Andreas Pastoors & Bärbel Auffermann (eds.):
Pleistocene foragers on the Iberian Peninsula: Their culture and environment.
Festschrift in honour of Gerd-Christian Weniger for his sixtieth birthday.
Wissenschaftliche Schriften des Neanderthal Museums 7, Mettmann 2013.

# SEEING THE LEAVES AND NOT MISSING THE FOREST: A PORTUGUESE PERSPECTIVE OF THE SOLUTREAN

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*Abstract*

In a 1964 synthesis, Roche concluded that the Upper Palaeolithic of Portugal remained largely unknown, the presence of the Solutrean being the only fact that could be unambiguously ascertained. Subsequent work has radically changed this situation and, where the Solutrean is concerned, has established that its culture-stratigraphy sequence accords well with the traditional subdivision systematised for France by Smith, which was based on the successive appearance of different index fossils. Where lithic point typology suggests a break, this is confirmed independently by accompanying changes in the basic technology of blade production. In some cases, the existence of a given unit of the subdivision can only be inferred from the identification of the corresponding index fossils in palimpsest contexts. The identification of such contexts as being mixed post-depositionally, and not as documenting a true coexistence of point types, which would falsify the overall sequence, is made easy by the fact that, in Portugal, most Last Glacial Maximum (LGM) sites are open air and feature few (if not single) occupation levels. This fact has advantages and disadvantages. On one hand, the fairly complete reduction sequences enable the reconstruction of total lithic production systems, and the enveloping geology well illustrates the impact of the period's environmental instability. On the other hand, issues of change through time have to be addressed largely through stratigraphic correlation and radiocarbon dating, and are often complicated by the representativity problems raised by special-purpose, logistical sites. These issues are of broader archaeological interest, as are the implications of the Solutrean's chronostratigraphic sequence for the palaeoanthropological interpretation of patterns of technological change. Where the LGM of south-western Europe is concerned, such implications are, namely, that the distribution and abundance of sites is conditioned by taphonomy more than by demography, and that considerations of social geography are of greater explanatory power to understand the emergence and development of the Solutrean than more traditional origins questions.

*Keywords*

Upper Palaeolithic, Solutrean, Portugal, Last Glacial Maximum

## Introduction

Writing at about the same time as Smith approached the conclusion of his monumental study of the Solutrean in France (Smith 1966), Roche (1964) stated that nothing much could be said about the Upper Palaeolithic occupation of Portugal beyond ascertaining human presence during the Solutrean. Almost fifty years later, the situation is dramatically different. However, since the characteristic index fossils of the Solutrean (Fig. 1) make it easy to recognise its manifestations even when the sites are no more than surface scatters or stray finds devoid of stratigraphic context, this techno-complex remains the better-known period of the Portuguese Upper Palaeolithic. In terms of the number of occurrences, however, the Gravettian comes close, if it has not overtaken it already (Zilhão 1997, 2001, 2002).

Most sites of the Gravettian and the Solutrean of Portugal date to a relatively short period of time, immediately before and immediately after the Last Glacial Maximum (LGM). This circumstance is largely a by-product of geological constraints controlling the formation and preservation of late Upper Pleistocene deposits (Angelucci 2002; Zilhão & Almeida 2002; Angelucci et al. 2005). As a result, investigations carried out during the last quarter of the 20th century in the littoral central part of the country (Portuguese Estremadura) revealed a record of the Gravettian-to-Solutrean transition featuring a level of resolution and detail that remains unparalleled in southwest Europe (Zilhão & Aubry 1995; Zilhão et al. 1997, 1999; Almeida 2000; Zilhão & Almeida 2002). The terms of this transition are:

1. An initial Late Gravettian (equivalent to the Perigordian VII or the Protomagdalenian of the Périgord), where carinated scrapers-cores make an initial, timid reappearance, and marginally backed bladelets made on blanks extracted from such cores are found alongside the backed-and-truncated bladelets and micrograveттes that dominate the microlithic component of the tool-kit.

2. An intermediate Terminal Gravettian, where the technology of blade production follows preceding traditions (primarily unipolar reduction of prismatic cores with platforms prepared by abrasion, producing slender, lipped products), but where the robust backed bladelet and micrograveттe components are replaced by smaller, thinner, marginally retouched bladelets made on blanks extracted from carinated or nosed scrapers-cores. This latter component is not a full-fledged, independent technological system defining an epigonical Aurignacian V, which is an artificial construct created by Bordes (1958, 1959) on the basis of material from Laugerie-Haute Est selected post-excavation among the lithic collections from a number of different stratigraphic units.

3. A final Protosolutrean, where the arming of any bone/wood projectile points that may have continued to be part of the hunting weaponry was effected with unretouched bladelets or small flakes, and where projectile tips were now predominantly, if not entirely, made of stone and obtained via minimal modification of large, hard hammer-extracted, triangular blanks with dorsally thinned butts — the Vale Comprido points (Fig. 1,10).

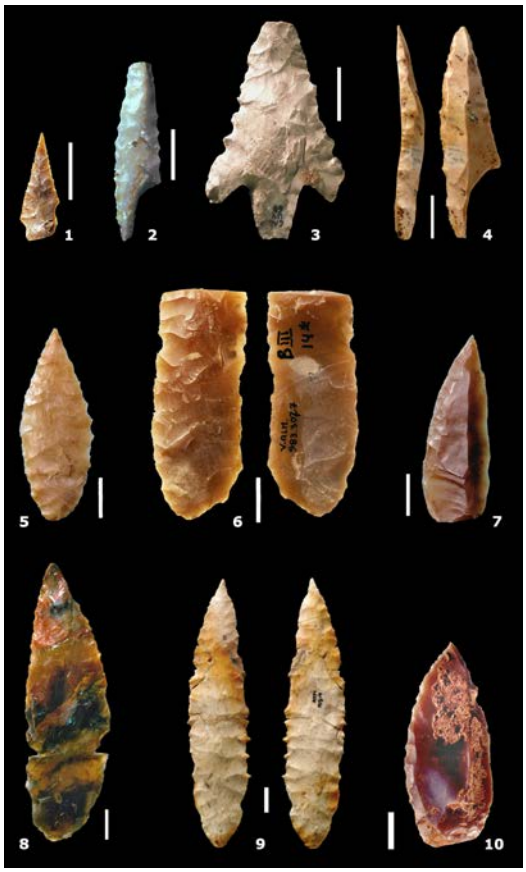



Fig. 1 Index fossils of the Portuguese Solutrean (all scale bars = 1 cm): 1. microlithic foliate point; 2. Cantabrian-type shouldered point; 3. barbed-and-tanged (Parpalló) point; 4. Mediterranean-type, backed-and-shouldered point; 5. small laurel-leaf; 6. willow-leaf; 7. *pointe à face plane*; 8. laurel-leaf with convex base; 9. laurel-leaf with denticulated edges; 10. Vale Comprido point. 1,5-8: Vale Almoinha; 2-3: Gruta do Caldeirão; 4,9: Galeria da Cisterna (Almonda); 10. Terra do Manuel (1940-42).

