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Les sociétés gravettiennes du Nord-Ouest européen : nouveaux sites, nouvelles données, nouvelles lectures

Gravettian societies in North-western Europe: new sites, new data, new readings

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Fire Features from the Gravettian Open-Air Site of Les Bossats (Ormesson, France): An Ongoing Collective Study

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Résumé

Parmi les sites d'habitat gravettiens connus en Europe occidentale, le locus des Bossats (Ormesson, France), attribué au Gravettien ancien, offre l'opportunité de conduire une analyse détaillée de la place des structures de combustion au sein d'un espace habité. Cette contribution fournit les premiers éléments de ce programme de recherche en s'intéressant en particulier à la nature de ces structures (par ex. foyers primaires ou zones de rejet secondaires), aux stratégies liées à leurs fonctionnements (aménagement et approvisionnement en combustible) et en abordant leurs fonctions potentielles et leurs relations. Pour ce faire, les roches chauffées, les restes anthracologiques et archéozoologiques, les sédiments et l'organisation générale des vestiges sont pris en compte afin de proposer une lecture de la place du feu au sein du locus. Bien que préliminaires, les résultats obtenus permettent d'ores et déjà de souligner la nature fortement structurée des activités liées au feu avec notamment des indices probants d'une sélection des combustibles, de l'implication de roches chauffées dans le fonctionnement et la réalisation d'une aire de combustion complexe formée de plusieurs structures. Finalement, cette étude souligne à la fois le besoin pour de plus fréquentes enquêtes sur les paléo-pyrotechnologies des débuts du Paléolithique supérieur, question plus complexe qu'il n'y parait et qui occupe une place cruciale dans notre perception des comportements techno- et socio-économiques passés, et l'intérêt d'une approche multi-proxy et collective de cette problématique.

Mots-clés : Gravettien, Les Bossats-Ormesson, structures de combustion, roches chauffées, anthracologie, archéozoologie, micromorphologie, géochimie organique.

Abstract

Among the rare Western European examples of Gravettian dwellings, the Early Gravettian locus from Les Bossats (Ormesson, France) provides material evidence that permits a thorough analysis of the status of fire features within living spaces. This contribution presents the first steps of this endeavour, namely an exploration of the nature of these features (*e.g.* primary fireplaces or secondary discards), the strategies entailed in their operation and realization (*e.g.* structure architecture and fuel selection), as their potential functions and relationships. By focusing on the analysis of heated rocks, charcoal remains, fauna, sediment samples and of the overall organization of fire-related remains, we will discuss the importance of such evidence for the interpretation of the site and the range of activities that occurred within. Despite the ongoing nature of this analysis, preliminary results already highlight the structured nature of fire-related activities on site, with evidence for the selection of mixed fuels, the use of heated rocks, and the elaboration of a multi-feature combustion area. This case study underlines the benefits of a multi-proxy and collective analysis applied to the question of Early Upper Palaeolithic pyrotechnologies, and ultimately argues for their more frequent and systematic interrogation. Pyrotechnology, while not a straightforward topic, plays a crucial role in our understanding of the elaborate techno- and socio-economic behaviors of past populations.

Keywords: Gravettian, Les Bossats-Ormesson, Fire features, Heated stones, Anthracology, Archaeozoology, Micromorphology, Organic geochemistry.

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Introduction

Among Upper Palaeolithic techno-complexes, the Gravettian provides some of the best-preserved examples of what can be interpreted as dwellings established on open-air sites. Some Eastern and Central European sites are probably the most renowned, with examples such as Kostienki 11, Avdeevo, Pavlov, Dolni Vestonice and Milovice (see Djindjian, 2013 and reference therein for an overview), but several other examples located elsewhere on the Eurasian continent are equally worth mentioning. In France, the stone structures from La Vigne Brun (Combier, 1980) and the concentrations of postholes from Corbiac (Bordes, 1968) can be highlighted, but other possible Gravettian structures are less easily interpreted as they are influenced by post-depositional processes of varying intensities, or simply do not provide clear traces of veritable dwellings (*e.g.* Plasenn-Al-Lomm: Monnier, 1982; Azé: Floss *et al.*, 2013; La Picardie: Klaric *et al.*, 2018; La Croix de Bagneux: Kildea and Guiot, 2014; Renancourt: Paris *et al.*, 2017). Within these open-air sites and structures, fire features have, to our knowledge, seldom been explored in detail with the exception of examples from Central Europe such as Pavlov/Dolni Vestonice (Beresford-Jones *et al.*, 2010; 2011; Pryor *et al.*, 2016), Krems-Wachtberg (Fladerer *et al.*, 2014; Simon *et al.*, 2014; Händel *et al.*, 2015) and Grub-Kranawetberg (Nigst and Antl-Weiser, 2012; Antl, 2013). It seems paradoxical, considering the importance of fire-related structures in overall interpretations of site and dwelling organization, as suggested by ethnographic and ethnoarchaeological studies (see Binford, 1978; 1983; 2001; Audouze, 1987; Mallol *et al.*, 2007; Vaté and Beyries, 2007; Henry and Théry-Parisot, 2009; Vaté, 2013 for ethnographic examples and Audouze, 1987; Bodu *et al.*, 2006; Julien and Karlin, 2014 for Paleolithic case studies).

Since it contains a well-preserved Gravettian open-air locus with several fire features, the site of Les Bossats (Ormesson, Seine-et-Marne: Bodu *et al.*, 2011; 2014a; 2014b; 2017; 2019) provides a good opportunity to explore multi-proxy approaches to palaeo-pyrotechnology and its integration within Gravettian technological systems, as well as reinvestigate the role of fire structures in our interpretative models of site organization. This contribution focuses on the presentation of ongoing interdisciplinary studies that combine palaeo-environmental and biomolecular approaches in their exploration of fire features from the Early Gravettian locus of les Bossats.

A Brief Overview of Les Bossats

Les Bossats is an open-air site located 70km (S-E) from Paris. It sits geologically within the Paris basin at the edge of the Loing River, a tributary of the Seine. The site is characterized by a succession of 7 archaeological levels (to date), ranging from the Middle Paleolithic to the Post LGM Upper Palaeolithic (see Bodu *et al.*, 2019 for an overview). Among these, the Gravettian layer is embedded within loamy aeolian and calcareous deposits, *i.e.* loess, that has been truncated to the east by a thalweg that is more or less contemporaneous with the occupation, as well as more recently by agricultural practices. The labouring of the fields has, however, allowed for the discovery of the locus by local prospectors, and has led to yearly archaeological interventions since 2007, under the direction of P. Bodu (CNRS, UMR 7041). Apart from these truncations, the Gravettian locus and its encasing sediments are affected to a lesser extent by bio-pedologic agents, among which the most notable are burrowing rodents (*Spermophilus* sp.) that have resulted in some localized vertical and horizontal movements of artefacts.

