1993).

This paradigm of a quite recent colonization of Europe by anatomically modern humans has been challenged during recent years by an alternative model of an *in situ* development of the Aurignacian out of the preceding regional Latest Middle Palaeolithic (LMP), based on the results of new excavations at El Castillo cave (Cabrera Valdés *et al.* 2001).

Due to the nature of population advances and the sparse typological evidence (i.e. the dispersal of Aurignacian I type split-based points in the northern part of the Iberian Peninsula; cf. Zilhão 2000a; 2000b) the Ebro Frontier model relies to a great extent on methods of chronometric dating, each with its own implicit chronological notions. The alternative hypothesis of an Aurignacian *in situ* development in SW Europe is based on a series of chronometric data, most of which are also radiocarbon measurements.

In the present paper we have aimed to test the "*Ebro-Frontier*"-model and to evaluate the possibility of an Aurignacian *in situ* development, using the "*Stage Three Project database*" of last interpleniglacial (Oxygene Isotope Stage 3 = OIS 3) radiometric dates for European archaeological sites (1), completed for the Iberian Peninsula as a part of assessments of the demographic processes underlying the transition from the LMP to the Earliest Upper Palaeolithic (EUP) in SW Europe.

3. THE MIDDLE TO UPPER PALAEOLITHIC TRANSITION AND AURIGNACIAN ORIGINS

Throughout the different regions of Europe, including its southwestern part, i.e. France and the Iberian Peninsula, regional archaeological records best displayed in numerous stratigraphies of cave sites and rock shelters, show exclusively Aurignacian industries post-dating LMP ones attributed to Neanderthals (Fig. 1). At several sites the latest MP is found in sediments formed under interstadial conditions of moderate to temperate climate attributed to the Hengelo-period (Carbonell *et al.* 2000), the most significant warm interval in the second half of OIS 3 (2).

In France and Northern Spain the Châtelperronian (3), which is restricted to these areas, is of-

(1) Davies 2000 (online): ARCH-DBASE.XLS at http://www.esc.ac.uk/oistage3/secure/arch-dbase.xls (August 2000 with bibliography for the cited dates; cf. Tab. 1 and Tab. 2). Some further extended databases have been compiled by Bocquet-Appel and Demars (2000: http://intarch.ac.uk/antiquity/additional/bocqtable1.html) and by d'Errico and Sánchez Goñi (2003 at QSR website: http://www.elsevier.nl/locate/quascirev), and Zilhão and d'Errico (1999).

(2) According to radiocarbon measurements available for Hengelo-interstadial deposits this warm interval most likely correlates with interstadial 12 of the Greenland ice cores (Greenland Interstadial 12 = GI 12; Jöris 2003). This temperate intervall possibly continues until GI 11 (cf. Fig. 7).

(3) Besides the rich evidence of Châtelperronien in France (Bosinski 1987; Demars 1996), in Northern Spain, level 10 from Cueva Morín, the small inventories from Labeko Koba IX and Ekain X, and those from El Pendo and A Valiña with their stratigraphical problems (Máillo Fernández 2003) are the only inventories known from Cantabria. From Catalunya only few Châtelperronian points have been recorded embedded in Aurignacian inventories (cf. Canal i Roquet and Carbonell i Roura 1989: 337: l'Arbreda, Cova Pau, Reclau Viver). Besides the problems concrening El Pendo (Montes Barquín and Sanguino González 2001), stratigraphical disturbances may also account to explain the interstratifications of Châtelperronian with Aurignacian levels at Roc de Combe (Rigaud 2001) and Le Piage in France (d'Errico *et al.* 1998; Rigaud 2001).

ten sandwiched between LMP and Aurignacian layers (Carbonell *et al.* 2000; d'Errico *et al.* 1998). The few hominid fossil remains currently known may imply that the Châtelperronian should also to be linked to Neanderthals (Hublin *et al.* 1996; cf. Asmus 1964). Therefore, one may assign the Châtelperronian to the Middle Palaeolithic, as can be also argued from the evolution of lithic technology (Gouedo 1990; cf. Bodu 1990) and tool spectra (de Sonneville-Bordes 1972; Bosinski 1987; 1990), both showing links to LMP industries.

In summary, the MP/UP transition of SW Europe comprises a well-established sequence of LMP, Châtelperronian-, and EUP Aurignacian-type techno-complexes (Fig. 1).

3.1. Radiocarbon evidence

During recent years numerous chronometric dates have been assembled from a large number of sites dating to the LMP and EUP on the European continent (Bocquet-Appel and Demars 2000; Davies 2001). The dates have been compared and interpreted in context with archaeological findings (d'Errico and Sánchez Goñi 2003; Zilhão and d'Errico 1999) (4). Most of the dates, with radiocarbon-measurements forming the bulk of dates from the entire corpus of radiometric age-determinations, have been obtained from sites in SW Europe, alltogether providing more than 700 radiocarbon measurements >17,500 ^{14}C BP, backed by more than 200 *non*-radiocarbon dates (TL/OSL; U-series; ESR). Due to its comprehensiveness the combined date list is a valuable instrument for studies on the demographic processes underlying the models in question.

However, due to a number of limitations of the different chronometric dating methods employed, in particular radiocarbon, caution in the meaning and interpretation of dates has repeatedly been expressed (e.g. Djindjian 1999; Pettitt 1999; Pettitt and Pike 2001). It is also most important to acknowledge that many of the ^{14}C-measurements on which the MP/UP transition is based range close to the technical limits of the dating equipment. With increasing age the dates become, as a rule, less reliable (one of the principles of the method underlying radiocarbon dating). This is reflected in increasing standard deviations as well as in the higher number of infinite ('greater than') age determinations – both parametres that largely depend on the technical equipment of the laboratory.

In the past developing radiocarbon methods did indeed produce a few dozen age determinations in the range of 10.0-12.5 half-lifes of radiocarbon. These were measured on large peat samples (*ca.* 100 g carbon) by a combination of thermal isotope enrichment with large ^{14}C-ß-counting systems (cf. Grootes 1977). Today, however, the technical limits of most modern laboratories for routine ^{14}C-(AMS)-measurements remain close to 9.5 half-lifes i.e. ca. 55,000 ^{14}C BP (Fig. 3). While some radiocarbon laboratories promise reliability of their measurements up to at least 40,000 ^{14}C BP (Hedges and Pettitt 1999), others have much lower technical age limits around 5.0-7.5 half-lives of radiocarbon age (5), i.e. the time of transition from LMP to EUP. Such problems principally effect radiocarbon dating and, consequently, the interpretation of dating results.

The most comprehensive study so far on the beginning of the EUP and the earliest occurences of the Aurignacian in Europe has been undertaken by Zilhão and d'Errico (1999) who, using a selected data set, (1) confirm the validity of the "*Ebro-Frontier*"-model and (2) state that no Aurignacian older than 36,500 ^{14}C BP (i.e. north of the Ebro basin) withstands their criteria of evaluation of sample taphonomy (6). This picture of earliest Aurignacian presence in Europe results from the omission of all radiocarbon dates older than 36,500 ^{14}C BP on charcoal samples that appear systematically older relative to bone.

(4) See annotation 1.

(5) Despite corresponding claims documented in the proposed analytical dating errors, we recognise that some radiocarbon laboratories, notably in earlier years, cannot achieve reproducible ^{14}C-measurements of such high age. A fair portion of the equipment earlier used in ß-decay counting quite apparently had rather large and at any rate often widely varying counter backgrounds, with statistical variations not always according to Poisson statistics, so that the reliability of the archaeological radiocarbon data available today is not in all cases beyond reasonable credence. Quality and reliability of dates thus relate to the age of the laboratory and the year a specific sample had been dated, rather than systematic offsets between conventional and mass spectrometric methods of radiocarbon dating as stated by d'Errico and Sánchez Goñi (2003).

(6) It is noteworthy that any dates are worthless without interpretation of the circumstances that may have contributed to the date, but the taphonomy and context of samples for radiometric dating are difficult to evaluate years after excavation. Any such 'evaluation' finally remains a selection judged by the authors' personal criteria. Testing the available data for integrity of their statistical properties should, at least, be carried out.

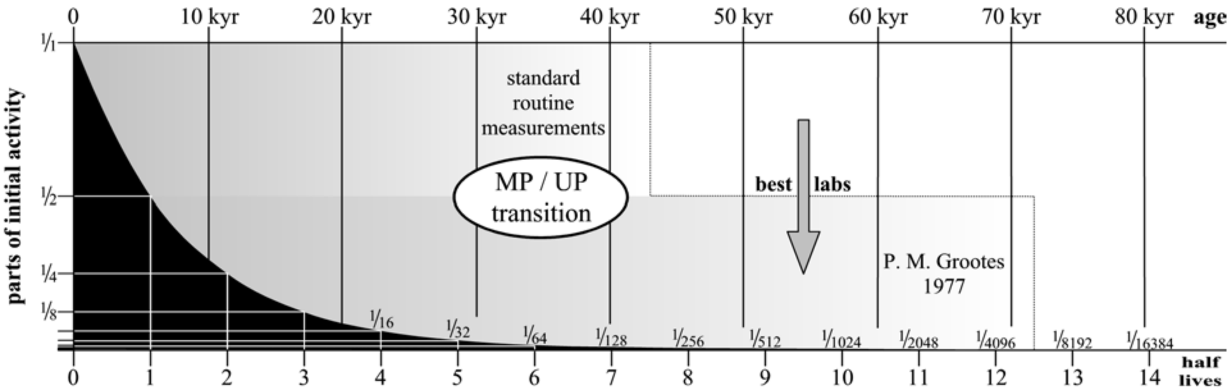

Fig. 3. Decay of radiocarbon with time relative to its initial activity in relation to the dating limits of radiocarbon laboratories. The Middle to Upper Palaeolithic transition (MP/UP) is close to the detection limits of most radiocarbon laboratories.

3.2. A material matter

In their analyses of data from the MP/UP transition Zilhão and d'Errico (1999) recognize that bone samples systematically turn out younger than charcoal ones, often diverging by several thousand ^{14}C BP. This phenomenon is independently and best illustrated by the example of the recently published ^{14}C data series from Kostienki 14 in Russia (Sinitsyn *et al.* 2002) (7). The main reason for Zilhão and d'Errico (1999) to trust the bone dates more than the ones produced from charcoal is that charcoal is often judged as 'mobile' material sensitive to stratigraphical disturbance, e.g. by processes of bioturbation. Based on the physical properties of the radiocarbon method of dating, there is no reason to rely more on the dating of bone rather than on charcoal samples, especially when the archaeological context is clearly identified, as is most likely to be the case with charcoal from hearths. For a variety of reasons, namely (1) the smaller initial content of datable carbon, (2) the well-known higher susceptibility of bone towards contamination with younger carbon, and (3) the disappearance of bone collagen due to decay (e.g. Schwarcz 2001), higher reliability should be given charcoal *versus* bone samples, especially when the samples are close to the detection limits of the radiocarbon method of dating.

