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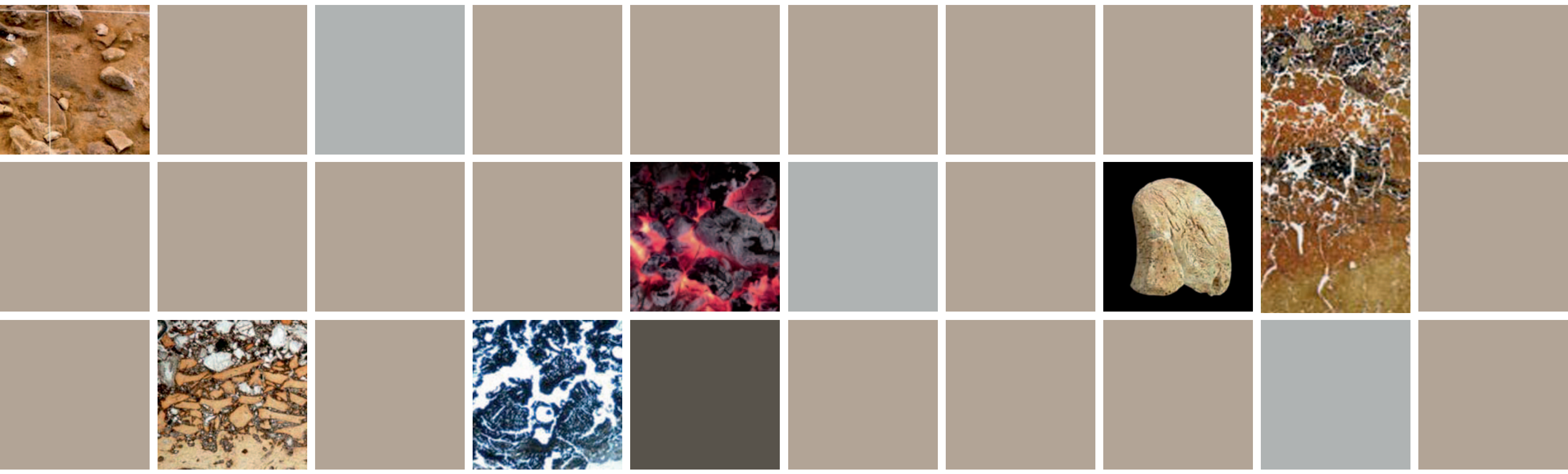
THE TAPHONOMY OF BURNED ORGANIC RESIDUES AND COMBUSTION FEATURES IN ARCHAEOLOGICAL CONTEXTS



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TAPHONOMIC IMPACT OF PROLONGED COMBUSTION ON BONES USED AS FUEL

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Delphine KUNTZ, François BON & Romain MENSAN

Abstract

The combustion of bones results in numerous processes whose impact on the representivity of fossil bone assemblages is increasingly well known due to the multiple experimental approaches developed over the last ten years. Recent experiments conducted with outdoor hearths have shown the consequences of prolonged combustion on bone combustion residues.

The average loss of bone mass after combustion is 65%. The weight of the fine fraction (ashes and fragments less than 2 cm) corresponds to more than one quarter of the residual mass of the remains collected, while the mass of calcined (i.e. white) bone represents an average of 77.2% of the residues. Finally, the residual bone mass is not correlated with the duration of use of a hearth, but with the manner in which it is maintained. These experiments thus clearly document the significant role of fire maintenance methods on the nature and form of bone residues.

Keywords : experimentation, burned bones, bone fuel, hearth, taphonomy

Introduction

The hypothesis that bone was used as fuel in hearths has been proposed for several Paleolithic sites. Until recently, these interpretations were most often based on the abundance of burned bones found in association, or not, with combustion features, regardless of the diversity of possible origins for bone combustion: intentional discard of bone waste in hearths (Spennemann & Colley, 1989; Cain, 2005), alimentary cooking (Gifford-Gonzalez, 1989; Pearce & Luff, 1994; Wandsnider, 1997; Costamagno & Fano Martínez, 2005), ritual combustion (Tchesnokov, 1995; Vaté & Beyries, 2007), accidental combustion after burying (David, 1990; Stiner *et al.*, 1995; Bennett, 1999; Cain, 2005) and natural fires (Bellomo & Harris, 1990; Bellomo, 1993). A series of laboratory experiments (tab. 1) enabled the definition of the combustible properties of bones (Théry-Parisot & Costamagno, 2005; Théry-Parisot *et al.*, 2005), as well as a more precise characterization of the bone remains originating from this type of hearth (Théry-Parisot *et al.*, 2004; Costamagno *et al.*, 2005). Based on these results, a statistical model of the origin of burned osseous assemblages was proposed

Experimental protocol	
	laboratory experiments bone (cow humerus) as only fuel used no fuel added
Variables tested	
	Bone dessication (dry (non humid)/fresh) Bone fragmentation (whole/fractured) Bone tissue (compact/spongy)

Tab. 1 - Experimental protocol and variables tested in the first experimental series realized in the laboratory.

(Costamagno *et al.*, 2009). Despite these advances, a certain number of questions persist concerning both the post-depositional processes that can modify burned osseous assemblages and the identification of burned osseous residues originating from other combustion contexts (Costamagno *et al.*, 2009). For example, with the exception of sites in acid contexts Gilchrist & Mytum, 1986; Costamagno *in* Bordes & Lenoble, 2000; Airvaux *et al.*, 2003), the quantity of intensively burned bones (gray or white) is generally low in archaeological sites, which strongly contrasts the quantities obtained through the experimental use of bone as fuel. According to different studies, calcined (i.e. burned white) bones are more reactive to mechanical constraints than bones that are simply carbonized or *a fortiori* non-burned (Stiner *et al.*, 1995; Thiébaut *et al.*, in press), which could explain the recorded distortions. A prolonged exposition to atmospheric agents could result in a similar phenomenon (Gerbe, 2004, Gerbe this volume). Experiments in progress by two of us, conducted as part of the Gavarnie research program (directed by P. Bertran) and taphonomy workshops (directed by M.-P. Coumont), will contribute new elements concerning the biases introduced by other taphonomic processes in the context of burned osseous remains (human trampling, gelifraction and dissolution).