The Gravettian locus is nonetheless well-preserved over ca. 50m², and consists of an accumulation of artefacts (mostly knapped flint, bone, osseous industry elements, shell ornaments, and one deciduous human tooth) associated with a ca. 7x5m floor of calcareous gravel (*radier*) that has been interpreted as the result of intentional anthropogenic transformation (fig. 1: A and B). ^{14}C measurements on bones indicate a radiometric date between 31,5 and 30 ka cal. BP (Lacarrière *et al.*, 2015; Bodu *et al.*, 2019), corresponding to the regionally defined Early Gravettian (Klaric, 2010). These dates are consistent with the lithic technology and typology. In detail, the archaeological locus probably results from successive stages of occupation, comprising an initial installation on bare soil, the construction of the gravel floor, and the subsequent use of this space as a living/work area. Considering the archaeological and geomorphological arguments, this setting is likely to reflect the actions of a single group over a relatively short span of time. Activities occurring on site are mostly related to the processing of bison carcasses and the production of flint tools (notably burins and unretouched blades) and projectile points (backed and microgravette points). Overall, the strategic location of Les Bossats, favourably placed for both bison hunting and the collection of siliceous raw materials, is believed to be a key parameter to explain its repeated occupation during prehistoric times.

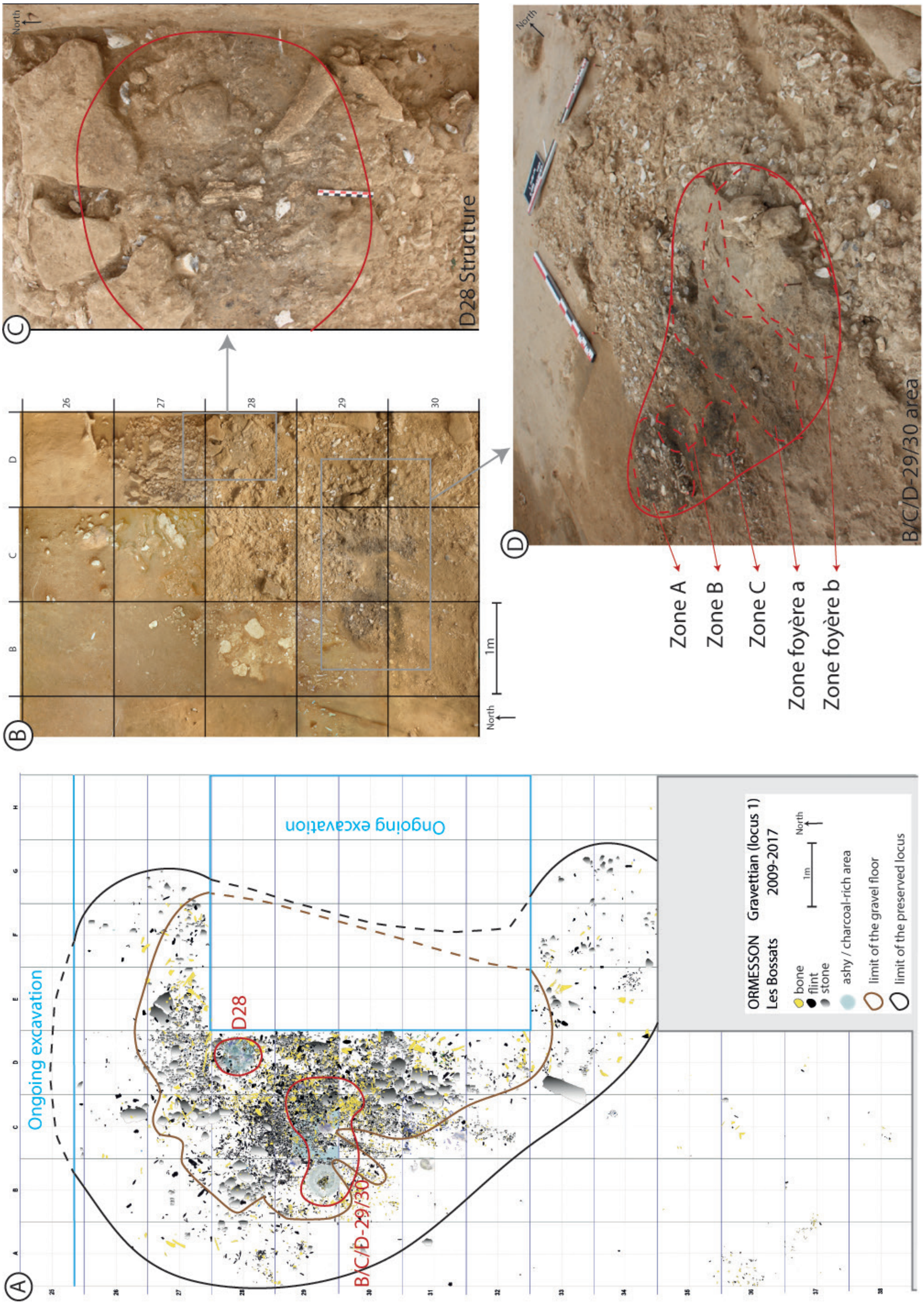

Fig. 1 – Ormesson – Les Bossats, the Gravettian locus. A/ Locus map up to the 2017 excavation campaign. B/ Vertical photomosaic of the north-western part of the locus before artefact and gravel floor removal. C/ Close-up of the D28 structure. D/ Close-up of the B/C/D-29/30 area and the internal distinction of different zones (© CAD: M. Ballinger / M. Lejay; Pictures: P. Bodu).