The initial Late Gravettian is well-represented at Terra do Manuel (layer 2s), and the intermediate Terminal Gravettian at Lapa do Anecrial (layer 2) and the Lagar Velho rock shelter (Hanging Remnant layer 9). It is the final Protosolutrean stage, now well-documented in France too (Renard & Teyssandier 2007), which provides the base line for all subsequent technological developments of the Solutrean. In the following, I will describe (after Zilhão 1997) the trajectory of such developments as currently known in Portugal. I will then discuss in what ways this trajectory does (or does not) set Portugal apart from the patterns documented elsewhere in the Solutrean world. Finally, in the light of my findings, I will conclude with a discussion of different explanations for the Solutrean phenomenon in terms of technology, culture and adaptation. Throughout, calibration of radiocarbon dates uses CalPal Online (www.calpal-online.de). The actual results cited in the text, and associated sample details, are given in table 1.

## Culture-stratigraphic sequence

### Lower Solutrean

The stratigraphic and chronometric evidence from the Abrigo do Lagar Velho — where multiple, concordant dates place the Terminal Gravettian in the ~21.5-21 14C (~25.5-25 cal) ka BP

interval — constrains the lower chronological limit of the Protosolutrean as defined above. At this and other Portuguese sites, the Middle Solutrean, as defined below, is no earlier than ~20.5 14C (~24.5 cal) ka BP. No sites are known where well-defined, individualised stratigraphic units dated to within the intervening five to ten centuries exist; moreover, in long stratigraphic sequences, this interval either coincides with a discontinuity (e.g., at Lagar Velho, the erosional scar between layers 9 and 6 of the Hanging Remnant) or is conceivably represented but subsumed in a palimpsest deposit (e.g., at Caldeirão, layer I) (Figs. 2-3).

The type-site for the Vale Comprido point (Vale Comprido – Encosta, Rio Maior) yielded a few examples where such points combined the characteristic dorsal thinning of the butt with some degree of unifacial, flat retouch along the edges (e.g., Zilhão 1997, vol. II, Fig. 23.13,14). A find complex presumably representing a nearby *locus* (Vale Comprido – A), in turn, yielded typical *pointes à face plane*, some with ventral thinning of the proximal end (e.g., Zilhão 1997, vol. II, Fig. 23.7,2-3). Combined with the fact that there are no reliable dates in excess of ~20.5 ka 14C age BP for assemblages containing laurel-leaves, neither in Portugal nor in adjacent regions, this evidence suggests that (a) the Protosolutrean dates to ~21 ka 14C age BP, and (b) the ~21-20.5 ka 14C BP black hole of the Portuguese sequence corresponds to a Lower Solutrean phase as typologically defined by Smith (1966) - featuring *pointes à face plane* with dorsal, invasive flat retouch (e.g., Fig. 1,7) but lacking in bifacial foliate points.

From a technological point of view, the emergence of the Lower Solutrean from a Protosolutrean background is easy to envisage: The *pointe à face plane* would come about as a by-product of the search for a better control of the final shape of points made on Vale Comprido blanks, or of the need to resharpen broken ones. There are examples at Vale Comprido that suggest experimentation with abrupt retouch as a means to achieve this end (e.g., Zilhão 1997, vol. II, Fig. 23.13,15). Eventually, however, the method of flat, progressively more invasive retouch was selected. Why this was the case remains to be explained, but the parsimonious hypothesis (and one that should be easy to test via experimental knapping) is a mechanical one: Given a triangular, carinated blank with a thick proximal end, flat, invasive retouch is probably more efficient, in terms of maintaining the length of cutting edges as much as in terms of the time and work processes involved.

## Middle Solutrean

The stratigraphic and chronometric evidence from Gruta do Caldeirão provides a *terminus ante quem* for the Middle Solutrean of ~19 14C (~23 cal) ka BP, the date obtained for Upper Solutrean layer Fc. However, the single occupation site of Vale Almoinha, dated to the 20.5-20 14C ka BP interval, yielded a Middle Solutrean assemblage featuring at least one Upper Solutrean index fossil, the willow-leaf (Fig. 1,6). This fact could be taken to suggest that the site dates to a transitional period between the Middle and the Upper Solutrean and, therefore, that the latter emerged at the turn from the 19$^{th}$ to the 20$^{th}$ radiocarbon millennium BP. On the other hand, the Vale Almoinha assemblage lacks unambiguous shouldered points and, typologically, it is overwhelmingly dominated by typically Middle Solutrean laurel-leaves (more than one hundred, including preforms). This evidence indicates that the Middle Solutrean lasted until at least ~20 ka 14C age BP, but the level of uncertainty that remains means that the following millennium is yet another black hole in our knowledge of the culture-historical development of the Portuguese Upper Palaeolithic. Another implication is that the index fossil significance of the willow-leaf cannot be taken for granted and should be open for reassessment.

Middle Solutrean blade production (as exemplified at the single component, open air sites of Vale Almoinha and Casal do Cepo) is radically different from that seen in the Protosolutrean. Core platforms are carefully prepared via microfaceting, with the purpose of extracting thin, slender blanks. At Vale Almoinha, 75 % of such blanks had widths comprised between 0.8 and 1.6 cm, with bladelets representing the lower end of the distribution of the elongated products, all of which were obtained in the framework of a single reduction sequence. The abundance of splintered pieces and of cores

for chips suggests that tools with handles or shafts made of bone and wood were at this time armed with non-standardised lithic elements (unretouched bladelets, small flakes and chippage).

Blanks from the initial stages of this reduction sequence were retouched into end scrapers and other substrate tools, while *plein débitage* products were used as knives (unretouched, or made into blades with continuous retouch). When the knapper intended to obtain blanks for *pointes à face plane*, reduction proceeded through the alternating exploitation of two opposed platforms, generating regular, thin, straight products with bidirectional dorsal scars, the wider of which were then transformed by retouch into objects that, for the most part, conform to Smith's (1966) tear-shaped subtype B and have an average width of 1.5 cm (1.58±0.34, at Vale Almoinha; 1.46±0.21 at Casal do Cepo). Analysis of the unfinished items indicates that such a transformation followed a standardised sequence of gestures: First, the base was given its rounded shape via the application of peripheral, direct retouch, then the bulb was eliminated via inverse, flat, often invasive retouch, and, finally, the mesial and distal parts of the point were given the required convergent morphology, including the shaping of the tip (as only a small percentage of blanks came out naturally pointed to begin with). Given experimental evidence (Aubry 1991, 181), the thinness of the blanks (≤0.5 cm thick in 89 % of the points whose length could be measured or reliably estimated), implies that pressure flaking was used.