In parallel to these experiments concerning the action of taphonomic processes after combustion, new experiments related to the combustion of bone materials have been undertaken. This project is conducted in conjunction with the study of the open-air Aurignacian site of Régismont-le-Haut (Poilhes, Hérault), which has yielded around a dozen combustion features, including several in association with wood charcoal and burned bone (Maurin & Ambert, 1979; Bon, 2002; Bon, Mensan and collaborators, 2007). In this paper, we present the results of a first series of experiments concerning the prolonged maintenance of hearths in which bone is used as fuel. These experiments, realized in August 2006 in close proximity to the site, were conducted with three objectives:

1 – to obtain a better understanding of the functioning of the hearths at Régismont-le-Haut and to determine the type(s) of combustible materials used by its Aurignacian occupants;

[1] - *e.g.* Abri Pataud (Théry-Parisot, 2002), Cuzoul de Vers (Castel, 2003), Esquilleu (Yravedra *et al.*, 2005), Le Flageolet I (Bombail, 1987), Hohle Fels (Schiegl *et al.*, 2003), Labeko Koba (Yravedra *et al.*, 2005), Pech de l'Azé I (Rendu, 2007), Le Placard (Costamagno *et al.*, 1998), Saint-Germain-la-Rivière (Costamagno *et al.*, 1998), Brassempouy (Letourneux, 2003) and several layers gravettians of central Europe (Soffer, 1985).

2 – to evaluate the constraints related to the behaviour of a fire fuelled with osseous materials;
3 – to evaluate the impact of prolonged combustion on osseous residues.
In this paper, we focus on the latter objective.

Experimental methods and procedures

The experiments were conducted outside, in the open-air. The hearths (8) were installed on a horizontal ground surface in shallow pits 5 cm deep and 50 cm in diameter (fig. 1). The bones used as fuel were principally salted pork bones and a few fresh cow bones (tab. 2). The bones were meticulously defleshed and then fractured with quartzite cobbles on limestone anvils (fig. 2) comparable to those found on the site (Bon, Mensan and collaborators, 2006). The marrow was removed from the bones before they were burned. The wood necessary to start the fire represents 5% of the weight of the bone used during ignition (fig. 3). The hearths were then exclusively fuelled with bone (fig. 4), except when the temperature dropped too low for the combustion to continue. In this case, a quantity of bone identical to the initial one was used. At the moment of ignition, and at each reloading with combustible materials, the hour and exact nature of the bones (taxon and anatomical portion) was recorded, along with their total weight and number of fragments.

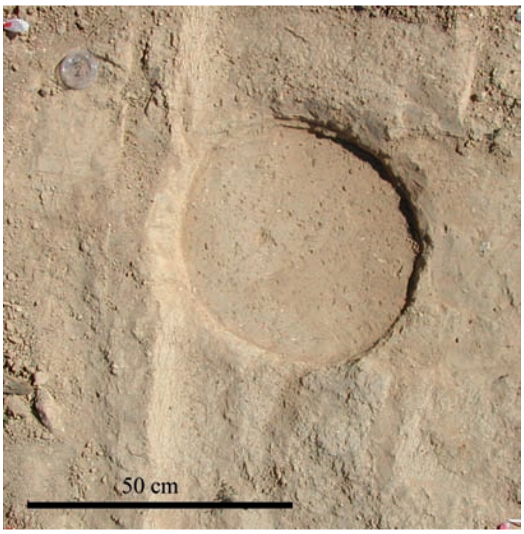


Fig. 1 - Hearth pit.

Fig. 2 - Bone defleshing and fracturation.

Fig. 3 - Combustibles before the fire was lit.

Fig. 4 - Feeding the fire with bones.

	Series 1				Series 2			
	Hearth 1	Hearth 2	Hearth 3	Hearth 4	Hearth 1	Hearth 2	Hearth 3	Hearth 4
Pork								
Pelvis	1	2	5	3	2	2	1	1
Proximal femur	30	32	32	31	15	16	17	16
Distal femur	33	30	32	33	18	15	15	14
Proximal tibia	35	33	33	32	15	15	15	15
Patella	17	16	18	18	5	5	6	5
Tarsal massif	1	1	1	1	2	2	1	2
Cow								
Cervical							1	
Thoracic						1		1
Rib	4	6	6	4		1		1
Scapula	1	1	1	1	1	1		
Proximal humerus				1		1		
Distal humerus							1	
Proximal radius	1							
Carpal massif			1					
Pelvis							1	1
Proximal femur					1			
Distal femur		1					1	
Proximal tibia					1			1
Tarsal massif						1		
Bone mass	**17040**	**17603**	**17214**	**18235**	**9781**	**10327**	**10143**	**9503**
Average maximal temperatures (°C)	**-**	**560,8**	**681,6**	**-**	**503,5**	**569,3**	**692,7**	**-**
Maintenance method	**rapid**	**rapid**	**rapid**	**rapid**	**slow**	**slow**	**slow**	**slow**

Tab. 2 - Experimental parameters: skeletal elements used, bone mass employed, fireplace maintenance methods, average maximal temperatures recorded by the three sensors in the same fireplace (the sensors in fireplace 1 of the first series did not function).

