Biostratigraphy of the Solutrean layers of Laugerie-Haute (Les Eyzies, Dordogne).
Archaeological implications

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Introduction

In order to gain insights into prehistoric cultures, the organization of societies and prehistoric human relationships with the environment, interpretations are generally based on material data extracted from the earth. The position of all objects is accurately recorded during exhumation, long before the analytical study, in order to define their spatial location and to determine their relative age. In this way, they can be regrouped into sets coming from a specific place or (and) period of time. This regrouping into sets is essential as isolated finds, however significant or original, are only of limited interest. Comprehensive studies of groups of data are the only way of defining the specific characteristics of a complex. The quest for evolutionary characteristics, for example, only becomes possible when studies of datasets from different time periods are carried out.

As prehistoric finds often come from stratified sites, it is essential to take account of the stratigraphy in order to classify these finds. However, this is only possible if the different sets of finds are grouped by stratigraphic units. The latter are defined by specific characters; archaeological characteristics for archaeological stratigraphic units, biological attributes for biostratigraphic units, chronological criteria for chronostratigraphic units... (Hedberg 1979). There are thus as many different stratigraphic units as stratigraphic branches and each aspect should be studied separately before comparing the different results in order to reply to specific questions raised by the diverse specialties. In prehistoric archaeology, the “level” or the “layer” has wrongly been considered as a stratigraphic unit, as diverse criteria are used to differentiate “levels” and “layers” from overlying or underlying strata.
Of all these different stratigraphy branches, biostratigraphy is the branch which provides the best stratigraphic correlations. It allows us to determine the relative age of the fossiliferous strata. This branch of study has always been used for marine applications, but was only adapted to the continental domain a few decades ago when it was used to establish biozonations based on Pliocene, Pleistocene and Holocene mammals (cf. notably Mein 1975; Guérin 1982; Cordy 1982; Guérin and Patou-Mathis 1996). Indeed, in some cases, biostratigraphic chronological resolution is more accurate than radiochronological dating (Delpech 2005, 2007; Delpech and Texier 2007).

A lot of “classical” archaeological sites excavated a long time ago were not subjected to such studies. Yet our knowledge of prehistoric industries has been largely determined by these reference sites. A collective research program focusing on the revision of some of these sites was carried out, directed by J.-Ph. Rigaud then by J.-P. Texier (Texier et al. 1999; Texier et al. 2004). A dating program was conducted on the Solutrean levels of the Laugerie-Haute site using different methods (Roque et al. 2001) accompanied by geological research on their stratogenesis (Texier 2009). During a colloquium on the Solutrean at Preuilly sur Claise in 2007, I reviewed the biostratigraphical issues of this site, with particular attention to the levels where several evolutionary stages of the Solutrean technocomplex were defined.

“Stratigraphies” at Laugerie-Haute

The large Laugerie-Haute shelter is located on the right bank of the Vézère river, two kilometers upstream from Les Eyzies de Tayac. “It is spread over a length of 25 meters, a width of 35 meters and the thickness of the deposits varies from 4.5 to 6 meters in places. A non excavated zone with a house on it divides the site into two loci: Laugerie-Haute-Est and Laugerie-Haute-Ouest” (Laville 1975 - p. 310).

The site was identified as a prehistoric site in the second half of the 19th century (Lartet and Christy 1864, 1865-1875; Girod and Massénat 1893; Capitan 1895; Capitan and Breuil 1902 apud Laville 1975) and was exploited by several generations of excavators. In 1938, D. and E. Peyrony published a site monograph containing detailed stratigraphic information, which was later reused and expanded upon by F. Bordes and Ph. Smith, when they carried out work there fifty years ago (Bordes 1958; Smith 1966). At roughly the same time, H. Laville established a “climato-stratigraphy” of the site (1964, 1973, 1975) through a sedimentological study.

