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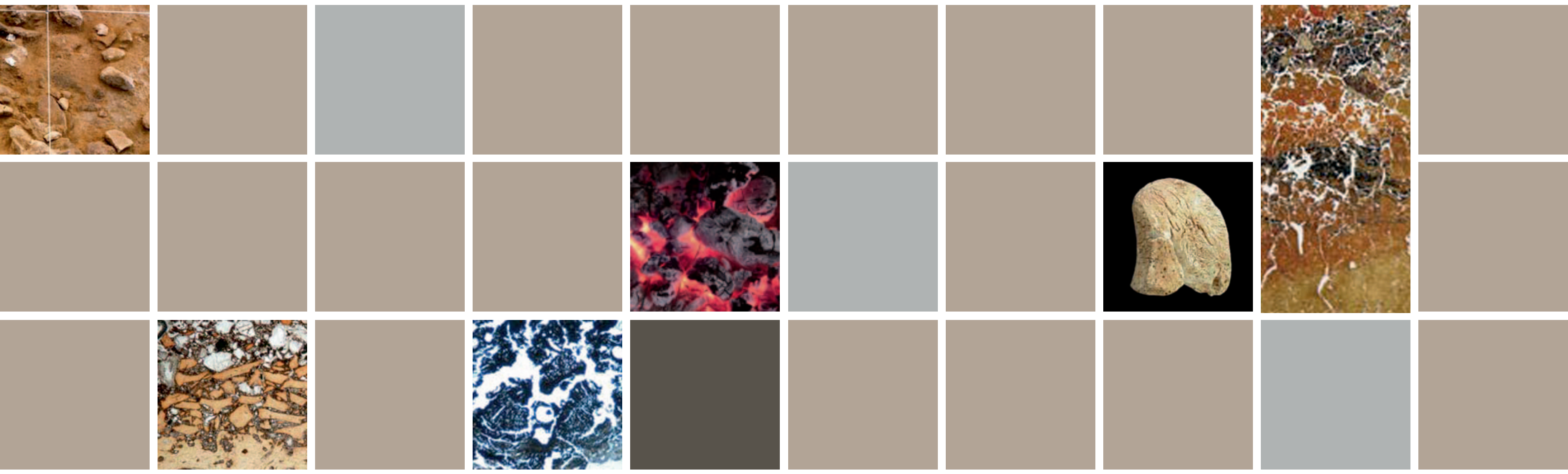
THE TAPHONOMY OF BURNED ORGANIC RESIDUES AND COMBUSTION FEATURES IN ARCHAEOLOGICAL CONTEXTS



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REFLECTIONS ON THE POTENTIAL FOR PRESERVATION OF BURNED BONE BASED ON THE MATERIAL FROM SAINT-ANTOINE (VITROLLES, HAUTES-ALPES)

Maryline RILLARDON & Jean-Pierre BRACCO

« Hommage to Jean Gagnepain »

Abstract

The faunal assemblage from the open-air site of Saint-Antoine at Vitrolles (Hautes-Alpes, Epigravettian) has yielded an atypical composition of burned bones (NRT = 23%), being composed mainly of charred compact bones. While in an experimental context a high proportion of charred bones is typical of the use of skeletal remains as fuel, their representation in archaeological contexts is generally low, particularly in comparison to that of the less intensely burned elements. Contrary to this general principle, the Saint-Antoine deposit shows a strong representation of charred bones in a difficult taphonomic context characterised by an acid sediment and by the intensive action of different taphonomic phenomena (weathering, sediment compaction, dissolution). The high representation of charred bones seems to result from a combination of various factors, including the purpose of the combustion (camp maintenance and/or use as fuel) and their intense fragmentation, together with a higher preservation potential for burned bones (compact and spongy), including charred bones, compared to unburned bone elements when they are buried in acid sediments.

Keywords : burned bones, combustion, taphonomy, Epigravettian

Introduction

In archaeological assemblages, charred bone is generally scarce compared to less burned bone. Only experimental contexts in which the bones are deliberately burned deliver such proportions (Théry-parisot *et al.*, 2004, 2005; Costamagno *et al.*, 2005, 2009). This under-representation in archaeological contexts is generally interpreted as the result of their greater vulnerability to taphonomic phenomena (trampling, burying). This fragility is due in part to their loss of structural coherence which renders them mechanically more friable (Stiner *et al.*, 1995).

