Abstract

In Portugal, the Aurignacian is represented at open air sites by lithic assemblages that comfortably fit the definition of the Aurignacian II (in the case of Gato Preto) or III/IV (in the case of Vale de Porcos) of the classical region of southwestern France. Three small cave sites (Pego do Diabo, Salemas and Escoural) yielded inventories of Dufour bladelets of the Dufour subtype which (a) are identical to those recovered in uppermost level 6 of the major Aurignacian sequence of the Abri Pataud and (b) correspond to a functional pose of the assemblage-type represented at Vale de Porcos. The stratigraphic and chronometric dating evidence (TL and radiocarbon) is fully consistent with the technological and typological features of these lithic assemblages. The emergence of the Aurignacian in the archeological record of Portugal is likely to be related to a dispersal of modern humans into Iberian regions south of the Ebro divide taking place some time during the thirty-fifth millennium cal BP (before ca.29 ka ^{14}C BP), after which time no reliable dates for the very late Mousterian of the region (and, hence, for Neandertals) are available.

Keywords: *Aurignacian, Iberian Peninsula, Modern Humans, Neandertals, Ebro frontier.*

Resumen

En Portugal, el Auriñaciense está representado por yacimientos al aire libre, cuyas colecciones líticas se adscriben perfectamente a la definición de Auriñaciense II (en el caso de Gato Preto) o III/IV (en el de Vale de Porcos) de la región clásica del suroeste de Francia. Tres pequeños yacimientos en cueva (Pego do Diabo, Salemas y Escoural) presentan hojitas Dufour, subtipo Dufour las cuales (a) son idénticas a las encontradas en la parte superior del nivel 6 de la secuencia del Abri Pataud y (b) forman conjuntos que corresponden a una variante funcional del tipo de industrias representado por Vale de Porcos. La evidencia estratigráfica y las dataciones cronométricas (TL y radiocarbono) son plenamente consistentes con las características tecnológicas y tipológicas de estos conjuntos líticos. Es probable que la aparición del Auriñaciense en el registro arqueológico portugués esté relacionada con la dispersión de los humanos modernos en las regiones de Iberia situadas al sur del Ebro, produciéndose ésta en algún momento del trigésimo quinto milenio cal BP (es decir, antes de H29 ka ^{14}C BP); después de esta fecha no hay dataciones fiables para el musteriense tardío (y, por lo tanto, para los Neandertales) de la región.

Palabras clave: Auriñaciense, Península Ibérica, Humanos modernos, Neandertales, Frontera del Ebro.

The Aurignacian of Portugal: A Reappraisal

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The Sites

At present, the evidence for an Aurignacian occupation of Portugal is restricted to a cluster of open air localities in the Rio Maior basin, 80 km north of Lisbon, and to three small caves in the Alentejo and Estremadura provinces (Zilhão, 1997; Fig. 1). The information provided by Aubry *et alli* (2006) on the open air site of Gândara de Outil 1 is also suggestive of an Aurignacian occupation of the lower Mondego valley; given its preliminary nature, however, these more recent data will not be considered in the following discussion.

The Rio Maior basin

The Rio Maior basin is filled with mainly sandy sediments originally accumulated in Plio-Pleistocene times. The subsequent fluvial shaping of the landscape produced a pattern of deeply incised drainages separated by interfluves that nowadays lie, on average, some 20 to 30 m above the valley bottoms. Downstream, in the Arruda dos Pisões depression, the presence of rolled Early Upper Paleolithic (EUP) artifacts in the lowermost terraces documents a phase of sediment accumulation prior to the Last Glacial Maximum (LGM); occurrences of Solutrean and later (Neolithic and Copper Age) artifacts are limited to the surficial levels of such terraces and bear a totally different surface appearance – often patinated, but never rolled. These observations indicate that, archeologically, the post-EUP finds made in the Arruda dos Pisões depression are largely *in situ*, with at most minor displacement over very short distances; they also imply, conversely, major pre-LGM erosion processes in the upstream drainage of the Maior river. This regional pattern of differential preservation and erosion, in turn, explains well why all known Aurignacian and early Gravettian sites so far identified in the Rio Maior basin are located in the interfluves, buried under shallow Tardiglacial or early Post-Glacial aeolian covers that provided little protection against the disturbance induced by human activities of later prehistoric and recent historic times.

Vale de Porcos, discovered and excavated in 1952-53, under the direction of Manuel Heleno (1944, 1956), is the only site in the Rio Maior basin which contained a large, unmixed, single-component lithic assemblage that, at the time of excavation, was still *in situ*. In 1975, surface collection of disturbed deposits generated by deep plowing of an adjacent area (Vale de Porcos II; cf. Fig. 2) for the plantation of eucalyptus trees yielded an assemblage with broadly similar technological features and also clearly derived from what, originally, had been a single archeological level. The two Vale de Porcos assemblages were studied and published by Zilhão (1988, 1997), who, moreover, identified an Aurignacian component in the mixed assemblage from Vascas, a nearby multi-level site also excavated by Heleno.

Over the last thirty years, the land-use and even the topography of the two localities were significantly transformed by mining, forestry and city expansion. As a result, no stratigraphic

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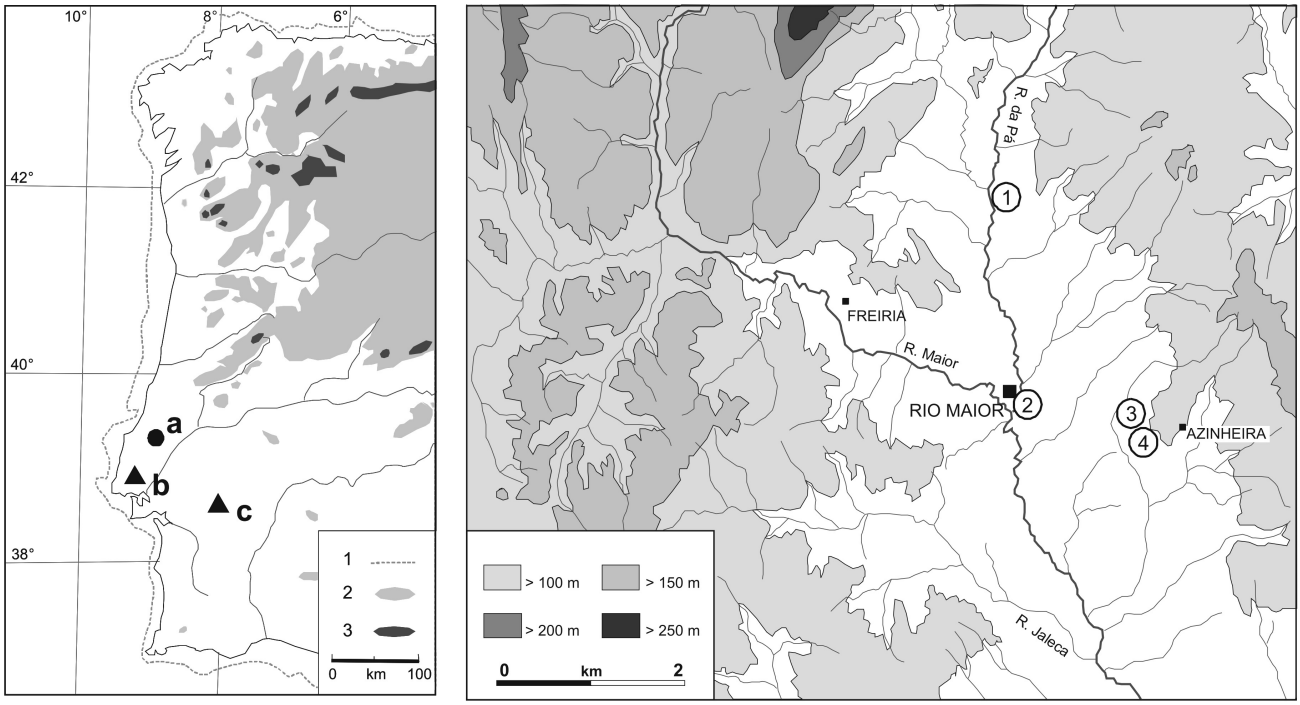

Fig. 1. Geographical location of the Aurignacian sites of Portugal. Left: 1. approximate position of the 100 m isobath; 2. land above 700 m; 3. LGM mountain glaciers; a. Rio Maior open air sites; b. cave sites of Salemas and Pego do Diabo; c. cave site of Escoural. Right: the Aurignacian sites of the Rio Maior basin (1. Vascas; 2. Gato Preto; 3. Vale de Porcos; 4. Chainça).

verification work could be effected in the context of new Paleolithic research undertaken in the Rio Maior area after 1987 (Zilhão, 1988; Marks *et alli*, 1991, 1994; Zilhão *et alli*, 1995), and no estimation of the size of excavated areas could be inferred from field observation. Given the evidence from other sites excavated by Heleno's team, those areas must have been of at least 100 square meters, probably much more at Vascas; and, as it was current at the time, it is likely that, in both cases, work at these sites did not cease until the find concentrations were completely excavated. In the museum collections, lumps of ochre- or yellow-colored sandy-silty concretions dotted by manganese were found adhering to both the small Aurignacian component of Vascas and to a significant percentage of the lithics from Vale de Porcos. Coupled with observations made at non-archeological exposures elsewhere in the basin, the presence of these concretions indicates that, originally, the Aurignacian material was contained in fine fluviatile/colluvial sediments altered by pedogenesis (Zilhão, 1997). As the excavation of the long stratigraphic sequence of the Lagar Velho rockshelter, 50 km to the north, has since made it clear, during OIS-2 times soil formation in the region was restricted to a short interval dated to ca.23-24 ka ^{14}C BP (Angelucci, 2002); thus, a *terminus ante quem* of ca.24 ka ^{14}C BP for the deposition of the Vale de Porcos and Vascas Aurignacian artifacts can be inferred from the sediments adhering to them, in good agreement with their typological and technological features.

In 1991-93, a low-density surface scatter was identified and systematically sampled, including subsurface testing, at the locality of Chainça, 250 m downstream from Vale de Porcos (Thacker, 2001). This small assemblage (only 9 cores and 33 blades were available for technological analysis) is consistent with the major features of the Vale de Porcos collections, and comprises types of "scrapers" and "burins" suggestive of Aurignacian affinities. Its significance, however, resides mostly in that the observed stratigraphy corresponds exactly to that inferred for Vale de Porcos. At Chainça, in fact, the cultural horizon was found to lie 4-12 cm below the surface of the lowermost Pleistocene terrace of the basin (Fig. 3); the enveloping sediments consisted of reddish yellow silty sands accumulated through low energy over bank flooding, as evidenced by the lack of size-sorting, the small debris (<3 cm) comprising nearly half of the chert artifacts recovered; this series of fine fluviatile sediments was in turn separated by a marked discontinuity from an overlying series of colluvial/aeolian white sands which, at the eastern edge of the site, were >1 m thick.

In 1987, an *in situ* archeological level was identified in deposits exposed by a road cut during construction of a new fire station within the city of Rio Maior itself, at the site of Gato Preto (Figs. 4-5), and was subsequently rescue excavated by A. E. Marks (Marks *et alli*, 1994; Zilhão *et alli*, 1995). From top to bottom, the stratigraphic sequence comprised a recent landfill

Fig. 2. Vale de Porcos in 1975. Left: overall view of the area immediately after deep ploughing for the plantation of eucalyptus. Right: a 2x3 m trench excavated by members of the GEPP (Grupo para o Estudo do Paleolítico Português) at Vale de Porcos II reveals the disturbed deposits lying on top of the caterpillar-imprinted surface of the undisturbed sandy substratum.