Bifacial shaping of nucleiform (plaquettes) or flaked blanks for the production of laurel-leaf points constituted a separate *chaîne opératoire* but shared many aspects of knapping technique with blade production and *pointe à face plane* retouch; for instance, preform edges were prepared for thinning via careful microfaceting, generating butts that, in this regard, do not differ from those seen in *plein débitage* blades. A significant innovation, and one that was used only in the context of foliate manufacture, is heat pre-treatment of the flint (e.g., Zilhão 1997, vol. II, Fig. 27.9,1). Typologically, laurel-leaves of the Portuguese Middle Solutrean are overwhelmingly of Smith's (1966) subtype C (with convex, rounded bases; cf. Fig. 1,5 & 8), including miniatures, but subtypes G, L and M also occur. Use of laurel-leaves as the hafted stone tips of projectile points is documented by the characteristic impact fractures present in some specimens (e.g., Fig. 1,8). The smaller (e.g., Fig. 1,1 & 5) are similar to the *pointes à face plane* in overall size, width of the base, and weight, but most are significantly larger, suggesting that they armed thrusting, not throwing weapons. However, in some cases, and particularly where subtype M is concerned, overall shapes are more suggestive of a use as knives, not points.

From a technological point of view, there is no clear break between the Middle Solutrean and the theoretical Lower Solutrean reconstructed above. One can easily imagine the development of the former out of the latter as a process whereby the technical demands of using flat retouch on thick, triangular blanks drive a change in production methods, geared towards the extraction of better-suited, less carinated blanks. Once the logic of optimising the blank's morphology through flat retouch is in place, extending such retouch to the entire blank (and, eventually, to both sides of it) is an almost inevitable further step. Therefore, in terms of both blade technology and foliate production, the Middle Solutrean can be seen as the result of emergent, self-organising properties of the flint knapping process, the fixation of which was favoured by inventions (such as the heat pre-treatment of flint) that facilitated and optimised manufacture.

### UPPER SOLUTREAN

At Gruta do Caldeirão, index fossils of the Upper Solutrean — shouldered points, and barbed-and-tanged points (Fig. 1,2-4) — occur in layers Fb and Fa. The radiocarbon result for the underlying layer Fc provides a *terminus post quem* of ~19 14C (~23 cal) ka BP for these two Caldeirão units. Sedimentologically, however, the characteristics of layers Fa, Fb and Fc are suggestive of a very rapid accumulation; therefore, the deposition of the entire ensemble may well have taken place within the time interval defined by the 95 % confidence interval associated with that date (~19.2-18.4 ka

14C age BP). The radiocarbon result for Ensemble 9 of Buraca Grande (17850 ± 200 BP, Gif-9502; Aubry & Moura 1994), in turn, suggests that this phase may not have come to an end until ~18 14C (~21.5 cal) ka BP.

There are no collections of Upper Solutrean unretouched laminar products that are large enough for statistically meaningful attribute analysis; but, when geared for the extraction of blanks for points, the basic features of the period's blade production can be reconstructed through analysis of the finished tools. Since a significant proportion of shouldered points feature straight profiles and bidirectional dorsal scar patterns, one can make a robust inference of continuity with the preceding Middle Solutrean method of producing blanks for *pointes à face plane* through the alternating exploitation of opposed platform cores. However, there is a return to more traditional techniques of platform preparation (abrasion and faceting); microfaceting remains unobserved (which needs not imply that it was abandoned altogether).

A significant discontinuity with the Middle Solutrean is apparent in the reappearance of a backed (often backed-and-denticulated) bladelet component, well represented at Gruta de Salemas; in all likelihood, this component is functionally associated with antler sagaies bearing lateral grooves, such as the specimen from layer Fa of Gruta do Caldeirão (Zilhão 1997, vol. II, Fig. 27.6,3; Chauvière 2002, Fig. 6,1). In both blade debitage and microlith production, the Upper Solutrean represents, to a large extent, a return to Gravettian traditions that had been abandoned (but, obviously, not forgotten) for more than two millennia. In this context, the use of abrupt retouch to manufacture the tangs of some shouldered points is not surprising; and, indeed, the backing of the side opposite to the shoulder with this type of retouch can be observed among both types of such points, Cantabrian (e.g., Fig. 1,2) and Mediterranean (e.g., Fig. 1,4).

Laurel-leaves (e.g., Fig. 1,9), and especially small ones, are still found in known Upper Solutrean contexts, but none yielded *pointes à face plane*. The different types of shouldered points must correspond, therefore, to functional replacements of the latter, as is further suggested by overall similarity in length and weight. Shouldered points, however, are narrower (measured at the top of the tang, average widths, in cm, are 1.13 ± 0.20 and 0.98 ± 0.23 for the Cantabrian and the Mediterranean types, respectively), indicating that the change in the morphology of projectile stone tips was in all likelihood driven by changes in hafting techniques.

A point that remains mute is that concerning the interpretation of the coexistence between shouldered and barbed-and-tanged points. At Gruta do Caldeirão, in agreement with Tiffagom's (2007) theoretical reconstruction of the Parpalló sequence, barbed-and-tanged points first appear in layer Fb, while *in situ* instances of shouldered ones were recovered in overlying layer Fa only (the small number of finds, however, means that the pattern cannot be generalised without a significant level of uncertainty). Technologically, the development of these different types of tanged points, out of laurel-leaf prototypes and in the order suggested by the Gruta do Caldeirão stratigraphy, makes perfect sense. In fact, the stage of abandonment of the barbed-and-tanged point preforms found in layer Fb of this site (e.g., Zilhão 1997, vol. II, Fig. 27.5,1 & 8) suggests a manufacture process derived from that of coeval small laurel-leaves, one where notching of the basal ailerons would have been the last operation. Given such a technological starting point, shouldered types can be seen as a by-product of the simplification of the tanging process (via unilateral as opposed to bilateral notching). In this model, the Mediterranean type would represent yet a further simplifying step, via reduction of shaping to a minimum, i.e., to the unilateral trimming of the blank, using abrupt instead of flat, invasive retouch.

### Solutreogravettian

Buraca Grande's ensemble 9 yielded an almost complete, rather short, single-bevelled sagaie, circular in cross-section (Aubry & Moura 1994). A diagnostic feature of this object is the fact that the bevel corresponds to more than a third of the total length. Such bone points are characteristic of the Solutreogravettian of Mediterranean Spain (Pericot 1942; Aura 1989). At Buraca Grande as well as at Gruta do Caldeirão, however, no intact Solutreogravettian stratigraphic units could be identified, probably

as a result of the fact that bioturbation significantly affected extensive areas of the uppermost Solutrean deposits, in turn separated from overlying levels by major discontinuities (Figs. 2-3). At Gruta do Caldeirão, the hiatus corresponds to the interval between ~18 and ~16 ka 14C age BP, but examples of small-sized, short-tanged, backed-and-shouldered points that are characteristic of the Solutreogravettian levels of Parpalló (Villaverde & Peña 1981) were recovered at the interface between layer Fa and overlying Magdalenian unit Eb. It seems legitimate to infer, therefore, that, in regional culture-stratigraphy, the time interval of the Caldeirão hiatus corresponds to a Solutreogravettian phase.

## DISCUSSION

The body of evidence reviewed above carries implications of broader archaeological significance. These implications can be grouped according to their main domain of scientific relevance - taphonomic, technological, culture-historical and social. I will now proceed to discuss them in this order.