In locus 2 of Saint-Antoine (Hautes-Alpes, France), attributed to the Recent Epigravettian, these remains, thus ostensibly fragile, have been found in an unusual taphonomic context. Buried in a sediment with an acid pH (limestone-rich marl) unconducive to preservation, the unburned bones were preserved only in a restricted area of the deposit, constituted of a very dense concentration of bones and lithic remains which, after archaeological analyses, have been attributed to a waste disposal area (midden type). The density of the bones in this zone seems to have permitted their preservation by protecting them from the aggressive surrounding environment.

In order to better understand and to attempt to explain the origin of this stock of charred bones, different hypotheses have been considered: does the existence of a midden explain the good preservation of the charred bones? Did the differential fragmentation of the burned bones as a function of the intensity of their combustion influence the over-representation of some of these elements? Apart from the depositional context, can the origin of the combustion (natural/anthropogenic) and its purpose (camp maintenance, cooking) explain in part this high rate of charred bones?

Presentation

The site

The Upper Paleolithic open-air site of Saint-Antoine is located in the commune of Vitrolles in the French department of the Hautes-Alpes (photo 1 and 2). It is situated on the right bank of the Durance river at an altitude of 575 metres above sea-level, on the southern flank of a marlaceous knoll. Discovered in 1982 by Alain Muret, an initial excavation campaign (1988-1990) concentrated on a zone since named locus 1 (Muret *et al.* 1991). In 1996, in the context of preventive operation linked to the construction of the A51 autoroute, this locus 1 was the subject of renewed excavations under the direction of J. Gagnepain and J.-P. Bracco. This second campaign permitted the completion of the excavation of locus 1 and the uncovering of two new loci (locus 2 and 3) (Gagnepain *et al.*, 1997, 1999) (fig. 1). Only locus 2 was excavated, locus 3 not being threatened by the construction.

Ph. 1 - Aerial view of the geographical context of the Saint-Antoine deposit (C. Hussy, SRA PACA).

Ph. 2 - Aerial view of the Saint-Antoine deposit during excavation (C. Hussy, SRA PACA).

The characteristics of the lithic tools from loci 1 and 2 allow their attribution to the Recent Epigravettian of the Italian series, and more precisely to its phase 3 defined by C. Montoya (Bracco *et al.*, 1997; Montoya and Bracco, 2005; Montoya and Peresani, 2005). This chrono-cultural attribution is confirmed by two radiocarbon dates (locus 2, level B) which situate the occupation at the end of the recent Allerød-Dryas period: Ly 1525 (OXA): 11180 ± 60 BP (burned bone); Ly 1526 (OXA): 10825 ± 55 BP (charcoal) (Montoya & Bracco, 2005).

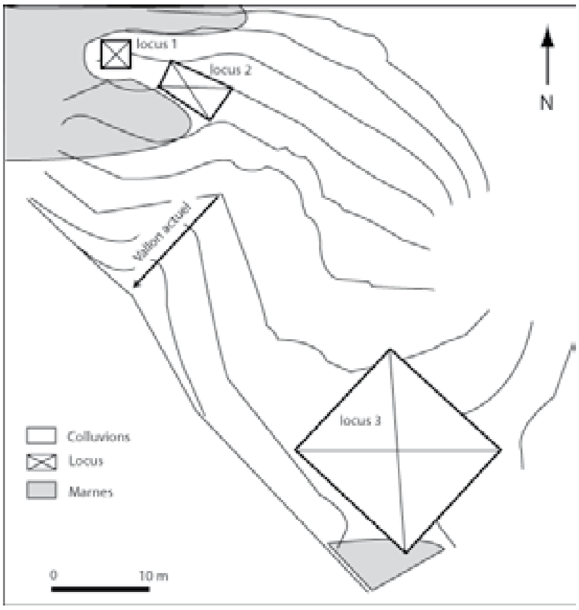


Fig. 1 - General plan of the Saint-Antoine site, with localisation of loci 1, 2, and 3 (Gagnepain *et al.*, 1999).