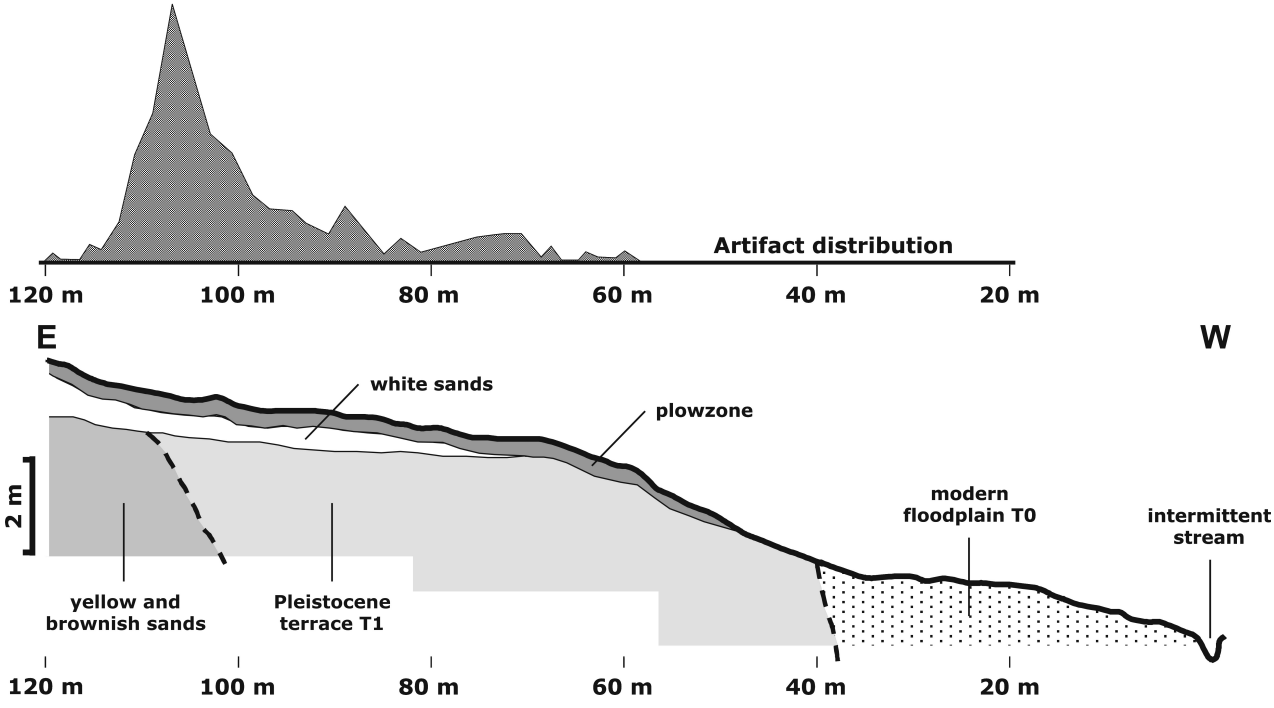

Fig. 3. Late Quaternary stratigraphy of the Rio Maior basin near the town of Azinheira, as observed in the generalized E-W geological cross section at Chainça; the graph above gives the artifact density along the same transect (after Thacker, 2001, modified).

(level A), a brown sandy sediment with small-sized pebbles (level B), a clay horizon significantly altered by pedogenesis and separated from the overlying units by a marked discontinuity (level C), and, at the base, a fluvial cobble deposit. The archeological horizon consisted of a 3-5 cm thick artifact scatter located in the upper reaches of level C and featuring a slight dip to the west; the part of the site not affected by the road cut was entirely contained in the 14 square meters excavated. As documented by extensive core reconstructions and refits (Almeida, 2000), and by the close spatial association between the lithic scatter and a preserved hearth feature, this horizontally well delimited cluster of artifacts was clearly *in situ*, both geologically and archeologically. However, there was a slight increase along the paleoslope, from east to west of the excavated area, of the percentage of small items (from 11% in rows A-D to 18% in row Z), which suggests some level of post-depositional, low-energy size-sorting; the action of such processes would explain well, together with the fact that no wet

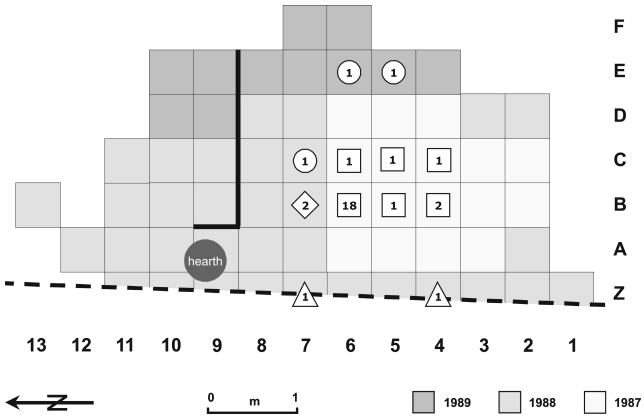

Fig. 4. Gato Preto. Excavation plan, with grid (in quarter square meter units). The position of the concentration of cobbles (hearth) in square A9 is indicated, as well as the location of the stratigraphic profiles studied. The numbers denote the distribution of refitted elements from a single red jasper nodule: circles = flakes; squares = chippage and debris from carinated reduction; diamond = chip and flake; triangle = formal tools (carinated "scraper" in Z4, splintered piece in Z7).

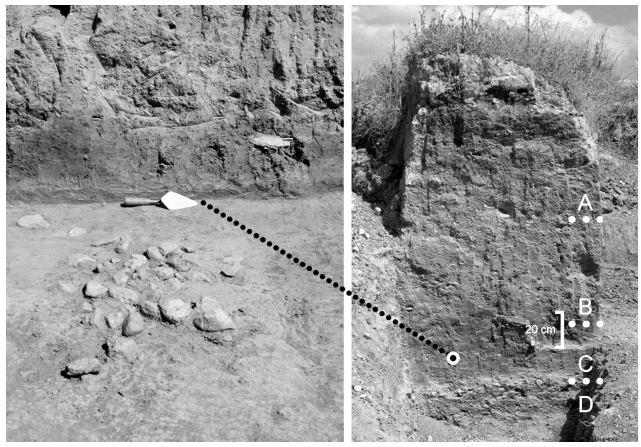

Fig. 5. Gato Preto. Left: the in situ concentration of cobbles (hearth) associated with the Aurignacian artifact scatter; the long dotted line leads to the approximate position, on the right photo, of the trowel shown for scale. Right: the local stratigraphy in the east profile of square A9, the short dotted lines indicating the approximate limits of the different units; A – recent landfill; B - brown sandy sediment with small-sized pebbles (disturbed in historical times); C – pedogenetically altered clay horizon (uppermost unit of underlying fluviatile succession), containing a ca.3-5 cm thick archeological level , at a depth of ca.152 cm from the ground surface extant at the time of excavation; D – coarse (sands, gravel and cobbles) fluviatile terrace deposits.

sieving could be carried out, the under-representation of chips and bladelets in the excavated inventory. Initially ascribed to the Aurignacian (Marks *et alli*, 1994; Zilhão, 1993a, 1993b), the lithic assemblage was subsequently considered to be of Terminal Gravettian or Protosolutrean affinities (Zilhão *et alli*, 1995, 1997, 1999; Zilhão, 1997; Almeida, 2000); as will be discussed below, several lines of evidence now suggest that the original diagnosis may well have been correct.

The cave sites

Pego do Diabo is a small, north-facing cave site situated ca.250 m above modern sea level in a small limestone massif in the outskirts of Lisbon. Some time in the 1960s, an unauthorized test trench was dug at the site; its authors remain unknown, as well as whatever archeological materials they may have recovered. Cleaning and description of the extant profiles would be carried out in the next decade (GEPP, 1979) and, in 1988-89, was to be followed by excavation work (Zilhão, 1997). The site's stratigraphy was recognized to a depth of ca.1.4 m below surface and comprised, from top to bottom, six different units (Fig. 6). Level A, made of medium-sized blocks enveloped in a clay matrix, formed a localized cone of recent Holocene deposits the source of which relates to a chimney in the roof a small chamber located in the innermost part of the cave, beyond the excavated area; it contained human remains, bones of domesticates, and Iron Age pottery. In squares L-M/11 and J12, the uppermost unit was a disturbed Pleistocene deposit with abundant Holocene intrusions which was differentiated as level 1. In those squares, the immediately underlying level 2 was a dense, 40 cm thick eboulis, enveloped in a silty-sandy brown matrix, and separated in two halves (2a, upper, and 2b, lower) by a level of slabs; in rows 5-7, at the entrance to the cave, level 2 formed the exposed ground surface and consisted only of a very thin deposit sandwiched between that surface and bedrock; in rows 8-10, as the cave fill became thicker, level 2 was traversed by a large animal (badger?) burrow running along the north wall of the cave, penetrating into the underlying level 3, and producing significant mixing of the deposits. Level 3 was a 20 cm thick yellowish silt and clay sediment containing rare, surface-weathered blocks, and a faunal assemblage featuring extensive manganese staining. Level 4 consisted of red clays exposed at the bottom of the 1960s trench and further excavated in 1988-89 to a total thickness of ca.90 cm. In square M9, a deposit of very fine, grey silts and sands (level 5) was observed to lie between these red clays and bedrock.

Level 4 of Pego do Diabo yielded rare bones of rabbits as well as a few bone fragments of unidentified large mammals. Level 3 yielded a bone assemblage comprised for the most part of rabbits and carnivore-damaged bone fragments of small- and medium-sized herbivores; wild cat bones were also identified, as well as hyena coprolites. Level 2 yielded a more diverse and more abundant fauna, studied by Cardoso (1993) and Valente (2004), who identified, besides rabbits, *Lynx pardina spelaea* (Iberian lynx), *Panthera (Leo) spelaea* (cave lion), *Canis lupus* (wolf), *Vulpes vulpes* (fox), *Meles meles* (badger), *Crocuta crocuta spelaea* (cave hyena), *Sus scrofa* (wild boar), *Equus caballus* (horse), *Cervus elaphus* (red deer), *Rupicapra rupicapra* (chamois) and *Capra pyrenaica* (ibex). Cut-marks and percussion damage were identified on bones of horse and on

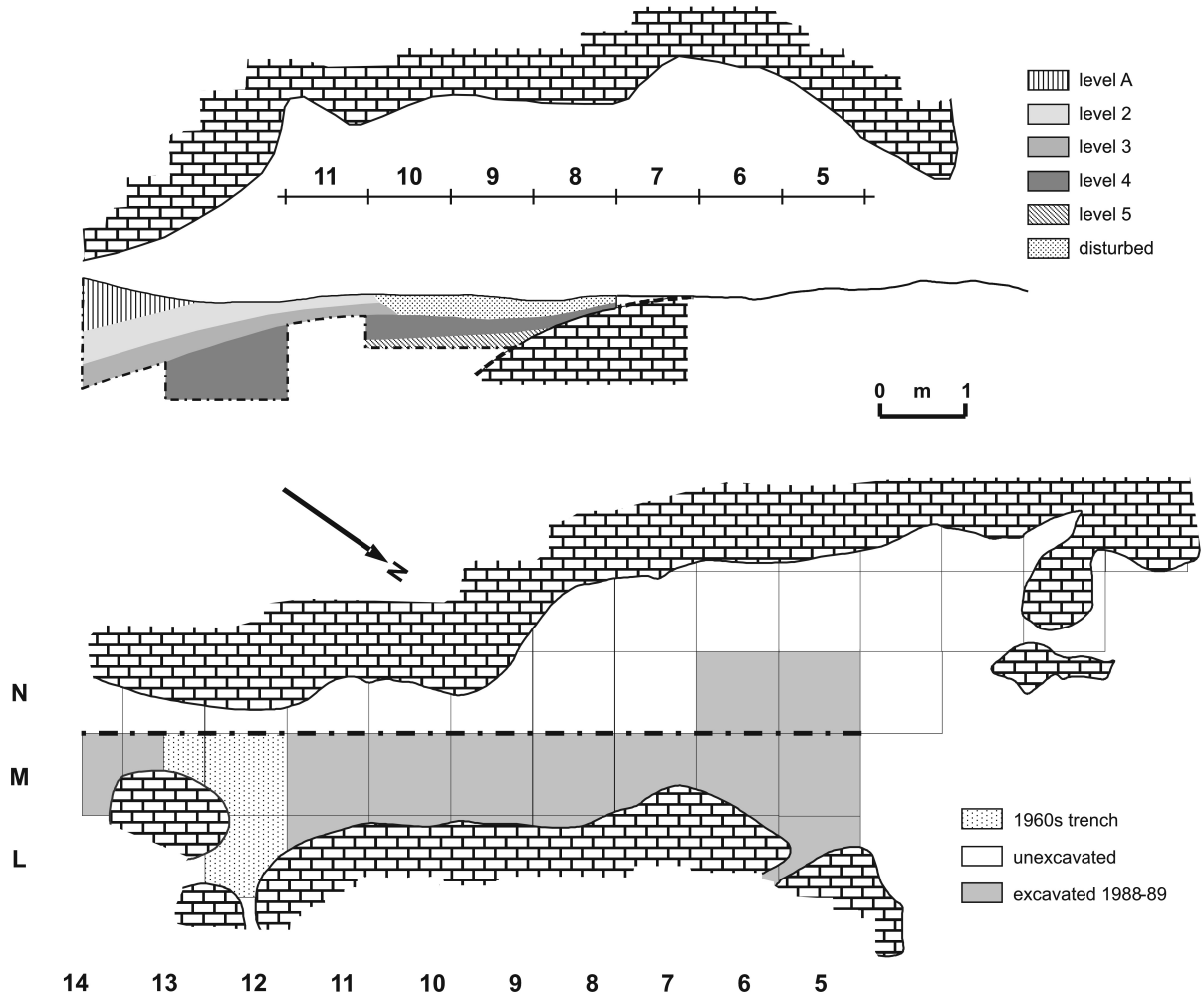

Fig. 6. Pego do Diabo: site plan with excavation grid (below), and schematic stratigraphic profile along the contact between rows M and N of the grid (above).

long bone fragments of herbivores of cervid/equid size (Davis, unpublished report), indicating that humans were at least in part responsible for the accumulation of the bone assemblage, whose species composition, on the other hand, is typical of the Portuguese EUP (Cardoso, 1993; Aubry *et alli*, 2001; Davis, 2002; Valente, 2004).