### THE CHRONOSTRATIGRAPHIC PARADOX

Given the nature and pattern of Last Glacial climate oscillations, it is to be expected that long stratigraphic successions in caves and rock shelters that span the LGM are affected by erosional scars and sedimentation hiatuses, favouring palimpsest formation, redeposition, and other post-depositional disturbance processes. This expectation is fully met and well-illustrated by the Lagar Velho and Caldeirão sequences (Fig. 2).

At Lagar Velho, heterogeneity in texture and colour, largely related to lateral and chronological variations in the sediment sources, facilitated the identification of the boundaries between the different stratigraphic units of the Hanging Remnant deposit. Therefore, the fact that laurel-leaves and Vale Comprido points were recovered at about the same elevation could readily be recognised for what it was: A simple manifestation of (a) the fact that layer 9 was laterally discontinuous, due to the presence of a deep, perpendicular channel cutting the sequence down to the bedrock shelf supporting the Hanging Remnant, and (b) the fact that the fill of this channel was a mix of sediments, charcoal, bones and artefacts derived from the adjacent units that it cut. At sites with more homogeneous fills, however, the detection of similar boundaries would no doubt have been a daunting task, and one can easily imagine scenarios where comparable topographic distributions of index fossils might be taken to suggest that Vale Comprido points and laurel-leaves truly coexisted in time.

Likewise, at Caldeirão, the slow sedimentation rates pertaining throughout the accumulation of layers Ja and I might have led to suggestions of genuineness for the apparent associations of 1) bladelets with marginal-inverse retouch and Vale Comprido points, in layer Ja (which is conceivable), and 2) unifacial foliates with faunal samples directly dated to ~22.3 ka 14C age BP, in layer I (which is inconsistent with regional chronostratigraphic patterns). Where the latter is concerned, an analogue is provided by layer 2s of Lapa do Anecrial (Almeida et al. 2007; Tab. 1), which also subsumed two occupations, dated to ~23.4 ka 14C age BP (a small set of patinated lithics and taphonomically distinct ibex bones) and to ~21.5 ka 14C age BP (a hearth filled-up with rabbit bones and the associated, almost 100 % refitted cores, debitage and knapping debris). In the case of Anecrial, the palimpsest could be disentangled, and allowed us to define the Caldeirão situation as one where a similar hiatus in sedimentation caused the conflation of material of Gravettian (the dated bone), Protosolutrean (Vale Comprido points) and Lower Solutrean (a unifacial foliate) age at the (otherwise poorly defined) interface between layers I and Ja.

Identification of such assemblages as a by-product of palimpsest formation is made possible by the single component sites, mostly open air, in which diagnostic items and production systems sometimes found together in cave levels occur in a segregated manner and, accordingly, when radiocarbon-dated, fall into different time slots. The Portuguese situation makes it clear that long sequence sites *à la* Laugerie-Haute, in the

finding and excavation of which 19th- and early/mid-20th-century Upper Palaeolithic archaeologists tended to focus their research efforts, are not necessarily, and often not at all, the best kind of sites for the construction of regional cultural stratigraphies. Such sites are good for the long term perspective - e.g., order of appearance of the index fossils, technological and economic trends, evolution in the adaptation to changing environments, etc. - but as a rule become rather fuzzy beyond a certain level of detail.

The successful building of solid chronostratigraphic sequences (cf. Fig. 3) is a task that requires, therefore, the correlation of well-dated, single-component, high-integrity sites that also feature significantly complete lithic reduction sequences (i.e., that are of a residential, not logistical nature). It is the lack of these kinds of sites, compounded with the site formation implications of LGM climates that, more than anything else, explains why such issues as the existence of the Protosolutrean in Mediterranean Spain (cf. Tiffagom et al. 2007), or the validity in Cantabria of Smith's (1966) tripartite organisation of the Solutrean (cf. Straus 1983, 1991, 2007), remain unresolved.

## Technology and adaptation

Although, at first glance, the Vale Comprido and the small backed-and-shouldered points of, respectively, the Protosolutrean and the Solutreogravettian could hardly be more different (in morphology as much as in underlying production technique), they are in fact no more than a few steps away from each other (Fig. 4). I suggested above that the development of a bifacial foliate complex out of Vale Comprido point production schemes is best understood as driven by the internal properties of the technologi-

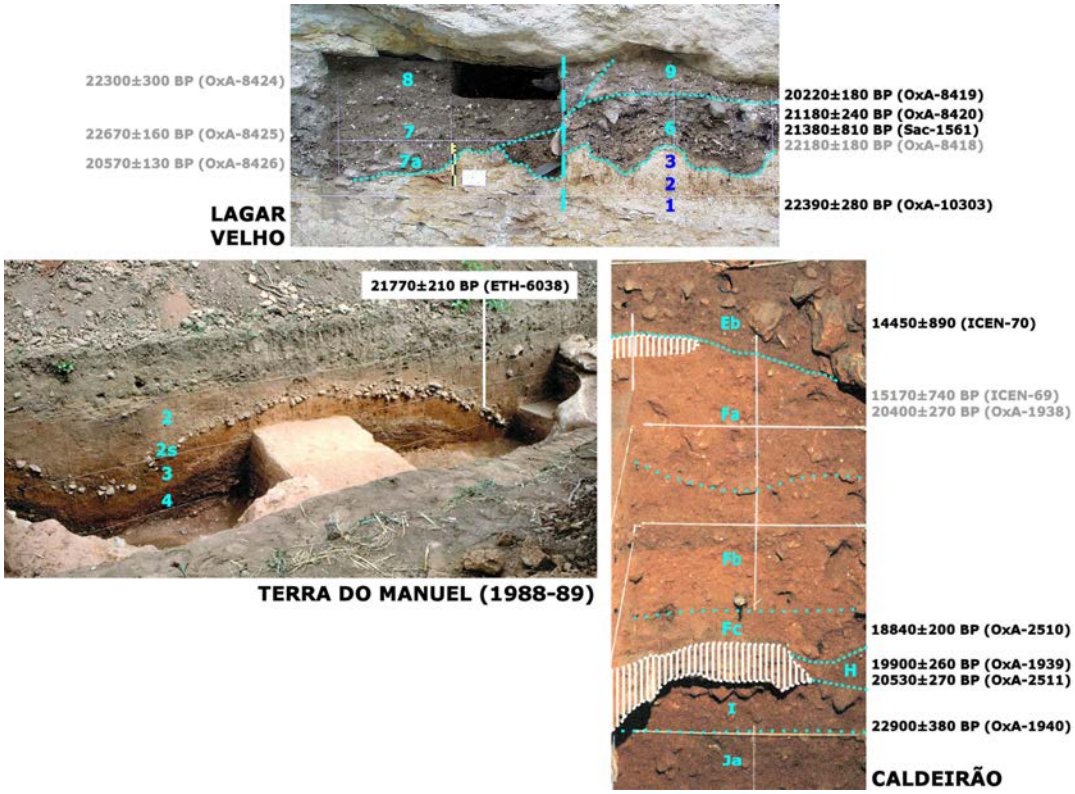
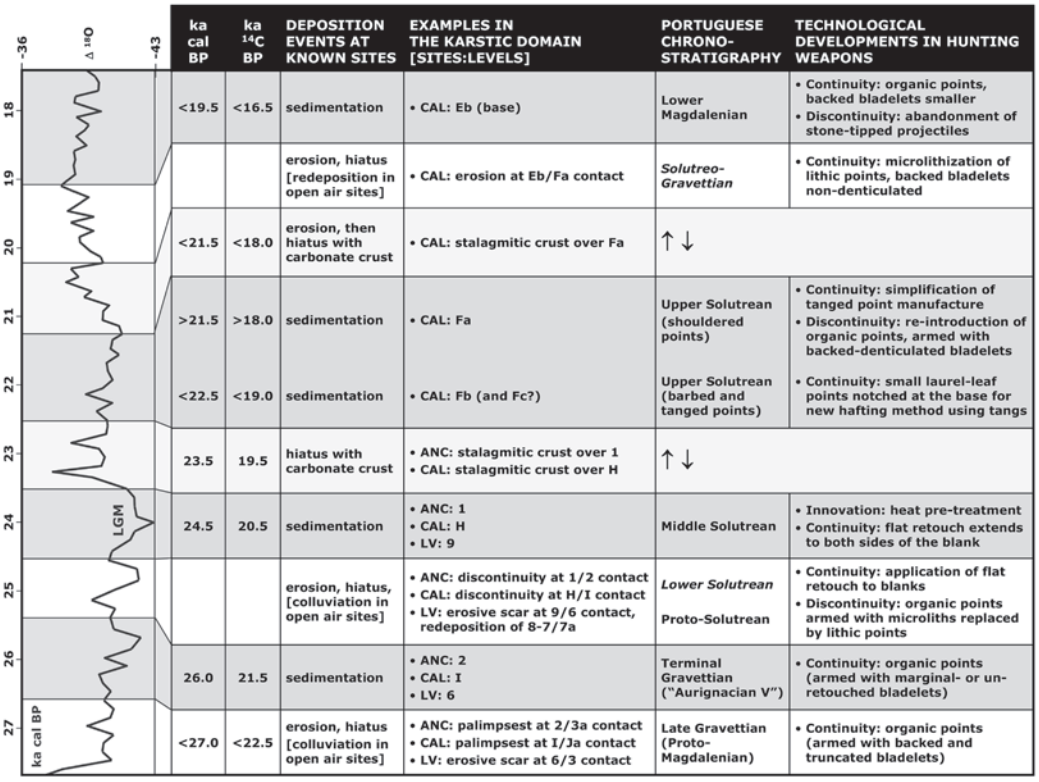