Taken at face value, the ^{14}C age-distributions of the MP and UP of SW Europe more or less overlap in the entire period from around 38,000 to 19,000 ^{14}C BP (Fig. 4, left), creating a "*Coexistence Effect*" (Conard and Bolus 2003). This results from the exponentially decreasing rate of ^{14}C-decay and the rapidly increasing susceptibility towards contaminaton in older samples, as shown by theoretical estimates of the surplus of modern carbon on dating (Grootes 1977). Due to the fact that the youngest LMP samples exclusively derive from samples of bone or burnt (cremated) bone, their young age-determinations are most likely due to effects of contamination and alterations of the physical properties of sample material during processes of combustion (cf. Schwarcz 2001; Gillespie 1997) and/or to difficulties in the techniques and methods of dating burnt bone (Lanting and Brindley 1999; cf. Gillespie 1997). It is often impossible to establish whether the material is contaminated or not, and apart from obvious anomalous samples, it is still difficult to judge until which age LMP dates may be considered reliable.

Having filtered for sample material type (i.e. bone *versus* charcoal), radiocarbon age-distributions for bone dates (Fig. 4, centre) appear similar to those that have already appeared in the entire data set, while a completely different picture of age-distributions is given with charcoal (Fig. 4, right). This is most clearly seen in MP charcoal dates that appear systematically older than those obtained on bone. Direct comparisons of both bone and charcoal samples, as undertaken exemplarily for the SW European MP on the one hand (Fig. 5, left) and the Aurignacian of the same region on the other (Fig. 5, centre; cf. Zilhão and d'Errico 1999), emphasize

(7) At Kostienki 14 a layer of volcanic ash most likely to be linked with the Campanian Ignimbrite eruption (Fedele *et al.* 2002) confirms the great antiquity of charcoal data from the underlying strata, while horse bone samples show remarkable offsets towards younger ages (Sinitsyn *et al.* 2002).

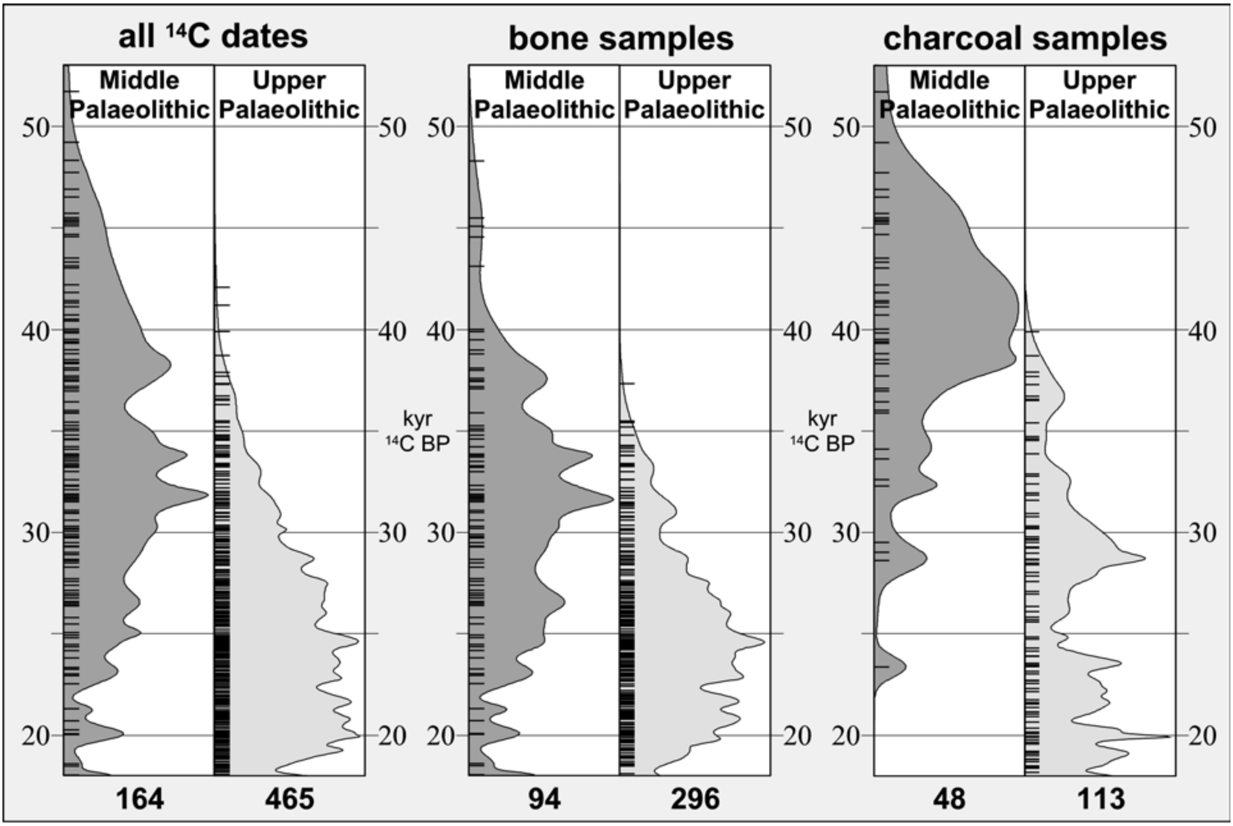

Fig. 4. Age-distributions [kyr ^{14}C BP] of Middle Palaeolithic (to the left of each diagram) radiocarbon-dates of SW Europe compared with those available for the Upper Palaeolithic (to the right of each diagram) of the same region comprising all ^{14}C-data (left), those sorted for bone (center) and samples on charcoal (right).
In the construction method applied to the resulting ^{14}C-dispersion graphs, each individual radiocarbon date has been defined by its given median value and standard deviation. The corresponding individual Gaussian curves have been added, to give a curve of the summed ^{14}C dating probability (Geyh 1969). Because each Gaussian curve is normalised with equal area, using this method each date/sample is given equal weight, independent of dating precision.

the complex difficulties with which radiocarbon-bone samples are generally endowed (Jöris *et al.* 2001; Schwarcz 2001). Demographic modelling of the processes underlying the MP/UP transition (Fig. 5, right) is thus strongly affected by the material dated.

3.3. Aurignacian origins

Against the background that different sample material may result in entirely different age-distributions, an ‘alternative’ radiocarbon chronology based solely on charcoal samples for the earliest occurences of the Aurignacian in Europe (1) pushes back earliest appearance of the Aurignacian to *ca.* 38,300 ^{14}C BP and (2) produces two distinct geographical clusters of possible Aurignacian origin (Fig. 6), i.e. the southeastern Central European region to the East and the Pyrenean and Cantabrian area to the SW (Jöris 2003). (3) The results do not, however, reflect a geographical pattern that one would assume in a model of anatomically modern humans colonizing Europe from the East to the West.

Since the Aurignacian lacks any readily apparent ‘cultural predecessors’ outside of Europe, it cannot be excluded that this culture may have evolved locally within these two regions in Europe (cf. Cabrera Valdés *et al.* 2001). The geographical dispersal of the oldest sites dated using ^{14}C-charcoal samples could imply Aurignacian genesis out of LMP leaf-point industries in the East and out of the Châtelperronian in the SW. In these regions youngest reliable radiocarbon dates on charcoal for the LMP range between 38,800 and 35,900 ^{14}C BP.

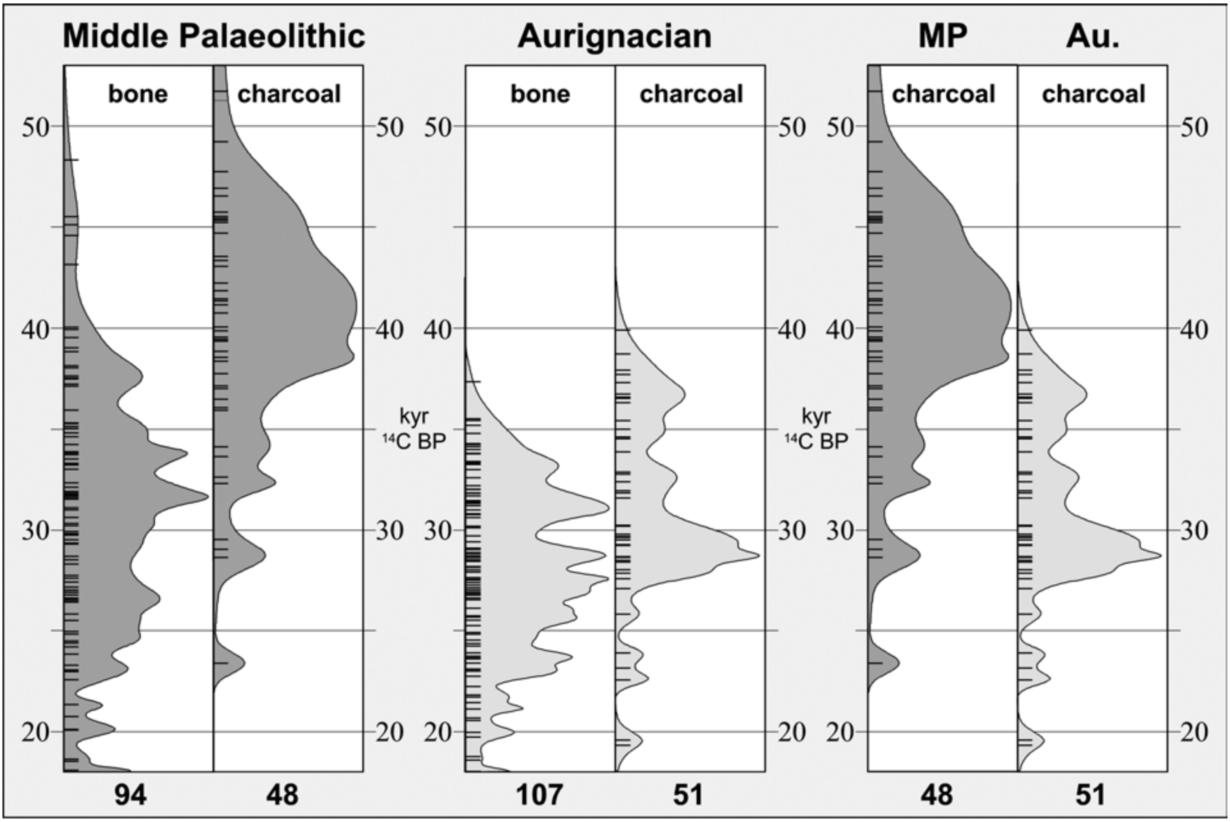

Fig. 5. Age-distributions [kyr ^{14}C BP] of radiocarbon samples on bone (to the left of the left and centre diagrams) compared with those derived from charcoal samples (to the right of the left and centre diagrams) for Middle Palaeolithic and Aurignacian technocomplexes in comparison with age-distributions based on charcoal samples (right) from the Middle Palaeolithic (MP) and Aurignacian (Au.).
In the construction method applied to the resulting ^{14}C-dispersion graphs, each individual radiocarbon date has been defined by its given median value and standard deviation. The corresponding individual Gaussian curves have been added, to give a curve of the summed ^{14}C dating probability (Geyh 1969). Because each Gaussian curve is normalised with equal area, by this method each date/sample is given equal weight, independent of dating precision.