Locus 2

Only locus 2 has yielded faunal remains. The total archaeological surface of this locus is 150 m^2, of which 120 m^2 have been excavated to a depth of 60 to 80 cm. 94 m^2 have been manually excavated, i.e., 78%, corresponding to the areas richest in remains. The rest of the surface was explored with the help of a mechanical excavator (Gagnepain *et al.*, 1999).

Three levels were discovered in a detrital sediment composed of Jurassic marls (from top to bottom: A, B and C) (fig. 2). The examination of all data from both the excavation and the analyses shows that levels A and B were deposited separately. In contrast, level C, poorer and only present in certain areas of the archaeological surface, may correspond to a vertical slip of the base of level B (Bracco 2004, Gagnepain *et al.*, 1997, 1999). The two main archaeological levels (A and B) are separated across a large part of the excavation by a quasi-sterile layer. The absence of sedimentary distinction between these two layers, together with a limited duration of excavation, means that the attribution of the archaeological material to one or other of these two levels has not yet been carried out. This disadvantage is limited by the fact that level A is poor in remains of all types (lithic industry, bone remains, charcoals). It has nonetheless produced a hearth composed of stones laid on edge which delimit a half-circle in which has been found a reddened area and some coniferous-type charcoals (Canals i Salomo *in* Gagnepain *et al.*, 1997). While no hearth was discovered in the lower level (B), this level, otherwise very rich in lithic remains and charcoal, has also yielded a large quantity of faunal remains distributed in midden form. Measuring on average 50 cm thick, this level may correspond either to a single archaeological level expanded by post-depositional processes or to a multi-stratified accumulation of several archaeological levels (Gagnepain *et al.*, 1999; Bracco 2004).

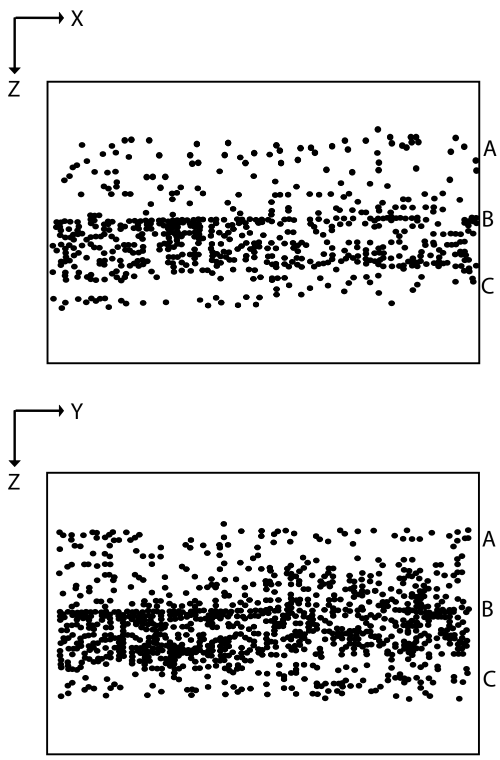


Fig. 2 - Locus 2. Stratigraphic projection of the lithic artefacts from square O20 and illustration of levels A, B and C (Gagnepain *et al.*, 1999).

The level B bone midden (locus 2)

The accumulation of faunal remains (photo 3) extends over an area 4 m long by 2.50 m wide and approximately 50 cm thick, spreading towards the south-west of the deposit, perpendicularly to the slope of the paleovalley (fig. 3) (Canal i Salomo, *in* Gagnepain *et al.*, 1997). This accumulation may be considered as a midden-type structure given the weak dispersion of the elements around a central core: “the layer of remains is organised in concentric rings with decreasing density towards the edge from an area of maximum density at the central bone midden” (Canal i Salomo, *in* Gagnepain *et al.*, 1997, 257) and its perpendicular orientation to the axis of the paleovalley which excludes deposition by sedimentary phenomena *lato sensu*.

Ph. 3 - View of the locus 2 bone midden during excavation.