Fig. 5 - Bone residues after combustion.

The experiments were realized following two distinct protocols with the purpose of varying the combustion durations and rate of maintenance of the hearths. In the first series, the fires were fed with no particular precaution, which we designate as a "rapid feeding". In the second series the fires were fed with objective of economizing the bone fuel and prolonging the combustion duration as long as possible: we designate this as "slow feeding". Each series was replicated four times. In the first series, an average of 16,326 grams of bone was burned versus 9,334 grams in the second series (tab. 2). After they were completely cooled, the bone residues were collected (fig. 5), with the exception of those of the fourth hearth of each series, which were left *in situ* in order to record their evolution over several years.

Several factors were recorded during these experiments, starting with temperature. To record the variability of thermal fluxes, the first three hearths in the two series were equipped with three sensors that simultaneously recorded the temperatures every two minutes during the full duration of the experiments. The data were recorded and transmitted into computer format by infrared. For each experiment, three curves that express the temperatures according to time were thus recorded. The second factor relates to kinetics by distinguishing between combustion with flame emission and pyrolysis without flames or calcination (the process that follows the extinction of the flames until the end of calcination). In practice, we considered that the combustion was finished when the average temperature of the hearth recorded by the sensors was below 100° C. In the experiments of the first series, the hearths were fed in two stages: in the morning for an average duration of two hours, then four hours later for a duration of two and a half hours. For the flame duration, we added the two recorded durations. For the calcination duration, we took into account only the first combustion phase. For this reason, the calcination durations of the fires of the first experimental series are not exploitable for taphonomic analyses as the osseous residues result from the two successive combustion phases.

The bone residues were then sorted by 10 mm size classes. The fragments over 20 mm were also sorted according to their tissue type (spongy, compact or compact + spongy) and combustion intensity (non burned, partially burned, mostly black, mostly gray or mostly white) (fig. 6). The bones of each category were then weighed. The fine fraction, after sieving the residues through 0.5 and 0.2 mm screens, were systematically weighed for each experiment (fig. 7 and 8).

The results of the experiments realized at Régismont-le-Haut were compared to those obtained in laboratory experiments (Théry *et al.*, 2004; Costamagno *et al.*, 2005; Théry *et al.*, 2005) according to the following criteria:

- combustion kinetics;
- loss of material, recorded through the percentage of residual mass, meaning the percentage of bone mass collected after combustion relative to that of the bone mass put into the fire;
- intensity of fragmentation, estimated based on the relative abundance of bone fragments by 10 mm size class;
- combustion intensity, estimated based on the relative abundance of calcined bones, meaning those that are mostly white (fig. 9).

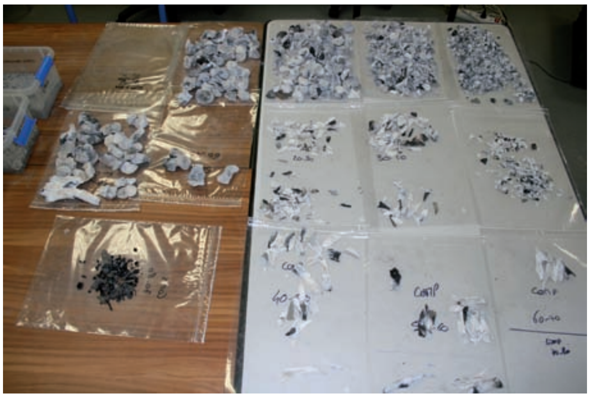


Fig. 6 - Sorting of bone residues.

Fig. 7 - Fragments less than 2 cm

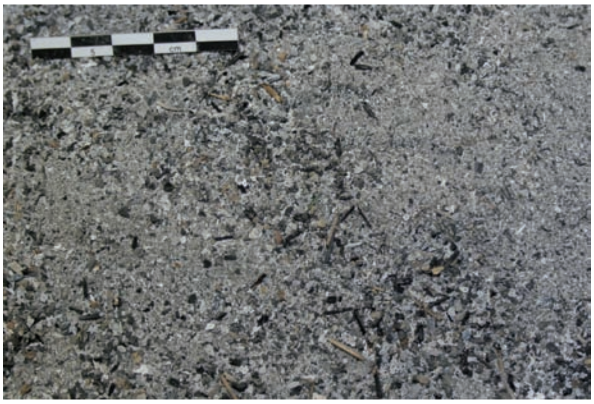


Fig. 8 - Bone ash.

Fig. 9 - Calcined bones

Results

Preliminary observations

The first experiments conducted in the laboratory showed that the fresh or dry state of bone strongly influences the degree of fragmentation of bone residues; the high fragmentation of fresh bone relative to dry bone is probably due to the high pressure created by water evaporation (Théry *et al.*, 2004; Costamagno *et al.*, 2005).

In the experiments conducted at Régismont-le-Haut, the use of salted pork bones, which are relatively dry, could thus explain the presence of numerous articular extremities and whole epiphyses among the bone residues (fig. 10). For comparisons, we thus favoured laboratory experiments in which the bones were burned after desiccation and fracturation.

Fig. 10 - Whole epiphyses of pork long bones.

Meanwhile, some effects were observed only on the cow bones, and thus exclusively on fresh and humid bones. On certain spongy fragments, we observe the formation of compact surface scales that develop in a concentric manner over the entire surface (fig. 11). As they detach, they progressively expose the spongy tissue. The bones affected can thus eventually take the form of a spongy ball with no *compacta*. Such objects have been observed in many faunal assemblages.

Numerous laboratory experiments have shown that the maximal temperatures attained in the hearths depends on the mass of the combustible material and not on the material itself (Théry-Parisot & Costamagno, 2005).