The comparison of the stratigraphic propositions advanced by D. and E. Peyrony and those who worked on the site after them shows their “preoccupation with a more accurate stratigraphic breakdown” (Texier 2007 - p. 49). This entailed the identification of localized subdivisions but also difficulties in synchronizing the east of the site with the west. At the east of the site, Peyrony’s 13 excavation complexes (layers A to K) correspond to 42 complexes from Bordes’ excavations. In addition, the number of non sterile layers varies depending on the excavated zone: the five Magdalenian layers 1, 2, 4, 6 and 8 at the east of the site correspond to 8 complexes on profile II (tab. 1). As for the comparison of the stratigraphic successions from the east and the west of the site, several questions have been raised. Without undertaking a comprehensive review of these issues, it is noteworthy that the Aurignacian level V overlies the Protomagdalenian level (Bordes 1964) and not the other way around (Peyrony and Peyrony 1938). It is not easy to
establish the limits between the Solutrean complexes (Lower, Middle or Upper Solutrean), nor between the east and the west of the shelter (Bordes 1958; Smith 1966). Moreover, it is pertinent to ask whether the material issued from Peyrony’s H” complex (Solutrean with shouldered points) was partly associated with the Magdalenian 0”, a technocomplex contemporaneous with the formation of layer 0 (on the west side), according to H. Laville (1973, 1975) (tab. 1).

Table 1 - Laugerie-Haute-Est and Laugerie-Haute-Ouest (Peyrony excavations, Bordes excavations, Bordes and Smith excavations). Relationships between stratigraphic subdivisions and technocomplexes.

Table 2 - Laugerie-Haute-Est (Bordes excavations, Bordes and Smith excavations). Number of identified specimens by stratigraphic unit and taxon.
The fauna from the Solutrean levels\(^3\) and “the Laugerie Interstadial”

In the Solutrean levels H’, H” et H”’(Peyrony excavations), the reindeer is the dominant taxon, followed by the horse and several ungulates: red deer, ibex, bovines, mammoth, rarer than the first two and varying in frequency in the different levels. The wolf and the common fox left behind some canines in H”’ and Ovibos is represented by a molar (determinations by H.G. Stehlin in Peyrony and Peyrony 1938). Since then, this bovid was identified in H” (Castel and Madelaine 2006) and six Saiga antelope remains were identified in H”’ (Madelaine 1989).

The faunal remains from the Bordes excavations and the Bordes and Smith excavations in the east and the west of the site were first studied by F. Prat (in Laville 1964 - p. 48; Prat 1968) and then by myself for my PhD thesis (Delpech 1975, 1983). François Bordes showed me the correspondences that he had worked out at Laugerie-Haute-Est, between the layers from profile II and those from the main profile (tab 1). Using this information, I made up the three batches of bones which were radiocarbon dated in Lyon (Ly 972 for the Magdalenian complex 0, Ly 973 for the Magdalenian complex II, Ly 974 for the Magdalenian complex III). The dates for the Magdalenian 0 and the Magdalenian III were accepted without debate but those for the Magdalenian II were considered “too old” and were rejected. This cast a doubt on data collection methods and tended to negate the existence of the Magdalenian II.

Table 2 - Laugerie-Haute-Est (Bordes excavations, Bordes and Smith excavations). Number of identified specimens by stratigraphic unit and taxon.

<table>
<thead>
<tr>
<th>Artiodactyles</th>
<th>Bosaurus</th>
<th>Bovides</th>
<th>Cervid</th>
<th>Chamois</th>
<th>Reven</th>
<th>Saiga</th>
<th>Paurodontes</th>
<th>Proboscidie</th>
<th>Manomorphs</th>
</tr>
</thead>
</table>

Table 3 - Laugerie-Haute-Ouest (Bordes excavations, Bordes and Smith excavations). Number of identified specimens by stratigraphic unit and taxon.