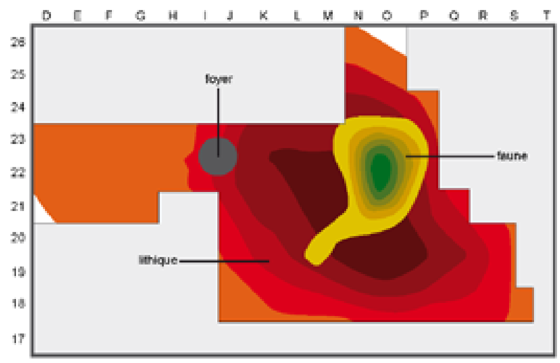


Fig. 3 - Locus 2. Planimetric projection of all lithic artefacts and relative positions of the bone midden and the hearth in the layer of remains (Gagnepain *et al.*, 1999).

The sediment is composed of partly decarbonated Jurassic marls (Muret *et al.*, 1991). The high limestone content of the marl (from 35 to 65%) gives this sediment an acid pH, unconducive to the preservation of the bones. However, the spatial concentration of the bones has led to the release of a large quantity of calcium carbonate. The current hypothesis is that this partially dissolved calcium carbonate protected the midden from the aggressive external environment, thus permitting preservation of the bone and dental elements (Bez, 1997 : *in* Gagnepain *et al.*, 1997). The faunal remains scattered outside the midden have in fact almost disappeared, only surviving as ghosts irrecoverable by excavation.

The bones present a relatively poor state of preservation, characterised by the strong action of the different pre- and post-burial taphonomic phenomena such as weathering, sediment compaction and dissolution. In general, the cortical surface is rarely preserved and the bones are very friable (photos 4, 5, and 6).

The faunal assemblage (Rillardon, 2003) is characterised by a very high predominance of red deer, which represents, depending on the counting unit employed, between 82 and 92% of the material identified (tab. 1). The study of the stages of dental eruption in this taxon indicate slaughter between midsummer and late autumn (July-December).

Ph. 4 - Bone demonstrating an advanced stage of alteration (scale: 1 cm) (Photo M. Rillardon).

The traceological data from the lithic industry (Philibert *in* Gagnepain *et al.*, 1997), reflect the

Ph. 5 - Red deer radius presenting concretion and vermiculations (scale: 1 cm) (Photo M. Rillardon).

Ph. 6 - Red deer mandible presenting a heavily altered bone surface (scale: 1 cm) (Photo M. Rillardon).

execution of various activities such as hunting, butchery and the different phases of working with hides (scraping, tanning).

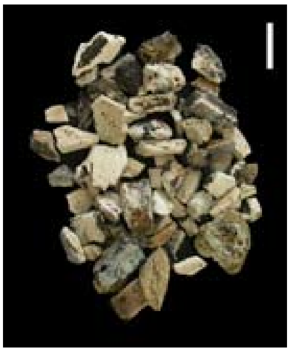
The predominance in the lithic material of elements relating to projectiles (armatures) and hide working (scrapers), and the specialisation of the cynegetic acquisition, together with the execution of operations for transforming hides into leather, reflect seasonal human occupation linked to the acquisition and treatment of red deer carcasses (Gagnepain *et al.*, 1997; Bracco 2004).

	NR	%	NMI	%
Cerf	421	92,1	19	82,6
Aurochs	35	7,7	3	13
Chevreuil	1	0,2	1	4,4
Total NRDt	**457**	**100**	**23**	**100**
NRDa	32			
cf. gd herb.	28			
cf. moy. herb.	176			
ND	16555			
Total	**17248**			

Tab. 1 - Faunal composition of locus 2 (Rillardon 2003).

The burned remains

3877 burned faunal remains were counted, i.e., 23% of the total number of remains. These are principally indeterminate remains (photo 7). Only four elements have been identified anatomically and taxonomically; all attributed to red deer (a large sesamoid, two phalange II bones - one vestigial - and a radius distal extremity) (photo 8). The burned bones are spread over nearly the whole of the excavated surface, contrary to the unburned bone remains.