As pointed out before (Zilhão, 1997), a few skeletal elements of sheep, as well as small fragments of pottery from proto-historical, medieval and post-medieval periods, representing very recent intrusions, were also recovered in level 2, but almost exclusively in those squares (rows 5 to 10) where that level formed the surface of the cave fill; further inside, such intrusive elements were rare and restricted to the upper reaches of level 2 (sublevel 2a), i.e., those in direct contact with the disturbed level 1 (in row 11) or with the Iron Age level A (in rows 13-14) (Table 1). A curved, elongated flint microlithic bi-point, with an unpatinated surface appearance completely different from that of the excavated lithics, was recovered in the disturbed deposits accumulated at the bottom of the 1960s trench removed and sieved during the 1976 profile recognition work; it likely represents a brief Magdalenian or Epipaleolithic incursion in the cave, which, in any case, remained open and accessible to animals throughout the LGM, the Tardiglacial, and the Holocene. Thus, it cannot be excluded that the animal bone assemblage from the upper part of level 2 (particularly where its small carnivore and lagomorph components are concerned) also includes a small percentage of material from these later periods.

Given the stratigraphic configuration of the site, the presence of these post-depositional intrusions is not unexpected, but the vertical distribution of those that are easy to identify (ceramics and sheep) clearly confirms the overall integrity (by cave standards) of the *in situ* Pleistocene sequence (i.e., levels 2-4) in rows 11-14 of the grid. The lithic assemblage recovered in level 2 during excavation is small and, in the way of diagnostic tool-types, restricted to a set of Dufour bladelets (Fig. 7), of which four (nos. 9, 11-12, and 14) come from row 11, the other

Table 1: Vertical distribution of ceramic fragments in squares L-M/11-14 of Pego do Diabo.

J12, L11, M11(a)		M13, M14 (b)	
Level 1	25	Level A	16
Level 2 upper	1	Level 2 upper	2
Level 2 lower	-	Level 2 lower	-
Level 3	-	Level 3	-
Level 4	-	Level 4	-

(a) all medieval and post-medieval
(b) Iron Age, medieval and post-medieval

Table 2: Radiometric results for Portuguese Aurignacian sites: Gato Preto, TL on burnt flint and OSL on sediments. Pego do Diabo, conventional radiocarbon, calibrated with CalPal (Weninger and Jöris, 2005).

Site	Level	Sample	Provenience	Lab No.	^{14}C age BP	Calendar age BP
Gato	B	Sediments	profile	-	-	<1500
Preto	C	Burnt flint	B4	GPR12	-	4940±640
	C	Burnt flint	A4	GPR9	-	5100±600
	C	Burnt flint	A6-Z4	GPR11	-	36,500±4500
	C	Burnt flint	E9	GPR4	-	40,700±5600
				average (a)	-	38,100±3900
Pego	2a	Charcoal (b)	M13	ICEN-306	2410±80	-
do	2a	Bone (c)	M11+L11	ICEN-490	23,080±490	-
Diabo	2b	Bone (c)	M11+L11	ICEN-732	28,120/-780/+860	32,970 ± 1160
	3	Bone (d)	M13+M14	ICEN-491	>18,630±640	-

(a) average of GPR 11 and GPR4
(b) intrusive from the overlying Iron Age in level A
(c) large mammal bone fragments
(d) rabbit bones and large mammal bone fragments; minimum age only ("impure", low quality collagen)

three having been recovered in rows 8 and 6, towards the cave entrance; accordingly, level 2 was assigned to the Aurignacian. Underlying levels 3 and 4 contained a few heavily patinated, somewhat edge-damaged artifacts whose technological features are consistent with the Middle Paleolithic, and whose patina is identical to that of the numerous scatters of Lower or Middle Paleolithic flint artifacts recovered in surficial or colluvial deposits covering the local Tertiary, basaltic bedrock.

Subsequent to the excavation of Pego do Diabo, Zilhão (1997) recognized a similar bladelet tool component in EUP level III of the nearby cave site of Salemas (Roche *et alli*, 1961, 1962; Zbyszewski *et alli*, 1961; Roche and Ferreira, 1970; Castro and Ferreira, 1972); featuring a lithic assemblage dominated by Gravettian elements and a faunal assemblage identical to that of Pego do Diabo level 2 (*Felis sylvestris*, *Lynx pardina spelaea*, *Canis lupus*, *Vulpes vulpes*, *Ursus arctos*, *Sus scrofa*, *Cervus elaphus*, *Rupicapra rupicapra* and *Bos primigenius* – Cardoso, 1993), the stratigraphic position of level III, underlying Solutrean level II and overlying Mousterian level IV, is consistent with an Aurignacian chronology for the three Dufour bladelets identified therein.

Zilhão (1997) also described a set of four similar Dufour bladelets among the lithics from the unpublished excavations carried out in the 1960s at the Paleolithic cave art site of Escoural, in the Alentejo (Santos, 1964, 1967, 1985; Glory *et alli* 1965; Gomes *et alli*, 1990; Santos *et alli* 1981; García *et alli*, 2000). In the interior galleries, the stratigraphic succession consisted of a surficial, calcite-incrusted Neolithic necropolis overlying cave clays that contained a rich Pleistocene faunal assemblage, probably accumulated by denning hyenas (Cardoso, 1993); excavation of an entrance opposite to that used in Upper Paleolithic and Neolithic times yielded a similar fauna, but this time in clear association with an abundant Middle Paleolithic quartz industry (Otte and Silva, 1996). In the Museum collection, only one Dufour bladelet remained associated with its original provenience label, which indicated that the object had been collected at a depth of 190-200 cm below datum. Elsewhere in the cave, a Solutrean laurel-leaf point and two sagaie bone points were found at similar elevations; these finds provide independent corroboration that the cave deposits included an Upper Paleolithic component as well.

The Dating

The overall spatial distribution pattern of the finds and the stratigraphic configuration of the deposits that contained them, combined with the composition of the associated fauna, are therefore entirely consistent with the notion that, as at Pego do Diabo and Salemas, the Dufour bladelets from Escoural are of EUP, more specifically, Aurignacian age; the same applies to the stratigraphy observed at Chainça, as well as to that inferred for Vale de Porcos. In and of themselves,

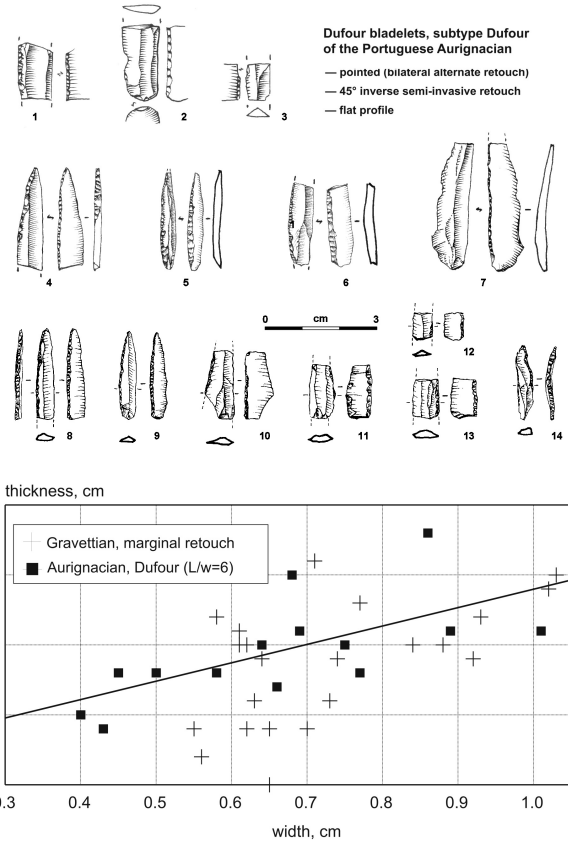

Fig. 7. Bladelet tools of the Portuguese Aurignacian (1-3. Salemas; 4-7. Escoural; 8-14. Pego do Diabo), which, by comparison with the marginally retouched bladelets of the Gravettian, are distinctively standardized in size, shape and mode of retouch, as well as larger, thicker, and more elongated: 1-13. Dufour bladelets; 14. bladelet with direct, bilateral, marginal retouch.

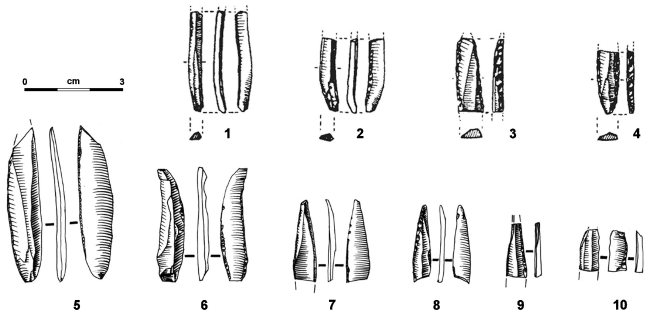

Fig. 8. Dufour bladelets from the Late Aurignacian of France and southern Spain: 1-4. Abri Pataud, layer 6; 5-10. Zafarraya cave (surficial Upper Paleolithic deposit, between -108 and -118 cm, or intrusive in the underlying Late Mousterian levels). After Chiotti (1999) and Barroso et al. (2003).

however, these data do not suffice to exclude a later age; additional empirical evidence supporting such an exclusion and corresponding assignment of these assemblages to the Aurignacian comes from the typological and technological patterns reviewed below, as well as from the radiometric dates obtained for Gato Preto and Pego do Diabo, to which we must now turn (Table 2).

Gato Preto

At Gato Preto, the dates are TL results on burnt flint obtained by Sheridan Bowman and Nick Debenham, then at the British Museum's Laboratory (Debenham, 1991). The two younger results are likely to result from re-heating of the artifacts at a later time, an interpretation that is consistent with the following critical observations: first, the fact that OSL dating of level B indicated an age of <1500 BP for the accumulation of the sediments; second, the fact that the two younger results come from samples collected in an area of the site where the archeological level was truncated by the discontinuity separating levels C and B and, therefore, lay at the interface between the two. In these circumstances, the most parsimonious interpretation of the combined stratigraphic and chronometric evidence is that the artifacts in this part of the site were exposed, and some re-heated, in the framework of land removal episodes affecting the area in historic, probably very recent times. The average of the two reliable results (GPR4 and GPR11) is 38.1 ka cal BP, which, at one standard deviation, translates into the 42.0-34.2 ka cal BP time interval. These temporal limits are almost coincident with those of the period during which the emergence and development of the Aurignacian takes place elsewhere in Europe; in fact, as shown by available calibration tools (Weninger and Jöris, 2005), that calendar year range corresponds, in the radiocarbon time scale, to the ca.36.4-29.0 ka ^{14}C BP interval.

When the Gato Preto TL dating work was carried out, more than fifteen years ago, it was not yet known that, in this time range, radiocarbon underestimated true calendar ages to such a large extent. Accordingly, the results were taken with extreme reservation, in spite of the fact that all possible sources of error considered in the ensuing intensive correspondence with the dating team could eventually be excluded (Debenham, personal communication). On the other hand, the technological and typological features of the assemblage are fully consistent with its appurtenance to the Evolved Aurignacian (see below), dates for which, elsewhere in southwestern Europe, tend to fall in the ca.32-29 ka ^{14}C BP interval (i.e., ca.37.0-34.3 ka cal BP). In these circumstances, it seems reasonable, therefore, to use this interval to constrain the wide age range indicated by the TL result for Gato Preto and to accept that this is indeed an Aurignacian site.

As mentioned above, however, Zilhão *et alli* (1995, 1997, 1999), Zilhão (1997) and Almeida (2000) related the Gato

Preto lithic assemblage to the Terminal Gravettian/Protosolutrean episode (ca.22-21 ka ^{14}C BP) of the Portuguese Upper Paleolithic sequence, at which time carinated reduction techniques are represented by diagnostic material at all levels of the production system (carinated and thick-nosed "scrapers" associated with bladelet blanks some times bearing a marginal, inverse retouch). This placement was largely inspired by the excavation of level 2 of the Lapa do Anecrial cave site, an extraordinarily well preserved short-term occupation where >90% of all artifacts could be refitted and which was organized around a hearth dated to ca.21.5 ka ^{14}C BP by several reliable determinations. One particular reconstruction (the grey flint core) provided the material evidence that carinated "scrapers" were indeed bladelet cores and that, at least in some cases, the respective blanks consisted of byproducts from the preparation or the maintenance of blade/bladelet prismatic cores. Both carinated and prismatic production methods were thus shown not only to co-exist in the same lithic production system but also to be conceivably combined in the same individual core reduction sequence. Other reconstructions further showed that quartz could be exploited in this way as much as flint and that, where bladelet production was concerned, there was no preference for a specific raw-material, flint and quartz being used for that purpose in similar proportions.

