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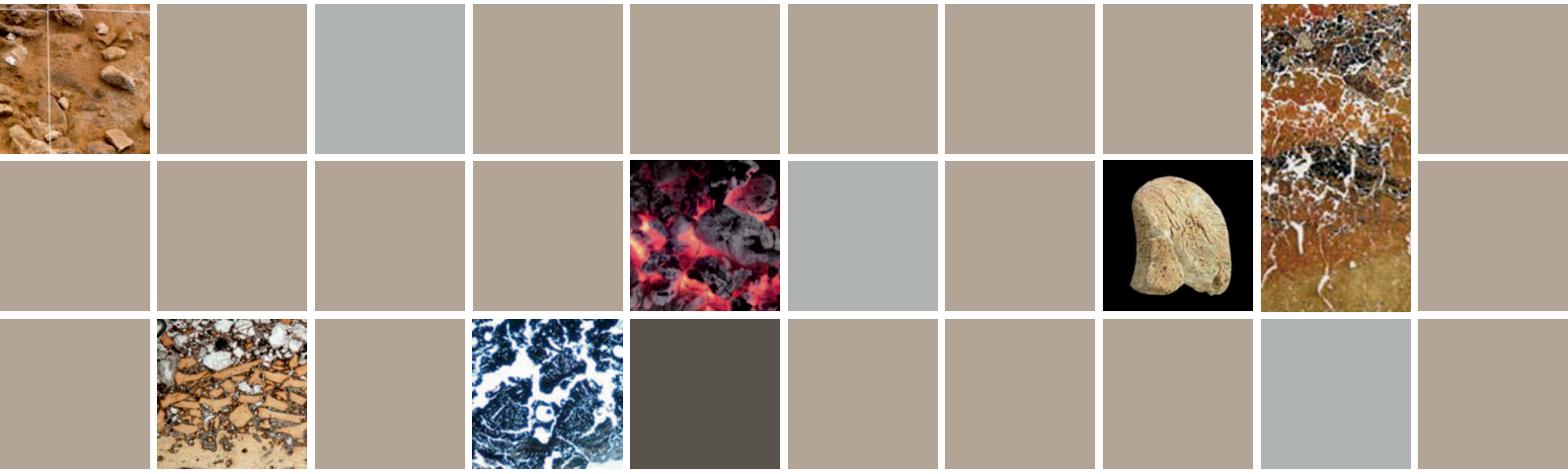
Isabelle THÉRY-PARISOT
Lucie CHABAL
Sandrine COSTAMAGNO

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



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Translation
Magen O'FARRELL

Layout
Yann BELIEZ

Cover
Fabien TESSIER

The contributions should be addressed to:

REVUE P@LETHNOLOGIE
Vanessa LEA, Research associates

TRACES - UMR 5608 of the CNRS
Maison de la recherche
5 allées Antonio Machado
31058 Toulouse cedex 9, FRANCE

Phone: +33 (0)5 61 50 36 98
Fax: +33 (0)5 61 50 49 59
Email: vanessa.lea@univ-tlse2.fr

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FROM MICROCHARCOAL TO MACROCHARCOAL: RECONSTRUCTION OF THE "WOOD CHARCOAL" SIGNATURE IN PALEOLITHIC ARCHAEOLOGICAL CONTEXTS

Laurent MARQUER

Abstract

The wood charcoal recovered during archaeological excavations represents only a partial image of the anthracological materials initially produced by human activities. Once buried, these objects are subject to diverse post-depositional processes that fragment them. While macrocharcoals (>500 µm) can be collected one by one and recorded within a coordinate system, or can be extracted by flotation and sieving during excavation, smaller fragments, such as "mesocharcoals" (500-160 µm) and micro charcoals (<160 µm), can be isolated from the sediments only through adapted procedures. A method of extraction and quantification through image analysis has thus been developed in order to record and evaluate the significance of the elements present in the finest sedimentary fractions. Such analyses have been applied in a Paleolithic context at the Magdalenian site of Grand Abri on the co*teau de La Garenne* (La Garenne hillside) (Saint-Marcel, Indre, France). This work shows that the quantity of charcoal found in the very fine sedimentary fractions (500-160 µm and <160 µm) is greater than that of the macrocharcoals. These quantifications allow us to reconstruct a "charcoal signature" from the macroscopic to the microscopic scale, and thus to identify, in situ, the smallest charcoal fractions resulting from the taphonomic processes that modified the archaeological site.