Ph. 7 - Indeterminate burned bones (scale: 1 cm) (Photo M. Rillardon).

Ph. 8 - Charred Red deer sesamoid (scale: 1 cm) (Photo M. Rillardon).

The different histological categories are represented (compact, compact/spongy, spongy, dental) (tab. 2). The fragments of compact bone represent 90% of the burned material. The other categories are less common and are represented in relatively similar proportions; between 3 and 4%.

	NR	%
Compact	3497	90,2
Compact/Spongieux	163	4,2
Spongieux	120	3,1
Dents	97	2,5
Total	**3877**	**100**

Tab. 2 - Histological composition of the burned bones from Saint-Antoine.

The burned remains are very small in size (fig. 4). They all measure less than 3 cm and 91% do not exceed one

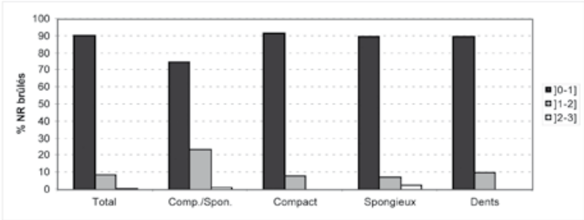


Fig. 4 - Size (in cm) of the faunal remains as a function of histology (NR = 3877).

centimetre. This characteristic is found in the different histological categories (92% for compact bone, 90% for spongy bone and dental fragments, and 75% for compact/spongy bone).

The colour code used is that established by M.-C. Stiner *et al*. (1995) and modified by S. Costamagno *et al.* (1999), to which we have added the blue shade, which appears, as does the grey shade, between the stage of carbonisation and that of charring (Hermann, 1977; Shipman *et al.*, 1984). The colouration of the burned remains is variable (fig. 5), varying from slightly burned (brown) to charred (white). However, the charred remains are predominant, representing 75% of the total of burned remains, for all histological categories with the exception of the dental fragments carbonised to 85%. This difference is probably explained by the different thermal behaviour of these two materials (Susini, 1988).

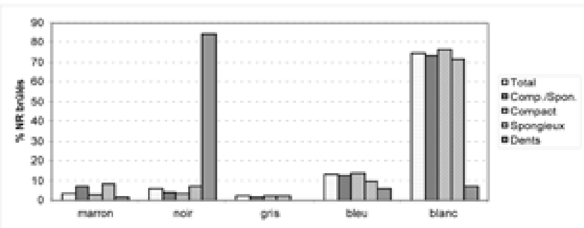


Fig. 5 - Proportion of the different colourations of burned faunal remains as a function of histology (NR = 3877).

Regarding the skeletal elements of the red deer, the three elements of the bottom of the hoof (large sesamoid and phalanges II) are charred while the radius distal extremity is blue in colour.

The combustion index (Costamagno *et al.*, 2009), is 0.86 (tab. 3). It is nearer to the index obtained in experimental contexts (average = 0.77) than that of several archaeological series of the French Palaeolithic (average = 0.5) (Costamagno *et al.*, 2009).

In conclusion, for the Saint-Antoine deposit, the burned bones are primarily composed of charred compact bone of small size.

Codes couleurs	Description	Nombre d'os	Coefficient	Indice de combustion
0	Non brûlés	7242	0	
1	Os partiellement brûlés	140	140	
2	Os carbonisés (majoritairement noir)	146	292	
3	Os majoritairement gris	98	294	
4	Os calcinés (majoritairement blanc)	2884	11536	
		10510	12262	0,86

Tab. 3 - Combustion index (according to Costamagno *et al.*, 2009) of the burned faunal remains from Saint-Antoine. (The blue shade and the dental material have been excluded from the calculations).

Hypothesis 1: The midden as a protective structure

The first hypothesis envisages the fact that the liberation of calcium carbonate, which permitted the preservation of the unburned bones in the interior of the midden, promoted the preservation of the charred bones by creating a favourable burial context. To test this hypothesis, a spatial analysis of the burned remains (bone and charcoal) according to their density per 0.25 m² (fig. 6 and 7) was conducted.