Description of Fire Features and Ensuing Interrogations

Two combustion features were identified within the Gravettian locus, both on the gravel floor (fig. 1: C and D). The first feature, named *Structure D28*, shows no indications of having been dug or placed in a depression. It is located to the north and consists of a 50cm-wide circular structure, bordered on its western and northern sides by calcareous blocks. Within *Structure D28*, dark charcoal-rich sediments, overlain by greyish sediments that occasionally contain burned artefacts (flints and bones) have been identified, often in association with small calcareous pebbles. The second feature, the *B/C/D-29/30 area*, consists of the association of 5 neighboring zones in the western portion of the gravel floor: *Zone A*, *Zone B*, *Zone C*, *Zone foyère a* and *b*. The first, *Zone A*, is a circular area (diam. 50cm) set in a depression and filled with dark charcoal-rich sediment mixed with abundant burned and unburned artefacts (bones, stones and flints). It partially overlays a concentration of unburned bone fragments. The second, *Zone B*, partially covered by *Zone A*, consists of a small circular depression (diam. 25cm, 3cm deep) with charcoal-rich sediment that is virtually empty of artefacts. *Zone C*, which has been truncated by ploughing and by a burrow, consists, as far as we can tell, of a flat concentration (in its present state: 30x25cm) of greyish sediment with burned artefacts. To the east of these zones, two additional areas were identified: *Zone foyère a* and *b*. The first is characterized by a greyish sediment and very abundant burned to calcined bone fragments. It overlaps with the western part of *Zone foyère b,* which is a concentration of seemingly thermally altered stones and pebbles.

Questions regarding these fire-features can be broadly summarized as follows: 1) Which structures are fireplaces and which are discard areas? 2) What can we say about their operation and function, in particular concerning cooking or technical uses? 3) How are these structures related to each other? And 4) How do these structures fit within the locus' internal chronology? To tackle these different issues, we have initiated a collective and interdisciplinary study of the Gravettian fire features from Les Bossats. The subsequent sections deal with the different ongoing analyses, and we will finish by proposing a first interpretation and discussion of the results.

Ongoing Studies and their Results

Characterization and Organization of Heated Stones

The dataset consists of material from the 2009-2017 excavations, and includes elements over 5cm in length. This limit allows us to exclude the gravels that forms the anthropogenic floor, which are smaller in size, but its arbitrary nature implies that rare small heated stones or fragments, which may be of interest, have been omitted from analysis. The observation of qualitative parameters (lithology, oxidation, use-wear etc.) was conducted macroscopically and when necessary completed with a stereomicroscope. Spatial data was processed with QGIS 2.18.

The sample (n = 320, m = 308.7kg; tabl. 1) is dominated by relatively small and light stones (mean length: 117mm, mean mass: 0.97kg). Elements over 200mm represent only 10% (n = 32) of the sample, yet they account for 61% (m = 187.1 kg) of the total weight. Small elements (< 200mm) are by far the more frequent (n = 288, 90%) but account for only 39% (121.6kg) of the total weight of the sample. Heated stones represent 63% of the sample (n = 205) but account for only 25% (m = 76.7kg) of its weight. This pattern can be explained by the fact that burned stones are predominantly found in the < 200mm size classes (n = 202) and only 3 individuals of larger size have been identified.

Most of the sample's petrography (tabl. 2) reflects very local geological origins, as accessible outcrops of Fontainebleau sandstone and "limestone", the latter being in fact a sandstone with a calcitic cement (Denizot, 1970; Denizot and Terrien, 1970), are located in immediate proximity to the site. Fontainebleau limestones are by far the most numerous (n = 190) in the sample, and are additionally the most "massive" (m = 270.1kg). When combined with the Fontainebleau sandstones (n = 32, m = 23.8 kg), these two types represent 95% of the total stone mass on-site. The sample is completed by Gâtinais limestone (n = 95, 4.7% of the total mass), collected as river cobbles in alluvial deposits in the vicinity of the site, and three limestone and sandstone river cobbles with potentially more exotic origins. Regarding the evidence of heating, 52% of the Fontainebleau limestones show traces of oxidation and/or reduction. Gâtinais limestones and Fontainebleau sandstones show higher proportions of heating (respectively 82% and 81%).

The spatial distribution of heated stones is slightly different depending on whether one considers weight or total count (fig. 2: A and B). When considering numbers only, therefore limiting biases induced by the location of the heaviest blocks on the edge of the gravel floor, which are seemingly unrelated to any fire activities, the areas around *B/C/D-29/30 area* and *Structure D28* show the highest densities of elements. Nonetheless, significant concentrations are identified on the periphery of the gravel floor, notably in the west of *B/C/D-29/30* and in two sectors to the east (F26-27, G27 and F/G-33/34). While the first cluster may be related to the maintenance or taphonomic alteration of the *B/C/D-29/30* features, the two others remain, at this stage, difficult to interpret.

Stones length classes (mm)	Count (n)	Count (% total)	Mass (kg)	Mass (% total)
0-99	**188**	**58,75%**	**34,3**	**11,11%**
unheated	*38*	*11,88%*	*7,3*	*2,36%*
heated	*150*	*46,88%*	*27*	*8,75%*
100-199	**100**	**31,25%**	**87,3**	**28,28%**
unheated	*48*	*15,00%*	*54,5*	*17,65%*
heated	*52*	*16,25%*	*32,8*	*10,63%*
200-299	**19**	**5,94%**	**70,5**	**22,84%**
unheated	*17*	*5,31%*	*63,1*	*20,44%*
heated	*2*	*0,63%*	*7,4*	*2,40%*
300-399	**10**	**3,13%**	**60,1**	**19,47%**
unheated	*9*	*2,81%*	*50,6*	*16,39%*
heated	*1*	*0,31%*	*9,5*	*3,08%*
400-499	**2**	**0,63%**	**34,5**	**11,18%**
unheated	*2*	*0,63%*	*34,5*	*11,18%*
500-599	**1**	**0,31%**	**22**	**7,13%**
unheated	*1*	*0,31%*	*22*	*7,13%*
Total	**320**	**100,00%**	**308,7**	**100,00%**

Table 1 – Ormesson – Les Bossats, Gravettian locus. Length distribution by count, mass and visual evidence of heating. Material 2009-2017 > 5cm.