The hearths in the new experiments conducted in the open-air attained maximal temperatures between 561 and 692°C. The temperatures of these fires thus appear inferior to those recorded for the fires in the laboratory (605–805°C), though the mass of combustible material was greater. The differences observed can be easily explained by the impact of atmospheric agents on the combustion temperatures during the open-air experiments. In addition, the intra-series variability is greater than the inter-series variability (tab. 2). For this reason, the results obtained are difficult to exploit for questions concerning temperatures.

Fig. 11 - Concentric surface scales that gradually expose the *spongiosa*.

Parameters that influence the kinetics of combustion

The first laboratory experiments showed that the flame duration is determined by the combined effects of humidity, the density of the bone tissues and their fragmentation, while the initial mass of the combustible material put into the fire explains only 24% of the variability (Théry-Parisot & Costamagno, 2005).

For an equivalent fuel mass, the flame duration appears to be longer in the open-air hearths than in the laboratory hearths (in which no bone materials were added) (fig. 10). In the latter, the average flame duration is 112 minutes for the hearths with proximal extremities versus 165 for those with distal extremities, as opposed to 232 minutes for series 1 at Régismont-le-Haut and 356 for series 2. A variance analysis shows that the average duration of the flames in series 1 differs significantly from that of series 2 (fig. 12). The hearths of series 1 (rapid feeding) require 54% more bone than the hearths of series 2 (slow feeding) to produce flames for an identical amount of time. In terms of bone fuel consumption, the flame durations in series 1 generally follow the same tendency as those observed in the laboratory experiments, in which no fuel was added to the fires (fig. 13). The hearths of series 2, on the other hand, show a real economy of bone fuel when the fires are progressively fed. This is not the case for

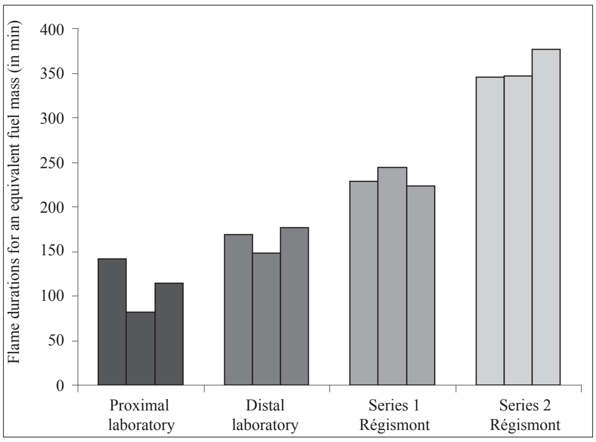


Fig. 12 - Flame duration for an equivalent fuel mass.

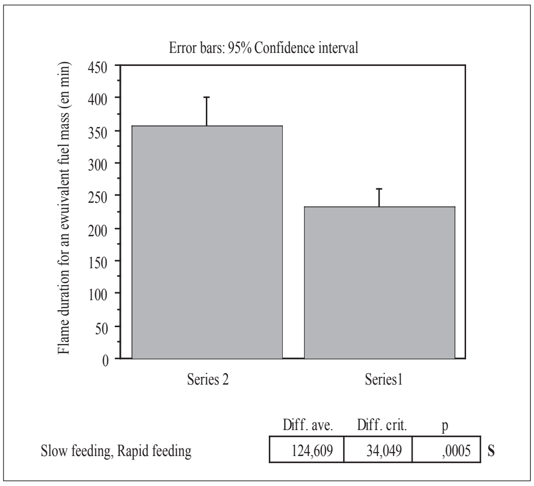


Fig. 13 - Effect of maintenance methods on flame duration (Fisher's exact test)

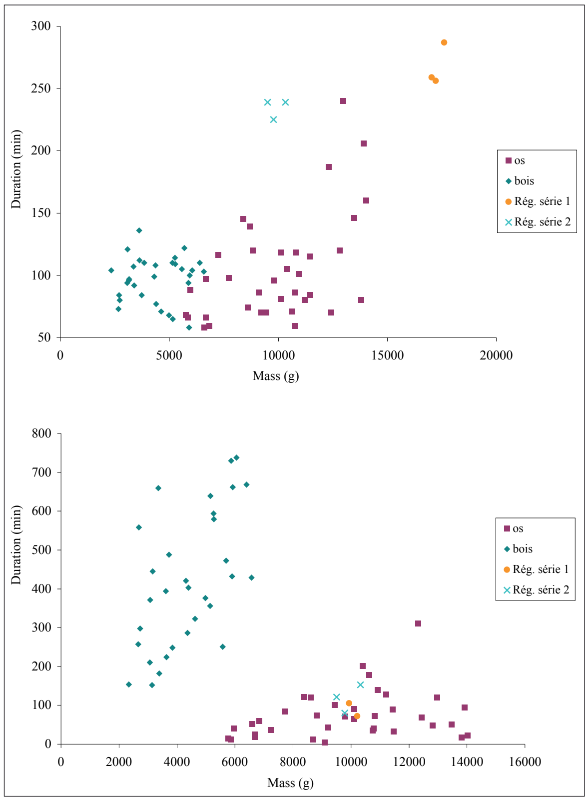


Fig. 14 - Combustion duration in function of the fuel mass used: a- flame duration, b- calcination duration.

the calcination durations. Regardless of the maintenance methods, they remain low and are comparable to those recorded in the laboratory experiments (fig. 14).

Loss of material

The laboratory experiments, conducted under controlled conditions, showed that the reduction of mass is strongly correlated with the bone density: the higher the density, the higher the percentage of residual mass. On the other hand, the state of the bone before combustion (fresh/dry, whole/fragmented) has no effect on this variable (Théry *et al.*, 2004 ; Costamagno *et al.*, 2005).