Keywords : charcoal, microcharcoal, taphonomy, Paleolithic, coteau de La Garenne (La Garenne hillside)

Introduction

The remains of combustion activities in Paleolithic contexts consist essentially of wood charcoal, burned bones, burned stones and ash. They originate from the remains of fireplaces that are more or less structured or dispersed with an archaeological level. In many Upper Paleolithic sites, wood charcoal absent or scarce, while other artifacts resulting from combustion, especially burned bones, are often abundant (Perlès, 1977; Théry-Parisot, 1998; 2001; Costamagno *et al.*, 1999; Théry-Parisot, 2002a; 2002b; Villa *et al.*, 2002; Théry-Parisot *et al.*, 2005; Yravedra *et al.*, 2005). Some believe that the high quantity of burned bone in fireplaces, compared to wood charcoal, could be explained by a limited collection of wood due to the low arboreous biomass during the last glacial period. The presence of charcoal in prehistoric contexts spanning the last 40,000 years has nonetheless been recorded in diverse cultural and bioclimatic contexts in Europe from the end of the Middle Paleolithic to the Final Paleolithic. Consequently, even if paleoenvironmental evolutions during the last glacial period in Europe (de Beaulieu & Reille, 1984; 1992a; 1992b; Reille & de Beaulieu, 1988; 1990; Guiter *et al.*, 2003; Beaudouin *et al.*, 2007; Naughton *et al.*, 2007) may have influenced the economy of combustibles, they cannot alone explain the absence or near absence of charcoal. The use of bone in fireplaces for economic, cultural and/or energetic reasons was then supposed (Théry-Parisot, 1998; 2001; Théry-Parisot, 2002a; 2002b; Villa *et al.*, 2002; Théry-Parisot & Costamagno, 2005; Théry-Parisot *et al.*, 2005).

Since wood is necessary to light a fire (Costamagno *et al.*, 2005; Théry-Parisot *et al.*, 2005), its combustion residues should be present in prehistoric occupation levels. Archaeological excavations only rarely consider the wood charcoal present in sediments finer than one millimeter. The smallest charcoal fragments produced on the surface of wood (or herbaceous plants) during combustion, then secondarily following the refragmentation of the largest particles, are thus not recorded. It is thus possible that some information concerning the presence of charcoal is lost.

Diverse quantification methods have been developed for the microparticles of burned vegetal materials, most of which are undeterminable, and are included in the category of microcharcoals. These quantifications were multiplied and perfected at the end of the 1980's in the context of quaternary sediments (Clark, 1984; Patterson *et al.*, 1987; Clark, 1988; McDonald *et al.*, 1991; Clark & Hussey, 1996; Rhodes, 1998; Carcaillet *et al.*, 2001; Vannière, 2001; Thevenon, 2003; Carcaillet, 2007; Daniau, 2008). Based on these analytical approaches, I have developed a study protocol for fireplace residues, from microscopy to macroscopy, in order to evaluate the potential loss of two combustion signatures (charcoal signature and burned bone signature) in the finest sediment fractions.