Stone type	Count (n)	Count (% total)	Mass (kg)	Mass (% total)
Fontainebleau "limestone"	**190**	**59,38%**	**270,1**	**87,50%**
unheated	*91*	*28,44%*	*223*	*72,24%*
heated	*99*	*30,94%*	*47,1*	*15,26%*
Gâtinais limestone	**95**	**29,69%**	**14,4**	**4,66%**
unheated	*17*	*5,31%*	*2,4*	*0,78%*
heated	*78*	*24,38%*	*12*	*3,89%*
Fontainebleau sandstone	**32**	**10,00%**	**23,8**	**7,71%**
unheated	*6*	*1,88%*	*6,5*	*2,11%*
heated	*26*	*8,13%*	*17,3*	*5,60%*
Shelly limestone	**2**	**0,63%**	**0,2**	**0,06%**
unheated	*1*	*0,31%*	*0,1*	*0,03%*
heated	*1*	*0,31%*	*0,1*	*0,03%*
Exogenous sandstone	**1**	**0,31%**	**0,2**	**0,06%**
heated	*1*	*0,31%*	*0,2*	*0,06%*
Total	**320**	**100,00%**	**308,7**	**100,00%**

Table 2 – Ormesson – Les Bossats, Gravettian locus. Stone type distribution by count, mass and visual evidence of heating. Material 2009-2017 > 5cm.

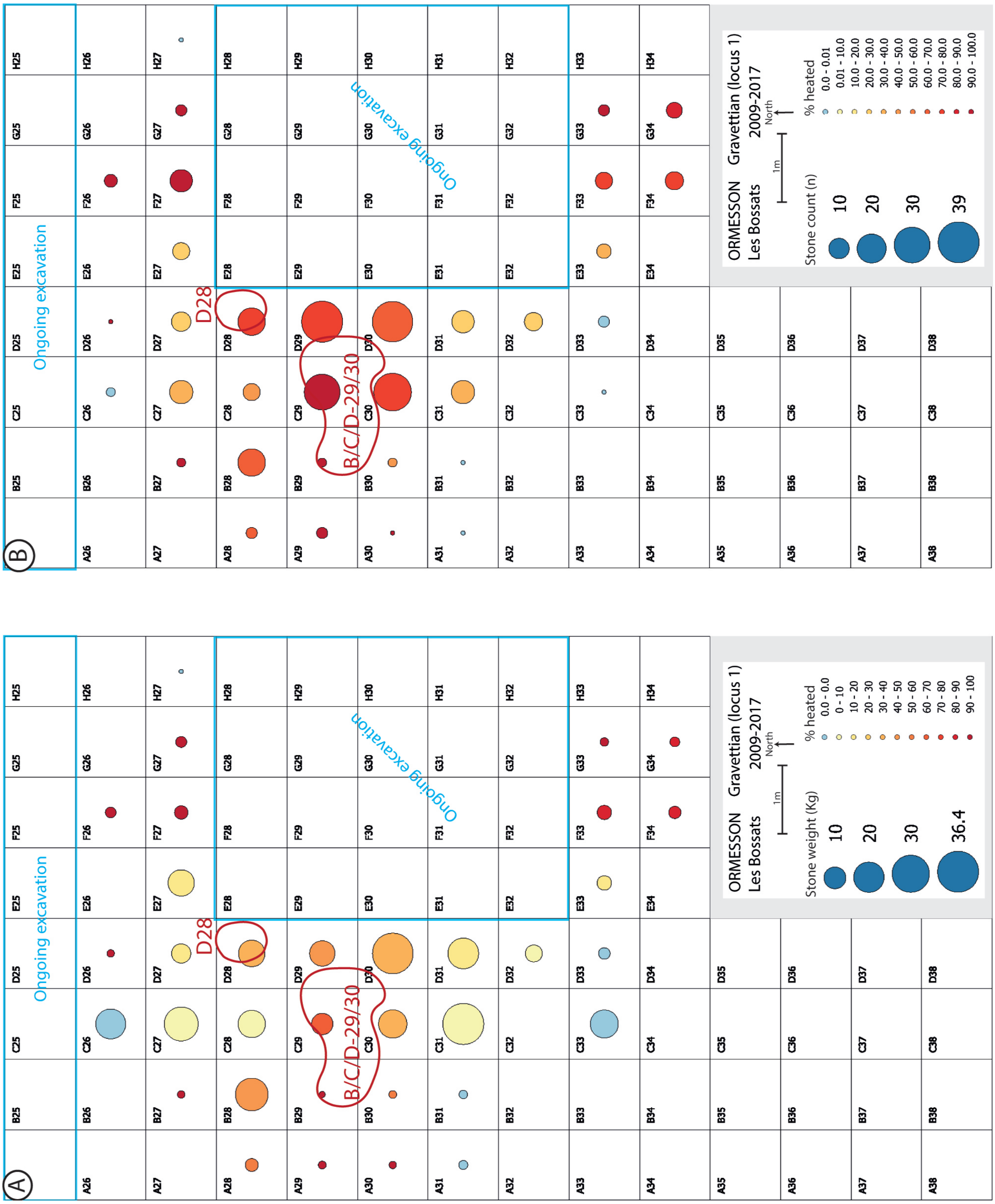

Fig. 2 – Ormesson – Les Bossats, stones over 5cm from the Gravettian locus. A/ Spatial distribution by square meter using weight. B/ Spatial distribution by square meter using count (© M. Lejay).

Anthracological Analysis

The anthracological analysis focused on the central area of the Gravettian locus. It is based on bulk samples of sediments sieved in the lab, as macroscopic charcoal remains are very few and difficult to collect on site. Results indicate that wood charcoal are highly fragmented, with dimensions mostly inferior to 1mm, and burned bones are numerous (see below). The poor state of preservation of charcoals inhibits the identification to specific taxa (tabl. 3). The remains are overwhelmingly represented by *Pinus* (*Pinus sylvestris* [Scots pine]/*Pinus nigra* [black pine] and subsp. *salzmannii*/*Pinus mugo* [dwarf pine]/*Pinus uncinata* [mountain pine]; the various species of pine cannot be differentiated with certainty on the basis of anatomical criteria. Twenty-four gymnosperm fragments, one angiosperm fragment, and eight undetermined samples make up the rest of the remains.

The burned residues mainly come from *Structure D28* and the *B/C/D-29/30 area*, with burned bones being significantly represented (27% of 176 remains) in square meters B/C/D-29/30, while they only represent 13% of burned residues (n = 61) found in D28.