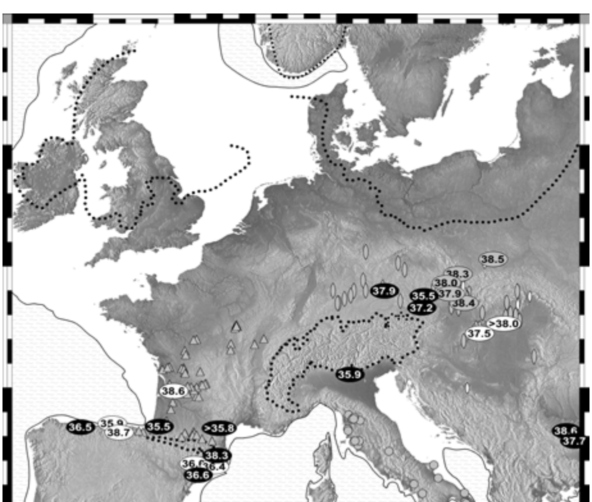

Fig. 6. Europe at the Middle to Upper Palaeolithic transition with Châtelperronian sites in the SW (Bosinski 1987; cf. Demars 1996), Uluzzian in Italy (Gioia 1990; Palma di Cesnola 1993), and leaf-point industries in south-central and southeastern Europe (Allsworth-Jones 1986; Bolus and Rück 2000) as well as 'last appearance data' (LAD's) for Middle Palaeolithic levels <40,000 and >35,000 ^{14}C BP (white underlain) and East European leaf-point industries (grey underlain) in comparison with first appearance data (FAD's) for the Aurignacian in Europe based on radiocarbon dates >35,000 ^{14}C BP (black underlain).
All radiocarbon FAD's and LAD's derive from charcoal samples and are given in kyr ^{14}C BP, in case of repeated measurements given as weighted means (cf. Jöris 2003; cf. Tab. 1-2).
Palaeogeography of Europe corresponds to the glacial maximum of the last glaciation at around 22.5 kyr cal BC with ice margins dotted and coastline lowered for some 120 m.

4. THE EARLIEST AURIGNACIAN AND THE LATEST MIDDLE PALAEOLITHIC OF SOUTHWESTERN EUROPE

The question of whether or not the Aurignacian originated from the regional LMP or is the result of anatomically modern humans colonizing Europe can best be approached from the point of view of available radiometric data (Tab. 1-2). In terms of this the "*Ebro-Frontier*"-model between *ca.* 40,000 and 30,000 ^{14}C BP is testable, since it requires two basic lines of evidence, which are (1) proof for Aurignacian presence NE of the Ebro basin at times for which (2) contemporaneous LMP is manifested in the region SW. Both lines can contribute to the colonization model in question, assuming that LMP lithic industries indeed represent Neanderthals, and that anatomically modern humans are the artisans of the Aurignacian.

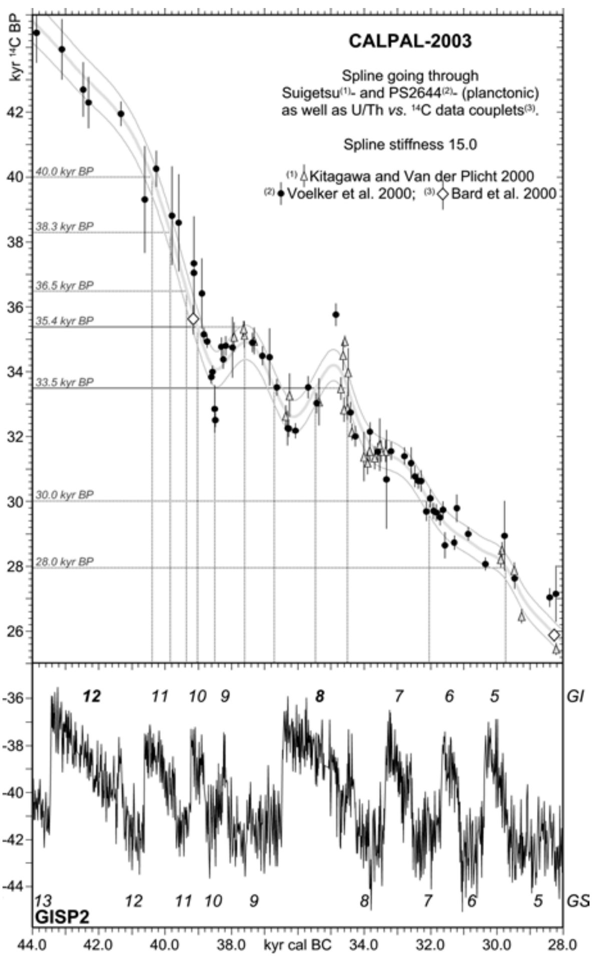

Fig. 7. Calibration of the radiocarbon scale [kyr ^{14}C BP] between 45,000 and 25,000 ^{14}C BP (Jöris and Weninger 1999a; 1999b; 2000, updated; see annotation 8) in relation to the Greenland GISP2 ice core record (‰ PDB δ^{18}O after: Stuiver and Grootes 2000), in the time-window 44.0 – 28.0 kyr cal BC.
GI – Greenland interstadial; GS – Greenland stadial.

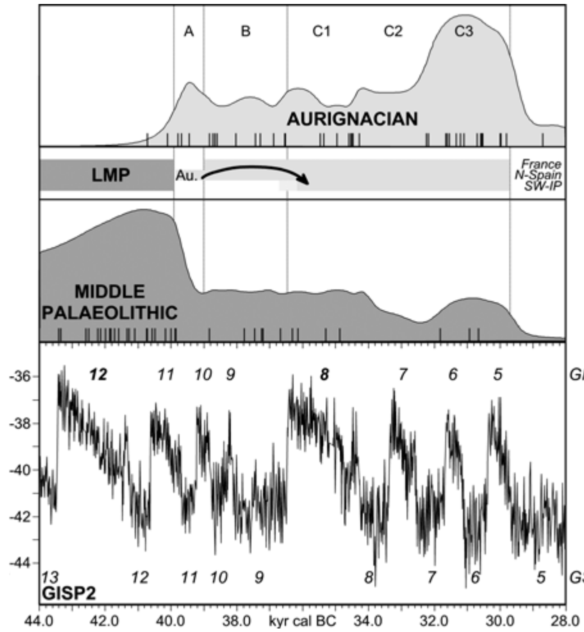

Fig. 8. Calibrated radiocarbon dates on charcoal of Middle Palaeolithic and Aurignacian of SW Europe (data identical with those in Fig. 5, right) against the GISP2 palaeoclimate record from Fig. 7, showing the abrupt ending of the Latest Middle Palaeolithic (LMP) at the onset of the Aurignacian (Au.) in SW Europe. For regional differences the Aurignacian is distinguished into A, B, C1, C2, C3.

While first appearance data (FAD's) of the Aurignacian in Europe – based on ^{14}C-charcoal samples – indeed demonstrate an early Aurignacian presence NE of the Ebro basin (Fig. 6), the second line of evidence is especially problematic to establish. Problems arise –as described in the preceding chapter–, in determining up to which age young LMP radiocarbon dates can still be regarded as reliable and, more importantly since only a few LMP sites in the southern part of the Iberian Peninsula are published in detail, with the exception of Gibraltar.

To derive 'realistic' latest-appearance estimates (LAD's) for LMP sites of that region, it is necessary to compare the radiocarbon dates availabe with *non*-radiocarbon age-determinations. But direct data pairs of different dating methods, radiocarbon *versus non*-radiocarbon, are unfortunately rare. Furthermore, it is necessary to acknowledge that the radiocarbon time-scale requires calibration to correct for variations in past atmospheric ^{14}C-levels (Fig. 7) (8) in order to achieve compatability with the results from other *non*-radiocarbon methods of dating. When calibrated, the ^{14}C-time interval covering the MP/UP transition proposed by different authors roughly corresponds to the period 40.6 – 30.2 kyr cal BC (Tab. 3), showing a remarkably clear distinction between LMP *versus* Aurignacian age-distributions on the calendric scale (Fig. 8).

4.1. Earliest Aurignacian evidence...

The oldest Aurignacian sites in SW Europe dated by radiocarbon are situated in the North of the Iberian Peninsula (Fig. 2; Fig. 9). These sites – in sum – form the base of the first line of arguments for the "*Ebro-Frontier*"-model, stating that the Aurignacian starts around 36,500 ^{14}C BP in most of Europe (Zilhão and d'Errico 1999), whereas the Aurignacian in the southwestern part of the Iberian Peninsula does not date before 33,500 ^{14}C BP (Vega Toscano 1990; Zilhão 1993).

(8) We note, however, that all radiocarbon "age"-estimates are measured on the conventional ^{14}C-scale, which is very precisely defined as a dimensionless logarithmic ratio (Mook 1983), so that an independent calibration of all ^{14}C-ages is necessary if we wish to sensibly discuss the chronological implications of the ^{14}C-data. Intensive progress in the construction of the calibration curves required for such age-transfer of (uncalibrated) radiocarbon dates into the calendric dimension has been made during the last few years (eg. Jöris and Weninger 1999a; 1999b; 2000; http://www.calpal.de: CALPAL-2003; cf. van der Plicht 2002), with the period in question being best recorded in the data sets from Suigetsu in Japan (atmospheric; Kitagawa and van der Plicht 2000) and PS2644 in the North Atlantic (marine; Voelker *et al.* 2000). Between 46.0 and 28.0 kyr ^{14}C BP (45.0-30.0 kyr cal BC) the combined 'synthetical' calibration data set (CALPAL-2003) allows for rough calendric estimates of the ^{14}C-time scale (Fig. 7), representing a pattern of highly fluctuating ^{14}C-levels, with periods of extremely high production of radiocarbon (steep parts in the calibration curve), i.e. between 42.0 and 35.0 kyr ^{14}C BP, and others with limited production rates, resulting in long ^{14}C-age-plateaux, i.e. between 39.0 and 35.0 kyr cal BC, normally accompanied with extreme age-distortions (cf. Beck *et al.* 2001). It is this complex 'pattern' of the calibration curve that allows for improvement of dating precison for periods of rising atmospheric radiocarbon contents as well as the age-distortions which make it difficult to interpret radiocarbon dates that fall into the period of extended *plateaux*.

Due to the method of construction of the CALPAL-2003 record, i.e. the transferral of radiocarbon-dates from marine oxygene isotope records into the GISP2 Greenland ice core age model (Jöris and Weninger 1998; 1999a; 1999b; cf. Voelker *et al.* 1998; 2002), ^{14}C-ages are reliably linked with palaeoclimate signatures (Fig. 7). This allows for high-precision age-transferral of ^{14}C-measurements into a calendrical age-model, combined with its positioning within the record of OIS 3 palaeoclimate change that is characterised by extremely rapid oscillations between cold and dry (glacial) and more temperate (interstadial) conditions (for the Iberian Peninsula cf. Carbonell *et al*. 2000; d'Errico and Sánchez Goñi 2003).