<table>
<thead>
<tr>
<th>Couches</th>
<th>Solutréen inférieur</th>
<th>Solutréen moyen</th>
<th>Solutréen supérieur</th>
<th>Solutréen final</th>
</tr>
</thead>
<tbody>
<tr>
<td>Artiodactyles</td>
<td>Bosaurus</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Bovides</td>
<td>3</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Cervid</td>
<td>3</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Reven</td>
<td>236</td>
<td>194</td>
<td>432</td>
</tr>
<tr>
<td></td>
<td>Paurodontes</td>
<td>3</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Proboscidie</td>
<td>20</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Mammoths</td>
<td>6</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Carnivores</td>
<td>3</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

As indicated by D. and E. Peyrony according to the information provided by H.G. Stehlin, the reindeer is predominant in all the Solutrean levels, followed by the horse which is much less frequent. All the other species are only episodically represented by sparse
remains (tab. 2 and 3). In levels 22 to 28 in Laugerie-Haute-Est with the Upper and Final Solutrean, F. Prat noted a lesser abundance of the reindeer than in underlying levels. This decrease in the percentage of reindeer corroborated, according to H Laville (1973, 1975), the climatic interpretation that he advanced for the same levels, that is an amelioration assimilated to the “Würm III-Würm IV Interstadial” or the “Laugerie Interstadial” (see also Paquereau 1978). However the decrease in reindeer remains cannot be interpreted in this way. Indeed, when the climate becomes milder and wetter, the decrease in the percentage of reindeer is accompanied by an increase in ungulates from humid fields and forests. However, this is not the case at Laugerie-Haute, where the Horse becomes more abundant. Yet, this ungulate adapts even better than the reindeer to cold and dry conditions in perigacial Europe (cf. infra). Moreover, the Ovibos molar from the upper Solutrean complex H” (Stehlin in Peyrony and Peyrony 1938; Castel and Madelaine 2006) confers a glacial note on this complex: the Ovibos occupies the northernmost zones of the northern hemisphere today. It is also noteworthy that F. Prat and then this author identified the Saiga antelope in the levels overlying the Solutrean levels, those which contained Bordes’ Magdalenian 0, Magdalenian II and Magdalenian III (respectively levels 20 and 18, 8 to 4, 2 and 1 at Laugerie-Haute-Est). S. Madelaine also identified the Saiga antelope in the Peyrony excavations of the Solutrean complex at Laugerie-Haute-Ouest. We cannot therefore exclude the possibility of an association of these remains with the Magdalenian 0 (which wasn’t recognized by Peyrony). However, if we admit their contemporaneity with the Solutrean, which is possible as other sites have yielded such associations (Castel et Madelaine 2006), then we have an additional element discrediting the hypothesis of a relatively humid climatic environment: the Saiga antelope lives in arid, semi-desertic steppe zones today. Other elements, such as the biometric study of the reindeer, also contribute to rejecting the hypothesis of the “Laugerie Interstadial”. This study was carried out in 1970 in order to test J. Bouchud’s hypothesis (1975), stating that during the Upper Palaeolithic, varying proportions of Tundra reindeer and forest reindeer were responsible for the size variations presented by this taxon. The results of this study showed that size variations occurred within the same species in response to environmental changes and that the modest size of the Solutrean reindeer and the Magdalenian reindeer in Laugerie denotes a particularly constraining environment (Delpech 1975, 1983, 1986; Delpech et al. 2000). Osteometric research conducted by Delphine Kuntz (2011) corroborates this hypothesis. These constraints are those of the Last Glacial Maximum, with severe climatic conditions, expanding cold deserts in boreal zones and a decreasing habitable zone (Delpech 1999). It is also important to recall that the existence of a “Laugerie Interstadial” (like the “Lascaux Interstadial”, which is later but close in time) (Leroi-Gourhan 1980) was refuted by palynologists in the 1980s (Beaulieu and Reille 1984) and more recently (Elanga et al. 2000; Sanchez Goni 1991, 1994).

It is unfortunate that the environmentally characteristic ungulate associations were used to support the hypothesis of the existence of an interstadial, as this goes against what these associations are supposed to represent.

**Which environmental changes occur during the course of the Solutrean?**

Apart from the onset of severe climatic conditions, is it possible to perceive any climatic evolution or change during the formation of the Solutrean complex? In order to tackle
this question, I will use data issued from the François Bordes and Philip Smith excavations with numerous stratigraphic subdivisions and associated faunal taxonomic samples. There are two datasets, from the east and the west of the site. On both sides, environmental phenomena have conditioned the formation of archaeological levels. Let us therefore try to discern any possible changes by using markers from both the east and the west of the site.