Fig. 2 Portuguese LGM stratigraphic successions. Dates in grey indicate samples in derived or uncertain context: At the Lagar Velho Hanging Remnant, a charcoal fleck at the base of a channel filled with layer 6 sediments must derive from the erosion of the channel walls (made of layers 1-3 sediments); at Caldeirão, a bone sample in square P11 of the back chamber, against the illustrated profile, probably derives from disturbance of the Fa-to-I sequence of deposits in the corridor area of the cave, towards the entrance and topographically higher-up. Layers 7a, 7 and 8 of Lagar Velho are subdivisions of a channel fill; the channel cuts layers 9 (and, therefore, post-dates the Middle Solutrean) and is filled with a mix of material derived from the cut units (layers 1-3, 6 and 9) and from other, intermediate occupations of the site not represented in the Hanging Remnant's stratification (including, namely, Vale Comprido points typical of the Protosolutrean). At Terra do Manuel, the occupation level, denoted by the cobble pavement well apparent in the profile is heavily deformed by subsidence and may well subsume two different occupations (sublayers 2s1 and 2s2) whose stratigraphic distinction could not be unambiguously ascertained at the time of excavation (cf. Zilhão 1997 for a detailed discussion).

cal system. This notion is also consistent with the fact that the Protosolutrean-to-Middle Solutrean sequence replicates the Bohunician-to-Szeletian one, which occurred 20,000 years earlier in central Europe (Svoboda et al. 1996).

The chronological and geographical separation between these two sequences leaves little doubt that, in terms of both culture-history and adaptation, they are totally unrelated processes, and, therefore, that such a convergent trajectory best can be explained as a by-product of the operation of similar technological constraints. Put another way, 25,000 years ago, with knowledge of the Bohunician-to-Szeletian antecedent, a competent observer could have predicted as a distinct possibility that the Protosolutrean would eventually generate the Middle Solutrean. And the subsequent transformation of the latter into the Upper Solutrean and Solutreogravettian complexes can easily be seen as technologically driven too, consisting of a progressive simplification of stone tip manufacture, coupled with a return to more traditional, more Gravettian-like weaponry kits (and blade debitage methods). In sum, at each step of the Protosolutrean-to-Solutreogravettian sequence, a small, incremental change in production or retouch technique suffices to explain the change in point types.

Although differences in width between the *pointes à face plane* and the shouldered points suggest that somewhere along this trajectory hafting techniques also changed, there is no evidence of any major development in haft types or propulsion methods. The fact that Middle and Upper Solutrean point types are of the same length and weight as those of the previous Gravettian suggests continued use, throughout, of the same basic weapon (Fig. 5): Light sagaies or throwing spears propelled by the force of the human arm alone, mostly if not exclusively stone-tipped in the Protosolutrean and the Middle Solutrean, both stone- and bone-tipped in the Gravettian, the Upper Solutrean and the Solutreogravettian. The notion of a Solutrean arms race triggered by the environmental pressures of the LGM (Straus 1991) is also difficult to reconcile with the fact that the technological developments subsumed under the Solutrean label occur simultaneously and with striking parallelism in ecologically very different regions of western Europe — including some (such as Portugal) where global environmental deterioration may in fact have corresponded, for groups of hunters focused on