Evidence for an Aurignacian presence in SW Europe dating prior to 36,500 ^{14}C BP is sparse, and a single radiocarbon age on bone dated to 40,000 ± 1400 ^{14}C BP (OxA-3727) obtained from the basal layer at Reclau Viver may be due to a reworked sample (Zilhão and d'Errico 1999). The upper part of the same level contains an Aurignacian I with split-based points (Canal i Roquet and Carbonell i Roura 1989). Similar problems seem to account for a radiocarbon measurement (GifA-97185: 37,200 ± 150 ^{14}C BP; bone) from layer G at Caminade-Est, where "*systematic refitting work carried out by J.-G. Bordes (1998) has demonstrated that around 30% of the archaeological material included in this layer comes from the underlying Mousterian deposits, to which the dated sample could conceivably be related*" (Zilhão and d'Errico 1999, 17). The overlying layer F at this site has produced an Aurignacian I with split-based points, and a radiocarbon date of 35,400 ± 1100 ^{14}C BP (GifA-97186) on bone (Rigaud 2001).

Whereas early Aurignacian sites are dispersed in SW France and Northern Spain (Fig. 2), oldest radiocarbon evidence for the Aurignacian (Tab. 1; Fig. 9) is exclusively restricted to the provinces of Cantabria and Catalunya in Northern Spain. Here the sites of Abric Romaní, L'Arbreda and El Castillo are most controversially discussed, due to their history of research, the antiquity of radiometric measurements with radiocarbon dates going back to > 36,500 ^{14}C BP, and typological arguments.

A series of radiocarbon measurements of charcoal samples from the new excavations of V. Cabrera Valdés immediately in front of the cave entrance at El Castillo gave results ranging between 41,100 ± 1700 (OxA-2477) and 37,100 ± 2200 (OxA-2473) ^{14}C BP (Tab. 2) (Cabrera Valdés and Bischoff 1989; Cabrera Valdés *et al.* 1996, 2000; 2001) for a layer inside the cave labeled "*Aurignacian Delta*" by H. Obermaier (Cabrera Valdés 1984; cf. Cabrera Valdés *et al.* 1996). Zilhão and d'Errico (1999) critically request (1) the stratigraphic correlation of the layer outside the cave with the inner deposits, (2) the cultural attribution of the recent finds, and (3) the association of the samples dated with the lithic industry, which they think has more affinities with Mousterian or Châtelperronian than the Aurignacian. According to Zilhão and d'Errico (1999), the Aurignacian of El Castillo is present only inside the cave in the upper portion of Obermaiers "*Aurignacian Delta*", while the lower part of this layer contains more MP types, and likely

AURIGNACIEN > 33.5 kyr 14C BP and/or > 36.5 kyr non-14C BP

LEVEL	CULTURE	WD	MAT.	METH.	LAB-NO.	DATE	STD+	STD-	*t-val.*
14C on CHARCOAL									
Gr. Tournal (Bize, Aude, France)]									
G (sq. P31)	Au.	748	charcoal	14C	Ly-1898	>35800			
F (sq. LM32)	arc. Au.	746	charcoal	14C	Ly-1895	>29000			
C (sq. L31)	arc. Au.	747	charcoal	14C	Ly-1031	>34200			
Esquicho-Grapaou (Sainte-Anastasie, Gard, France)									
SCL1B	Au. 0	372	charcoal	14C	MC-2161	34540	2000	2000	
Isturitz (Saint-Martin-d´Aberoue, Pyrénées Atlantiques, France)									
V1 26	Au.	708	charcoal	14C	GifA-98233	34630	560	560	
U27, 4d	Au.	707	charcoal	14C	GifA-98232	36510	610	610	
	Au.	*707-708*	*charcoal*	*14C*	*weighted mean*	*35490*	*413*		
La Vina (Manzaneda, Asturias, Spain)									
XIII inf.	Au. I	92	charcoal	14C	Ly-6390	36500	750	750	
14C on CHARCOAL vs. 14C on BONE									
L'Arbreda (Serinyà, Girona, Spain)									
CE 103 [Level H]	Au.	151	bone	14C	OxA-3729	37340	1000	1000	
B1 [Level H] sq. E2	arc. Au.	147	charcoal	14C	AA-3779	37700	1000	1000	*0,53*
B1 [Level H] sq. E2	arc. Au.	148	charcoal	14C	AA-3780	37700	1000	1000	*0,53*
B1 [Level H] sq. E2	arc. Au.	150	charcoal	14C	AA-3782	38700	1200	1200	*0,30*
B1 [Level H] sq. E2	arc. Au.	149	charcoal	14C	AA-3781	39900	1300	1300	*1,13*
B1 [Level H] sq. E2	*arc. Au.*	*147-150*	*charcoal*	*14C*	*weighted mean*	*38307*	*552*		
BE 111 [Level H]	arc. Au.	152	bone	14C	OxA-3730	35480	820	820	
14C on CHARCOAL vs. 14C on UNKNOWN MATERIAL									
Beneito (Muro, Alicante, Spain)									
VIII	Au.	160	?	14C	Gif-7650	26040	890	890	
VIII	Au.	159	charcoal	14C	AA-1388	33900	1100	1100	
14C on CHARCOAL vs. U-SERIES									
Romaní (Capellades, Barcelona, Spain)									
above lev. 2		142	charcoal	14C	USGS-2839	36600	1300	1300	
2	arc. Au.	135	charcoal	14C	AA-8037A*	35400	810	810	
2	arc. Au.	136	charcoal	14C	AA-8037B*	37900	1000	1000	
2	arc. Au.	135-136	charcoal	14C	weighted mean*	36390	629		*0,35*
2	arc. Au.	137	charcoal	14C	NZA-2311	36590	640	640	*0,07*
2	arc. Au.	141	charcoal	14C	AA-6608	36740	920	920	*0,10*
2	arc. Au.	140	charcoal	14C	AA-7395	37290	990	990	*0,61*
2	*arc. Au.*	*all level 2*	*charcoal*	*14C*	*weighted mean*	*36644*	*373*		
2	arc. Au.	144	travertine	U-series	?	43000	1000	1000	
below lev. 2		143	charcoal	14C	USGS-2840	35000	500	500	
					** = identical sample*				
14C on BONE									
Flageolet I (Bézenac, Dordogne, France)									
XI	Au. I	321	bone	14C	Ly-2727	>31500			
XI	Au. I	323	bone	14C	GifA-95538	32040	850	850	*0,90*
XI	Au. I	320	bone	14C	OxA-598	33800	1800	1800	*0,42*
XI	Au. I	322	bone	14C	GifA-95559	34300	1100	1100	*1,03*
XI	*Au. I*	*320+322-23*	*bone*	*14C*	*weighted mean*	*32997*	*630*		
Pataud (Les-Eyzies-de-Tayac, Dordogne, France)									
14	Au. 0	258	burnt bone	14C	GrN-4610	33300	760	760	*0,28*
14	Au. 0	259	bone	14C	GrN-4720	33330	410	410	*0,38*
14	Au. 0	257	burnt bone	14C	GrN-4507	34250	675	675	*0,97*
14	*Au. 0*	*257-259*		*14C*	*weighted mean*	*33529*	*318*		

Tab 1.

Mollet (Serinyà, Girona, Spain)									
0.6-0.8m	Au.	158	bone	14C	OxA-3728	33780	730	730	
Combe Sauniere (Sarliac-sur-l'Isle, Dordogne, France)									
VIII	Au.	724	bone	14C	OxA-6507	34000	850	850	
Caminade (La Canéda, Dordogne, France)									
D21	Au. II	450	bone	14C	GifA-97187	34140	990	990	
Roc de Combe (Payrignac, Lot, France)									
7c	Au.I	433	bone	14C	OxA-1263	34800	1200	1200	
Castanet (Sergeac, Dordogne, France)									
inferieur	Au.	712	bone	14C	GifA-97313	35200	1100	1100	
Caminade (La Canéda, Dordogne, France)									
F	Au. I	448	bone	14C	GifA-97186	35400	1100	1100	
Caminade (La Canéda, Dordogne, France)									
G	Au. I?	449	bone	14C	GifA-97185	37200	1500	1500	
Reclau Viver (Serinyà, Girona, Spain)									
T III	arc. Au.?	165	bone	14C	OxA-3727	40000	1400	1400	
14C on BONE vs. 14C on UNKNOWN MATERIAL									
Tuto de Camalhot (Saint-Jean-des-Verges, Ariège, France)									
	Au. I?	156	bone	14C	Gif-2941	24200	600	600	
	Au. I		?	14C	?	34750	570	570	
Ferrassie (Savignac-de-Miremont, Dordogne, France)									
K6	Au. I	344	?	14C	GrN-5751	33220	570	570	
K6	Au. I	343	bones	14C	Gif-4279	>35000			
14C on UNKNOWN MATERIAL									
Arenillas (Cantabria, Spain)									
II	Au.	87	?	14C	GrN-?	33870	1700	1700	*0,20*
II	Au.	88	?	14C	GrN-?	34660	1600	1600	*0,19*
II	*Au.*	*87-88*	*?*	*14C*	*weighted mean*	*34289*	*1165*		
Pataud (Les-Eyzies-de-Tayac, Dordogne, France)									
?	Au. I	265	?	14C	GrN-3230	34760	1000	1000	
TL / OSL									
Gato Preto (Rio Maior, Santarém, Portugal)									
	Au.	1	burnt silex	TL	BM-?	38100	3900	3900	

Tab 1 (Cont.). Radiometric dates for the SW European Aurignacian. WD – No. in William Davies datelist (see annotation 1); MAT. – material dated; METH. – dating method; STD – standard deviation; *t-val*. – t-value. (arc.) Au. – (archaic) Aurignacian.

correlates with layer 18 of V. Cabrera Valdés' excavation. Due to the fact that Obermaier did not observe a sterile horizon between the upper and lower portions of the "*Aurignacian Delta*"-sediment, one may conclude that the Aurignacian immediately followed 38,679 ± 744 ^{14}C BP, which is the weighted mean (WM) of five radiocarbon measurements on charcoal samples from *sub*-unit b of layer 18. The underlying *sub*-unit c has produced five additional radiocarbon dates– again all on charcoal – resulting in a WM of 40,621 ± 750 ^{14}C BP paired with three ESR dates on bone (Rink *et al*. 1996; WM: 38.4 ± 2.6 kyr BP).