In spite of such overall similarities in the use of quartz and of carinated reduction, the data in Tables 3-4 make it clear that Gato Preto differs in some fundamental ways from the assemblages of the Terminal Gravettian/Protosolutrean. For instance, at Gato Preto, quartz was as important, if not actually more frequent, but it was being used in different ways and for different purposes: only 12% (3 out of 26) of the quartz cores were reduced as prismatic bladelet cores at Gato Preto, as opposed to values of 62% (5 out of 8), 41% (13 out of 32), and 21% (10 out of 47), respectively, in the truly Terminal Gravettian/Protosolutrean levels of Cabeço de Porto Marinho II, Cabeço de Porto Marinho III, and Terra do Manuel 1988-89; the same contrast is apparent when the percentage of bladelets among all debitage products is considered, although in this case the differences may be exaggerated by the under-representation of small items at Gato Preto (due to post-depositional sorting or to the lack of wet-sieving of the clay deposits that contained the finds). Thus, the systematic utilization of quartz even when flint is abundant and local would seem to retain its validity as a diagnostic feature of the Terminal Gravettian/Protosolutrean only if appropriately accompanied by the qualification "for the production of bladelets extracted from prismatic cores". By this criterion, Gato Preto falls outside the range of confirmed Terminal Gravettian/Protosolutrean sites, and the same applies when the relative importance of the carinated "scraper"/carinated "burin"/thick-nosed "scraper" method of bladelet production is assessed: whereas it corresponds to 93% of the Gato Preto bladelet cores, the corresponding percentages are of 13% to 16% only in the truly Terminal Gravettian/Protosolutrean levels of Cabeço de Porto Marinho II, Cabeço de Porto Marinho III, and Terra do Manuel 1988-89 (Table 4).

In Mediterranean Spain, the typological and technological features of the assemblage recovered in level 11 of Bajondillo cave (Malaga) – dominated by carinated and thick-nosed "scrapers" and with a few Dufour bladelets of Roc-de-Combe subtype, whose characteristic small, twisted blanks are well represented in the debitage (Cortés and Simón, 1998, 2001; Cortés, 2003) – indicate that assemblages fully consistent with the Evolved Aurignacian as defined in southwestern France are also to be found well beyond the "Ebro frontier", as is also suggested by the lozenge-shaped bone point recovered in level XII of the Mallaetes cave (Valencia), in association with a reliable charcoal date of 29,690±560 BP (KN-I 926) (Fortea and Jordá, 1976). The techno-typological features of the Gato Preto lithic assemblage and the associated TL dates indicate that the geographical range of these Evolved Aurignacian industries extended as far west as the Portuguese Estremadura.

Pego do Diabo

Of the four dates available for Pego do Diabo, only three are finite results. Where the level 3 sample (ICEN-491) is concerned, the dating lab reported that the collagen extracted was rather impure, indicating that contaminants had not been entirely removed and, therefore, that the result is a minimum age only. The ICEN-306 date, in turn, clearly corresponds to charcoal percolating downward from the Iron Age deposits which immediately overlay the Pleistocene sequence in the M13/14 profile (cf. Tables 1-2 and Fig. 6). The sample comes from the upper part of level 2 in square M13, excavated in the 1988 field season, at which time the charcoal was collected for dating because no intrusive artifacts had been identified; in 1989, however, the excavation of the adjacent half of square M14 yielded two ceramic sherds at this elevation, indicating that Iron Age material had indeed penetrated the upper reaches of the Pleistocene sequence in this innermost part of the cave and providing sufficient explanation for the apparently anomalous result.

The ICEN-490 (sublevel 2a) and ICEN-732 (sublevel 2b) results are in stratigraphic order and, taken at face value, would indicate that the upper part of level 2 is of Gravettian age and that only the lower part was deposited during the Aurignacian; as a whole, level 2 of Pego do Diabo would thus span the same time range as that inferred on the basis of artifactual contents for level III of the nearby site of Salemas, the two sequences differing in that sedimentation would have ceased at Pego do Diabo before the LGM but would have continued throughout the later Pleistocene and early Holocene at Salemas, where the EUP levels underlay Solutrean (level II) and Neolithic (level I) deposits. In the interpretation of the ICEN-490 result, however,

TABLE 3: Different indicators of the use of quartz at Gato Preto and in Terminal Gravettian/Protosolutrean assemblages from modern excavations in the Rio Maior basin (for each parameter, the total figures upon which the percentages were calculated are given in parentheses; after Zilhão, 1997).

ASSEMBLAGE	QUARTZ IN TOTAL ARTIFACT INVENTORY (%)	QUARTZ IN ARTIFACT INVENTORY (DEBRIS EXCLUDED) (%)	QUARTZ CORES REDUCED FOR BLADELETS (%)	BLADELETS IN QUARTZ DEBITAGE (%)
Gato Preto	43 (N=1162)	38 (N=893)	12 (N=26)	0.6 (N=310)
Cabeço de Porto Marinho II lower (upper part)	32 (N=872)	28 (N=469)	62 (N=8)	10 (N=119)
Cabeço de Porto Marinho III middle (=level D)	22 (N=3949)	21 (N=2471)	41 (N=32)	10 (N=467)
Terra do Manuel 1988-89 (level 2s)	37 (N=4757)	28 (N=2306)	21 (N=47)	6 (N=575)

TABLE 4: Bladelet core types at Gato Preto and in Terminal Gravettian/Protosolutrean assemblages from modern excavations in the Rio Maior basin (after Zilhão, 1997).

	AURIGNACIAN "SCRAPERS" AND "BURINS" (A)		CLASSICAL "BURINS"		PRISMATIC CORES FOR BLADELETS	
ASSEMBLAGE	N	%	N	%	N	%
Gato Preto	39	93	-	-	3	7
Cabeço de Porto Marinho II lower (upper part)	2	13	8	53	5	33
Cabeço de Porto Marinho III middle (=level D)	8	13	24	39	29	48
Terra do Manuel 1988-89 (level 2s)	10	16	22	35	31	49

(a) typical and atypical carinated "scrapers"; thick-nosed "scrapers"; nucleiform "scrapers"; carinated, Vachons and busked "burins"

one must bear in mind that the upper reaches of level 2 were in direct contact with disturbed (level 1) or recent Holocene (level A) deposits, and, as mentioned above, contained some material that, although rare (two sherds in square M14, one sherd in square M11, Iron Age charcoal in square M13), was clearly intrusive. This fact carries the implication that similar intrusions must have affected the faunal assemblage as well and, therefore, because the ICEN-490 result was obtained on a bulk sample of bone fragments, that the ca.23 ka ^{14}C BP date they yielded is possibly rejuvenated by the accidental inclusion in that sample of a small amount of later, cf. Holocene, bone material. If so, then the accumulation of level 2 would in fact date in its entirety to pre-Gravettian times; the vertical distribution of the bladelet tools recovered *in situ* (i.e., in the area of the cave corresponding to rows 11-14) is consistent with this hypothesis, since such items were found in both sublevels, 2a and 2b.

Given these data, a number of chronostratigraphic interpretations are possible, which can be summarized as follows:

(a) level 2 is a palimpsest of animal bones accumulated by carnivores over a long period of time, encompassing both the late Middle and the early Upper Paleolithic (i.e., conceivably covering the Mousterian, the Aurignacian and the Gravettian periods); the presence of artifacts (and of the few cut-marked bones) signals short and very sporadic uses of the cave by humans, among which an Aurignacian occupation can be recognized because it left behind diagnostic lithics; that occupation, however, bears no necessary chronological or behavioral relationship with the faunal material sampled for dating; since they would have combined material accumulated over extended periods of time, the ICEN-490 and ICEN-732 samples would in any case have yielded averaged-out results with no meaning other than that of confirming the relative chronological position (mid-Upper Pleistocene, pre-LGM) of the deposits;

(b) the accumulation of the level 2 deposits was restricted to the late Mousterian and the Aurignacian, the former possibly represented by undiagnostic lithics (such as unretouched flakes), and the latter certainly represented by diagnostic bladelet tools; the few bone fragments with anthropic marks relate to these occupations, but the background fauna is mostly carnivore-accumulated; the ICEN-490 result is rejuvenated by later material post-depositionally incorporated in the upper part of level 2, whereas the ICEN-732 result would be the average age of bone material belonging to both the Mousterian and the Aurignacian periods;

(c) the radiocarbon results for sublevels 2a and 2b are a genuine indicator of the history of human use of the cave during the EUP; the bladelet tools have no value as index fossils and would have been discarded in the framework of both Aurignacian and Gravettian occupations of the site;

(d) sublevel 2b was deposited in the Aurignacian and sublevel 2a in the Gravettian, but the bladelet tools are all Aurignacian, those in sublevel 2a having undergone post-depositional upward displacement; a corollary of this hypothesis is that no Pleistocene human activity occurred in the cave after the Aurignacian (or, if it did occur, left no diagnostic artifacts behind), and that the faunal remains in sublevel 2a were entirely accumulated by natural processes,

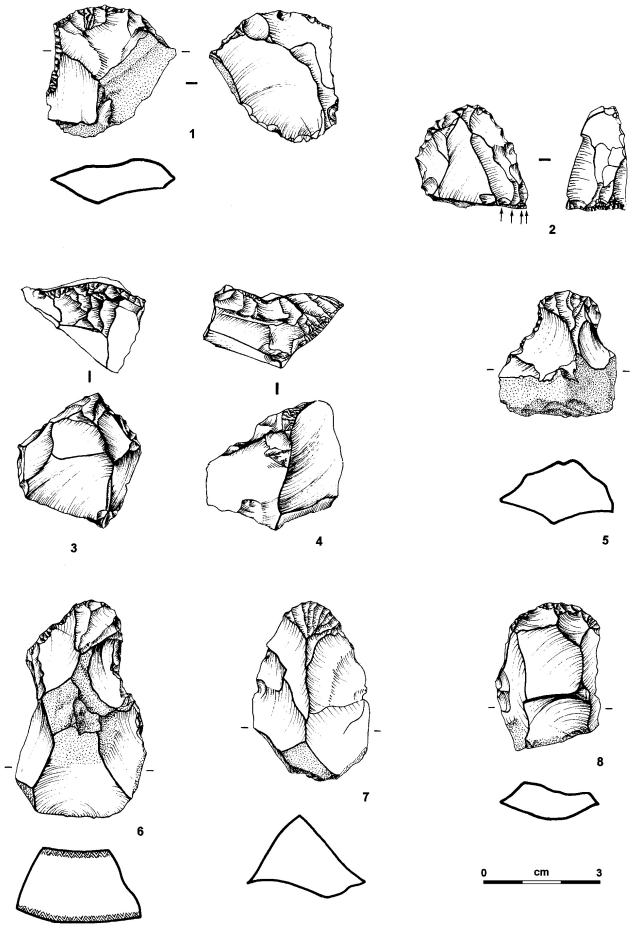

Fig. 9 . Gato Preto lithics (all flint): 1. endscraper on flake with ventral splintering; 2. endscraper-burin; 3. carinated "scraper"; 4. busked "burin"; 5-7. thick-nosed "scrapers"; 8. simple endscraper on flake. After Zilhão, 1997.

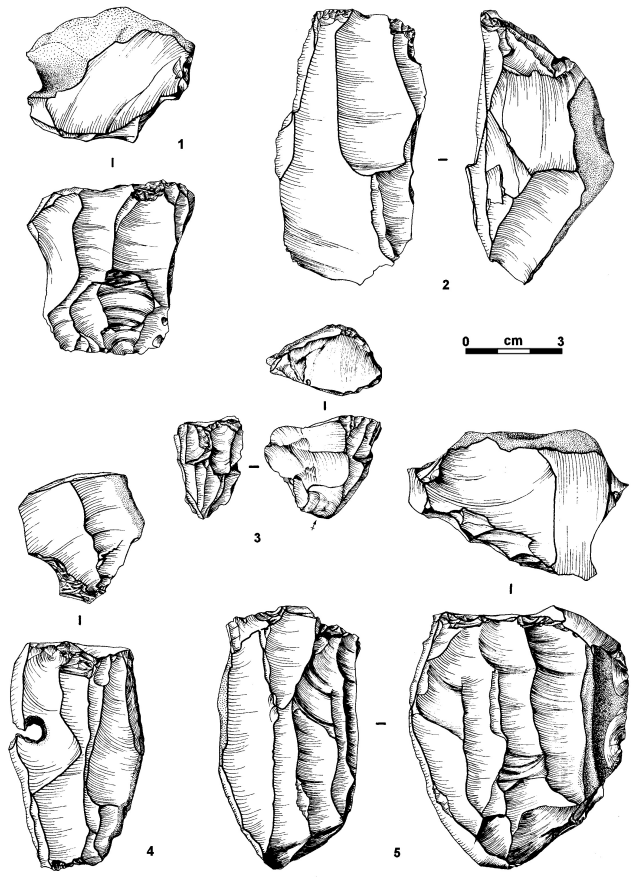

Fig. 10. Vale de Porcos lithics (all flint): prismatic cores for blades (nos. 1-2, 4-5) and bladelets (no. 3). After Zilhão, 1997.

namely carnivore activity, whereas those in 2b are at least to some extent related to Aurignacian subsistence practices;

(e) reversing the preceding hypothesis, the bladelet tools are all Gravettian, those in sublevel 2b having undergone post-depositional downward displacement; only the bones in 2a would thus relate in part to human activity, bone accumulation in Aurignacian times relating entirely to natural agency;

(f) all of level 2 is Aurignacian in age, the ICEN-490 date having been rejuvenated by physical contamination of the dated bulk sample with younger material;

(g) level 2 is entirely Gravettian in age, the ICEN-732 result being contaminated by the incorporation of bones from underlying Middle Paleolithic level 3.