| ka cal BP | ka 14C BP | DEPOSITION EVENTS AT KNOWN SITES | EXAMPLES IN THE KARSTIC DOMAIN [SITES:LEVELS] | PORTUGUESE CHRONO-STRATIGRAPHY | TECHNOLOGICAL DEVELOPMENTS IN HUNTING WEAPONS |
|---|---|---|---|---|---|
| <19.5 | <16.5 | sedimentation | • CAL: Eb (base) | Lower Magdalenian | • Continuity: organic points, backed bladelets smaller<br>• Discontinuity: abandonment of stone-tipped projectiles |
| | | erosion, hiatus [redeposition in open air sites] | • CAL: erosion at Eb/Fa contact | *Solutreo-Gravettian* | • Continuity: microlithization of lithic points, backed bladelets non-denticulated |
| <21.5 | <18.0 | erosion, then hiatus with carbonate crust | • CAL: stalagmitic crust over Fa | ↑ ↓ | |
| >21.5 | >18.0 | sedimentation | • CAL: Fa | Upper Solutrean (shouldered points) | • Continuity: simplification of tanged point manufacture<br>• Discontinuity: re-introduction of organic points, armed with backed-denticulated bladelets |
| <22.5 | <19.0 | sedimentation | • CAL: Fb (and Fc?) | Upper Solutrean (barbed and tanged points) | • Continuity: small laurel-leaf points notched at the base for new hafting method using tangs |
| 23.5 | 19.5 | hiatus with carbonate crust | • ANC: stalagmitic crust over 1<br>• CAL: stalagmitic crust over H | ↑ ↓ | |
| 24.5 | 20.5 | sedimentation | • ANC: 1<br>• CAL: H<br>• LV: 9 | Middle Solutrean | • Innovation: heat pre-treatment<br>• Continuity: flat retouch extends to both sides of the blank |
| | | erosion, hiatus, [colluviation in open air sites] | • ANC: discontinuity at 1/2 contact<br>• CAL: discontinuity at H/I contact<br>• LV: erosive scar at 9/6 contact, redeposition of 8-7/7a | *Lower Solutrean*<br>Proto-Solutrean | • Continuity: application of flat retouch to blanks<br>• Discontinuity: organic points armed with microliths replaced by lithic points |
| 26.0 | 21.5 | sedimentation | • ANC: 2<br>• CAL: I<br>• LV: 6 | Terminal Gravettian ("Aurignacian V") | • Continuity: organic points (armed with marginal- or un-retouched bladelets) |
| <27.0 | <22.5 | erosion, hiatus [colluviation in open air sites] | • ANC: palimpsest at 2/3a contact<br>• CAL: palimpsest at I/Ja contact<br>• LV: erosive scar at 6/3 contact | Late Gravettian (Proto-Magdalenian) | • Continuity: organic points (armed with backed and truncated bladelets) |

Fig. 3 The geological and cultural processes documented in Portuguese sites dated to either side of the LGM.

the exploitation of medium- and large-sized herbivores, to a local amelioration of the resource base.

## Culture history

The real question in culture-history terms seems to be, therefore: Why the Protosolutrean? It is only at this point, in fact, that discontinuity is the dominant feature of technological change over the millennia on either side of the LGM (cf. Fig. 3). In this long-term perspective, the emergence of the Protosolutrean is difficult to conceptualise in the framework of strict progressivist or economicist paradigms. On one hand, the Vale Comprido point stands for no less than the comeback of an essentially Middle and initial Upper Palaeolithic weapons system, one that, presumably, should have been definitively superseded by the supposedly more efficient systems of the Aurignacian and the Gravettian. On the other hand, from the point of view of extraction efficiency (using point and core size as proxies for edge-length per unit of raw material weight), Protosolutrean blade production deviates negatively from expectations and, in evolutionary terms, corresponds to a maladaptive blip, as shown by the diachronic trends illustrated in figure 5. Although the graph suggests otherwise, the same applies to at least the Middle Solutrean (and, in all likelihood, to the Upper Solutrean as well), because of the amount of waste generated by bifacial foliate production. In fact, counting as cores the (mostly failed) foliate preforms in the Vale Almoinha collection would bring the values of the plotted parameter into line with those for Vale Comprido – Encosta.

The mid-20th century standard explanation for such a pattern would have been immigration of a foreign culture, one that would have borne a distinct, more primitive, Mousterian-rooted tradition of stone tool production, along the lines discussed by Smith (1966) for the origins of the Solutrean as a whole. A major empirical hurdle for such kinds of explanations lies, of course, in the identification of the original source of the putative immigrants, given that, ~21.5 14C (~25.5 cal) ka BP, Europe was entirely occupied by peoples with Gravettian or Gravettian-like technologies. For supporters of migration models, a traditional last resort resides in the identification of the Middle Palaeolithic Aterian of North Africa as the presumed ancestor, but such propositions are inconsistent with the chronometric evidence, which suggests an entirely early

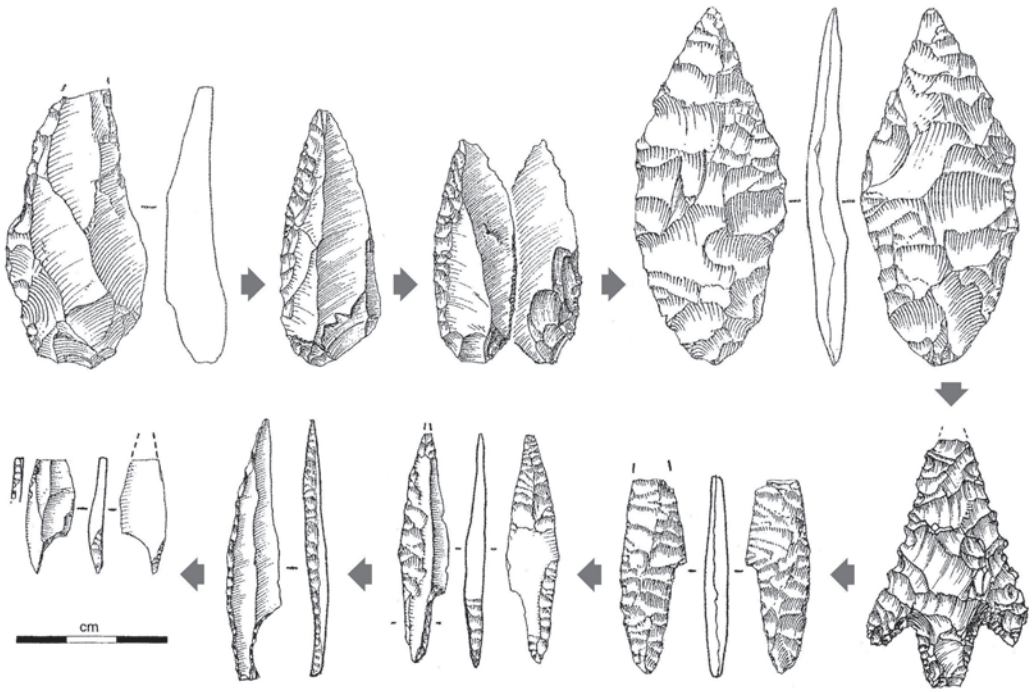


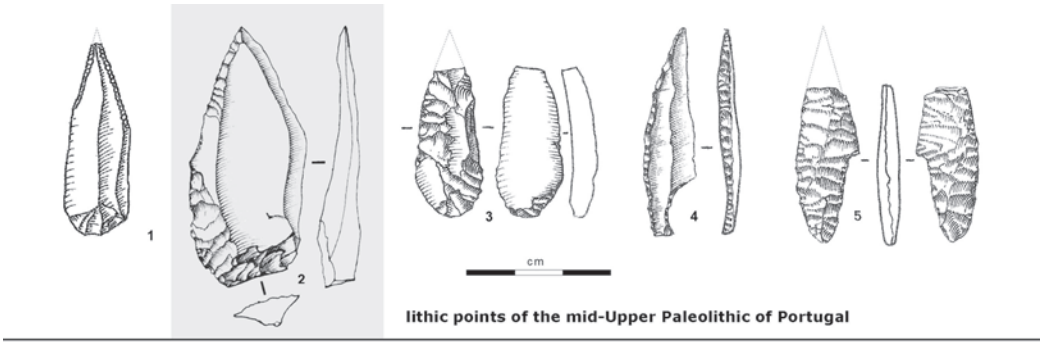

Fig. 4 From Protosolutrean to Solutreogravettian: A trajectory of technological change and development involving no more than eight steps, each bringing about a typological innovation through minor modifications of previous models.