In the experimental series realized at Régismont-le-Haut, the percentage of resdidual mass varies between 33.2 and 36.6% (fig. 15). These values, which are statistically comparable to those recorded for the distal extremities of humeri, could be explained by the simultaneous combustion of spongy and compact portions (fig. 16). If we consider the ensemble of experiments, it appears that flame duration is not a significant factor in the loss of mass, as is shown by the Spearman's rank correlation coefficient, which is not statistically significant (r_s = - 0,215). Even if we distinguish the laboratory experiments (proximal series and distal series) and those at Régismont-le-Haut, the correlation coefficients remain low and non significant, respectively - 0,288: ddl 13; - 0,350: ddl 13 et - 0,551: ddl 6 (fig. 15).

Concerning the relationship between the loss of mass and calcination duration, in previous experiments we have shown the existence of three distinct groups: fires in which diaphyses without marrow were burned, fires in which distal extremities were burned, and fires with proximal extremities (fig. 17). In these latter, the loss of mass is strongly correlated with the duration of calcination (r_s = - 0,790, $p < 0,01$): the longer the calcination duration, the greater the amount of material lost, which is not the case for combustions

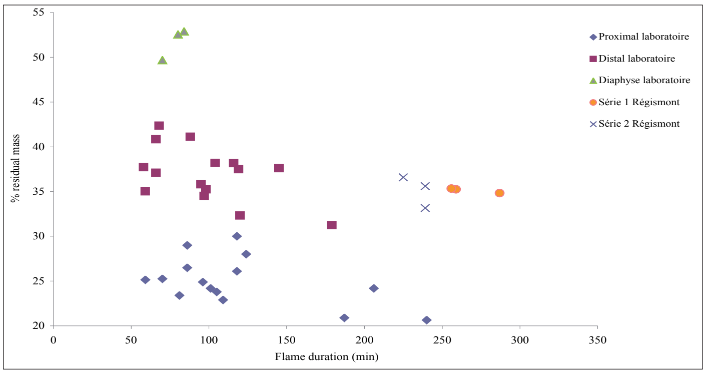
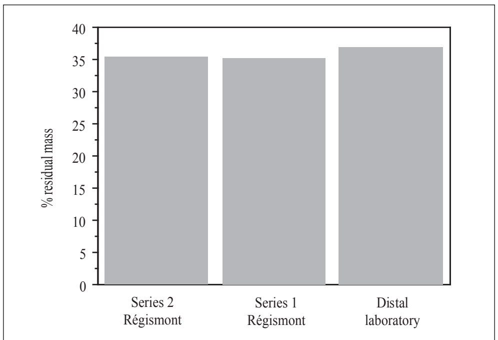


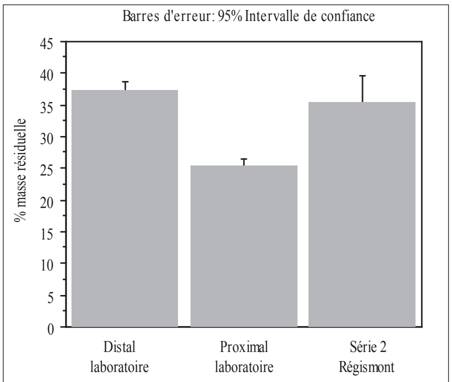
Fig. 15 - Percentage of residual bone mass in function of flame



	Diff. ave.	Diff. crit.	p
Series 1, Series 2	-,012	4,794	,9960
Series 2, Distal laboratory	-1,859	3,713	,3067
Series 1, Distal laboratory	-1,848	3,713	,3096

Fig. 16 - Effect of maintenance methods on the percentage of residual bone mass (Fisher's exact test).

realized with distal extremities (r_s = - 0,358). If we make the same comparison with series 2 of Régismont-le-Haut (the data from series 1 is not exploitable in this context (*cf. supra*) the same type of relationship appears; once again, the longer the calcination duration, the greater the loss of material. Additional data will be necessary to determine if this relationship is statistically significant. In comparison to the hearths fueled by the proximal extremities of humeri, for the same calcination duration, the loss of mass in the hearths at Régismont-le-Haut is clearly lower. It thus appears that the proximal extremities of humeri, and probably the portions with a low density, behave in a very specific way in fire, as is shown by a variance analysis (fig. 18).



	Diff. moy.	Diff. crit.	Valeur p	
Distal, Proximal	11,978	2,106	<,0001	S
Distal, Série 2 Régismont	1,859	3,648	,3062	
Proximal, Série 2 Régismont	-10,119	3,648	<,0001	S

Fig. 18 - Effect of bone density on the percentage of residual bone mass (Fisher's exact test).

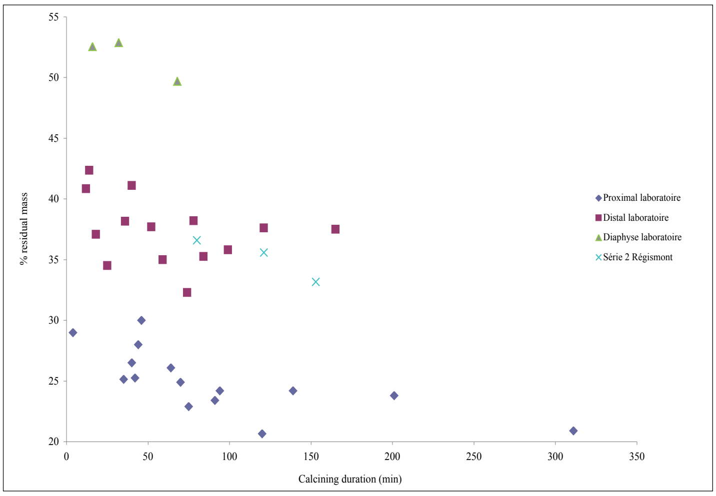


Fig. 17 - Percentage of residual bone mass in function of calcination duration.