Methodological approach

Extraction procedure for macro- meso- microcharcoals

Several samples are collected depending on their presence in the sediment and the archaeological feature studied. They are collected throughout the feature in order to obtain the best representivity possible. One sample corresponds to a 100 to 500 cm^3 volume of sediment. The sample is then treated in a sieving column (fig. 1). Water sieving was favored over dry sieving because by diffusing water homogeneously and at a very low pressure over the sediment it is possible to remove the other micro-particles that can be deposited on the macro-, meso- and microcharcoals, which can hinder observations during optical analyses. For sediments with a high clay content, a deflocculation agent can be used (sodium hexametaphosphate: $Na_6O_{18}P_6$). Sieving meshes of 500 µm and 160 µm were employed in order to extract the charcoal fragments contained in the macroscopic (>500 µm: lowest limit possible for taxonomic identification in most cases), "mesoscopic" (500-160 µm) and microscopic (<160 µm: starting limit at which charcoal micro-particles are analyzed on palynological slides) sedimentary fractions (Hounslow & Chepstow-Lusty, 2002; 2004; Marquer *et al.*, 2008a; Marquer, 2009). In these three fractions, burned bone fragments are found along with the charcoal

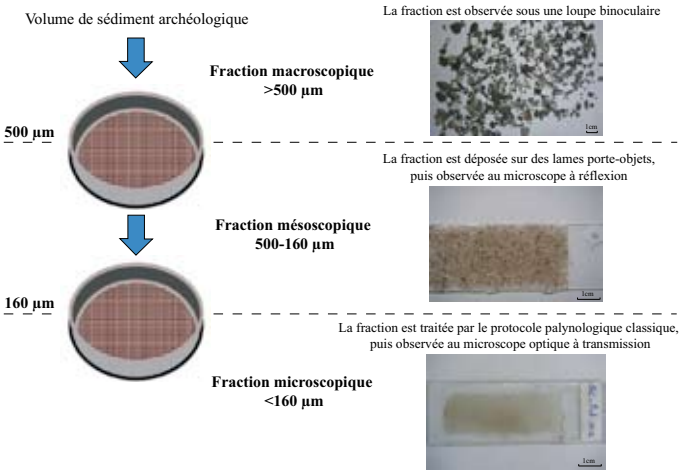

Fig. 1 - Extraction of the three sedimentary fractions: macroscopic (> 500 µm), mesoscopic (500-160 µm) and microscopic (<160 µm).

fragments. They were thus analyzed in the same manner as the charcoals to allow a direct comparison of the data concerning the relative presence of these two types of combustion remains.

The sediment of the macroscopic fraction was conserved in a Petri dish before being sorted with the aid of a binocular magnifier. The mesoscopic fraction was successively quartered and a final volume of sediment retained. This volume was placed on a microscope slide that was specially adapted for analysis by reflected light microscopy. Finally, a volume of the microscopic sediment fraction was treated using the classic palynological procedure (Cour, 1974; Faegri & Iversen, 1989) in order to eliminate the diverse mineral and organic fractions of the sediment that can hinder microscopic observations (Asselin & Payette, 2005). However, the chemical treatment used can bias the charcoal/burned bone proportions as the acids may partially dissolve the microfragments of burned bones. This is particularly true of hydrochloric acid, which attacks the carbonated elements (Marquer *et al.*, in press). Consequently, on the microscopic slides, only the quantifications of microcharcoals are considered.

Discrimination by microscopy

Different procedures were carried out with each of the sediment fractions in order to clearly discriminate the black burned bone fragments from the charcoal particles (Stiner *et al.*, 1995; Cain, 2005). To define the main criteria of identification, experimental macroscopic samples of wood and bone were submitted to diverse combustion temperatures, and then crushed and observed in each of the sedimentary fractions.

The macrocharcoals (>500 µm)

Charcoal and burned bone fragments are discriminated based on multiple criteria observed with a binocular magnifier: colorimetric (black for charcoal and diverse gradients of color for burned bone), morphological/anatomical (with observations of vegetal fibers for charcoal and cancellous elements for the bone tissues) and textural (fragment density).

The macrocharcoals possess three observable planes of wood anatomy and are thus potentially determinable at the species, gender or family level. The precision of the identification depends on the taxon and the condition of the fragment.

The "mesocharcoals" (500-160 µm)

The mesoscopic fraction is observed with the aid of a reflected light microscope in order to discriminate the charcoal from burned bone based on differences in the reflection of their superficial structures, which allows identification of the ligneous or herbaceous vegetal fibers (fig. 2).