However, a consistent group of radiocarbon age-determinations (Tab. 1), significantly older than 36,500 ^{14}C BP, has been produced for the Aurignacian layers of L'Arbreda (Bischoff *et al.* 1989; Canal i Roquet and Carbonell i Roura 1989). Four charcoal samples taken in an artificial 5cm-horizon (5,50-5,55m below surface) in square E2 (BE 111) immediately sheltered by the travertine wall in the lower Aurignacian, have produced a WM of 38,307 ± 552 ^{14}C BP (Bischoff *et al.* 1989). Furthermore a radiocarbon measurement of 35,480 ± 820 ^{14}C BP (OxA-3730) on bone assigned to the same cultural unit is available. A few metres to one side (CE 103) a radiocarbon measurement, again on bone, ages the upper Aurignacian level to 37,340 ± 1000 ^{14}C BP (OxA-3729), whereas one further measurement (Gif-6422) obtained earlier, is considered to be too young. Against the homogeneity of the available data we can hardly follow the vague assumptions of

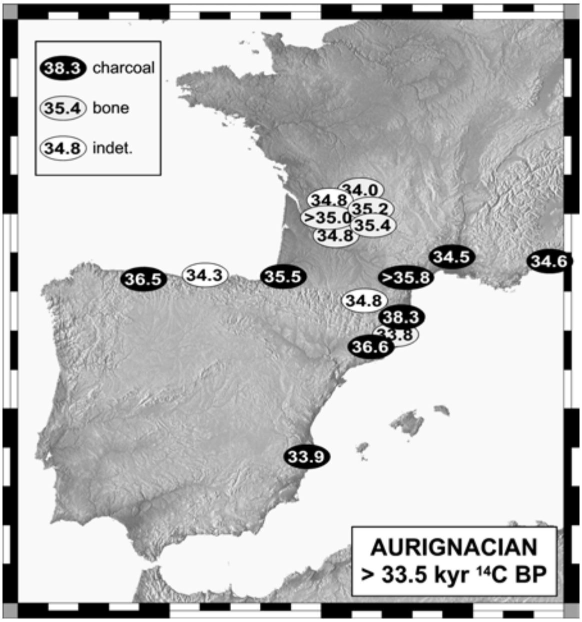

Fig. 9. Radiocarbon dates (first appearance data: FAD's) for the SW European Aurignacian, sorted for material dated and given in kyr ^{14}C BP, when required as weighted means.

Zilhão and d'Errico (1999) who claim possible stratigraphical disturbances in the various parts of the area excavated, and cannot assign the spatial origin of samples to areas that may be stratigraphically problematic. On the contrary:The samples from square E2 come from the very base of the Aurignacian deposits, immediately next to the main profile published by Canal i Roquet and Carbonell i Roura (1989).

Although the Aurignacian of L'Arbreda displays some similarities with that of "*layer 2*" at Abric Romaní (e.g. in terms of the presence of Dufour bladelets; Carbonell *et al.* 2000, 18), G. Laplace and N. Soler have emphasized the likelihood that the small assemblage from this layer may have resulted out of palimpsests of different occupations, one during the late Gravettian, another during the Aurignacian, based on the similarities of some (6) backed tools with Gravettian points (Canal i Roquet and Carbonell i Roura 1989; Carbonell *et al.* 1994). This 'Aurignacian' layer from the initial excavations conducted by A. Romaní between 1909 and 1929 ("*layer 2*") is preserved in remnant deposits – labeled "*level A*" – along the back wall of the central part of the rock-shelter as well as in the Coveta Nord, where it is stratified between two travertine horizons (Bischoff *et al.* 1994). "*Level A*" – although only 2cm in thickness – produced "*abundant faunal remains, dispersed charcoal and artifacts*" (Bischoff *et al.* 1994: 544) and most likely represents a living floor sealed by the overlying travertine. Seven radiocarbon measurements on charcoals were obtained from the remnant "*level A*" deposits at three different places of the site all together. Five of these form a WM of 36,644 ± 373 ^{14}C BP, with individual dates ranging from 37,290 ± 990 (AA-7395) to 36,390 ± 629 (WM of AA-8037A and AA-8037B) ^{14}C BP. These dates are in strong contrast to two measurements from the radiocarbon laboratory in Waikato, New Zealand, which – due to possible contamination with younger carbon – are significantly younger (NZA-1817; NZA-1818). The same laboratory has also produced a date of 36,590 ± 640 ^{14}C BP (NZA-2311, contained in the WM given above). All these dates are stratigraphically consistent with a further radiocarbon measurement of a charcoal sample that was embedded in the travertine (USGS-2839: 36,600 ± 1300 ^{14}C BP; Bischoff *et al.* 1994). Furthermore, the great antiquity of these deposits is confirmed by U-series dating of this travertine (Bischoff *et al.* 1994; with corrected U/Th-ages of between 39.1 and 42.9 kyr BP given in Carbonell *et al.* 1994) (9). Concerning the difficulties with the archaeological assignment of "*layer 2*" Zilhão and d'Errico (1999), plead for the stratigraphical reliability of this sequence. Whereas it is highly likely that the radiocarbon measurements from "*level A*" material do indeed date the Aurignacian, stratigraphical mixing on top of the Aurignacian layer may also have played a role, close to the wall of the rock-shelter, and only a few metres away from the sampled area (as observed by A. Romaní).

Contra the interpretation of Zilhão and d'Errico (1999) the evidence from Castillo, L'Arbreda, and Romaní strongly indicates earliest Aurignacian presence in the North of the Iberian Peninsula before 36,500 ^{14}C BP (Fig. 10), confirmed by the constistency of both radiometric dating and stratigraphy. Insignificantly younger radiocarbon measurements – all on charcoal – derive from the lower part of layer XIII at La Viña (Ly-6390: 36,500 ± 750 ^{14}C BP), from Isturitz (WM of two dates: 35,490 ± 413 ^{14}C BP), and possibly at Tournal G (oldest date: Ly-1898: >35,800 ^{14}C BP).

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(9) Although less precise than radiocarbon dates, due to the high standard deviations, the results from U-series dating at Romaní approximately fit the ranges of the calibrated radiocarbon measurements (cf. CALPAL-2003: http://www.calpal.de).

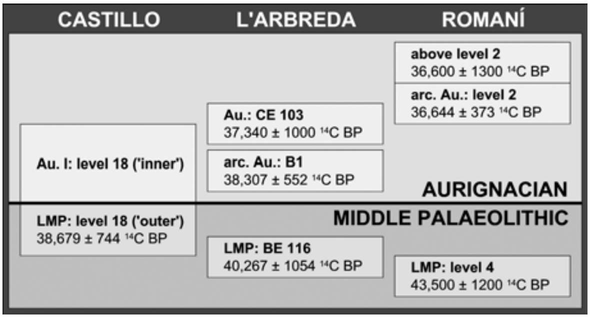

Fig. 10. Aurignacian (Au.) and archaic Aurignacian (arc. Au.) >36,500 ^{14}C BP in the northern part of the Iberian Peninsula and its relation to Latest Middle Palaeolithic (LMP) industries.

Towards the North (north of 44.0° N; Fig. 9) radiocarbon FAD's of the oldest regional Aurignacian turn out slightly younger (starting with 35,400 ± 1100 ^{14}C BP [GifA-97186] in layer F of Caminade-Est; Tab. 1), and in the south of the Iberian Peninsula, the oldest Aurignacian is present in Beneito VIII (AA-1388: 33,900 ± 1100 ^{14}C BP on charcoal). Further to the South and to the West radiocarbon dates for the Aurignacian are even younger than 33,500 ^{14}C BP (Vega Toscano 1990; Zilhão 1993), with the Portugese site of Gato Preto, dated by TL to 38.1 ± 3.9 kyr BP, representing the oldest Aurignacian in the SW of the Iberian Peninsula.

4.2. ... and evidence for the latest Middle Palaeolithic

For SW Europe the "*Ebro-Frontier*"-model assumes LMP industries at times when Aurignacian people had already populated the North and Northeast of the Iberian Peninsula (Zilhão 1993; cf. Fig. 2). For the second line of arguments underlying the "*Ebro-Frontier*"-model it is thus important to verify the contemporaneity of LMP industries in the SW of the Iberian Peninsula with the earliest Aurignacian in the North and Northeast, i.e. evidence persisting significantly later than 38,300 ^{14}C BP. This is all the more difficult since Aurignacian layers in general overlay LMP ones and are subject to some reworking of deposits. Relying more on ^{14}C-bone data for the MP/UP transition, Zilhão and d'Errico (1999: 10) note the "*apparent contradiction between stratigraphy and dating*" because the radiometric dates do imply a significant chronological overlap. They try to explain this contradiction as "*simply an artifact of serious errors of method and interpretation in the use of radiometric results*".

Due to the problems of possible sample contamination and the fact that – as a trend – radiocarbon charcoal data are shown to be more reliable than bone data, we will base our study solely on radiocarbon dates on charcoal as well as on the chronometric data available from the different *non*-radiocarbon methods of dating (e.g. TL/OSL, U-series; ESR, Tab. 2; Fig. 11), in order to trace reliable LMP LAD's in SW Europe

Regarding the charcoal-dated LMP (incl. Châtelperronian) of SW Europe only two sites – Fuentes de San Cristobal (Mousterian) and Morín (layer 10: Châtelperronian) – have produced finite radiocarbon age-determinations younger than 38,300 ^{14}C BP. At Morín the same sample (SI-951) has produced two contradictory radiocarbon measurements, one with an extremely high standard deviation of several thousand BP. These measurements along with a single sample (OxA-8591) for the LMP at Fuentes de San Cristobal with a high standard deviation (± 1900), cannot be interpreted as reliable proof for a long persistence of the LMP in SW-Europe.

One sample from the basal LMP layer X at Beneito in the SE of the Iberian Peninsula has been dated to 30,160 ± 680 ^{14}C BP (unknown lab.-no.), whereas a second sample (AA-1387) on charcoal, obtained from the same layer, dates to 38,800 ± 1900 ^{14}C BP and is thus similar in age to the WM of the radiocarbon measurements available for the LMP layer 18b of El Castillo (38,679 ± 744). Sample AA-1388 from the overlaying Aurignacian level VIII at Beneito confirms the antiquity of the AA-1387 sample.