Of these different alternatives, only the last can be securely removed from any further consideration; the difference in surface appearance between the bones from levels 2 and 3, namely the extensive manganese staining of the latter, was so striking that any such potential contaminant material would have been easily identified when the sample sent for dating was selected. Moreover, given the exponential nature of radioactive decay, in order for an age of ca.28 ka ^{14}C BP to be obtained for a sample that should actually date to about ca.23 ka ^{14}C BP the potential contaminating fraction should significantly outweigh (in a proportion of 4:1, in fact) the putative genuine one. In such a situation, however, the concept of "contamination" would not apply in the first place, and we would in fact be dealing with a heterogeneous sample mixing clearly distinct components, not with "a few Mousterian bones making a Gravettian sample too old". Put another way, alternative g) above implies a non-homogeneous level 2 with a predominant pre-Gravettian component, in contradiction with the postulate that its contents were entirely accumulated in the Gravettian.

Given the typological and chronostratigraphic arguments discussed below in favor of a Late Aurignacian age for the

TABLE 5: Proportion of the different bladelet tool classes from Pego do Diabo compared with assemblages of the Portuguese Gravettian (only assemblages with more than five pieces were tabulated; after Zilhão, 1997).

	DUFOUR BLADELETS (A)		BLADELETS WITH MARGINAL, DIRECT RETOUCH		BACKED BLADELETS AND POINTS		GEOMETRICS	
	N	%	N	%	N	%	N	%
Aurignacian								
Pego do Diabo, level 2	6	86	1	14	-	-	-	-
Early Gravettian								
Vale Comprido-Barraca	3	12	1	4	21	84	-	-
Middle Gravettian ("Fontesantian")								
Fonte Santa	-	-	-	-	4	40	6	60
Late Gravettian ("Protomagdalenian")								
Terra do Manuel	14	5	6	2	234	91	2	1
Cabeço de Porto Marinho II, lower inf	-	-	-	-	17	100	-	-
Terminal Gravettian ("Aurignacian V")								
Terra do Manuel 1988-89, level 2s	1	7	-	-	13	93	-	-
Cabeço de Porto Marinho III, middle	1	12	-	-	7	88	-	-

(a) in the Gravettian assemblages, the "Dufour bladelet" category is totally comprised of elements with inverse, marginal retouch, none featuring the kind of alternate, semi-abrupt, invasive retouch of the strictly-speaking Aurignacian Dufours from Pego do Diabo, Salemas and Escoural

lithics recovered in this level, the range of possibilities therefore remains limited to hypotheses (a), (b), (d) and (f). Under (a) and (b), the radiocarbon dates available are of limited utility in the assessment of the chronology of the human occupation documented by the Dufour bladelets. Under (d) and (f), an age of ca.28.1 ka ^{14}C BP (ca.32.5 ka cal BP) for the Aurignacian use of the cave is implied, in good agreement with typology. However, given that only 3% contamination by material of historical age (for instance, 1500 years old) suffices to produce a ca.23 ka ^{14}C BP result for a bulk sample composed in 97% of material with an age of ca.28,000 ^{14}C years, and that such modern contaminants were indeed present in sublevel 2a, it must be concluded that, with present evidence, hypothesis (f) is the most parsimonious.

In fact, the Dufour bladelets from Pego do Diabo, Salemas and Escoural (cf. Fig. 7) are quite distinct from the bladelet tools of the Portuguese Gravettian (Zilhão, 1997, 2000). Their characteristics fit the definition of the strictly-speaking Dufour subtype of Dufour bladelets (Demars and Laurent, 1989), no specimen of the Roc-de-Combe subtype (made on short, twisted blanks extracted from thick-nosed "scrapers") being at present known in Portugal. In the country's Gravettian, marginally-retouched bladelet elements are some times also found but, contrary to the norm respected by the specimens from those three cave sites, the retouch tends to be direct; and, when at all present, the inverse retouch borne by such Gravettian elements never is of the semi-abrupt, invasive kind seen in the Dufour bladelets from Pego do Diabo, Salemas and Escoural. Moreover, not a single Gravettian assemblage of any of its phases (early, middle, late or terminal) has yielded examples of the specific type of elongated bladelet point obtained by continuous, regular, semi-abrupt, bilateral/alternate retouch that characterizes the assemblages from Escoural and Pego do Diabo. Finally, in such Gravettian assemblages, whatever marginally-retouched elements exist are always a rather small percentage of the global microlithic tool-kit, which is overwhelmingly dominated by a diverse array of types of backed bladelets, backed points (micrograves) and geometrics, all of which are conspicuously lacking in the Pego do Diabo assemblage (Table 5).

It is well known that, in the classical region of southwestern France, the Dufour subtype and the related Font-Yves point are characteristic of the Protoaurignacian. The Dufour subtype is still represented, in highly variable but generally low percentages, in the subsequent Aurignacian I (or Early Aurignacian), at which time the numerous bladelets extracted from carinated "scrapers" remain for the most part unretouched. In the Aurignacian II (or Evolved Aurignacian), the Roc-de-Combe subtype appears and almost entirely replaces the Dufour subtype (Lucas, 2000; Bon, 2002; Bordes, 2002). Less well know, however, because of the scarcity of reliable stratigraphies for the Late Aurignacian, is the fact that the Dufour subtype re-appears at the end of the sequence, as documented in level 6 of the Pataud rockshelter (Chiotti, 1999) (Fig. 8, nos. 1-4).

In this respect, it is significant that, in the only other known occurrence of bladelet tools clearly belonging to this subtype so far known south of the Ebro basin (the Spanish cave site of Zafarraya, near the boundary between the Malaga and Granada provinces), the collection is composed of intrusive material recovered in the uppermost, late Mousterian deposits of the sequence, which are dated to ca.32-30 ^{14}C BP (Hublin *et alli*, 1995). Barroso *et alli* (2003) suggest that these items (Fig. 8, nos. 5-10) are related to an occupation of the cave dating to the Protoaurignacian *sensu strictu* (i.e., contemporary with that documented ca.36.5 ka ^{14}C BP at l'Arbreda, Labeko Koba and Morin, in northern Spain); given the site's chronostratigraphic

Table 6: Gato Preto formal tool typology (after Zilhão, 1997).

Type	N	%
Simple endscraper on blade	2	2.08
Simple endscraper on flake	1	1.04
Atypical endscraper on blade	1	1.04
Endscraper on retouched blade	2	2.08
Endscraper on retouched flake	4	4.17
Endscraper on flake	7	7.29
Carinated scraper	4	4.17
Atypical carinated scraper	4	4.17
Thick-nosed scraper	26	27.08
Thin, unilaterally nosed scraper	1	1.04
Nucleiform scraper	3	3.13
Scraper-burin	1	1.04
Busked burin	2	2.08
Blade with continuous, unilateral retouch	2	2.08
Notch	9	9.38
Denticulate	8	8.33
Splintered piece	3	3.13
Retouched flake	16	16.67
TOTAL	96	100.00

Table 7: Vale de Porcos formal tool typology (after Zilhão, 1997).

Type	N	%
Simple endscraper on blade	5	3.82
Simple endscraper on flake	1	0.76
Atypical endscraper on blade	1	0.76
Atypical endscraper on flake	1	0.76
Double endscraper	1	0.76
Ogival endscraper	1	0.76
Endscraper on Aurignacian piece	1	0.76
Endscraper on flake	1	0.76
Carinated scraper	1	0.76
Atypical carinated scraper	2	1.53
Thin, bilaterally nosed scraper	1	0.76
Thin, unilaterally nosed scraper	1	0.76
Scraper-burin	2	1.53
Burin-truncation	1	0.76
Straight dihedral burin	4	3.05
Déjeté dihedral burin	12	9.16
Dihedral burin on angle	6	4.58
Dihedral burin on break	9	6.87
Multiple dihedral burin	2	1.53
Busked burin	7	5.34
Carinated burin	16	12.21
Vachons burin	2	1.53
Burin on oblique truncation	7	5.34
Burin on concave truncation	6	4.58
Burin on convex truncation	4	3.05
Transversal burin on lateral truncation	4	3.05
Multiple mixed burin	1	0.76
Plan burin	2	1.53
Blade with continuous, unilateral retouch	1	0.76
Aurignacian blade	1	0.76
Notch	8	6.11
Denticulate	5	3.82
Flakes and blades with partial retouch	9	6.87
Retouched tool fragments	4	3.05
Pebble-tools	1	0.76
TOTAL	131	100.00

TABLE 8: Pego do Diabo level 2 inventory (after Zilhão, 1997).

ARTIFACT TYPE	FLINT	QUARTZ	TOTAL
Flakes	6	6	12
Chips	6	3	9
Tools			
Atypical endscraper on flake	1 (a)	-	1
Atypical borer	1	-	1
Sidescraper	1 (a)	-	1
Dufour bladelet	6	-	6
Bladelet with marginal, direct, bilateral retouch	1	-	1
Retouched tool fragment	1	-	1

(a) recovered in level 1 (i.e., the disturbed, uppermost part of level 2 in squares L-M/11 and J12)

pattern, and the evidence from Pataud and the Portuguese sites, however, it is more likely that, as at Pego do Diabo, the Zafarraya microliths document instead a Late Aurignacian use of the site.

The Lithic Production System

The number of items from Vascas featuring the characteristic pedogenetic concretions is limited to 37, all of which are technologically and typologically consistent with the kind of assemblage-type recovered at Vale de Porcos in 1952-53. The inventories from Chainça and Vale de Porcos II, although larger (2345 and 1785 objects, respectively), come from surface collections and are for the most part composed of chips and debris (in the case of Chainça, where such items are 74% of the total inventory), or of cores, decortication material and debris (5%, 37% and 24% of the total inventory, respectively, at Vale de Porcos II). Moreover, in order to be secure, inferences about the lithic production system and the stone economics of the Portuguese Aurignacian must be based on the features of assemblages recovered *in situ* and in stratified contexts. The relevant samples are thus reduced to Gato Preto and Vale de Porcos, supplemented by the poor but functionally significant and stratigraphically coherent assemblage from level 2 of Pego do Diabo; the remaining assemblages will be used only when consistent with the overall pattern and required to support the inferences derived from the key sites.

Gato Preto

At Gato Preto, as mentioned above, quartz was exploited mainly for the production of flakes (only three unretouched quartz blades were found, 0.7% of the total debitage products); when retouched, such flake blanks were transformed into sidescrapers, notches and denticulates. Only seven retouched flint pieces were made on blades (five endscrapers and two continuously retouched pieces), and five of those were partly cortical, suggesting that they correspond in fact to elongated objects produced in the initial stage of the reduction of cores for flakes.

The most striking feature of the formal tool assemblage (Table 6; Fig. 9) is the fact that it is overwhelmingly dominated by nosed (27%), carinated (8%), and nucleiform (3%) "scrapers", and that it also includes two good examples of busked "burins". Almeida's (2000) refitting work demonstrated that these objects (in fact cores for the production of bladelets) were mostly made on blanks obtained through the hammering of small- or medium-sized flint nodules in order to split them in angular fragments whose sharp edges were then used, with no additional form of preparation, as the ridges guiding bladelet extraction. In spite of the scarcity of blade blanks in the debitage (one blade per each hundred flakes), another refit (Almeida, 2000, Fig. 6-34) illustrates the production of blades from prismatic cores prepared by crest removals, as in the Vale de Porcos assemblage (see below).