These vegetal meso-particles have two to three anatomical planes, in certain cases allowing determinations that generally remain imprecise (Monocotyledons, Dicotyledons or Gymnosperms).

The microcharcoals <160 µm

The microcharcoals present in the microscopic fraction (<160 µm) are observed with an optical transmission microscope. The minimal dimension for the discrimination of vegetal micro-particles retained in our analyses is approximately 20 µm. These micro-elements are produced during combustion and then secondarily by the refragmentation of macrocharcoals and mesocharcoals. Based on their shape and structure,

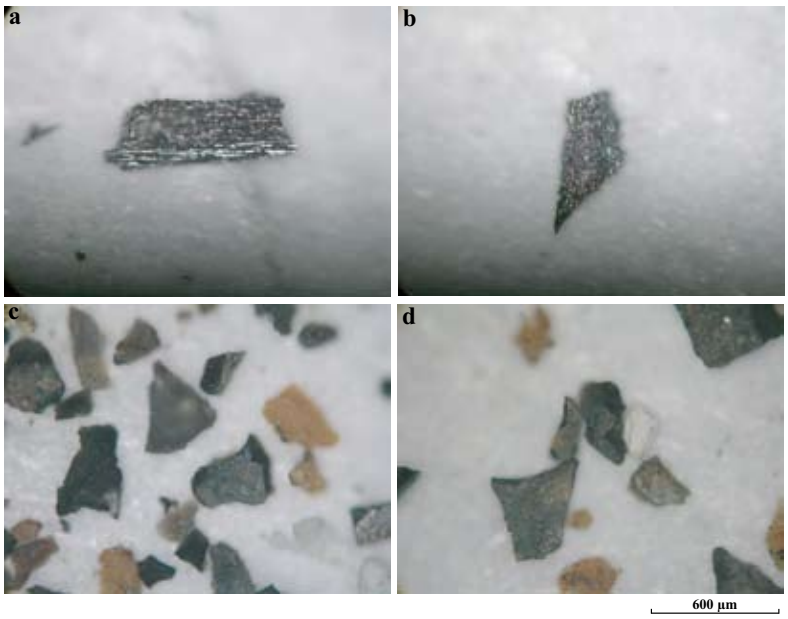

Fig. 2 - Mesoscopic fraction (500-160 µm) observed with a reflected light microscope: fragments of charcoal (a, b) and burned bone (c, d).

observed. These latter may correspond to longitudinal fragmentations with no visible characteristic vegetal structures. In addition, these micro-particles are generally opaque in transmitted light due to the thickness of the fragments, and probably to the degree of combustion as well.

The discrimination of vegetal micro-particles in this microscopic fraction is thus realized based on optical density and morphological criteria: black color, opaque, angular form, sometimes with the presence of well defined vegetal cells (Patterson *et al.*, 1987; Clark, 1988).

it is sometimes possible to identify cellular elements in one of the anatomical planes of wood or other vegetal organs (fig. 3; fig. 4).

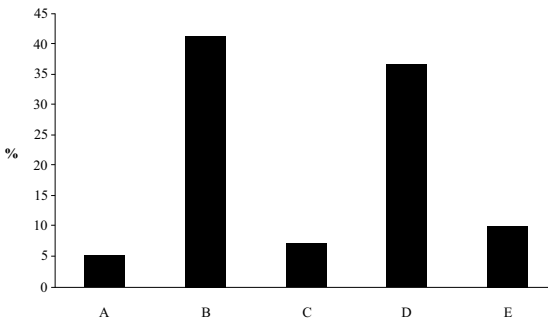

Fig. 3 - Percentages of the different types of microcharoals (<160µm), observable on palynological slides (study conducted with ground wood charcoal) A: opaque microparticles with cellular remains, B: opaque microparticles with an angular form, C: opaque microparticles with an elongated form, D: other types of opaque microparticles, E: translucent microparticles.