Intensity of fragmentation

The state of bone before combustion (dry/fresh, whole/fragmented) plays a role in the degree of fragmentation of bone residues (Théry *et al.*, 2004; Costamagno *et al.*, 2005). The bones dried before burning fragment six times less than humid bones, while the fractured bones re-fracture very little, the average size of the combustion residues being greater. Therefore, for the comparisons, only the laboratory experiments in which the humeri were dry and fractured were used.

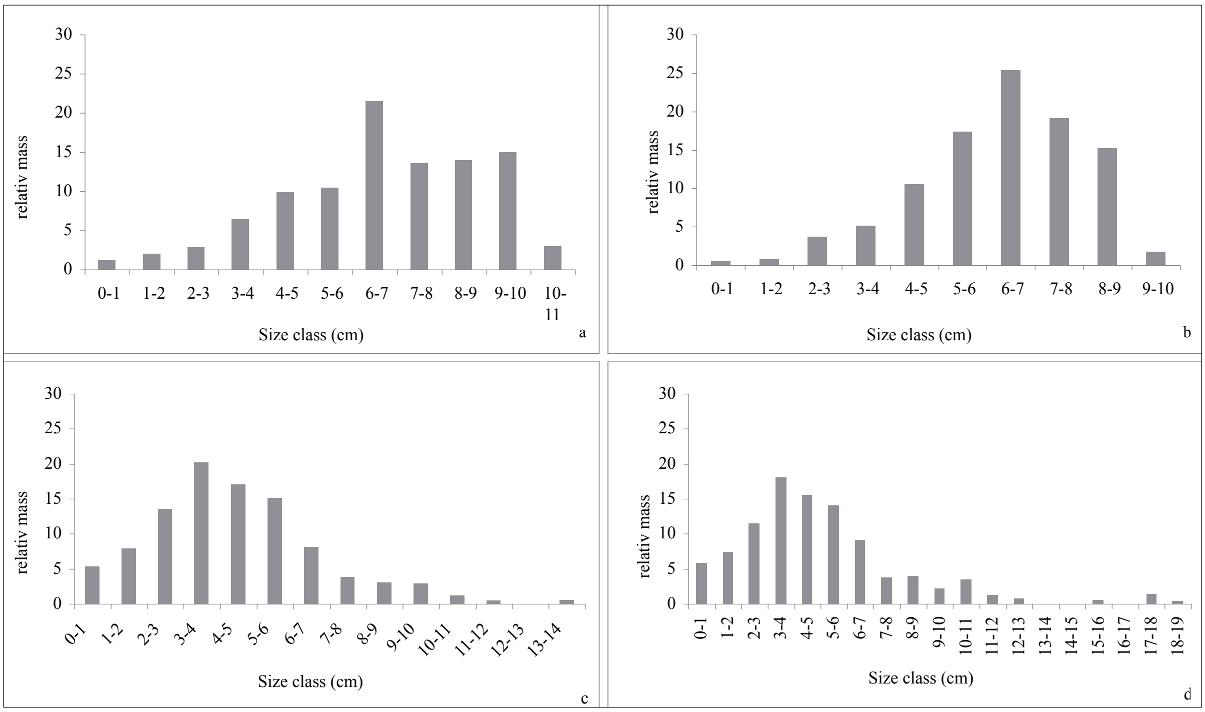


Fig. 19 - Distribution of bone residues according to their size: a- laboratory series, dry and fragmented proximal extremities; b- laboratory series, dry and fragmented distal extremities; c- Régismont, series 1; d- Régismont, series 2.

In the experiments realized at Régismont-le-Haut, the 3-4 cm fragment class is the best represented in all series, while in the laboratory experiments, the 6-7 cm class is always dominant (fig. 19). Is this difference due to a more intensive fragmentation of bones in the series with a prolonged combustion? It is difficult to respond to this question since the bones used were not of the same size (tables 1 and 2). For the small fragments, the question of the size of bones put into the fire is not relevant. The fragments less than 2 cm appear clearly more abundant in the experimental series of Régismont-le-Haut, (average 13.3%) than in the laboratory series (2.3%) (fig. 19). As we could expect, a prolonged combustion results in a more intensive fragmentation of residues, which is represented by a significant increase in the quantity of small fragments (lower than 2 cm). At the same time, in the prolonged combustions, a notable part of the bone residues is reduced to the state of ashes (between 12 and 14% of the residual mass. The values recorded for the fine fraction (% of ash and fragments smaller than 2 cm) are comparable from one series to the other, as is shown by a variance analysis (fig. 20).

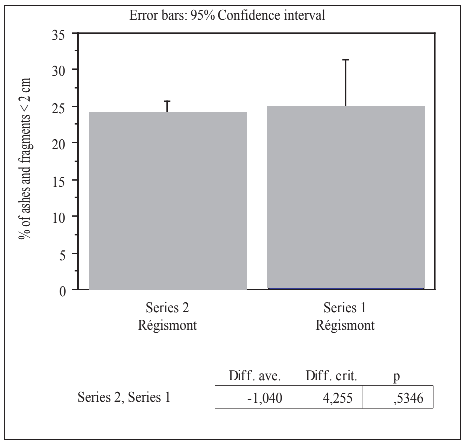


Fig. 20 - Effect of maintenance methods on the relative mass of the fine fraction (Fisher's exact test).

Intensity of combustion

The calcined remains in the prolonged combustion hearths represent an average of 77.2% of the total weight of the osseous residues versus 32% in the laboratory experiments (fig. 21).