By the presence of busked "burins" and the dominance of nosed over carinated forms, the Gato Preto lithics are clearly related to the Aurignacian II or Evolved Aurignacian of the classical French sequence. However, no Roc-de-Combe bladelets were recovered, which at least in part can be explained by post-depositional size-sorting, or by the lack of water-sieving. Given that it was nonetheless possible to recover a small number of unretouched chips and bladelets, it is also conceivable that this absence relates instead, or at least to a much greater extent, to the fact that the occupation may have been rather short-lived, with most bladelet products having been exported as blanks for future use, or taken away mounted as barbs on pieces of logistical or domestic equipment that were manufactured or re-tooled at the site.

A short duration and/or a functional specialization of the occupation would in turn explain well the under-representation of blades and blade cores. Put another way, it is quite conceivable that the assemblage recovered at this site is strongly biased towards a particular aspect of the overall lithic production system – the extraction of short, twisted bladelet blanks for retouch and use as Roc-de-Combe bladelets that were consumed and discarded elsewhere in the landscape.

Vale de Porcos

Contrary to Gato Preto, at Vale de Porcos, located less than 2 km away (cf. Fig. 1), the lithics are almost entirely (99.6%) flint. This fact must result to some extent from the 1950s

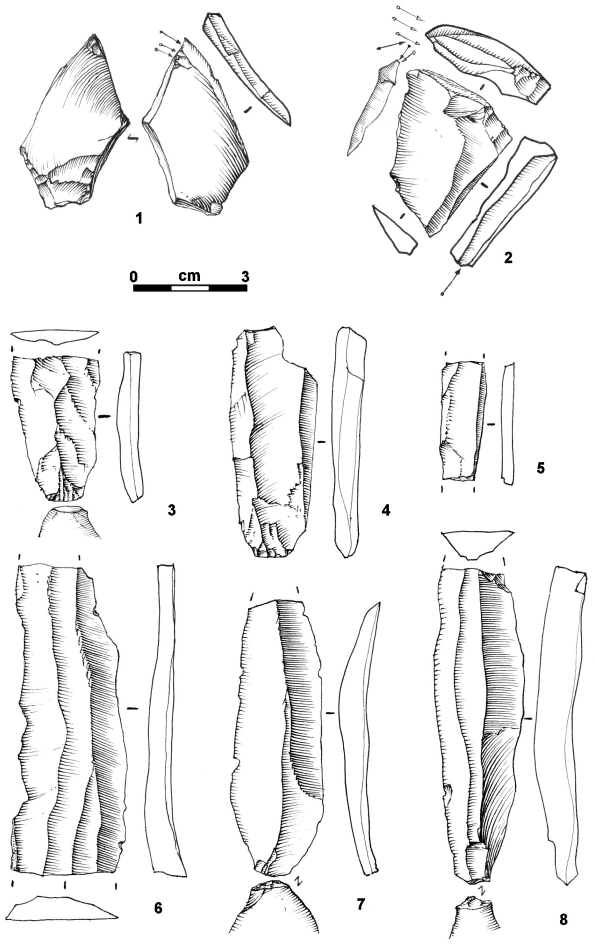

Fig. 11. Vale de Porcos lithics (all flint): 1. Vachons burin; 2. Busked burin associated with dihedral burin on angle; 3-8. blade debitage. After Zilhão, 1997.

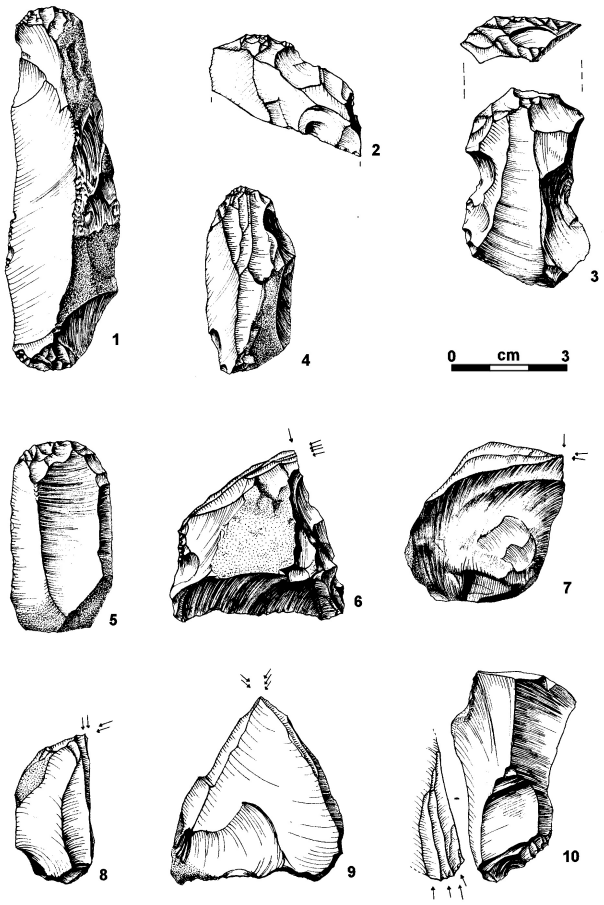

Fig. 12 . Vale de Porcos lithics (all flint). 1. double endscraper on crested blade; 2. thin, unilaterally nosed scraper; 3. Aurignacian endscraper (on strangled piece); 4. carinated scraper; 5. simple endscraper; 6. busked burin; 7. carinated burin; 8. déjeté dihedral burin; 9. straight dihedral burin; 10. burin on oblique truncation. After Zilhão, 1997.

excavators' bias against the recovery of quartz and quartzite items, which evidently characterizes all museum inventories of the Rio Maior Upper Paleolithic assembled at that time. The 1975 surface collection at Vale de Porcos II, however, showed that, in this particular case, non-flint raw-materials were indeed of negligible importance: debris excluded, the corresponding percentage is 1% (Zilhão, 1997). The value reported for Chainça by Thacker (2001) is more significant (5%), but in any case much lower than the 38% observed at Gato Preto (cf. Table 3). A possible explanation for this near-exclusive choice of flint resides in the fact that Vale de Porcos is located in the immediate vicinity of a rich flint source, consisting of abundant, medium- and large-sized cobbles contained in Tertiary and Quaternary gravel deposits of which extensive exposures exist in and around the village of Azinheira, which was a center of gun flint production well into the twentieth century.

That primary, on-site raw-material "quarrying" may have been the main activity carried out at Vale de Porcos is also indicated by several features of the lithic assemblage (Zilhão, 1997). First, the fact that formal cores (118) are as almost as numerous as formal tools (131; cf. Table 7 and Figs. 10-12), and that the number of real cores is actually much higher because the type-list counts as "retouched tools" many items that in actual fact correspond to cores, such as choppers and chopping-tools (flake cores) or thick "scrapers" and thick "burins" (bladelet cores); at Vale de Porcos, such bladelet cores make up almost two thirds of the formal tool assemblage (84 out of 131 pieces), which means that, excluding the broken pieces, the true core:tool ratio is 4.61 (194 cores to 42 tools). Second, the fact that the number of cores whence blades and bladelets were extracted (177) is almost as high as the MNI of blades and bladelets (225, calculated as the sum of the complete specimens and the proximal fragments, and including both

TABLE 9: Counts of relevant lithic production indicators in the Evolved and Late Aurignacian assemblages from the Abri Pataud, Gato Preto and Vale de Porcos (after Zilhão, 1997, and Chiotti, 1999).

ARTIFACT TYPE	GATO PRETO	VALE DE PORCOS (A)	PATAUD 8	PATAUD 7 LOWER	PATAUD 7 UPPER	PATAUD 6
Flint flakes (including formal tool blanks)	487	252	3646	2273	685	2560
Flint blades (including formal tool blanks)	10	252	499	1018	165	769
Flint flake:blade ratio	48.70	1.00	7.31	2.23	4.15	3.33
Bladelet core types						
Prismatic	3 (b)	33	<11	<12	<3	<23
Typical carinated scraper	4	1	43	11	6	13
Atypical carinated scraper	4	2	12	3	3	-
Thick-nosed scraper	26	-	55	6	3	2
Nucleiform scraper	3	-	2	1	-	-
Busked burin	2	7	-	65	3	12
Carinated and Vachons burins	-	18	-	18	2	18
Classical burins	-	57	86	148	11	61

(a) unretouched cortical material in general, and unretouched flakes in particular, are clearly under-represented in the museum collection
(b) all quartz

crested pieces and burin spalls); that such a low core productivity (1.3 blades/bladelets per blade/bladelet core) is not due to an under-representation of bladelets, resulting from putatively deficient 1950s sieving practices, is indicated by the fact that a similar situation pertains at Vale de Porcos II (where the corresponding index is 2), and by the fact that, in the Gravettian and Magdalenian sites of the Rio Maior basin excavated at the same time by the same team, both retouched and unretouched bladelets feature in the large numbers one would expect. Third, the fact that such a low productivity is simply an artifact of the marked deficit in the kinds of blanks to which production was geared, namely the low percentage of the regular, non-cortical blades with trapezoidal cross-section that would have been produced during the main reduction stage of the cores; such blanks, in fact, make up only 35% of the unretouched blades, and 16% of those that were transformed into formal tools. The figure for unretouched blades at Vale de Porcos II is 15%, which may well be closer to the original situation in the locality excavated in the 1950s, because Heleno's team used to discard on-site the pieces that were not so "fine" (i.e., quartz and quartzite flakes, on one hand, and cortical flint material on the other), thereby artificially increasing the proportion of non-cortical flint among the pieces that eventually went to make up the extant museum collections.

These facts suggest that the deficit in the final, intended products of blade debitage, as well as the small number of bladelets, retouched or unretouched, relates to a spatial dissociation between production and consumption/discard, the latter being under- and the former over-represented at the site. As seen above for Gato Preto, therefore, the insight into Aurignacian stone tool economy provided by the assemblage from Vale de Porcos is also strongly biased. In this case, the bias favors blade production, which, for the analyst, has the advantage of allowing detailed reconstruction of the methods of blade debitage that were in favor at this time (Fig. 13). Blade cores were set up on cobbles, the initial removals being guided by crests; for the most part, these cores feature a single striking platform, the edges of which were prepared by abrasion or, less frequently, by faceting. In the initial phase of core set-up and exploitation, a hard hammer was used but, when the core entered full production, the knapper would switch to a soft hammer, as suggested by the difference in the percentages of lipped butts observed among cortical blades (40%) and non-cortical blades with trapezoidal cross-section (77%); inferred by Zilhão (1997) on the basis of attribute analysis and "mental refitting" (Pelegrin, 1995), this change of knapping tool along the way, within single core reduction sequences, has since been confirmed by physical refits (Aubry *et alli*, 2006). The intended blade products were for the most part exported, although some were retouched into domestic tools (endscrapers, knives) used and discarded at the site. The byproducts of blade core decortication and set-up, in turn, were used as blanks for notches, denticulates and other substratum tools. Often, however, such cortical masses of raw-material were re-introduced in the production system as blanks for the production of bladelets, either through the prismatic method (39% of prismatic cores were made on decortication flakes) or through the "burin" method (among which the percentage of decortication flake blanks is 42%); of the two, "burins" were clearly preferred and in fact outnumber prismatic bladelet cores in a proportion of 2:1.

Although some blade cores continued to be exploited for bladelets, most were abandoned upon becoming too small to produce blades of the intended size. From the dimensions of the non-cortical blanks (which have an average width of 2.09±0.55 cm) it can be inferred that the knappers were intent on producing 2 cm wide blades; the average length of abandoned blade cores (7.26±1.72 cm), in turn, suggests that the average length of such blades would have been >8 cm, with many pieces >10 cm long, i.e., rather large, by

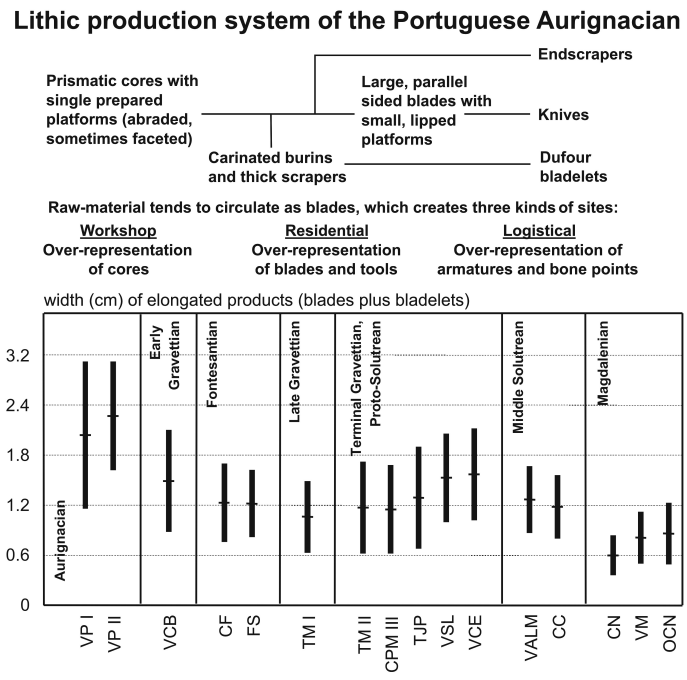

Fig. 13 . The stone economics of the Late Aurignacian of Portugal, as inferred from the features of the assemblages excavated at Vale de Porcos and level 2 of Pego do Diabo. Compared with those from later periods on the basis of their width (average ± standard deviation), the elongated products are significantly larger than at any other time in the Portuguese Upper Paleolithic. Such blades are the preferred mode of circulation of raw-material, generating a marked spatial fractionation of the lithic production system. Aurignacian: VP I = Vale de Porcos; VP II = Vale de Porcos II. Early Gravettian: VCB = Vale Comprido – Barraca. Middle Gravettian ("Fontesantian"): CF = Casal do Felipe; FS = Fonte Santa. Late Gravettian ("Protomagdalenian"): TM I = Terra do Manuel. Terminal Gravettian ("Aurignacian V"): TM II = Terra do Manuel 1988-89; CPM III = Cabeço de Porto Marinho III middle (level D); TJP = Terra do José Pereira; VSL = Vales da Senhora da Luz. Protosolutrean: VCE = Vale Comprido – Encosta. Middle Solutrean: CC = Casal do Cepo; VALM = Vale Almoinha. Magdalenian: CN = Cerrado Novo; VM = Vale da Mata; OCN = Olival da Carneira.