As firewood most often comes from the immediate surroundings of the dwellings, charcoal analysis therefore provides information on the ecology of forest stands and on the available wood resources for fuel (Heinz and Thiébault, 1998; Théry-Parisot, 2001; Théry-Parisot *et al.*, 2018). The pines (from this group) are very characteristic of the vegetation during the Palaeolithic, from Eastern Europe to southern Spain, and are typical of open and closed cold forests. Nonetheless, nothing can be deduced from the biomass available, nor from the quantitative representativeness of this taxon in the environment. Its occurrence near Ormesson is, nevertheless, clearly linked to cold climatic conditions. The "over-representation" of Pinus among charcoal remains may reflect its overall abundance in the vicinity of the site and/or the preferential collection of this abundant resource as dead wood, possibly already dry and easy to collect for mobile societies. Burned bone also appeared to be an important contributor to the fuel residues found on site, and naturally raises questions regarding its intentional use as fuel in addition to wood.

Square meter / Taxon/group	B28	B29	B30	C26	C28	C29	C30	C34	D28	D29	D31	D32	E27	L40	Total
Pinus cf Pinus sylvestris/Pinus nigra and subsp. salzmannii/ Pinus mugo /Pinus uncinata	16	68	1	4	1	25	23	1	44	1		1		1	186
Gymnosperm		2		8		4			9				1		24
Angiosperm		1													1
Indeterminate						3					2		3		8
Total charcoal	**16**	**71**	**1**	**12**	**1**	**32**	**23**	**1**	**53**	**1**	**2**	**1**	**4**	**1**	**219**
Burned bones		**29**	**1**	**1**		**12**			**8**	**6**					**57**

Table 3 – Ormesson – Les Bossats, Gravettian locus. Anthracological remains from the central part of the locus.

Characterization and Organization of Burned Faunal Remains

The Gravettian faunal assemblage (n = 2879 piece-plotted artefacts, completed by sieved refuse from the 2009-2016 excavation campaigns) is dominated by bovids: *Bos/Bison* represents 85,8% of the Number of Identified SPecimen (NISP *sensu* Grayson, 1984) and a Minimum Number of Individuals of 6 (MNI *sensu* Lyman, 1994). Comparatively, the contributions of reindeer (*Rangifer tarandus*: 8,5% of the NISP, MNI = 2) and horse (*Equus caballus*: 5,7% of the NISP, MNI = 2) appear low (see Lacarrière *et al.*, 2015, based on data collected up to and including 2013 fieldwork). Apart from taphonomic modifications, the faunal remains bear scarce butchery cutmarks (likely biased by poor cortical preservation) and rare percussion marks that would indicate the intentional breaking of limb bones for marrow extraction. Bones are frequently burned (n = 293, 10.2% of piece-plotted artefacts), and this relatively high proportion is even more marked when sieved refuse (including bone fragments < 2cm, mostly unidentified) are taken into account (43% of burned remains among the 5.8kg of bone chips). The colorimetric approach applied to the sieved fraction, which will complete the analysis and permit a detailed discussion of the different degrees of thermal alteration, has yet to be conducted. Initial counts from the C29 and D29 sieves, collected during the 2019 campaign, indicate significant heterogeneity between these two squares (Martin, 2018). This heterogeneity could be related to sample biases, taphonomic processes, or possibly differential spatial distribution.

Most of the burned piece-plotted remains are found within the *B/C/D-29/30 area* (n = 253, 86,3%; fig. 3: A). The same pattern is also true for bone fragments and chips, among which those square meters account for 90% of the burned elements (m = 2.2kg; fig. 3: B). Among the identified burned bone fragments from this area (tabl. 4), most are large mammals such as bovids or horses, and virtually every part of the skeleton is represented, with instances of bones from the axial skeleton, long bones with intact spongiosa, and short bones (the absence of skull fragments is not surprising, as these elements are relatively rare on site; Lacarrière *et al.*, 2015). These bone fragments are commonly (75%) lightly thermally altered (Stage 1 according to Costamagno *et al.*, 2010 and Smolderen, 2016), which explains their lower fragmentation and, in turn, facilitates their identification. This data is preliminary as the analysis of bone refuse from C/D-29/30 square meters is not yet completed. Nonetheless, observations made during the last campaign indicate that final calculations will serve only to further accentuate the concentration of burned bone within this area, most notably within *Zone Foyère a* and *b*.

The *Structure D28* area is, by contrast, relatively poor in burned bone, even when sieve-retrieved chips are also taken into account. The piece-plotted remains (n = 10) are smaller (< 20mm long) and more thermally altered (Stage 2; Costamagno *et al.*, 2010 and Smolderen, 2016). Finally, regarding the small quantities of burned bone fragments found in small amounts virtually everywhere around the Gravettian occupation (fig. 3: B), taphonomic processes must be suspected, as many burrows and plough traces were recognized in those areas. Therefore, no evidence for another latent fire feature emerges through this simple spatial analysis.

Micromorphological and Geochemical Analysis

Micromorphological investigations presented here concern the *Structure D28,* in addition to *Zones A, B* and *C* from area B/C/D-29/30. The objectives were to characterize possible anthropogenic actions while also considering the influence of post-depositional processes (Mallol *et al.*, 2017). Thin sections were produced from resin-hardened undisturbed samples and studied with a Zeiss AxioImager A2m petrographic microscope, following the guidelines provided by Stoops (2003), Stoops *et al.* (2010), and Macphail and Goldberg (2017).

The local background consists of loess deposits, with few organic and anthropogenic constituents but important bio-pedologic features related to soil fauna, root action, and calcitic dissolution/precipitation processes (Durand *et al.*, 2010; Kooistra and Pulleman, 2010; Canti, 2017).

The sample from the *Structure D28* displays a thin (0.5cm) layer with abundant combustion residues (mostly fragmented wood charcoal) that sits on top of loess. The whole is covered by calcareous gravels and small pebbles (fig. 4: A). No clear evidence of thermal alteration (oxidation, reduction or microstructure transformation) of the underlying sediment nor of the overlying calcareous constituents was observed, which is at odds with the initial assumption of an *in situ* fireplace. Consequently, this structure more likely corresponds to a discard area that remains to be connected to a primary combustion structure. Within the structures from the *B/C/D-29-30 area*, *Zone A* and *C* display similar types of evidence, or rather an absence thereof, but are rich in burned bones and more affected by bioturbation. The fact that gravels do not overlay these areas can partly explain the importance of these perturbations relative to the *Structure D28*. Concerning *Zone B*, however, a thin layer of oxidized sediment underlays a deposit of combustion residues (fig. 4: B). While bioturbation is also substantial within this small depression, this organization indicates a primary combustion structure, *i.e.* a fireplace, that in contrast with the *Structure D28* we failed to recognize during excavation.