The burned bones and charcoal are present over nearly the whole of the excavated surface, although two areas of concentration appear, which are common to these two categories of remains: one situated in I-J 22 and one in N 20a which is spatially less extensive. Thus the finding that much of the charcoal and burned bones, whatever their histology and stage of combustion, were preserved outside the midden, indicates that the presence of the midden cannot explain the strong representation of charred bones.

The analysis of the spatial distribution of the burned remains shows the preservation of the burned bones in an area of the deposit where the unburned bones were not preserved. This indicates, in the present case, a greater potential for the preservation of burned compared to unburned bone. This fact is contrary to numerous experimental data which demonstrate that burned bones are more fragile and friable than unburned bones due to changes in diagenesis experienced by the former (Stiner *et al.*, 1995; David, 1990; Walters 1988). However,

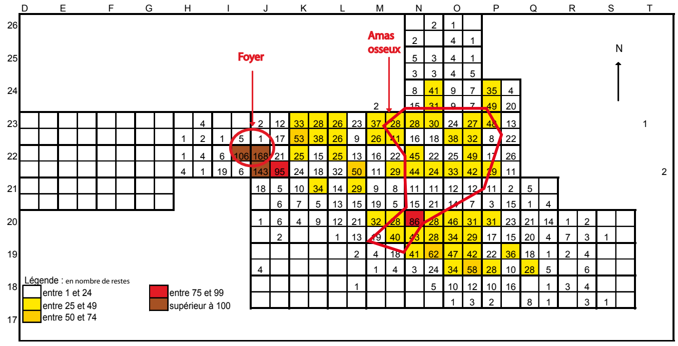


Fig. 6 - Spatial distribution of the burned bones (NR = 3836) as a function of their localisation by 0.25 m².

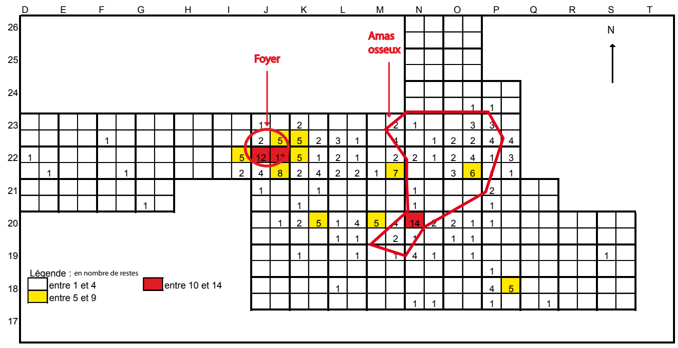


Fig. 7 - Spatial distribution of the charcoals (NR = 236) as a function of their localisation by 0.25 m².

there do exist other archaeological deposits which demonstrate better preservation of burned bone than of unburned bone, such as the Iron Age hillfort of Castell Henllys (Wales) (Gilchrist & Mytum, 1986) and the megalithic monument of Castelluccio (Vigne, 1983; David, 2001). The common feature of these deposits is their preservation in acid soils (clay, gravels, marl). It appears thus that the experimental results do not apply to all sedimentary contexts. In acid soils the burned bones would have a higher potential for preservation than unburned bones.

Hypothesis 2: High fragmentation

The second hypothesis tested in order to attempt to explain the over-representation of charred bones is that of a higher fragmentation of these elements. Several experiments highlight the great friability of charred bones as a result of different taphonomic phenomena such as trampling, sediment compaction (Stiner *et al.*, 1995) and weathering (Gerbe, 2004).

Indeed, at Saint-Antoine we note a higher fragmentation of charred bone compared to less intensely burned bone (fig. 8). However, the fact that the fragments measuring less than one centimetre are in the majority in all colourations indicates that the phenomenon of fragmentation as a function of the intensity of combustion did not play a fundamental role in the over-representation of the burned bones.

The relatively high total percentage (23%) of burned bones found in the deposit is certainly largely influenced by the high fragmentation of these elements. The original percentage of burned compared to unburned bone was probably much lower.

Hypothesis 3: Origin of combustion

Finally, it is necessary to estimate whether the origin of combustion (natural *vs* anthropogenic), and its purpose in the case of an anthropogenic combustion, influenced the strong representation of charred bones.