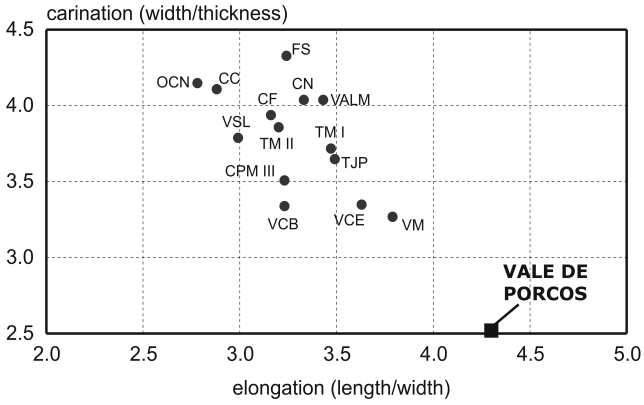

Fig. 14. Metric proportions of the Vale de Porcos bladelets, compared with those from later Upper Paleolithic periods (caption to assemblages as in Fig. 13). After Zilhão, 1997.

comparison with later periods (cf. Fig. 13). On average, the bladelets from Vale de Porcos are both more elongated and thicker than in periods when bladelet production was effected through prismatic cores as much as or more than through "burin" cores (Fig. 14). The fact that none are retouched and that, as discussed above, their numbers are too low by comparison with the number of corresponding cores, indicates that, as suggested for Gato Preto, most such blanks were exported as retouched microlithic barbs and points used to arm composite tools, manufactured or repaired at the site, but discarded elsewhere in the landscape.

Pego do Diabo

Table 8 lists the total amount of artifacts recovered in Pego do Diabo level 2, the most conspicuous tools being the Dufour bladelets discussed above. Technologically, their straight profiles and marked elongation suggest blanks extracted from "burin"-type cores of the diverse dihedral and on truncation varieties so well represented in the Vale de Porcos assemblage; when sufficiently complete, these bladelets are bilaterally pointed (by marginal, direct retouch, combined with invasive, semi-abrupt, ventral retouch). A seventh bladelet tool, made on a short, curved blank and bearing a bilateral direct marginal retouch is probably a variant of the type; the pattern of dorsal removals shows prior extraction of bladelets from opposed striking platforms, which excludes the possibility that the core whence the blank was extracted was of the carinated or thick-nosed "scraper" variety, and suggests instead a multiple, arched or carinated "burin", the most common type of bladelet core at Vale de Porcos (see below). The overall low numbers of items, as well as the absence of cores, unretouched blades and bladelets, combined with the reduced amount of chippage, indicate that this was a place of consumption without production, of the kind whose existence one might predict from the predominantly workshop characteristics of the assemblages documented in the Rio Maior basin.

Inter-assemblage variability

The under-representation of the intended blade products in the workshop sites suggests a system where such blade blanks would have been the preferred form under which flint was transported across the landscape as people moved from camp to camp. However, the residential sites whose existence can be inferred from such a system – and which should be characterized by significant amounts of discarded, retouched and resharpened blades and blade tools, combined with comparatively low numbers of blade cores – have not yet been found.

When Gato Preto is compared with Vale de Porcos (Fig. 15; Table 9), it is also clear that these two workshop sites differ in the nature of the preferred bladelet production method. Whereas prismatic cores and dihedral and on truncation "burins" largely predominate at Vale de Porcos, at Gato Preto carinated, thick-nosed and nucleiform "scrapers" and "burins" are almost

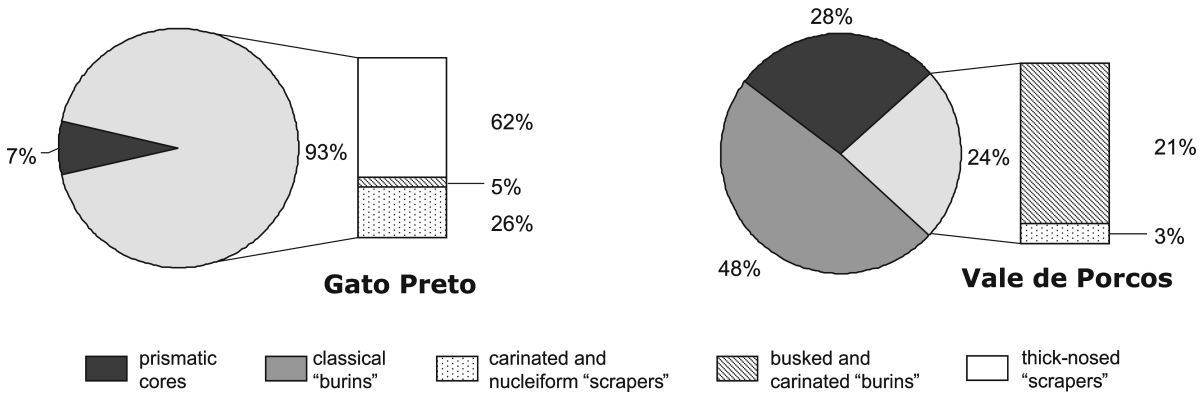

Fig. 15. The composition of bladelet core assemblages at Gato Preto and Vale de Porcos. After Zilhão, 1997.

exclusive; and, among the latter forms, thick-nosed "scrapers", the most numerous at Gato Preto, are altogether absent from Vale de Porcos, where their role in bladelet production is taken over by carinated "burins". These contrasts are consistent with those observed in southwestern France between the Aurignacian II (with which Gato Preto compares well) and the Aurignacian III/IV (with which Vale de Porcos compares well), as defined in the classical sequence of La Ferrassie (Delporte and Mazière, 1977; Delporte, 1991; Mellars *et alli*, 1987); they also confirm that, as suggested above, the differences between the assemblages described in the previous sections relate to both functional and diachronic factors.

Comparison with the Abri Pataud Sequence

The role played by diachronic change in the inter-assemblage variability of the Portuguese Aurignacian becomes quite apparent as soon as the Portuguese sites are compared with the Abri Pataud sequence. This comparison is now possible because the technological and typological attribute analysis of the Pataud assemblages carried out by Chiotti (1999) provides a previously unavailable level of detail akin to that produced for the Portuguese Upper Paleolithic as a whole by Zilhão (1997).

The dominance of thick-nosed "scrapers" over carinated ones that characterizes Gato Preto suggests affinities with layer 8 of Pataud (Fig. 16; cf. Table 9). The latter, moreover, features the highest flake:blade ratio of all of Pataud's Evolved and Late Aurignacian occupations, the "flakier" nature of its lithic assemblage being consistent with the scarcity of blades at Gato Preto; the comparison also makes it clear that the extremely high value obtained for that ratio at the Portuguese site (six times higher than at Pataud 8) must relate to the functional specificity of Gato Preto, not to a putative lack of blade production in Aurignacian II times. The two assemblages also differ in that Gato Preto yielded two busked "burins", which are altogether absent, as are carinated "burins", from layer 8 of Pataud; in the French site, such "burin" forms appear in layer 7 lower for the first time in the sequence. If this contrast between Gato Preto and Pataud 8 is not caused by differences in the criteria of typological classification used by the analysts, and assuming that the variation in the use of (or the preference for) such kinds of "burins" has temporal significance, Gato Preto would then be no earlier than Pataud 7 lower. Thus, on one hand, the high value (3.25) of Gato Preto's thick-nosed:carinated "scraper" ratio suggests contemporaneity with Pataud 8 (that ratio decreasing markedly, from 1.00 to 0.43, when the Pataud 8 lithics are compared with those from Pataud 7 lower), whereas, on the other hand, the few busked "burins" from Gato Preto suggest contemporaneity with Pataud 7 lower. Given that the Pataud assemblages are themselves low resolution palimpsests of many different individual occupations, a simple solution to the apparent dilemma is that the affinities presented by the single, short-lived occupation of Gato Preto with both the Pataud 8 and Pataud 7 lower lithics relate to the fact that the Portuguese site is of intermediate chronology.

Unfortunately, the chronometric evidence associated with these two Pataud inventories is ambiguous, and consistent with their being either rather close in time or separated by a major hiatus. Layer 8 is dated on an ash sample from Hearth A to ca.31,800±280 ^{14}C BP (GrN-6163), whereas layer 7 lower is dated by two charcoal samples from a single hearth (Hearth W1) to 32,900±700 ^{14}C BP (GrN-3116) and 32,800±450 ^{14}C BP (GrN-3117); a third date from the same hearth (29,300±450 ^{14}C BP, GrN-3105), however, is significantly younger (Chiotti, 1999). Given that layer 7 lower is described by Chiotti as "a large ovoid depression dug into the underlying deposits" (idem, p. 90-91), it is conceivable that the two earlier results for Hearth W1 relate to the

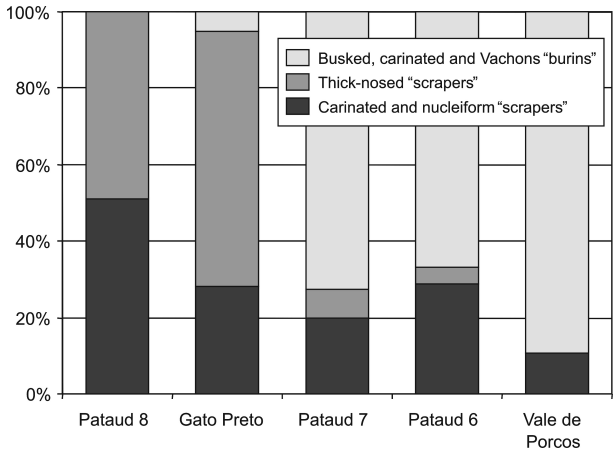

Fig. 16 – The composition of the assemblages of special bladelet core types characteristic of the Aurignacian at Gato Preto and Vale de Porcos, compared with the Evolved and Late Aurignacian levels of the Abri Pataud. After Zilhão, 1997, and Chiotti, 1999.

incorporation in the dated samples of considerable amounts of older material, and that only the younger result represents a reliable assessment of its age; another possibility is that this hearth should actually be considered as part of layer 8 (in which case all the other hearths included by the excavators in layer 7 lower – W2, W3, X and Y – would also have to be considered as part of layer 8, because the stratigraphic relation between these different features shows that W1 is the most recent). That the dates for Hearth W1 simply represent a *terminus post quem* for layer 7 lower is in any case made clear by the fact that the feature was situated at the base of the unit, and entirely covered by the deposits that actually contained the fauna and the artifacts labeled 7 lower. These facts are consistent with an age somewhere between ca.32 and ca.29 ka ^{14}C BP (or between ca.37.0 and ca.34.3 ka cal BP) for Gato Preto, well within the one sigma range of its TL chronology (cf. Table 2).