The internal stratigraphy of the Gravettian locus is also documented through this analysis. The *Structure D28* was created before the deposition of the gravel floor, but *Zone A, B* and *C* were installed within an empty area arranged inside it. Additionally, the *Zone B* fireplace is partly intersected by *Zone A*, indicating its anteriority.

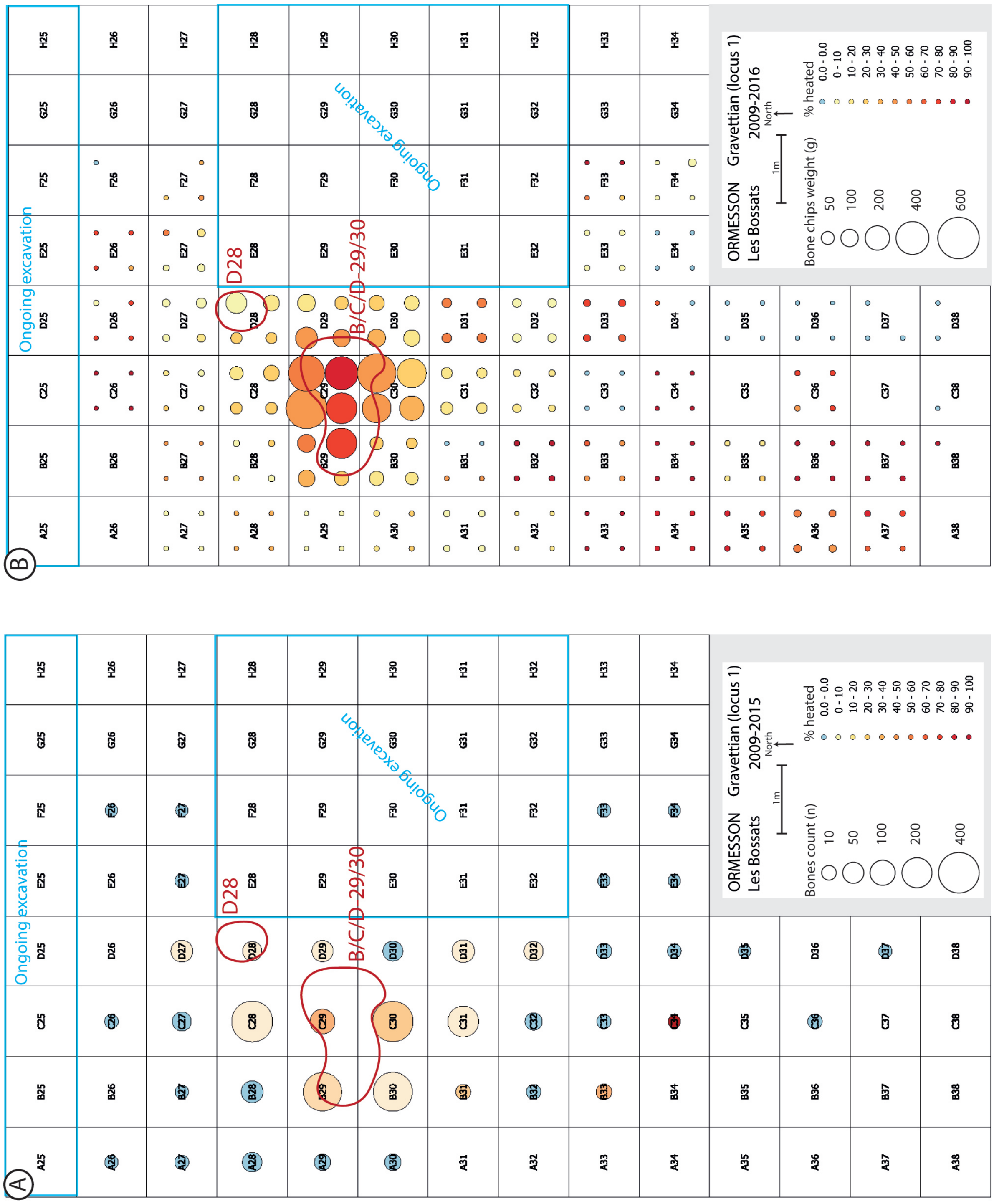

Fig. 3 – Ormesson – Les Bossats, bones and sieved bone chips from the Gravettian locus. A/ Spatial distribution of bones by square meter using count. B/ Spatial distribution of bone chips by ¼ square meter using weight (© M. Lejay).