10 At the west of the site, 14 levels have yielded enough material to be taken into consideration, whereas at the east, seven levels make up five complexes as the remains discovered in levels 22 and 23 on the one hand and 25 to 28 on the other, were regrouped before we undertook our identification study. This study (Delpech 1975, 1983) brought to light a majority of ungulate remains (tab. 2 and 3). In both loci, the reindeer dominates. If differences exist between the two loci, they thus have to be sought out elsewhere.

11 At Laugerie-Haute-Est (or LHE) the ungulate associations evolve in an orderly fashion from the base to the summit; the horse increases regularly while the reindeer decreases (tab. 2, fig. 2a), which is perfectly logical from a palaeoenvironmental point of view with the approaching Last Glacial Maximum. The horse is a very ubiquitous ungulate, adapting faster than any other species to the most diversified conditions, even the most severe. The horse was present during the Upper Pleistocene in Aquitaine, a perennially occupied region, during the coldest and driest periods and also during the least rigorous conditions. Of all the other European ungulates, only the red deer could compete with the horse in terms of adaptation, but during the most severe climatic conditions, the horse is always “more apt to adapt” than the red deer and there always appear to be more horses than deer (Delphech et al. 1983; Delpech 1999). In the LHE stratigraphic sequence, the Solutrean complex is quite clearly differentiated from the underlying Protomagdalenian, in which the reindeer is dominant, the horse is very rare and red deer and mountain ungulates are relatively well represented (fig. 3a). The Solutrean complex only differs from the first Magdalenian complex (levels containing the Magdalenian 0) which overlies it, by the presence of several mountain ungulates and Ovibos, represented by a molar discovered during the Peyrony excavations. This molar could however, like the sculpture of an Ovibos head found in the Hauser spoil (Peyrony and Peyrony 1938 - pl. III, fig. 2), come from the Magdalenian complex 0 and the overlying Magdalenian levels where the horse is rare. Thus, at LHE, the process of the development of the horse seems to begin in the lower levels with the Solutrean and end in the Magdalenian level 0.

12 At Laugerie-Haute-Ouest (or LHO), the mammoth is quite well represented in levels 11A, 10 and 9 as well as in level 2, whereas it is absent from LHE5 (tab. 3; fig. 2b). These mammoth remains are mainly made up of incisor fragments which could be linked to ivory working at the west of the site. From an environmental point of view, their presence indicates a cold climate with an abundant plant biomass on which the largest of the Pleistocene ungulates could feed. Still on the west side, there is a relatively strong increase in horse remains in levels 11A and 10, i.e., in the levels with Lower and Middle Solutrean remains. The gradual increase documented at the east of the site, presented as an evolutionary process beginning at the base of the Solutrean sequence and continuing until the summit is not duplicated here. How is it thus possible to establish links between the Solutrean sequence in the east and in the west of the site? Let us examine the question from a biostratigraphic viewpoint.
Figure 3 - Biostratigraphic units. 2a, Laugerie-Haute-Est; 2b, Laugerie-Haute-Ouest (Bordes excavations, Bordes and Smith excavations).

Figure 4 - Laugerie-Haute, $^{14}$C Chronology (years cal BP). 1a, the whole archaeological sequence; 1b, the Solutrean cultural sequence.
Biostratigraphic units of the Solutrean complexes and chronology

To define these units, we took into consideration all the stratigraphic sequences of the site concerning the Solutrean in LHO and the Perigordian VI, the Protomagdalenian, the Solutrean and the Magdalenian in LHE. These units were established according to the principles developed in the work of diverse authors (cf. notably Guérin 1982; Cordy 1982), whereby the associations of ungulates and characteristic species serve as guidelines. As this particular sequence was formed during a short period of the Pleistocene, it is hardly surprising that the species characteristic of these guidelines were not used much here (Delpech 2007). Indeed, these taxa, *Equus caballus gallicus* (Prat 1968) for the horse and a small-sized reindeer (Delpech 1975, 1986; Delpech *et al.* 2000; Kuntz 2011), are present throughout the sequence and thus provide no discriminatory element for the levels in question.