Other sites that have produced radiocarbon age-determinations younger than 38,300 ^{14}C BP have either been dated several decades ago (e.g. Ermitons, Quinçay, Tournal, Brugas) or the dates have been obtained from "*inadequate dating material*" (Zilhão 2000a: e.g. Columbeira) that is likely to be contamined with modern carbon (Zilhão 1997: 35). Possible contamination is furthermore likely for some radiocarbon measurements from LMP layers that have been independently dated by *non*-radiocarbon methods. At Zafarraya (Hublin *et al.* 1995), for example, teeth of *Capra ibex* were dated by radiocarbon as well as by U-series methods, but due to a variety of reasons mostly related to the stratigraphical properties of this site, these samples are

MIDDLE PALAEOLITHIC < 40.0 kyr 14C BP and/or < 43.5 kyr non-14C BP

LEVEL	CULTURE	WD	MAT.	METH.	LAB-NO.	DATE	STD+	STD-	*t-val.*
14C on CHARCOAL									
St-Marcel (Bidon, Ardèche, France)									
G2	MP	761	charcoal	14C	Ly-2901	>25000			
Devil's Tower (Gibraltar)									
3	MP	256	charcoal	14C	GrN-2488	>30000			
Trozoul (Trébeurden, Bretagne, France)									
hearth	MP?	505	charcoal	14C	Gif-1312	>35000			
Los Moros I (Gabasa, Huesca, Spain)									
a	MP	*	charcoal	14C	OxA-5671	>39000			
a+c	MP	*	charcoal	14C	OxA-5672	>45000			
** = Blasco Sánchez and Montes Ramírez 1997*									
Cueva Morin (Villanueva, Villaescusa, Cantabria, Spain)									
10	Chat.	100	charcoal	14C	SI-951*	27777	577	577	
10	Chat.	99	charcoal	14C	SI-951-A*	35874	6777	6777	
					** = identical sample*				
Fuentes de San Cristobal (Veracruz, Huesca, Spain)									
	MP	*	charcoal	14C	OxA-8591	36000	1900	1900	
** = Rosell Ardèvol et al. 2000*									
Barbas III (Creysse, Dordogne, France)									
4	MP	731	charcoal	14C	?	38300	500	500	*0,37*
4	MP	732	charcoal	14C	GifA-93050	43500	2200	2200	*2,19*
4	*MP*	*731-732*	*charcoal*	*14C*	*weighted mean*	*38555*	*488*		
Castillo (Puente Viesgo, Cantabria, Spain)									
18b-upper	MP	124	charcoal	14C	AA-2407	37700	1800	1800	*0,50*
18b-upper	MP	123	charcoal	14C	AA-2406	38500	1800	1800	*0,09*
18b	MP	127	charcoal	14C	OxA-2473	37100	2200	2200	*0,68*
18b	MP	126	charcoal	14C	OxA-2474	38500	1300	1300	*0,12*
18b-lower	MP	125	charcoal	14C	OxA-2475	40700	1600	1600	*1,15*
18b	*MP*	*123-127*	*charcoal*	*14C*	*weighted mean*	*38679*	*744*		
20b2	MP	128	charcoal	14C	GifA-89144	39300	1900	1900	*0,48*
20b2	MP	129	charcoal	14C	GifA-92506	43300	2900	2900	*0,85*
20b2	*MP*	*128-129*	*charcoal*	*14C*	*weighted mean*	*40501*	*1589*		
L'Arbreda (Serinyà, Girona, Spain)									
BE 116 (level I) sq. E2	MP	154	charcoal	14C	AA-3777	34100	750	750	
BE 116 (level I) sq. E2	MP	155	charcoal	14C	AA-3776	39400	1400	1400	*0,92*
BE 116 (level I) sq. E2	MP	156	charcoal	14C	AA-3778	41400	1600	1600	*0,24*
BE 116 (level I) sq. E2	MP	153	charcoal	14C	OxA-3731	44560	2400	2400	*1,39*
BE 116 (level I) sq. E2	*MP*	*153+155-56*	*charcoal*	*14C*	*weighted mean*	*40961*	*965*		
Gorham's Cave (Gibraltar)									
context 24*	transitional	239	charcoal	14C	OxA-7857	32280	420	420	
context 18**	transitional	240	charcoal	14C	OxA-7791	42200	1100	1100	
** = remnant combustion zone*									
*** = combustion zone*									
14C on CHARCOAL vs. 14C on BONE									
Ermitons (Sales de Llierca, Girona, Spain)									
IV	MP	163	bone	14C	OxA-3725	33190	660	660	
IV	MP	164	charcoal	14C	CSIC-197/IAB-3	36430	1800	1800	
L'Arbreda (Serinyà, Girona, Spain)									
BE 116	MP	153	bone	14C	OxA-3731	44560	2400	2400	
BE 116	MP	154	charcoal	14C	AA-3777	34100	750	750	
BE 116	MP	155	charcoal	14C	AA-3776	39400	1400	1400	*0,49*
BE 116	MP	156	charcoal	14C	AA-3778	41400	1600	1600	*0,59*
BE 116	*MP*	*155-156*	*charcoal*	*14C*	*weighted mean*	*40267*	*1054*		
14C on CHARCOAL vs. 14C on HUMUS									
Quincay (Quincay, Vienne, France)									
black unit	Chat.	577	charcoal	14C	Ly-790	11910	200	200	
black unit	Chat.	578	humus	14C	Ly-791	20300	500	500	

Tab 2.

14C on CHARCOAL vs. 14C on UNKNOWN MATERIAL

Beneito (Muro, Alicante, Spain)									
basal; X (D1)	MP	162	?	14C	?	30160	680	680	
basal; X (D1)	MP	161	charcoal	14C	AA-1387	38800	1900	1900	

14C on CHARCOAL vs. TL / OSL on SEDIMENT / BURNT SILEX

Tournal (Bize, Aude, France)									
C (Sq. K29)	MP	749	charcoal	14C	Ly-1676	33600	1300	1300	
	MP	744	burnt silex?	TL?	Gif-?	33000	4000	4000	*0,00*
	MP	745	burnt silex?	TL?	Gif-?	33000	8000	8000	*0,00*
	MP	*744-745*	*burnt silex?*	*TL?*	*weighted mean*	*33000*	*3578*		
Gorham's Cave (Gibraltar)									
context 22/22D*	MP	245	sediment	OSL	MacGor-3	35000	7000	7000	
context 22/22D*	MP	244	charcoal	14C	OxA-6075	45300	1700	1700	*0,59*
context 22/22D*	MP	246	charcoal	14C	OxA-7790	51700	3300	3300	*1,39*
*context 22/22D**	*MP*	*244+246*	*charcoal*	*14C*	*weighted mean*	*46642*	*1511*		
** = combustion zone (=G?)*									
Brugas (Vallabrix, Gard, France)									
4	MP	679	charcoal	14C	Ly-2351	29000	860	860	
4	MP	678	charcoal	14C	Ly-2038	>32000			
4	MP	676	burnt silex	TL	Gif-?	58200	7500	7500	*0,58*
4	MP	677	burnt silex	TL	Gif-?	65900	9900	9900	*0,27*
4	MP	674	burnt silex	TL	?	63000	5800	5800	*0,01*
4	MP	675	burnt silex	TL	Gif-?	69000	10800	10800	*0,55*
4	*MP*	*674-677*	*burnt silex*	*TL*	*weighted mean*	*63063*	*3843*		

14C on CHARCOAL vs. ESR

Castillo (Puente Viesgo, Cantabria, Spain)									
18c	MP	121	bone	ESR	?	36200	4100	4100	*0,46*
18c	MP	122	bone	ESR	?	39900	4600	4600	*0,28*
18c	MP	*	bone	ESR	?	40000	5000	5000	*0,28*
18c	*MP*	*121-122+*	*bone*	*ESR*	*weighted mean*	*38427*	*2610*		
18c	MP	120	charcoal	14C	GifA-89147	39500	2000	2000	*0,36*
18c	MP	119	charcoal	14C	OxA-2478	39800	1400	1400	*0,29*
18c	MP	116	charcoal	14C	AA-2405	40000	2100	2100	*0,12*
18c	MP	117	charcoal	14C	OxA-2476	40700	1500	1500	*0,26*
18c	MP	118	charcoal	14C	OxA-2477	41100	1700	1700	*0,45*
18c	*MP*	*116-120*	*charcoal*	*14C*	*weighted mean*	*40621*	*750*		
** = Cabrera Valdés et al. 2001*									

14C on CHARCOAL / CARBONACEOUS EARTH vs. U-SERIES

Columbeira (Bombarral, Portugal)									
16=7	MP	57	cc/ce*	14C	Gif-2703**	26400	750	750	
16=7	MP	58	tooth	U-series	SMU-235E1	35876	27299	35583	*0,34*
16=7	MP	59	tooth	U-series	SMU-238E1	54365	22240	27525	*0,26*
16=7	*MP*	*58-59*	*tooth*	*U-series*	*weighted mean*	*46990*	*17240*		
20=8	MP	54	cc/ce*	14C	Gif-2704**	28900	950	950	
20=8	MP	55	tooth	U-series	SMU-236E1***	60927	27405	35522	*0,39*
20=8	MP	56	tooth	U-series	SMU-236E1***	101487	38406	55919	*0,61*
20=8	*MP*	*55-56*	*tooth*	*U-series*	*weighted mean*	*74620*	*22310*		
** = charcoal/carbonaceous earth*					*** = inadequate dating material (Zilhao 2000)*				
					**** = identical sample*				

14C on BONE / TEETH vs. U-SERIES

Zafarraya (Alcaucín, Málaga, Spain)									
I (3-7)	MP	167	tooth	14C	Gif-9140-II*	29800	600	600	
I (3-7)	MP	168	tooth	U-series	Gif-9140-II*	25100	1300	1300	*0,55*
I (3-7)	MP	169	tooth	U-series	Gif-9140-II*	26900	2700	2700	*0,30*
I (3-7)	MP	170	tooth	U-series	Gif-9140-II*	31700	3600	3600	*1,50*
I (3-7)	*MP*	*168-170*	*tooth*	*U-series*	*weighted mean*	*26038*	*1114*		
I (8)	MP	172	tooth	U-series	Gif/LSM-9140-I*	31700	3600	3600	
I (8)	MP	171	tooth	14C	Gif/LSM-9140-I*	31800	550	550	
D	MP	173	tooth	U-series		33400	2000	2000	
					** = identical samples, respectively*				

Tab. 2 (Cont.).