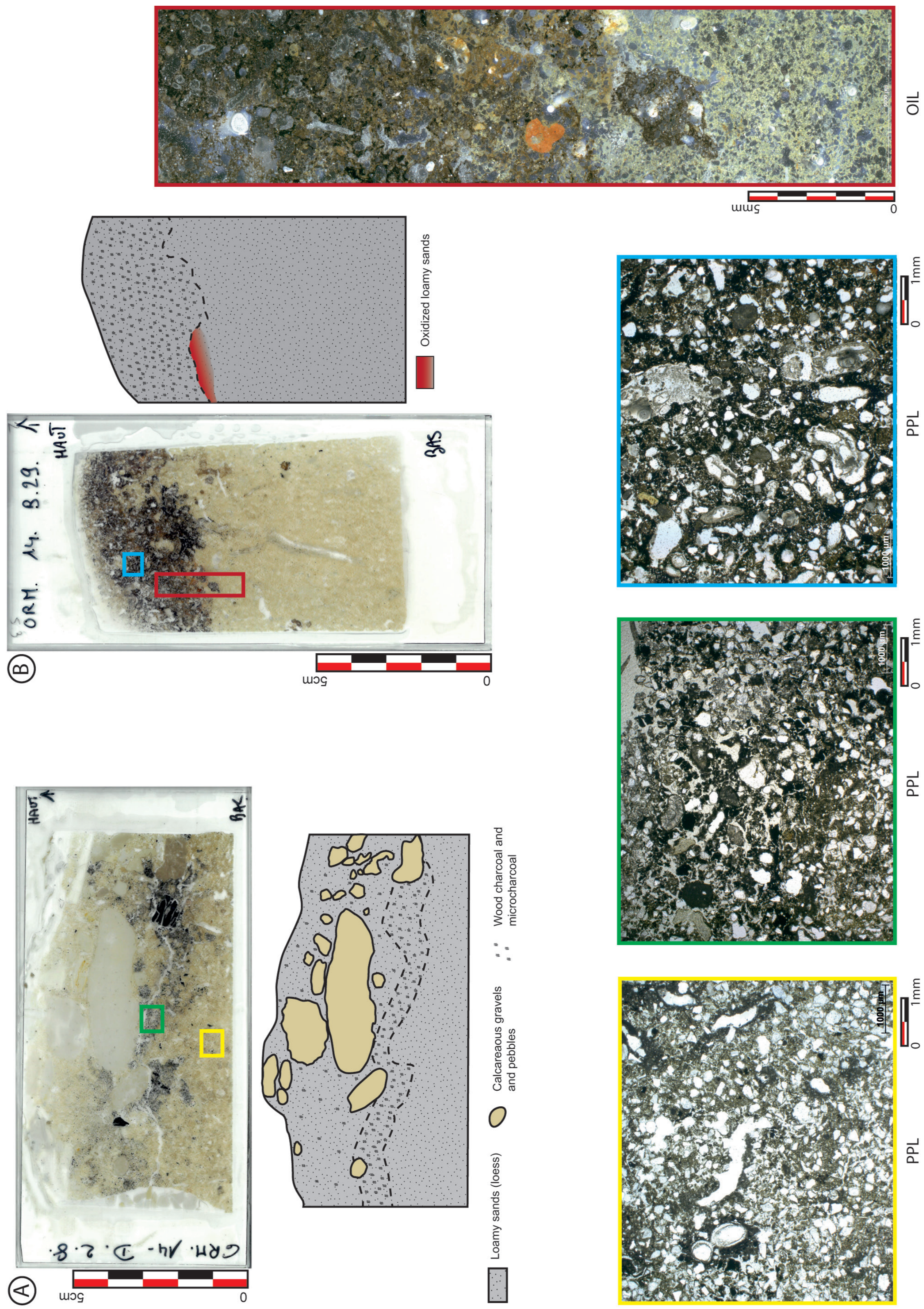

Fig. 4 – Ormesson – Les Bossats, thin sections and microphotos from the Gravettian locus. A/ Structure D28 thin section and outline. Yellow insert: Underlying loess with bio-pedologic features (mesofauna and root channels, calcite coatings and hypocoatings. Green insert: loess mixed with wood charcoal, microcharcoal and bone fragments and displaying intense bioturbation features. B/ Zone B (from B/C/D-29/30 area) thin section and outline. Blue insert: loess mixed with wood charcoal, microcharcoal and bone fragments, displays intense bioturbation features. Red insert: thermally altered contact between underlying loess and top layer with abundant combustion residue. Note the orange hue of the fine fraction and several calcareous gravels indicating their oxidation (stitched microphotos in Oblique Incident Light) (© M. Lejay).

	Bos/Bis	*Equus caballus*	Size III	Size II/III
Vertebra	3			
Rib	1	1	12	2
Axial undet.			12	8
Humerus	3			
Ulna	1			
Tibia	1			
Long bone shaft undet.			36	6
Articular portion undet.			5	7
Phalanges & sesamoids	5			
Unidentified			36	
Total	**14**	**1**	**101**	**23**

Table 4 – Ormesson – Les Bossats, Gravettian locus. Number of burned bone fragments from the B/C/D-29/30 area. Identified taxa and anatomical parts for size classes III (= *Bos/Bison* or *Equus caballus*) and II/III (= *Bos/Bison*, *Equus caballus* or *Rangifer tarandus*).

In order to look deeper into the functional interpretations of these fire features, a geochemical set of analyses is under way to characterize the organic matter (OM) related to anthropogenic activities (*e.g.* March *et al.*, 2006; Hérisson *et al.*, 2013; Choy *et al.*, 2016). It includes organic carbon quantification, lipid extract characterization by GC-MS, and bulk OM characterization by py(TMAH)-GC-MS (see Lejay *et al.*, 2016 for a detailed presentation of the methods employed). The local organic background was considered via the use of control samples. Despite a low carbon content (0.3 - 0.5%C_{org}), this background displays a variety of vegetal OM-related compounds (long-chain fatty acids, lignin derivatives, benzene derivatives, polycyclic aromatic hydrocarbons; Simoneit, 2002), and even some by-products of thermally altered animal OM (lactones, ketones, diacids; Rogge *et al.*, 1991; Evershed *et al.*, 1995; Lucquin, 2007). Considering the context and the fact that examples of artefact redistribution by taphonomic processes have been observed around the Gravettian locus, both at macro- and micro-scales, it is likely that this first set of control samples is insufficient to entirely dissociate natural and anthropogenic contributions. Consequently, a second and more extensive set of samples is currently under study and will help provide an in-depth interpretation of archaeological samples.

For now, several pieces of information are nonetheless perceptible in samples from archaeological fire features (*Structure D28, Zone A* and *B*). Organic content measurements indicate a significant input of OM in fire features (D28: 0.8-1.8%C_{org}; Zone A: 1.9%C_{org} and Zone B: 2.7%C_{org}). Lipids and bulk OM contents are also richer and more diversified than in control samples. In every archaeological sample, the main signature is related to vegetal OM and its thermally altered by-products, which is not surprising considering their charcoal-rich nature. In the same vein, numerous compounds indicate a significant contribution of animal OM, in part thermally altered, that may be related to the use of bones as fuel (Kedrowski *et al.*, 2009; Lejay *et al.*, 2016) and/or to cooking (Rogge *et al.*, 1991; Evershed *et al.*, 1995, 2002; Lucquin, 2007). Numerous instances of nitrogen compounds are also detected and, given their occurrence in protein-rich products (notably meat: Rogge *et al.*, 1991; Schauer *et al.*, 1999; Simoneit *et al.*, 2003), these strengthen the cooking hypothesis, without excluding the very likely existence of a mixed fuel strategy involving bone and wood.

Discussion and Perspectives

Status of the Fire Features and their Relationships

When connecting these different sets of information, all the while bearing in mind their preliminary nature, several answers to our initial set of questions can be proposed. The identification of the nature of each structure and the cross-referencing of field observations with lab-analyses allow us to propose a sturdier classification. Unlike our initial working hypothesis, *Structure D28* is likely a secondary fire feature, *i.e.* a dump area. This conclusion also holds for the case of *Zone A* and *C,* but not for *Zone B*. The latter displays discreet, but nonetheless clear, evidence for *in situ* combustion supporting its interpretation as a genuine fireplace.