In LHE, we identified 5 biostratigraphic units (fig. 3a); one of which regroups three levels with similar associations (unit A which corresponds to levels bearing Magdalenian III, II and I); three others each correspond to a single level with a specific association (this is the case for units B, D and E with Magdalenian 0, Protomagdalenian and Perigordian VI); the last unit (unit C) regroups all the Solutrean levels. Each of these has yielded a slightly different association, but from one level to another, the horse increases regularly and progressively, while at the same time, diversity decreases: the red deer and the bovines disappear first, followed by the ibex. From the base to the summit, the LHE biostratigraphic units allow us to chart a logical environmental evolution (cf. preceding §). No biostratigraphical arguments have challenged the chronological succession of the Solutrean unit, made up of five superposed complexes, which is part of this sequence.

At LHO, all the levels have yielded Solutrean finds. From a faunal association viewpoint, these levels are differentiated from those of the east by the presence of the mammoth. This cannot be used to establish correlations between LHE and LHO as it is a specific characteristic of LHO. From a biostratigraphic point of view, five units called C, can be retained (fig. 3b). Unit C3 is characterized by the presence of mammoth. In two other units, C5 and C2, the reindeer leaves very little room for other ungulates, mostly represented by the horse. There are only slight variations in their representation which appear to be random. However, the presence of red deer in unit C5 (level 12b) and bovines (level 12c) allows us to establish a link between the two loci. At LHO and at LHE, these two taxa are represented at the base of the stratigraphic complex yielding Solutrean remains. Unit C1, which corresponds to the summit of level 2, is characterized by a wide taxonomic diversity (number of ungulates = 5) and by the presence of the horse, bovines and the deer, like in the LHO base unit C5 (level 12b) and the LHE base unit C. There thus appears to be a link between units C1 and C5 in LHO on one hand and the base unit C in LHE on the other. Lastly, unit C4 is characterized by a clear, although not a very strong increase in horse (then mammoth). It is worth recalling that the increase in horse remains in the Solutrean levels at LHE justifies the sequencing of the archaeological levels; at LHO it is in unit C4 that the horse is better represented than elsewhere (cf. fig. 2b and fig. 3b).

The correlations established between LHE and LHO clearly show that the LHO units are not laid out in a normal chronological order. Indeed, the C unit formation in the east (levels 31 to 22) corresponds successively in the west to units C5 (level 12) and C1 (level 2),...
then to unit C2 (levels 8 to 3) and lastly to unit C4 (levels 10 and 11A), which would be the most recent. The closeness in time between the formation periods of levels 12 and 2 was suggested by the dates: in LHO, the oldest dates for Upper and Final Solutrean levels were those from layer 2 (fig. 4b). However, given the upheaval that these slight variations would provoke, it appears to be more reasonable to regroup all of the LHO Solutrean levels in a single biostratigraphic unit.

**Chronology and dates**

Biostratigraphy thus leads to the validation of the chronological order of the LHE Solutrean levels 31 to 22 but not that of levels 12 to 2 at LHO. These latter levels should thus be considered globally for any study based on chronologically ordered data.

Other studies carried out on the Solutrean levels in the west of the site have reached conclusions which support these points of view. In this way, the Solutrean levels clearly appear to have been deposited by solifluxion which can lead to the formation of “pseudo-stratified levels” in the same archaeological level “and cause significant perturbations in layers of remains” (Texier 2009 - p.140). Moreover, in the context of a joint TL/\(^{14}\)C program, “the comparison of results from the different stratigraphic levels shows that the old breakdown of the Laugerie-Haute sequence” (west side), “based on tools, is not associated with any significant chronological differences... When using these dates, prehistorians should take account of the “blur” resulting from the physical uncertainties of the date” (Roque et al. 2001 - p. 231, fig. 6). Figure 4 regroups all the radiocarbon dates obtained for the east and the west of the site, and the TL dates in the west and sheds light on the question. Globally, the dates are coherent: from the base to the summit of the sequence the chronology progresses (fig. 4a) but in the west, for the Solutrean, it is impossible to give an age for each stage of the technocomplex (fig. 4b). It is noteworthy that the Laugerie-Haute Solutrean sequence formed after the Heinrich 2 event which lasted for about 2.2 millennia and would have started about 26,400 years ago (Sanchez-Goni M.F. and Harrison S.P. 2010).