14C on BONE vs. ESR									
Combe Sauniere (Sarliac-sur-l'Isle, Dordogne, France)									
X	Chat.	723	tooth	ESR	?	36400	2500	2500	
X	Chat.	722	bone	14C	OxA-6504	33000	900	900	2,30
X	Chat.	720	bone	14C	OxA-6503	35900	1100	1100	0,36
X	Chat.	721	bone	14C	OxA-6503*	38100	1000	1000	2,30
X	*Chat.*	*720-722*	*bone*	*14C*	*weighted mean*	*35449*	*572*		
					* = tripeptide				
14C on SHELL vs. U-series									
Figueira Brava (Sesimbra, Portugal)									
2?	MP?	9	shell	14C	ICEN-387	30930	700	700	
2	MP	11	tooth	U-series	SMU-232E1*	30561	11759	10725	0,33
2	MP	12	tooth	U-series	SMU-232E2*	44806	15889	13959	0,50
2	*MP*	*11-12*	*tooth*	*U-series*	*weighted mean*	*35600*	*9450*		
					** = identical sample*				
TL / OSL									
Conceicao (Alcochete, Portugal)									
C-topo	MP*	70	sediment	TL/OSL	QTSL-CNC-11	27200	2500	2500	
	** = MP lies in layer D below C*								
Roche a Pierrot (Saint-Cesaire, Charente-Maritime, France)									
10	MP	390	?	TL	?	40900	2500	2500	0,20
11	MP	391	?	TL	?	38200	3300	3300	0,55
12	*MP*	*392*	*?*	*TL*	*?*	*42400*	*4800*	4800	0,41
	MP	*390-392*	*?*	*TL*	*weighted mean*	*40281*	*1840*		
Carigüela (Pinar, Granada, Spain)									
	MP	189	silex	TL	TB-2	28000			
	MP	187	silex	TL	TB-5	31000-35000			
	MP	188	silex	TL	TB-1	32000			
	MP	186	silex	TL	TB-12	39000			
	MP	185	silex	TL	TB-3	46000			
	MP	184	silex	TL	TB-9a	48000			
TL vs. ESR									
Le Moustier (Le Moustier, Dordogne, France)									
K	MP/Chat.?	801	burnt silex	TL	Gif-?	42600	3700	3700	0,37
J	MP	800	burnt silex	TL	Gif-?	40300	2600	2600	0,23
I	MP	799	burnt silex	TL	Gif-?	40900	5000	5000	0,03
K-I	*MP*	*799-801*	*burnt silex*	*ESR*	*weighted mean*	*41036*	*1957*		
H[2a-7c]	MP	798	tooth	ESR: LU	?	41000	2600	2600	0,22
H[2a-7c]	MP	797	tooth	ESR: EU	?	39700	2400	2400	0,20
H[2a-7c]	*MP*	*797-798*	*tooth*	*ESR*	*weighted mean*	*40298*	*1764*		
H2-H9	MP	796	burnt silex	TL	Gif-?	42500	2000	2000	
El Pendo (Escobedo de Camargo, Cantabria, Spain)									
26	MP	*		ESR	?	33700	1300	1300	
28	MP	*		ESR	?	14300	300	300	
32 (H)	MP	*		ESR	?	30500	300	300	
B	MP	**		ESR	?	<40000			
D	MP	**	burnt silex?	TL	?	83790	8291	8291	
F	MP	**	burnt silex?	TL	?	39626	3864	3864	
** = Montes Barquín and Sanguino González 2001; ** = Montes Barquín 2000*									
U-SERIES									
Gruta do Escoural (Évora, Montemor-o-Novo, Portugal)									
test 3a (90-100)	MP	33	tooth	U-series	SMU-248*	26400	5800	5500	1,33
test 3a (80-90)	MP	34	tooth	U-series	SMU-249*	39800	10000	9000	0,61
test 3a (60-70)	MP	35	tooth	U-series	SMU-250	48900	11000	10000	0,98
test 3a	*MP*	*33-35*	*tooth*	*U-series*	*weighted mean*	*33070*	*4560*		
					** = low U content (Zilhao 2000)*				
Foz do Enxarrique (Ródao, Portugal)									
C	MP	6	tooth	U-series	SMU-225	32938	1055	1055	0,74
C	MP	7	tooth	U-series	SMU-226	34088	800	800	0,29
C	MP	8	tooth	U-series	SMU-224	34093	920	920	0,27
C	*MP*	*6-8*	*tooth*	*U-series*	*weighted mean*	*33806*	*524*		

Tab. 2 (Cont.).

Almonda (Casais Martanes, Santarém, Portugal)									
EVS cone	MP	26	tooth	U-series	SMU-231E1*	35000	2000	2000	
					** = low 230Th/232Th ratio (Zilhao 2000)*				
Almonda (Casais Martanes, Santarém, Portugal)									
EVS cone	MP	26	tooth	U-series	SMU-231E1*	35000	2000	2000	
					** = low 230Th/232Th ratio (Zilhao 2000)*				
U-SERIES vs. ESR									
Bajondillo (Torremolinos, Málaga, Spain)									
basal level	MP	226	travertine	ESR: EU		25300	2530	2530	*0,48*
basal level	MP	227	travertine	ESR: LU		26500	3975	3975	*0,04*
basal level	MP	228	travertine	U-series		27300	1700	1700	*0,30*
basal level	*MP*	*226-228*		*all*	*weighted mean*	*26658*	*1330*		

Tab. 2 (Cont.). Radiometric dates for the SW European Middle Palaeolithic excluding radicarbon measurements on bone samples. WD – No. in William Davies datelist (see annotation 1); MAT. – material dated; METH. – dating method; STD – standard deviation; *t-val*. – t-value. MP – Middle Palaeolithic; Chat. – Châtelperronian.

to be regarded "*highly questionable and/or irrelevant*" in contribution to the issue discussed (Pettitt and Pike 2001: 416). A 'transitional industry' from Gorham's Cave may be due to stratigraphic palimpsests, since both radiocarbon measurements obtained on charcoal diverge by some 10,000 ^{14}C BP (OxA-7857 for context 24: 32,280 ± 420 ^{14}C BP *vs*. OxA-7791 for context 18: 42,000 ± 1100 ^{14}C BP). Stratigraphical inversion of layers most plausibly account for the El Pendo series (Montes Barquín 2000; Montes Barquín and Sanguino González 2001).

At Brugas and Columbeira *non*-radiocarbon age-determinations all dating older than 45.0 kyr ago have produced results significantly older than radiocarbon measurements. In contrast, two radiocarbon measurements on charcoal at Gorham's Cave (context 22/22D) are much older than the OSL-dated sediment. At Figueira Brava a radiocarbon measurement on a *Patella* sp. shell has been dated to 30,930 ± 700 ^{14}C BP (ICEN-387). Although Zilhão (2000) attributes the date to the LMP level 2, its precise stratigraphic proveniance remains unclear. Two U-series measurements of the

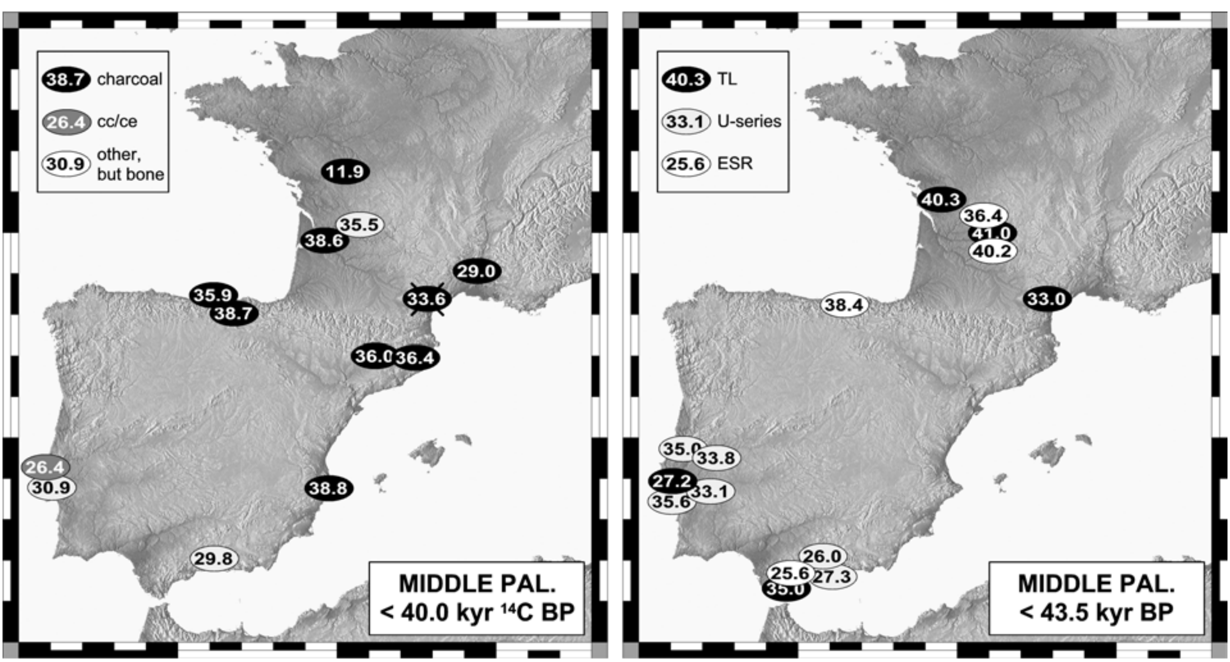

Fig. 11. Radiometric dates ('last appearance data': LAD's) for the SW European Middle Palaeolithic, with radiocarbon measurements (left) sorted for material dated and given in kyr ^{14}C BP, when required as weighted means, and *non*-radiometric measurements (right) sorted for method of dating and given in kyr BP, when required as weighted means.

same sample gave strongly divergent results with extremely high standard deviations. Whereas the younger date was given as 30.6 ± 11.8 kyr BP (SMU-232E1), the older one resulted in 44.8 ± 15.9 kyr BP (SMU-232E2).

For the period under discussion in general, *non*-radiocarbon methods of dating have to be regarded as less reliable due to the often extremely high standard deviations, when compared with ^{14}C (e.g. Schwarcz 2001). Even in cases where radiocarbon measurements appear in agreement with results obtained from the various *non*-radiocarbon dating techniques, this may be simply coincidental (10).

The LMP from Tournal C is dated to 33,600 ± 1300 ^{14}C BP (Ly-1667) by radiocarbon and to 33.0 ± 3.6 kyr BP by TL on burnt silex (WM of two dates), whereas a sample from the overlaying Aurignacian of level G is older than 35,800 ^{14}C BP (Ly-1898; Tavoso 1976; cf. Tab. 1). The Châtelperronian of Combe Sauniere has been dated by ESR (36.4 ± 2.5 kyr BP; Tab. 2) as well as by radiocarbon on two bone samples. Although the WM of the radiocarbon measurements (35,449 ± 572 ^{14}C BP) is largely in agreement with the date produced by ESR, the individual measurements are strongly divergent. Moreover, OxA-6503 gave a date of 35,900 ± 1100 ^{14}C BP, whereas a tripeptide-measurement of the same sample resulted in 38,100 ± 1000 ^{14}C BP, close to the date that we propose for the earliest Aurignacian in the North of the Iberian Peninsula (L'Arbreda; cf. Fig. 10).

Non-radiocarbon dates younger than 30.0 kyr BP have been obtained from Bajondillo (ESR and U-series) with a WM of 26.7 ± 1.3 kyr BP and from Conceicão (TL), for a level overlaying the LMP (QTSL-CNC-11: 27.2 ± 2.5 kyr BP). TL-dates from Roche à Pierrot (St. Césaire) and Carigüela – although rather heterogeneous – indicate that LMP layers are older than 40.0 kyr BP. The same accounts for the TL and ESR-measurements obtained from the Le Moustier sequence.

A low ^{230}Th/^{232}Th-ratio explains the relatively young age for the MP finds from the EVS-cone at Almonda (Zilhão 2000b), and low U-contents for the samples SMU-248 and SMU-249 at Gruta do Escoural (Zilhão 2000b) point to the higher reliability of the SMU-250-sample, giving an age of 48.9 ± 11.0 kyr BP.

The only consistent series of U/Th-measurements comes from Foz do Enxarrique C with an WM of 33.8 ± 0.5 kyr BP. Unfortunately the relation between LMP lithic artefacts and the faunal material dated at this site remains unclear (cf. Zilhão 1997).

5. CONCLUSIONS AND DISCUSSION

Our analyses of the radiometric evidence for the MP/UP transition in SW Europe has augmented a range of criteria for quality control in data mining as well as in terms of advanced numeric data processing. The results emphasize sample material, problems of possible adhering contamination, and on measuring precision. Comparisions of bone and charcoal radiocarbon dates points to extreme discrepancies between these sample categories, with bone dates being systematically too young (Jöris *et al.* 2001; cf. Fig. 4-5). These findings do not refute the reliability of radiocarbon measurements of bone in general, but call for circumspection in evaluation of quality and reliability of such dates. Against this background, bone dates may contribute less than initially hoped to the understanding of the chronological issues surrounding the transition from the LMP to the EUP in Europe, and in particular we must remain cautious when interpreting ^{14}C-bone data close to the detection limits of the radiocarbon method (Fig. 3).