While a more complete understanding is still limited by the incomplete analysis of the *Zones foyères a* and *b*, our current interpretation is that this area corresponds to an association of two primary combustion features (*Zone Foyère b* and *Zone B*), with a set of secondary discard / maintenance structures (*Zone A* and *C, Zone foyère a* and *Structure D28*). The relationship between *Zone Foyère a* and *b* is clear and the former seems to correspond to the spreading of fuel residues from *Zone foyère b*, even if we cannot yet say whether this reflects a post-depositional process or a human intervention during the operation of the structure. The close spatial association between *Zone A* and the fireplace *Zone B* may indicate the same type of relationship, but this needs to be further demonstrated. The fire features from *B/C/D-29/30 area* form a rather complex combustion area consisting of several fireplaces and secondary structures. This indicates repeated use, as evidenced by maintenance activities, and a need for at least two types of fireplaces: one small fire set in a depression (*Zone B*) and a larger one, flat, but covered with stones (*Zone foyère b*).

Within our current understanding of the Gravettian locus' internal chronology, studied fire features fit within the basic model of a two-phase occupation. *Structure D28*, set directly in the loess soil, seems to correspond to a dump (that remains to be connected with a fireplace) associated with the first group of activities occurring before the placement of the gravel floor. During the second phase the combustion features group within the *B/C/D-29-30 area*, begin operating in an area partially devoid of such gravel, and demonstrate several maintenance operations.

Operation and Function

The operation of fireplace(s), as far as we can tell, relies on the combined use of wood and bone. The concentration of burned residues of both types is highest in the vicinity of the *B/C/D-29/30 area*. While wood charcoal is dominated by *Pinus* sp., the faunal assemblage corresponds mostly to large bovids. The carcass transport strategy (Emerson, 1993), as well as the few instances of intentional fragmentation of long bones observed on site, may indicate that marrow and grease extraction were important components of an intensive bison exploitation strategy (Lacarrière, 2015). These operations are generally conducted close to fireplaces, due to the necessity of a source of heat, especially when boiling articular portions to obtain red marrow (Costamagno, 2013; Costamagno and Rigaud, 2014). The abundance of burned bone fragments, notably within *Zone Foyère a*, may indicate a subsequent and/or a parallel use of bone as a complementary source of fuel. Such complementary use implies knowledge of the intrinsic properties of different fuel types and therefore both a systematic and strategic exploitation of said properties. Indeed, previous experimental studies have shown that these types of fuel are complementary. The addition of fresh bone extends the duration of combustion and significantly increases flame production. These specific properties of bone could be exploited for all activities related to flame production (*e.g.*, lighting, heat, direct heat treatments; see Théry-Parisot, 2002; Théry-Parisot and Costamagno, 2005; Costamagno *et al.*, 2009).

The geochemical results show great potential but require further development. However, they are nevertheless consistent with the data on the fuels used. Notably, signatures for the combination of vegetal and animal OM, both thermally altered and unaltered, were identified. Traces of protein-rich material should also be mentioned, and if confirmed, may add weight to the hypothesis of the use of fireplaces for domestic tasks such as cooking and/or transformation of meat (smoking, drying, etc.). The use of stones, both in a structural or a functional role, appears to mostly concern the *Zone foyère b*. The heated stones are rather small, rounded and calcareous, which may indicate a possible use as an indirect source of heat for boiling (Soler Mayor, 2003; Lucquin, 2007; Dumarçay *et al.*, 2008) and explain their subsequent dispersion all over the site. Overall, the architecture of fireplaces is rather minimal, limited to a small depression for *Zone B* and to a covering of small rocks and pebbles for the *Zones foyères*. The bigger stones observed on site don't seem to have been heated but may have played a role in either delimiting fireplace edges or as surfaces used in food preparation.

Comparison with Contemporaneous Examples

When considering possible comparative and contemporary examples, usable data is limited and is generally found in cave sites from south-western France. The abri Pataud provides a significant part of the documentation, both regarding fuel management (Théry-Parisot, 2002; Marquer *et al.*, 2010) and the overall morphologies of fire features (Movius, 1966). The occurrence of burned and fragmented bone remains appears to have been quite common and invites us to consider its regular use as fuel as of, at least, the Aurignacian (see Théry-Parisot, 2002; White *et al.*, 2017). Fireplace morphologies are quite variable at Pataud (Movius, 1966, 1977) and also at Le Flageolet I (Bombail, 1989; Rigaud *et al.*, 2016) where both flat fireplaces, occasionally encircled by stones, and dug-out fireplaces coexist. The occurrence of heated stones is frequently reported in these sites and in open-air contexts such as Les Treilles (Bazile *et al.*, 2001), La Croix-Bagneux (locus 11: Kildea, 2008), or Renancourt 1 (Paris *et al.*, 2017). However, the interpretation of their function is still undemonstrated even if their implication in cooking operations is generally assumed in other contexts (Thoms, 2017). Complex combustion areas, such as the one described in the *B/C/D-29-30 area*, appear quite original, even if at least one case from Pataud (Lens J-1, Level 5) may correspond to a similar configuration.

Several examples from Central Europe are perhaps more relevant, probably because of their similar geomorphological context (*i.e.* open-air sites in loess deposits). As an example, *hearth 1* from Krems-Wachtberg is described as a fireplace with 3 phases of use and associated secondary features (Simon *et al.*, 2014). The fireplace was primarily set in a flat depression paved with some stones and was subsequently filled and re-arranged. A detailed study of faunal remains indicates a likely multipurpose area including activities of meat consumption and grease exploitation, coupled with a potential mixed-fuel strategy (Fladerer *et al.*, 2015; Händel *et al.*, 2015). These results are, at this point of our study, quite similar to our hypothesis regarding the *B/C/D-29/30 area* and its surroundings.

Conclusion

While this presentation of our results and their interpretation is voluntarily prudent because of the incomplete exploration of the Gravettian locus, it nevertheless contributes novel data to the field of Upper Palaeolithic pyrotechnology. From an archaeological perspective, the Gravettian, and in fact all the early phases of the Upper Palaeolithic, are still remarkably undocumented and understudied. The Gravettian locus of Les Bossats, and ultimately its other levels, provide us with the unique opportunity to begin a (re)investigation of this major human technological breakthrough and socio-economic turning point. From a methodological point of view the study of Les Bossats benefits from recent and ongoing excavations, therefore providing potential for direct observation and sampling by different specialists and their regular interaction. These fortuitous working conditions promote effective collaboration between distant fields of research, which is essential to the, inherently interdisciplinary, study of palaeo-pyrotechnology.

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