Very few micro-particles with cellular forms are observable on the microscopic slides. This is probably because most of the macro and mesocharcoals are fragmented along a longitudinal axis, rather than a transversal one. Some internal parts of vessels with intervascular punctuations can also be identified and correlated with a longitudinal fragmentation. Meanwhile, opaque black particles with an angular form constitute the largest proportion of the vegetal micro-elements

Quantification of the charcoal signature

Quantifications of charcoals are most often expressed as numbers of charcoal objects. These counts, which represent a final state of fragmentation, are influenced by the hazards of fragmentation (Chabal, 1992; 1997; Chabal *et al.*, 1999). In paleoecological analyses of microcharcoals, the results are calculated as a surface concentration of charcoal (cm^2) per volume of sediment treated (cm^{-3}). These global quantifications in the form of a surface do not take into account the final state of fragmentation and thus ignore the hazards of the fragmentation. In effect, if we take the example of a sample containing a charcoal whose largest surface is 20 mm², fragmented into four 5 mm² elements, the value attributed to the sample is 4. This value is dependant on the fragmentation processes. On the other hand, in the case of surface measures, whatever the number of resulting fragments, the original surface will be reconstituted (4 x 5 mm^2 = 20 mm²). These measures thus allow us to compare the different sedimentary fractions with each other and to add them to obtain a total, while eliminating the hazards linked to the fragmentation processes, with the goal of reconstituting the global charcoal signature present in the sediments. We have applied this quantification scale to the three