In the laboratory experiments, we showed that the percentage of calcined bones was not correlated with the flame duration. The differences recorded are related to the density of the spongy tissue and the degree fragmentation of the bones before combustion (Théry-Parisot *et al.*, 2004). In the prolonged combustions, the hearths were initiated and then secondarily fed with the same types of combustible materials. In these experiments, in which the type of fuel does not play a role, the percentage of calcined bones seems logically correlated with the flame duration: the longer the hearth functions, the more intensively the bones are burned (fig. 21). The variance analysis shows a highly significant difference between the two experimental series at Régismont-le-Haut in terms of the proportion of calcined bones: the rapidly fed hearths (series 1) have an average of 15% more calcined bones than the slowly fed hearths (series 2) (fig. 22). Therefore, in addition to

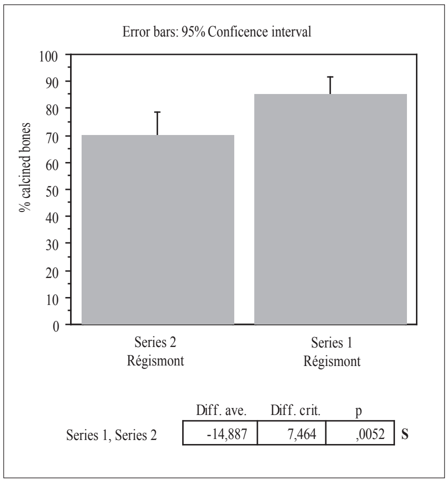


Fig. 22 - Effect of maintenance modalities on the relative mass of calcined remains (Fisher's exact test).

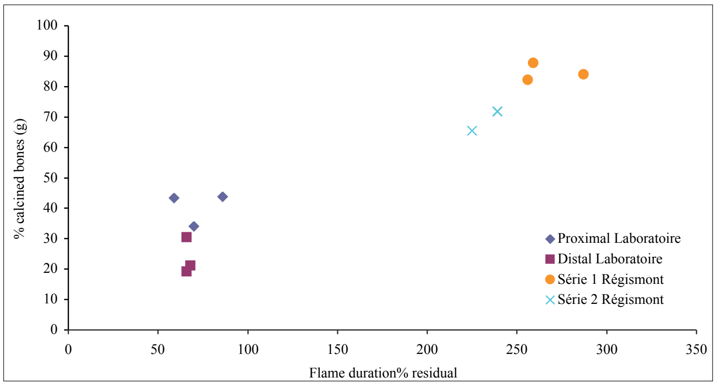


Fig. 21 - Relative mass of calcined bones in function of flame duration.

Concerning the tissue type, the spongy portions in both experimental series are more frequently calcined than the fragments of compact tissue or compact tissue with spongy tissue (fig. 24). Carbonized spongy remains are very poorly represented. The spongy tissues appear, moreover, to be more intensively fragmented than the compact tissues, which themselves are smaller in size than the fragments of *compacta* with *spongiosa* (fig. 25). The fragments smaller

the flame duration, the methods of maintaining the hearths also play a notable role in the combustion intensity of osseous residues. In the rapidly fed hearths, the greater intensity of the flames accentuates the combustion process.

Multi-criteria interrelations

A confrontation of the criteria "fragment size class" and "combustion intensity" indicates that the calcined remains are more intensively fragmented once the combustion is completed than the mostly black or mostly gray remains, regardless of the series considered. Measured by weight, the fragments over 6 cm are clearly dominant among the black and gray bones, while for calcined bones, the 3-4 cm class dominates, the distribution by size class being more homogeneous (fig. 23).

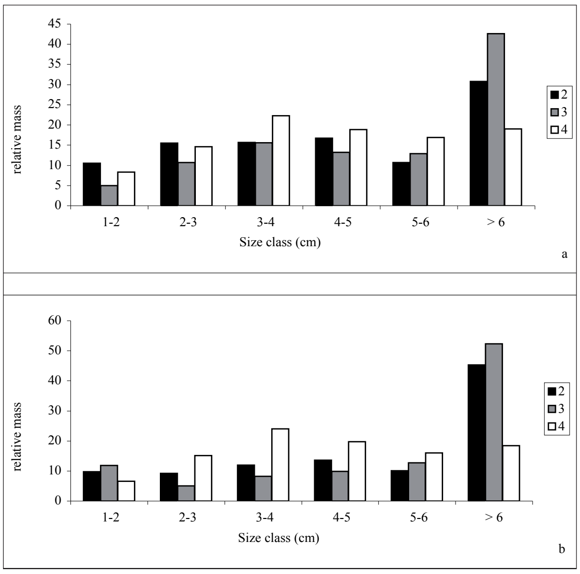


Fig. 23 - Relative size of bone fragments according to combustion intensity: a- Régismont, series 1; Régismont, series 2 (2: mostly black bones, 3: mostly gray bones, 4: mostly white bones).

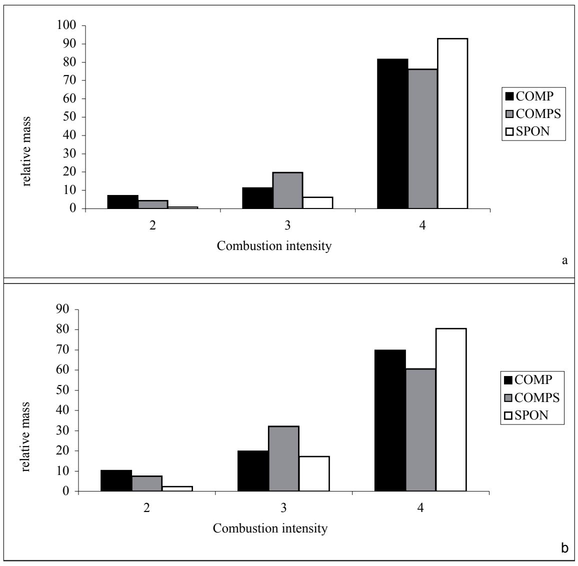


Fig. 24 - Relative combustion intensity of bone fragments according to bone tissue type: a- Régismont, series 1; b- Régismont, series 2 (COMP: compact tissue fragment, COMPS: compact tissue with spongy tissue fragment, SPON: spongy tissue fragment).