5.1. On the age of the MP/UP transition in SW Europe

Evaluation of LMP radiometric dates from SW Europe <40,000 ^{14}C BP and <43.5 kyr *non*-^{14}C BP (Tab. 2; Fig. 11) has shown that minimal reliability – if any – is given for dates younger than 38,300 ^{14}C BP. Based on radiocarbon dates obtained on charcoal, SW European LMP LAD's range between 35,900 ^{14}C BP (Morín, level 10: SI-951-A) and 38,800 ^{14}C BP (Beneito: AA-1387), with a WM of Beneito-, Castillo- (level 18b), Barbas-, Ermitons-, Fuentes de San Cristobal- and Morín-LAD's of 38,391 ± 381 ^{14}C BP (Fig. 11, left). This SW European LMP LAD is statistically identical with the FAD of the archaic Aurignacian at L'Arbreda (WM: 38,307 ± 552 ^{14}C BP) and is in overall agree-

(10) Strikingly, at some sites radiocarbon measurements and *non*-radiocarbon methods have produced identical ages – at least within the errors contained in the standard deviations (e.g. Combe Sauniere, Zafarraya). This is the more surprising, since the calibration records that are available today, imply that radiocarbon age-determinations underestimate the calendric scale for several thousand BP within the time-period under discussion.

14C-Age [BP]	Cal Age [cal BC] 68% (95%)	Cal Age [cal BP] 68% (95%)	Notes
40000 ± 800	40550 ± 430 (41410-39690)	42500 ± 430 (43360-41640)	(1)
38300 ± 766	39890 ± 290 (40470-39310)	41840 ± 290 (42420-41260)	(2)
36500 ± 730	38610 ± 940 (40490-36730)	40560 ± 940 (42440-38680)	(3)
35400 ± 708	37950 ±1080 (40110-35790)	39900 ±1080 (42060-37740)	(4)
33500 ± 670	36360 ±1710 (39780-32940)	38310 ±1710 (41730-34890)	(5)
30000 ± 600	31900 ± 700 (33300-30500)	33850 ± 700 (35250-32450)	(1)
28000 ± 560	30190 ± 690 (31570-28810)	32140 ± 690 (33520-30760)	(6)

(1) commonly accepted limits of the MP/UP transition
(2) FAD for the Aurignacian in SW Europe, this work
(3) FAD for the Aurignacian in SW Europe after Zilhão and d'Errico (1999)
(4) FAD for the Aurignacian in France, this work
(5) FAD for the Aurignacian in the SW of the Iberian Peninsula after Vega Toscano (1990) and Zilhão (1993)
(6) average of youngest dates for the European MP after various authors
(e.g.: Bocquet-Appel and Demars 2000; Zilhão 1993; cf. Hublin et al. 1995)

Tab 3. Calibration of seven fictive radiocarbon measurements [BP] spanning around the Middle to Upper Palaeolithic (MP/UP) transition with typical errors in the range of 2% of total radiocarbon BP. Calibration was established using the CAL-PAL-2003 data set (see annotation 8). FAD – First appearance data.

ment with LMP LAD's available for other parts of Europe (Fig. 6), implying a sudden and simultaneous ending of the MP all over Europe.

To summarize, we note

- that the LMP discontinues over the whole of SW Europe at ca. 38,300 ^{14}C BP,
- at a time for which similar LMP LAD's and Aurignacian FAD's can be fixed in various parts of Europe (Fig. 6).

In terms of calibrated radiocarbon-'years' this transition falls into the shift from the interstadial conditions of GI 11 (GI = *Greenland interstadial*) to the stadial ones of GS 11 (GS = *Greenland stadial*) at around 39.9 kyr cal BC (Fig. 8; cf. Tab. 3) (11).

We can therefore confirm the high antiquity of the oldest Aurignacian in the North of the Iberian Pensinsula, i.e. Cantabria and Catalunya, but - in contrast to the radiocarbon record – evidence from the *non*-radiocarbon methods of dating for the LMP (Tab. 2; Fig. 11, bottom) does not withstand criticism and the data available are too weak to prove LMP persistence in the southern half of the Iberian Peninsula until 33,500 ^{14}C BP or later, at least not until the Aurignacian of Gato Preto.

(11) Whereas our FAD's for the Aurignacian of SW Europe preceded those proposed by Zilhão and d'Errico (1999) by some 1800 ^{14}C BP, in calibrated terms FAD-differences would be in the range of only 1.3 kyr cal, still placing the transition into GS 11.

Although the available radiometric dates represent regionally different patterns of hominid presence, we cannot confirm the existance of an "*Ebro Frontier*", that geographically distinguishes between Aurignacian industries to the NE and LMP ones in the SW against the background of these data. Rather our data implies that the southern part of the Iberian Peninsula was already void of MP hominids long before the appearance of the first Aurignacians.

5.2. Climate controlled population dynamics?

Based on radiocarbon evidence, the oldest Aurignacian sites of SW Europe cluster in the North of the Iberian Peninsula (Fig. 12: A; cf. Fig. 9), while the southern French Aurignacian does not date to before 35,400 ^{14}C BP and Aurignacian sites from the southern part of the Iberian Peninsular do not pre-date 33,500 ^{14}C BP (Vega Toscano 1990; Zilhão 1993). This pattern may best be explained by a northward spread (Fig. 12: B) of Aurignacian populations in a severe cold phase (GS 9 = Heinrich-event 4: H4; Fig. 8) shortly after GS 11. In a recent study F. d'Errico and M. F. Sánchez Goñi (2003) have characterized the highly arid desert-steppe-like H4-environments found over large areas of the Iberian Peninsula as inhospitable: conditions that

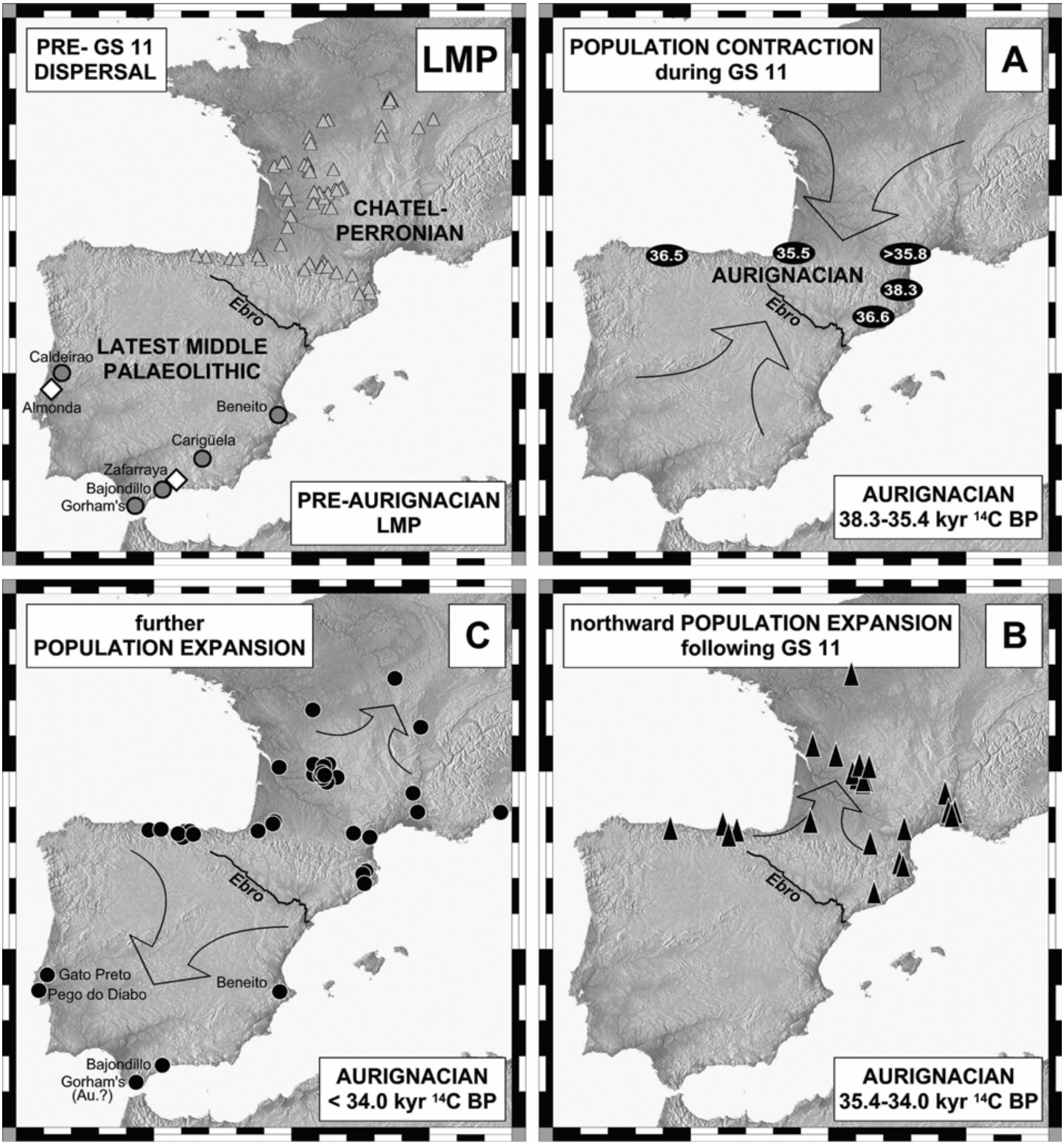

Fig. 12. Model of regional population shifts (arrows) around the transition from the Latest Middle Palaeolithic (LMP) to the Aurignacian in SW Europe (clockwise: LMP-A-B-C; cf. Fig. 8), covering the time span of *ca*. 42,000 – 28,000 ^{14}C BP over a period of strong climatic fluctuations during the last interpleniglacial (OIS 3; cf. Fig. 2, 7-8).
GS – Greenland stadial.

may have triggered a northward shift of populations (Fig. 8, 12: B), followed by a further expansion into the NE as well as into the SW at the onset of GI 8 (Fig. 12: C).

5.3. Makers of the Aurignacian

Based on the chronometric dates that cover the European MP/UP transition there is neither radiometric nor stratigraphic indication for incoming populations that may have colonized Europe from East to West (12), nor is there reliable proof for a late persistence of LMP younger than 38,300 ^{14}C BP. Against these data, the geographical pattern of both LMP LAD's and Aurignacian FAD's (i.e. the MP/UP transition) can be best explained by a contraction of regional population dispersal into glacial refugia during GS 11. Such an interpretation would imply local *in situ* developments (13) of Aurignacian industries simultaneously in two different areas of Europe, separating the SW European Aurignacian without leaf-points from that of south-central and southeastern European sites which are characterized by the addition of a few of these artefact types. Consequently, this would imply that Neanderthals did indeed produce at least the earliest Aurignacian industries (cf. Churchill and Smith 2000).

Since the hominid fossil evidence is sparse and not entirely unambiguous during the Aurignacian, it would appear that unambiguous evidence of anatomically modern humans is not known prior to the European Middle UP.

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