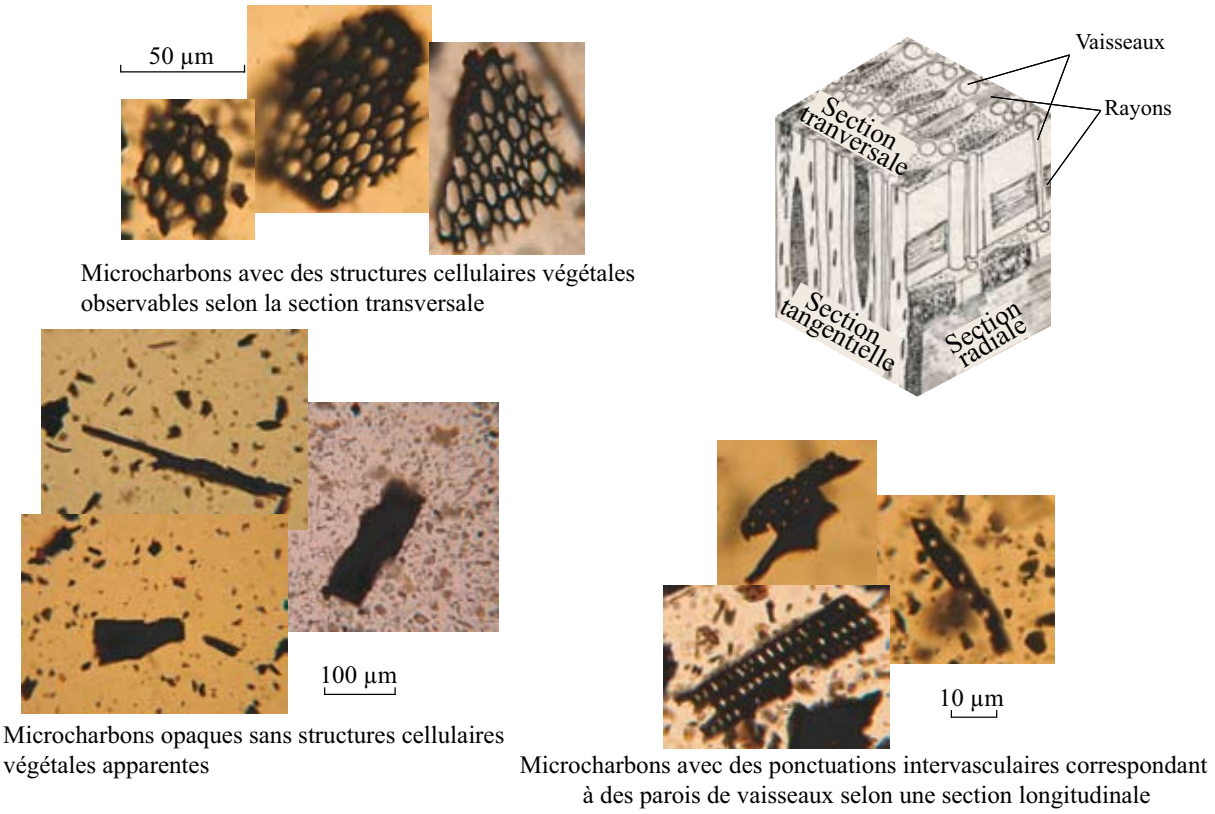

Fig. 4 - Different types of microparticles present on pollen slides observed through optical transmission microscopy (observations made with ground wood charcoal).

sedimentary fractions, allowing us to measure the concentrations on the macroscopic, mesoscopic and microscopic scales. It is important to note that the quantification of surfaces underestimates the relative quantity of macrocharcoals relative to microcharcoals. This is because the macrocharcoals have a third side (thickness that we do not see) that is on average larger than the micro-particles. The surfaces thus give an approximation of the volumes that overestimates the small fragments relative to the larger ones. Meanwhile, our analyses were applied to sites characterized by a great scarcity or absence of macrocharcoals and the few macrocharcoals found have very small volumes, thus minimizing this bias.

An image analysis method that allows an automatic quantification of charcoal surfaces was developed following Marquer *et al.* (2008b). This method calculates the total surfaces of each size class (>500µm; 500-160µm; <160µm). The samples are scanned with a camera connected to a computer. For each sample, the field of numeric observations is captured and analyzed with an image analysis program (©*Image J.1.41*) that allows identification of the burned particles based on their gray levels (fig. 5). A threshold of the image is then manually set by the analyst after identification of the nature of the particles. Several calculation parameters can then be obtained for all of the numeric fields of a sample, such as the average surface of a particle and the total surface of all the particles present. Based on these measures, we calculated for each sample the average surface of a particle (cm^2, mm^2 or μm^2 depending on the sedimentary fraction analyzed) and the concentrations ($cm^2\ cm^{-3}$) for each sediment fraction.

First applications in an archaeological context

We present here the case of the "Grand Abri" rock shelter located on the *coteau de La Garenne* (La Garenne hillside) (Saint-Marcel, Indre, France), which contains archaeological levels dated to the Middle Magdalenian (fig. 6; for a summary of the archeological data of this site, see Allain, 1985 and Despriée *et*