Chiotti's (1999) description of the lithic assemblage contained in layer 6 of Pataud – which caps the site's Aurignacian sequence, and is separated from underlying layer 7 upper (archeologically poor and containing a lithic assemblage akin to that in layer 7 lower) by an almost sterile eboulis varying in thickness between 20 and 50 cm – matches point by point that made by Zilhão (1997) for Vale de Porcos. Metrically, the cores from Vale de Porcos and Pataud 6 were abandoned at identical stages of reduction, 5.99 cm long and 130 g on average at the French site, 6.70±2.22 cm and 162±132 g at the Portuguese one; of those cores, 36 out 56 (64%) are prismatic or "*à tendance prismatique*" in Pataud 6, the corresponding figure at Vale de Porcos being higher (91%), the difference probably relating to the functionally specialized nature of the latter site. Of the prismatic cores, 63% at Vale de Porcos and 57% at Pataud 6 are single platform, the corresponding percentages for blades with unidirectional dorsal scar patterns being 80% and 89%, respectively. At both sites, prismatic blade cores were set up with crests – the blades:crested blades ratio (using the MNI of complete pieces plus proximal fragments) being of 8:1 at Vale de Porcos and 9:1 at Pataud 6 – and, initially, reduced with hard hammers, soft hammers being used only when the volume was ready for extraction of the intended products to begin (where Pataud 6 is concerned, Chiotti infers this change on the basis of the difference in butt thickness between debitage products extracted early and late in the reduction sequence). Preparation of the striking platform was made through both abrasion and faceting in the two assemblages, originating blade blanks with identical butt types (overwhelmingly unfaceted-abraded, faceted, linear or punctiform) and dimensions: the average width and thickness of the Pataud 6 blades (both unretouched and transformed into tools) are 2.32 cm and 0.76 cm, respectively, the corresponding values at Vale de Porcos being of 2.25±0.62 cm and 0.75±0.30 cm.

The two assemblages are also identical in that, for the production of bladelets, "classical" burins were clearly preferred over "Aurignacian" forms (thick-nosed, carinated and nucleiform "scrapers" and "burins") and prismatic cores (cf. Table 9; Figs. 16-17). Where the latter are concerned, exact figures are not available for Pataud 6, but the number of prismatic cores for bladelets has to be less than the total of 23 "*vrais nucléus prismatiques*", i.e., significantly below the numbers for the other two categories. Chiotti (1999, p. 626-629) describes instances of prismatic cores reduced for bladelets and, given that >75% of the complete blades are >4.5 cm long, it is clear that all cores exploited to sizes smaller than that (10 in total), as well as some of the slightly longer ones, must have been used for the production of bladelets. In light of these data, one can assume that the proportion of those prismatic and "*à tendance prismatique*" cores from Pataud 6 that were reduced for bladelets was of the same order of magnitude as at Vale de Porcos, where that proportion was of 34%; under this assumption, the number of prismatic bladelet cores at Pataud 6 can then be calculated within reasonable error limits to have been of around 19.

This estimate was used for the comparisons in Fig. 17, which also show that, among the typically Aurignacian kinds of bladelet cores, carinated (including Vachons) and busked "burin" forms are as dominating at Pataud 6 as they are at Vale de Porcos, followed by carinated "scrapers", whereas thick-nosed "scrapers", absent at Vale de Porcos, are only marginally represented at Pataud 6. The unretouched bladelets (excluding those clearly identifiable as "burin spalls", formally counted as retouch residues at both sites and, hence, not included among the debitage, even if it is clear that the role played by most "burins" in the lithic production system was that of bladelet cores), in turn, have exactly the same dimensions at both sites,

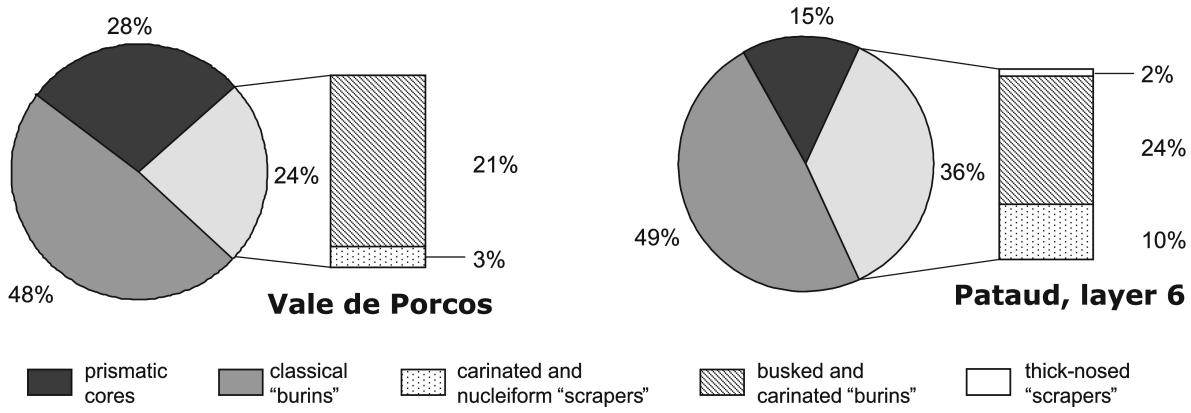

Fig. 17. The composition of bladelet core assemblages at Vale de Porcos and layer 6 of the Abri Pataud (where the latter is concerned, because no exact figures are available, the number of prismatic cores reduced for bladelets is estimated on the basis of the assumption that their proportion in the total number of prismatic cores is identical at both sites). After Zilhão, 1997, and Chiotti, 1999.

their average width and thickness being of 0.92 cm and 0.34 cm at Pataud 6, and of 0.87±0.24 cm and 0.33±0.07 cm at Vale de Porcos, respectively. The latter site yielded no retouched bladelets, but four were recovered at Pataud 6. Among these, two are clearly Dufour subtype specimens (cf. Fig. 8, nos. 1-2), and the other two (cf. Fig. 8, nos. 3-4) bear the same kind of bilateral, marginal, direct retouch observed in one of the Pego do Diabo pieces (cf. Fig. 7, no. 14). It must also be stressed that this is the only moment in the >2 m thick Aurignacian sequence of Pataud (which lacks a Protoaurignacian, and begins with the classical Aurignacian I) where bladelets of the Dufour subtype occur, supporting the inference that the identical material from Zafarraya and Pego do Diabo belongs to the Late Aurignacian indeed.

Thus, although no chronometric dating is available to support the attribution of the Vale de Porcos assemblage to the Late Aurignacian, the inference that such is its age is clearly brought up by the comparison with the Pataud sequence, as well as by the fact that the technological and typological features shared by the two collections are, in turn, undocumented in any of the numerous Portuguese assemblages of known Gravettian, Solutrean or Magdalenian age. Where chronometric dating is concerned, two AMS bone dates (OxA-582 and OxA-690 – 24,340±700 and 26,600±800 ^{14}C BP, respectively) are available for the uppermost part of Pataud 6; the exact provenience of the samples is unknown, but the fact that the results are clearly too young for the Aurignacian, and fall in the time range of the Gravettian occupations contained in immediately overlying layer 5, probably relates to their being truly of Gravettian age. This view is consistent with the fact that, as pointed out in Chiotti's (1999, p. 100) description of layer 6, this unit was extensively "truncated and completely disturbed by the occupants of layer 5" over a significant percentage of the excavated area. The conventional result of 28,510±280 ^{14}C BP (GrN-6273) also reported by Chiotti for layer 6 would thus seem to be at present the best age estimate for the lithic assemblage contained therein and, hence, for that recovered at Vale de Porcos too.

Conclusion

In spite of the limitations of the corpus, the combined weight of the evidence reviewed above is strongly in favor of the following conclusions:

- The Portuguese Upper Paleolithic sequence does begin with the Aurignacian;
- Given the features of the assemblages, and in agreement with the dating evidence, all known occurrences must relate to the later phases of the technocomplex;
- A marked differentiation exists between sites where procurement/primary production activities predominate (workshop sites, such as Gato Preto or Vale de Porcos), and sites where discarded armatures are the most significant tools and no production is documented (logistical sites, such as Pego do Diabo, Salemas and Escoural);
- Gato Preto represents a functionally specialized pose of the Aurignacian II, contemporary with layer 8 (or intermediate between layers 8 and 7 lower) of the Abri Pataud;
- Vale de Porcos and the Dufour bladelet assemblages from the cave sites of Pego do Diabo, Salemas and Escoural correspond to functionally contrasted poses of the Late Aurignacian (III/IV of the La Ferrassie sequence), contemporary with layer 6 of the Abri Pataud.

If the appearance of the Aurignacian in Portugal is taken as a proxy for the first dispersals of modern human groups into Iberian

regions south of the Ebro divide (Zilhão, 1993a, 1993b, 1997, 2000; Zilhão and Trinkaus, 2002), further implications of the comparison between the Portuguese sites and the Abri Pataud sequence are, then, that such dispersals (1) must have occurred before the end of the Aurignacian II in southwestern France and northern Spain, and (2) at a time which is consistent with the range of dates obtained for the Neandertal-associated late Mousterian of Portugal. Where the end of the Aurignacian II is concerned, the GrN-3105 result of 29,300±450 ^{14}C BP (ca.34.8 ka cal BP) for Hearth W1 of Pataud, situated in intermediate stratigraphic position between layers 8 and 7 lower, provides a good *terminus ante quem*, and is consistent with both the TL age for Gato Preto and the already mentioned KN-1/926 result for Mallaetes (29,690±560 ^{14}C BP, i.e., ca.35.2 cal ka BP). To assess the end of the Mousterian in Portugal, in turn, one can use the U-series result of 33,600±500 cal BP obtained for the open air site of Foz do Enxarrique (Raposo *et alli*, 1985; Brugal and Raposo, 1999). Since the overlap between these results is situated in the second half of the thirty-fifth millennium cal BP, that is where the lower limit of the Portuguese Aurignacian range would therefore have to be placed. Accepting the date for sublevel 2b of Pego do Diabo (ca.28.1 ka ^{14}C BP, or ca.32.5 ka cal BP) as a good estimate of the age of the site's assemblage of Dufour bladelets, the upper limit, in turn, would fall somewhere in the thirty-second millennium cal BP. Thus, the duration of the initial, Aurignacian episode of the Portuguese Upper Paleolithic sequence may be estimated at some 1500 radiocarbon years, which, given the shape of the calibration curve at this point, actually translates into at least some two and a half calendar millennia.

Given the nature of the cultural interaction between hunter-gatherer groups characterized by exogamic marriage rules, it can be safely assumed that, once contact was established, the coexistence of Aurignacian and Mousterian technologies would have been a rather short-lived phenomenon (i.e., of a duration inferior to the error inherent to chronometric dating results in this time range). Under these premises, two other important implications inevitably follow: first, that the ca.27.6 ka ^{14}C BP result (ca.31.6 ka cal BP) obtained for uppermost layer K of Caldeirão cave (Zilhão, 1997) represents a minimum age only, or signals intrusiveness of the sample from overlying EUP level Jb (which is supported by the fact that all other attempts at dating bones from level K failed due to the insufficient collagen content of the samples); second, that, conversely, the dates in the ca.33 ka ^{14}C BP range (ca.37.5-39.0 ka cal BP) obtained on "sediments and charcoal" samples for the Aurignacian II industry contained in Bajondillo's level 11 are too old, reflecting important contamination from bedrock. At this latter site exceptionally, the possibility of such a contamination must in fact be seriously entertained because the cave/shelter is excavated into earlier Upper or Late Middle Pleistocene travertines. Thus, the sediment fill comes to a large extent from the degradation of the walls and, consequently, the "sediment" in the hearth samples must have incorporated carbon material significantly older than the wood burned there, and in an unknown proportion. If we bear in mind that, given the laws of radiocarbon decay, 12% of sediment carbon with an age in the 100-200 ka BP interval, mixed in a sample otherwise made of wood charcoal with an age of ca.31 ka ^{14}C BP, suffice to produce a measurement of ca.33 ka ^{14}C BP for the total sample, it becomes obvious why the Bajondillo dates must be taken with serious reservations.

Alternatively, if the results for Caldeirão and Bajondillo are confirmed by future research, the implication would be a rather more delayed, mosaic interaction process, with (1) "pockets" of Aurignacian people (either representing dispersing modern humans or the precocious acquisition of Aurignacian technology by aboriginal Neandertals) penetrating into Mousterian territory quite early on, and (2) conversely, small "pockets" of Mousterian Neandertals surviving for many centuries in total isolation in at least some parts of western Iberia. For reasons exhaustively discussed elsewhere (Zilhão, in press), this alternative scenario is rather unlikely.

Thus, as a corollary of the evidence reviewed above for the taxonomic entity and chronometric dating of the Portuguese Aurignacian, it would seem that the dispersal of modern humans into southern and western Iberia, and the ensuing disappearance of aboriginal Neandertal groups (by whatever mechanism, most likely absorption – Zilhão and Trinkaus, 2002), can at present be dated to the cold phase following the GIS-7 (Greenland Interstadial 7) temperate episode, the peak of which is ca.35.2 ka cal BP (ca.29.8 ka ^{14}C BP). This cold phase brings to its end a rather extended period, beginning after the end of Heinrich Event 4, ca.39.0 ka cal BP (ca.33.0 ka ^{14}C BP), characterized, in Iberia, by predominantly mild conditions. The simultaneous timing of such significant events in the spheres of cultural process and climate history – the calendar ages for which are derived from Abreu *et alli* (2003), Roche *et alli* (2004), Shackleton *et alli* (2004) and Weninger and Jöris (2005) – probably reflects an underlying causal link, not simple coincidence.

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