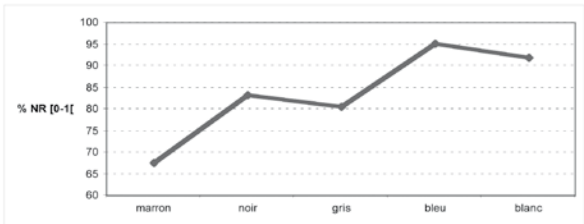


Fig. 8 - Percentage of burned bones measuring less than one centimetre as a function of different stages of combustion (NR = 3523).

Natural *vs* Anthropogenic

The spatial analysis of the burned remains (fig. 6 and 7) shows the superposition in squares I-J 22-23, of the hearth from the higher level (A) and of the main area of concentration of the burned elements in level B. It is thus necessary to verify whether these organic residues are linked to the combustion activity in the hearth. The analysis of the stratigraphic distribution of the burned remains (fig. 9 and 10) highlights the presence of about ten centimetres of sediment poor in remains between the

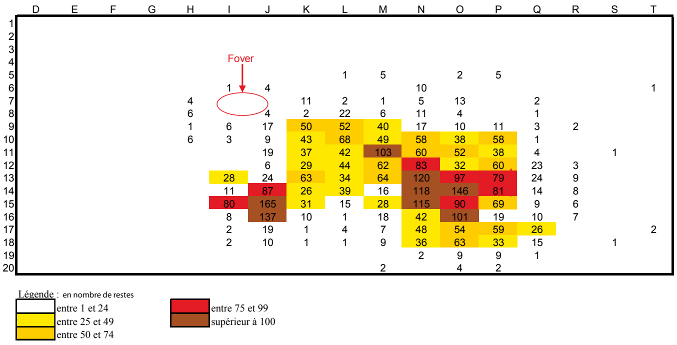


Fig. 9 - Stratigraphic distribution of the burned bones (NR = 3836) as a function of their localisation by 0.25 m².

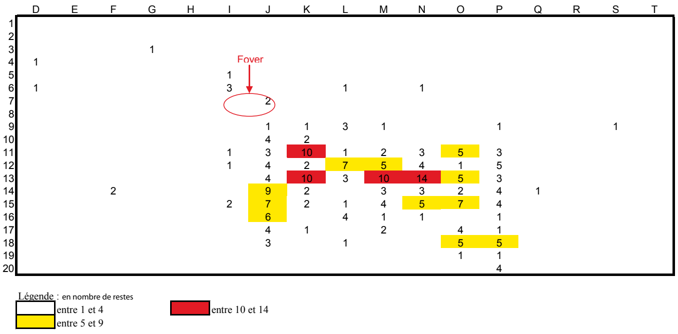


Fig. 10 - Stratigraphic distribution of the charcoals (NR = 236) as a function of their localisation by 0.25 m².

hearth and the burned elements. While the archaeological material may have undergone some vertical movements, these latter were only small-scale (Gagnepain *et al.*, 1997). This stratigraphic separation thus indicates the independence of these two combustion indicators. Indeed, as regards bones buried beneath a hearth, several experiments (Stiner *et al.*, 1995; Bennett 1999) have shown on one hand that the thermal stigmata were primarily present on the bones buried in the first ten centimetres, and on the other hand that these bones never achieved the final stage of charring (white colouration) even in the case of a long combustion.

Regarding other possible causes of natural origin, the intensity of the combustion (maximal degree of heat achieved) is not coherent with the data obtained from natural fires. These latter generate temperatures significantly lower than those created during an anthropogenic fire, rarely leading to bone charring (David, 1990; Bellomo, 1993). In addition, the fact that only 23% of the bone elements discovered possess traces of combustion allows the exclusion of the hypothesis of a natural fire.

Thus, the stratigraphic position of the burned remains and their combustion intensity allow us to reject the hypothesis of combustion linked to the hearth of the higher level or combustion linked to a natural fire. It thus appears that the combustion from which the burned remains issue is of anthropogenic origin.