**Conclusion**

At Laugerie-Haute, the fauna associated with the Solutrean characterizes a generally cold and dry climate. This interpretation was already advanced in 1975 (Delpech 1975 - p. 296, 1983 - p. 279), and was, at that time, in disagreement with the hypothesis of a warming considered as an interstadial, defended by palynologists and sedimentologists (Paquereau 1978; Leroi-Gourhan 1980; Laville 1964, 1973 and 1975). The latter were following the conclusions of D. and E. Peyrony who thought that a warming occurred during the Solutrean (Peyrony and Peyrony 1938 - p. 77). Today, the Solutrean has become definitively “cold”. This paper contains several palaeontological arguments. Moreover, moving upwards through the stratigraphic sequence in Laugerie-Haute-Est, everything points towards a gradation of the severity of the climate, as if the Last Glacial Maximum was approaching and the coldest phase was reached during the formation of the Magdalenian 0 complex. This gradual progression supports the hypothesis that the fossiliferous Solutrean levels are stratigraphic entities ordered in time. But this progression is only visible at the east of the site; at the west there are no traces of gradual evolution. The biostratigraphy also shows that there is a chronological disorganization of the levels and that it is thus indispensable to regroup them for any work relying on
chronologically classified data. Other authors in other research domains also call for the same precautions (Roque et al. 2001; Texier et al. 1999; Texier et al. 2004; Texier 2009). An archaeostratigraphic revision appears to be necessary as Laugerie-Haute is the site where the Solutrean industry was characterized and the different phases of the Solutrean were defined. Ph. Smith presents Laugerie-Haute as “the central pillar of the reconstitution of the French Solutrean” (Smith 1966 - p. 57). If this pillar is to resist the ravages of time, it needs to be bolstered by an archaeostratigraphic study with chronological anchors at the east side, rather than at the west of the site. But that is only the point of view of the biostratigrapher!

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NOTES


2. I have retained the denomination “Magdalenian” used at the time of excavation (and afterwards); today we refer to the “Badegoulian”.

3. The Protosolutrean complex (layer G from the Peyrony excavations, layer 14 from the Bordes excavations) yielded very few faunal remains and will not be considered here.

4. The Solutrean is not a “period” but a technocomplex, the Solutrean referred to here designates the period during which the Laugerie-Haute Solutrean “levels” formed.

5. We only identified a mammoth’s molar fragment in the complex with Magdalenian III.

6. All the mammoth remains from the west of the site (n = 91) are incisor fragments (in ivory) apart from 14 of them which are molar fragments (1 in 5, 1 in 9, 11 in 10 and 1 in 12c).
ABSTRACTS

Biostratigraphic analysis applied to prehistoric archaeological contexts can establish chronological ties between strata at different sites and document stratigraphic perturbations within a given site. This paper provides such an analysis for the Solutrean levels of Laugerie-Haute (Les Eyzies, Dordogne). I first address the stratigraphy of the site as a whole and then the environmental significance of the faunal associations found there, including the role that these associations have played in supporting the reality of the famous Laugerie Interstadial. The results of this work support the chronological order of Solutrean levels 31 to 22 at Laugerie-Haute-Est but reject that of levels 12 to 2 at Laugerie-Haute-Ouest. These latter levels should be considered as a single unit in all future chronological analyses. As a result, archaeostratigraphic analyses of the Laugerie-Haute Solutrean should only be based on the sequence from Laugerie-Haute-Est.

INDEX

Keywords: Laugerie-Haute-Est, Laugerie-Haute-Ouest, Solutrean, biostratigraphic units, archaeostratigraphic units, Solutrean chronology

AUTHOR

FRANÇOISE DELPECH

Université Bordeaux 1, PACEA-PPP-UMR 5199, Bâtiment B18, avenue des Facultés, 33405 Talence, France - francoise67.delpech@orange.fr