Upper Pleistocene age for this techno-complex (e.g., Stringer & Barton 2008). Moreover, Africanist views of Solutrean origins also fail to address the question of why the Aterian influence putatively represented in the barbed-and-tanged concept of Iberian Upper Solutrean points would only manifest itself at the end, not at the beginning, of the Solutrean sequence.

In any case, as shown by research into aspects of human behaviour that are much richer in cultural information than lithics (e.g., artistic styles), the Protosolutrean discontinuity in technology and hunting equipment is not associated with a correspondent discontinuity in figurative conventions. A case in point is Villaverde's (1994) study of the hundreds of slabs from Parpalló that are painted and engraved with animal motifs, which concludes for broad stylistic similarity across the Gravettian-to-Solutrean transition. Alternatively, one might explain the Protosolutrean as a cultural regression with demographic causes, and take the rarity of well-defined Protosolutrean contexts as supporting evidence. However, as more extensively discussed by Zilhão & Almeida (2002), such taphonomic constraints as those described above imply (contra Marks 2000, and Straus et al. 2000) that the number of sites per unit of chronostratigraphy is a very poor retrodictor of Palaeolithic demography, so this line of reasoning is not very productive either.

## SOCIAL GEOGRAPHY

At present, the most promising avenue of inquiry into the Solutrean phenomenon seems to be that concerning its geographical properties. Given the stylistic similarities between the early phase of the Côa valley art and such manifestations of Franco-Cantabrian cave art as the painted aurochs from the Tête du Lion, it seems fair to infer that the two regions must have been united by exchange and alliance networks encompassing all of southern France and Iberia. Only the steady flow of information across such networks can explain these similarities, and the parallel trajectory from Protomagdalenian to Protosolutrean followed by culture-stratigraphic sequences in the Aquitaine




lithic points of the mid-Upper Paleolithic of Portugal

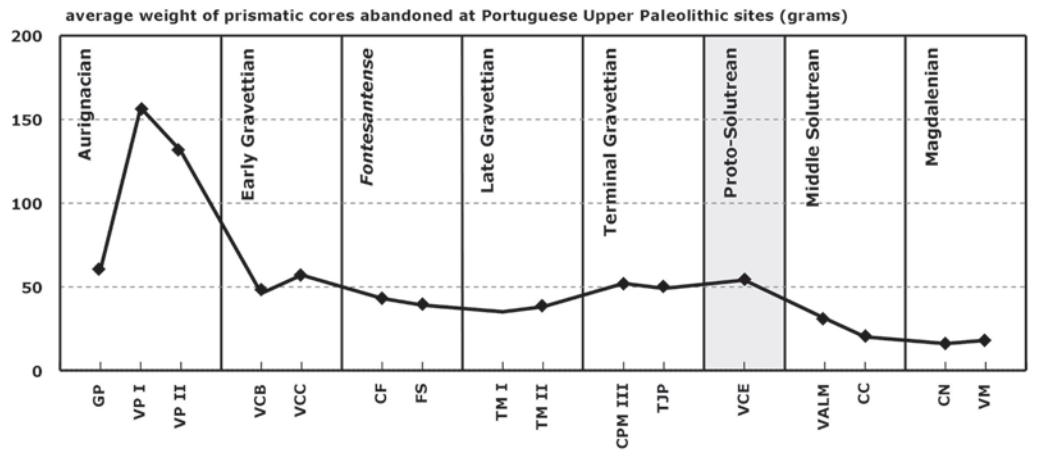



Fig. 5 Projectile stone tips of the mid-Upper Palaeolithic of Portugal (1. Casal do Felipe point; 2. Vale Comprido point; 3. *pointe à face plane*; 4. Mediterranean shouldered point; 5. Cantabrian shouldered point), and diachronic change in efficiency of raw material exploitation (using as a proxy the average weight of prismatic cores abandoned at sites).

and in Portuguese Estremadura is consistent with the inference (Zilhão 2003).

In this context, several observations become meaningful. The fact that the Protosolutrean and subsequent developments are restricted to south-west Europe suggests that the continent-wide networks of the Gravettian were broken as the cold maximum closed-in, with populations living west of the Rhône becoming progressively isolated from those that, in Italy and in central and south-east Europe, went through the LGM with an Epigravettian stone tool-kit. Thus, it is in the spatial boundaries of its expression, not in its specific technological features *per se*, that lies the potential of the Protosolutrean phenomenon to illuminate issues of culture-history and adaptation at this time.

Following the same logic, it becomes apparent that, after the Middle Solutrean, regional trajectories begin to differ in significant aspects. For instance, barbed-and-tanged points are only found in Portugal and southern Spain, Plisson & Geneste's (1989) subtype A of shouldered points is only known in the Aquitaine basin, and concave-based laurel-leaves are restricted to Cantabria and the Pyrenees. On the other hand, and as one should expect anyway, given spatial continuity in settlement and the open nature of hunter-gatherer exchange networks, areas of overlap are also known; the coexistence of both the Mediterranean and the Cantabrian types of shouldered points in Portuguese sites is a significant case in point.

Figure 6 suggests that a correlation may exist between global environmental constraints and these features of the archaeological record, with epochs of regional convergence broadly coinciding with periods of colder climate, and epochs of regional divergence broadly coinciding with stretches of more temperate, or unstable climate. The underlying cause of these coincidences can only have been the fluctuations in size, extension and shape of social exchange networks, expanding (or shrinking) in response to changes in the environment. Under more rigorous climates, the long-distance circulation of individuals, objects and ideas would have been made easier by the decrease in tree cover and the expansion of prairie-steppe landscapes, and required by the social constraints of production and reproduction. Under warmer climates, a more broken, mosaic landscape with significant woodlands would have existed in at least Iberia, decreasing the frequency and intensity of long-distance contacts and favouring regional isolation and cultural drift.

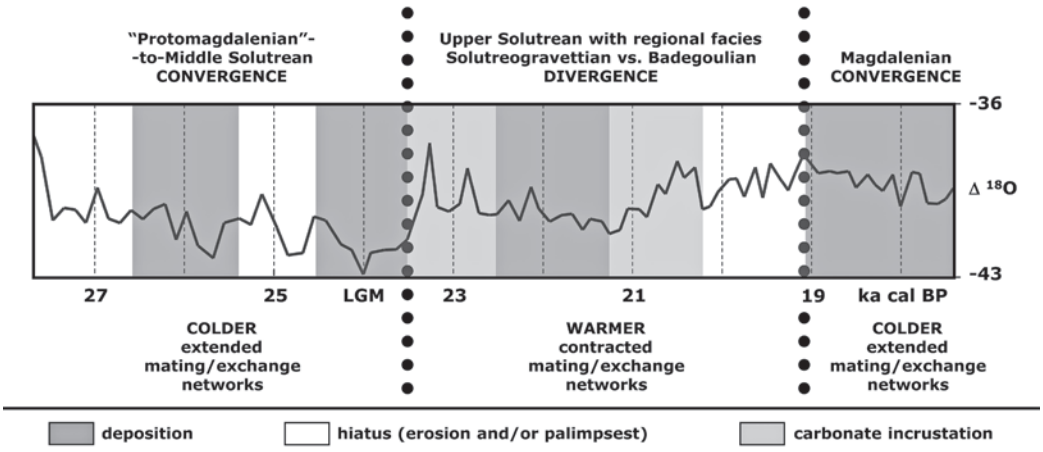



Fig. 6 Patterns in the culture-histories of Iberia and southern France across the LGM, against a background of global climate change and regional site formation patterns.