Cooking *vs* waste *vs* fuel

The deliberate burning of bone may result from different activities such as the cooking of anatomical portions (Vigne *et al.*, 1981), use as fuel (Beyries, 2002; Théry-Parisot, 2002; Villa *et al.*, 2002; Castel, 2003; Théry-Parisot & Costamagno, 2005; Théry-parisot *et al.*, 2004, 2005; Costamagno *et al.*, 1999, 2005, 2009), the burning of waste during camp maintenance (Cain, 2005) or for ritual purposes, in particular to favour the reincarnation and renewal of the herd (Vaté & Beyries, 2007).

The distinction between these different purposes may be clarified through the use of various indices proposed by S. Costamagno *et al.*, (2009). At Saint-Antoine (tab. 4), the high percentage of fragmentation (99% of remains smaller than 2 cm) together with the high percentage of at least carbonised bones (86%) seems to indicate deliberate combustion of skeletal elements. However, the percentage of spongy parts burned (7%), the most combustible parts of the bone (Costamagno *et al.*, 1999), is low. Experimental data (Gerbe, 2004; Thiébault *et al.*, in press) indicate the much greater sensitivity of burned spongy bone to taphonomic processes both pre- and post-burial (trampling, weathering, etc.,) compared

Indices	Formule de calcul	Résultat Saint-Antoine
Pourcentages d'os spongieux brûlés	(SPON2 + SPON3 + SPON4)/ (NR2 + NR3 + NR4 X 100	6,8%
Pourcentages d'os brûlés inférieurs à 2 cm	NR brûlés < 2cm/ NRT brûlés X 100	98,8%
Pourcentage d'os brûlés au moins carbonisés	(NR2 + NR3 + NR4)/ NRT brûlés X 100	86,4%

Tab. 4 - Calculation of the different indices (according to Costamagno *et al.*, 2009, SPON = spongy portions (ribs, vertebrae, rib bones, scapular glenoid cavity, hip bone, articular extremities of long bones, carpals, tarsals, sesamoids, fragments of indeterminate spongy tissue); NRT = total number of remains; the index corresponds to the colour codes from table 3) (For the initial calculation, the compact/spongy elements were distributed in each of these two categories).

to fragments of diaphyses. While at Saint-Antoine the only anatomically and taxonomically identifiable burned remains are bone extremities or charred spongy bone from red deer, thus indicating the potential for preservation of these elements in the interior of this deposit, it is not possible to totally exclude the possibility of differential preservation of the burned spongy parts.

Thus, the burned remains discovered at Saint-Antoine are indicators of an intentional combustion of anthropogenic origin. However, due to a potential taphonomic bias concerning the spongy parts, it is difficult to determine whether the purpose of combustion was the camp maintenance and/or the use of bone as fuel during particular activities (drying of hides, etc.).

The absence of clear structure prevents determination of whether the concentrations of burned remains found at Saint-Antoine are indicators of a combustion zone[1] in the real sense of the word or of a waste zone[2] from a hearth located in an unexcavated or non-preserved part of the site. However, the analysis of lithic remains deposited at the heart of this midden of burned bones, and in particular the presence of numerous cores in the phase of exhaustion and cessation of lamellar production (Montoya 2004), may indicate a secondary accumulation in a waste area.

Conclusion

The burned bones from locus 2 of Saint-Antoine are primarily composed of charred compact bones preserved in an excessively unfavourable sedimentary context. The strong representation of these remains seems to result from the conjunction of different factors:

- The purpose of the combustion (maintenance of camp and/or use as fuel).

- The intense fragmentation of the charred bones.

- A greater preservation potential of the burned bones (compact and spongy), including charred bones, in comparison to unburned bone elements when they are buried in acid sediments.

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[1] - Combustion zones: *«Presumed site of fire(s) for which the perimeter may be defined with the help of various indices particular to combustion (reddening of the sediments, ash deposit, etc.)»* (Gascó, 2003, 109).

[2] - Waste zones: «*These are comprised of waste issued from hearths. They generally come from a maintenance operation of the hearth (cleaning). Generally these are more or less dense scatters or layers*» (Vicherd, 2003, 16)

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