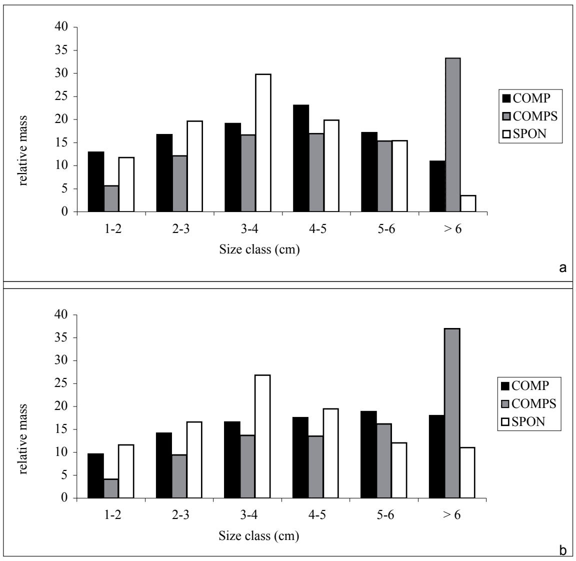


Fig. 25 - Relative size of bone fragments according to bone tissue type: a- Régismont, series 1; b- Régismont, series 2 (COMP: compact tissue fragment, COMPS: compact tissue with spongy tissue fragment, SPON: spongy tissue fragment).

than 4 cm thus represent an average in the two series of 58.1% of the residual mass of spongy tissues versus 44.6% of the compact tissue and 30.8% of the fragments of compact tissue with spongy tissue. Since the initial size of the fragments of each tissue type was not recorded before combustion, a potential bias related to the type of material used cannot be excluded. In series 1, relative to series 2, we observe a greater fragmentation of osseous remains regardless of the tissue type in relation to the flame intensity (remains less than 4 cm: spongy – series 1: 61.2%; series 2: 55.1%; compact – series 1: 48.8%; series 2: 40.4%; compact + spongy – series 1: 34.4%; series 2: 27.2%).

Conclusions

The experiments conducted at Régismont-le-Haut provide information complementary to that obtained in laboratory experiments and contribute to a better characterization of burned osseous residues associated with the use of bone as fuel.

It appears that in a hearth maintained with bone fuel, the duration of the flames is not correlated with the mass of combustible material burned. In addition to the factors identified in laboratory experiments (tissue type, degree of fragmentation), the methods of hearth maintenance play a determinant role. If we vary only this parameter, for the production of an equivalent flame duration, the slow feeding method allows an economy of one third of the fuel necessary for the rapid feeding method. Therefore, even if we could identify the impact of the different taphonomic agents that can modify burned bones, it is impossible based on the mass of bone fuel recorded in an archaeological assemblage to estimate the use duration of hearths at a given site.

These new experiments confirm that flame duration has very little influence on the loss of bone residue mass. It is the bone density, and thus probably the quantity of fat (Lyman, 1985), that plays a determinant role. In the experiments realized at Régismont-le-Haut, the loss of bone mass is on average 65%. A prolonged combustion also results in a more intensive fragmentation and combustion of osseous residues: fragments less than 2 cm long are six times more abundant in the experiments conducted at Régismont-le-Haut than in the laboratory experiments, and the calcined pieces two times more abundant. The fine fraction (ash and fragments less than 2 cm) corresponds to more than one quarter of the residual bone mass in the two open-air series, while the calcined pieces represent more than three quarters of this mass.

Contrary to the degree of fragmentation, the intensity of calcination depends largely on the methods of maintaining the hearths: the residues from rapidly fed hearths (series 1 at Régismont-le-Haut) are more intensively burned than those of slowly fed hearths (series 2 at Régismont-le-Haut). It would be interesting, through the maintenance of hearths over several days, to determine if the fine fraction and calcined piece proportions increase progressively according to the duration of use of the hearths.

Among the osseous residues produced by the combustions realized at Régismont-le-Haut, calcined pieces are smaller in size than the black and gray fragments. They are also more numerous regardless of the bone tissue type (60.5 to 92.9% of the residual mass), though in both experimental series, the spongy fragments are always more intensively burned than compact bone or compact bone with spongy tissue fragments.

What conclusions can be drawn from these observations? The experiments conducted at Régismont-le-Haut show that a fire fuelled with bone for a few hours produces a significant quantity of ash (approximately 15% of the residual mass), as well as a multitude of bone fragments less than 2 cm long (13% of the residual mass). Since small fragments can be further reduced in size by diverse taphonomic agents, the use of bone as fuel can considerably diminish the proportion of faunal remains at a site relative to lithic remains, which can be problematic for interpretations of site function and animal exploitation. Various studies have moreover shown that certain taphonomic processes, such as trampling (Stiner *et al.*, 1995; Thiébaut *et al.*, in press) or weathering (Gerbe, this volume), result in a preferential destruction of spongy and calcined bones, which correspond more or less to the osseous residues collected when bone is used as fuel. In rock shelters and caves, where occupations can be repeated over time, human trampling can have significant repercussions for the preservation of burned bone residues and thus mask a potential use of bone as fuel. The same is true for the action of atmospheric agents at open-air sites.

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