## CONCLUSIONS

To sum up, I list below the four main conclusions that I have derived from my study of the Portuguese Solutrean in its wider context:

- Firstly, at individual sites as much as over wider regions, continuity and discontinuity may reflect the overarching impact of common, climate-driven geological processes (palimpsest formation, post-depositional mixing, erosional hiatuses), rather than events taking place in the realm of cultural process (local transition, extinction, immigration, etc.).
- Secondly, given the small size of the area where the techno-complex is known, the coarse nature of stratigraphic sequences, the poor resolution of dating methods, and the speed with which objects, ideas and people can travel across hunter-gatherer networks, traditional culture-history research questions, such as the search for origins (of the techno-complex as a whole, or of any of the innovations that appear in the course of its developmental trajectory) are unanswerable and, hence, scientifically uninteresting.
- Thirdly, the adaptive value of Solutrean point technology cannot lie on its putative advantages in terms of production efficiency or mechanical effectiveness and, if seen as a response to the selective pressures brought to bear on human groups by the onset of the LGM, then it probably must be related, at least in part, to factors operating in the social and ideological realm (as suggested also by the big, non-functional laurel-leaves of the Volgu/Maitreaux type; cf. Pelegrin 2007).
- Fourthly, it is the expansion and shrinking of exchange networks, as well as the modifications in their composition, that explain the wide and rapid diffusion and adoption, over vast geographical areas, of the new technological traits that define the Solutrean as a whole and its subdivisions; in and of themselves, from the point of view of culture as adaptation, such traits, however, were essentially neutral.

## ACKNOWLEDGEMENTS

This paper was originally given at the conference 'Le Solutréen … 40 ans après Smith'66' (Preuilly-sur-Claise, 28-31 October 2007). I thank the Société d'Étude et de Recherche Archéologique sur le Paléolithique de la vallée de la Claise for the invitation to participate and for its organisation of a highly successful and very instructive meeting.

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## TABLE

| site | layer (square) | 14C age BP | δ13C | material | lab-number | method | phase | obs. |
|---|---|---|---|---|---|---|---|---|
| Buraca Grande | 9a (L19) | 17,850 ± 200 | - | charcoal | Gif-9502 | conventional | Solutrean | (a) |
| Lagar Velho (Hanging Remnant) | 9 (Q.W) | 20,220 ± 180 | -25 | charcoal | OxA-8419 | AMS | Middle Solutrean | - |
| | 8 (Q.Z) | 22,300 ± 300 | -25.5 | charcoal | OxA-8424 | AMS | top of channel fill | - |
| | 7 (Q.Z) | 22,670 ± 160 | -24.2 | charcoal | OxA-8425 | AMS | | - |
| | 7a (Q.Z) | 20,570 ± 130 | -24.2 | charcoal | OxA-8426 | AMS | base of channel fill | - |
| | 6 (Q.Z West) | 21,380 ± 810 | -24.45 | charcoal | Sac-1561 | conventional | Terminal Gravettian | - |
| | 6 (Q.A) | 22,180 ± 180 | -23.2 | charcoal | OxA-8418 | AMS | | (b) |
| | 6 (Q.W) | 21,180 ± 240 | -25.4 | charcoal | OxA-8420 | AMS | | - |
| | 1 (Q.B) | 22,390 ± 280 | -24.5 | charcoal (*Pinus sylvestris*) | OxA-10303 | AMS | undiagnostic | - |
| Caldeirão | Eb-base (O13+O14) | 14,450 ± 890 | -19.09 | bulk rabbit bones | ICEN-70 | conventional | Magdalenian | - |
| | Fa-top (O13+O14+N14) | 15,170 ± 740 | -22.97 | bulk bones (mostly rabbit) | ICEN-69 | conventional | Upper Solutrean | (c) |
| | Fa-top (K16+L16) | 21,200 +2300/-1800 | -25 | charcoal | ICEN-295 | conventional | | - |
| | Fa-top (P11) | 20,400 ± 270 | - | *Cervus* sp. | OxA-1938 | AMS | | (d) |
| | Fc (P12) | 18,840 ± 200 | - | *Cervus* sp. | OxA-2510 | AMS | | - |
| | H (P12) | 19,900 ± 260 | - | *Capra* sp. | OxA-1939 | AMS | Middle Solutrean | - |
| | H (P12) | 20,530 ± 270 | - | bone | OxA-2511 | AMS | | - |
| | I (P12) | 22,900 ± 380 | - | *Cervus* sp. | OxA-1940 | AMS | Lower Solutrean, Protosolutrean | - |
| Anecrial | 2b (K21) | 23,410 ± 170 | -19.5 | *Capra* sp. (cut-marked pelvis) | OxA-11235 | AMS | undiagnostic | (e) |
| | 2b (K21, hearth) | 21,560 ± 220 | -26.1 | *Erica* sp. | OxA-5526 | AMS | Terminal Gravettian | - |
| | 1 (M20-SW, hearth) | 20,520 ± 100 | - | charcoal | GrA-12019 | AMS | Middle Solutrean | - |
| Terra do Manuel | 2s (North profile) | 21,770 ± 210 | - | charcoal | ETH-6038 | AMS | Late Gravettian (Protomagdalenian) | - |
| Vale Almoinha | 5 (S III) | 20,380 ± 150 | -24.18 | charcoal | ICEN-71 | conventional | Middle Solutrean | - |
| | 5 (A III) | 19,940 ± 180 | -23.2 | charcoal | OxA-5676 | AMS | | - |

Tab. 1 Radiocarbon dates for the sites discussed in the text (after Aubry & Moura 1994, Zilhão 1997, Almeida et al. 2007).

a) sample collected during initial testing, possibly an average of the different occupations subsequently differentiated within the stratigraphic unit of provenance
(b) as layer 6 fills small channels cut into underlying layers 1-3, this sample, statistically the same age as that for layer 1, probably corresponds to charcoal material in derived position
(c) although the bulk sample dated was selected from apparently undisturbed areas of the layer, the presence of large burrows in adjacent areas means that the parsimonious interpretation of this obviously underestimated result is the presence in the sample of intrusive rabbit material
(d) the sample probably corresponds to an item derived from the stratigraphically lower but topographically higher Middle Solutrean levels of the corridor area of the site, toward the entrance of the cave
(e) sample from a taphonomically distinct, small set of bones constituing background noise for the more substantial Terminal Gravettian occupation of the same surface; given this palimpsest situation, the other conventional results on bulk charcoal samples available for this level are not considered here because they are potentially mixed