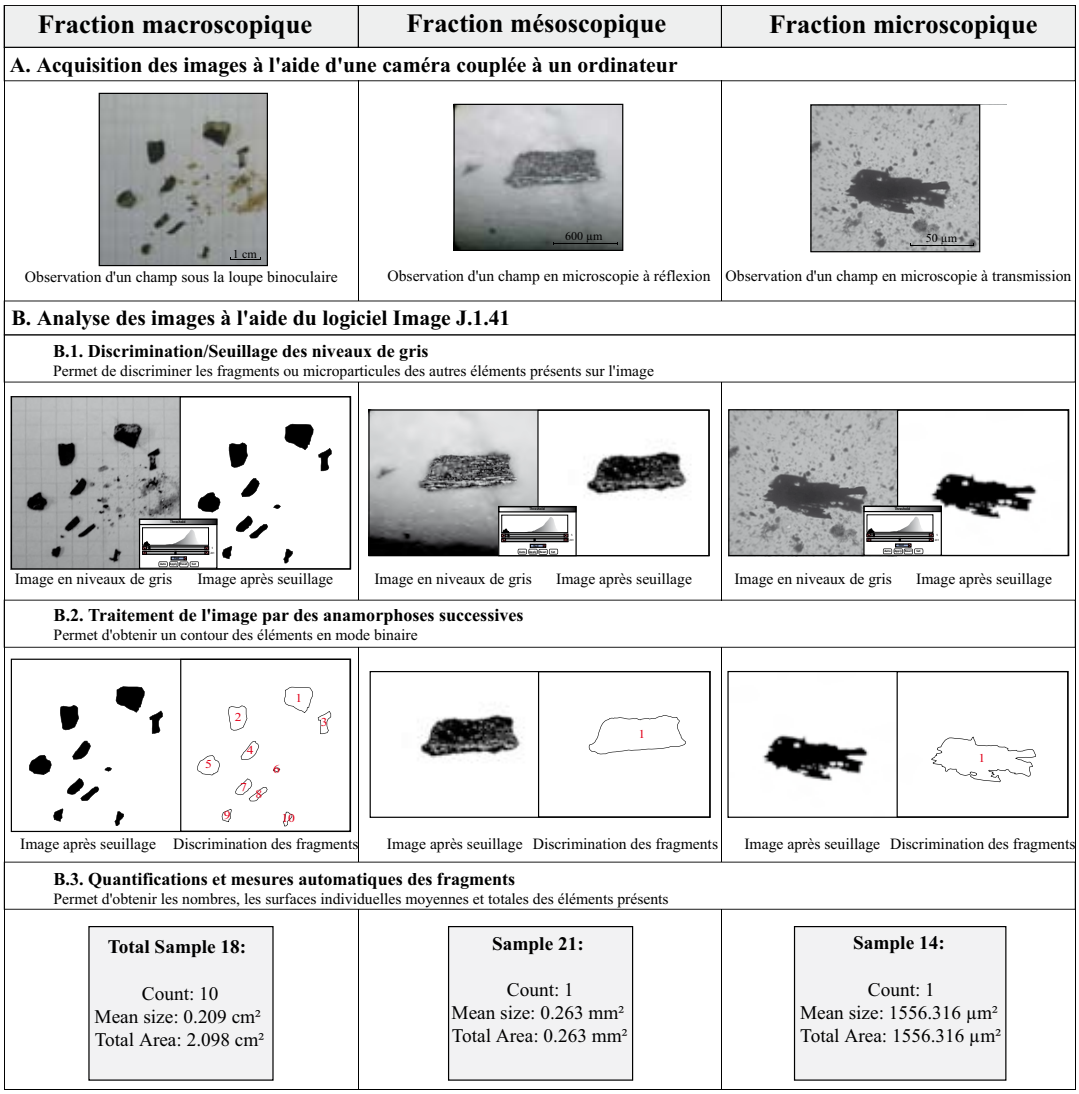

Fig. 5 - Synthesis of the procedure for quantifying macro-, meso- and microcharcoals though image analysis.

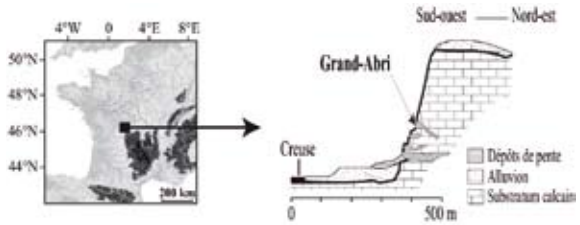

Fig. 6 - North-south profile of the coteau de La Garenne (Saint-Marcel, Indre, France): location of the Grand Abri rock shelter.

al., 2004). Two hearths in stratigraphic position in archaeological levels (A and B) were fully excavated. Descriptions of the combustion features at La Garenne are available in the field notes of Dr. Jacques Allain (Musée Argentomagus at Argenton-sur-Creuse) and in the publication by Allain (1953).

During the excavations directed by Dr. Allain (1946-1976), a near absence of wood charcoal was noted. Our search for charcoal remains within the fine sediment fractions confirms these first observations (fig. 7). The charcoal concentrations are indeed very low and only a few very small macroremains are preserved. Intensive fragmentation is likely responsible for the alteration of the macrocharcoals. In addition, we find the signature of these remains almost solely in the mesocopic and microscopic fractions. Charcoals are thus present, but are too small to have been extracted during excavation, suggesting a loss of information concerning hearth residues.

Pre- and post-depositional processes that modify wood charcoal must thus be considered. The main pre-depositional factors linked to combustion and that can

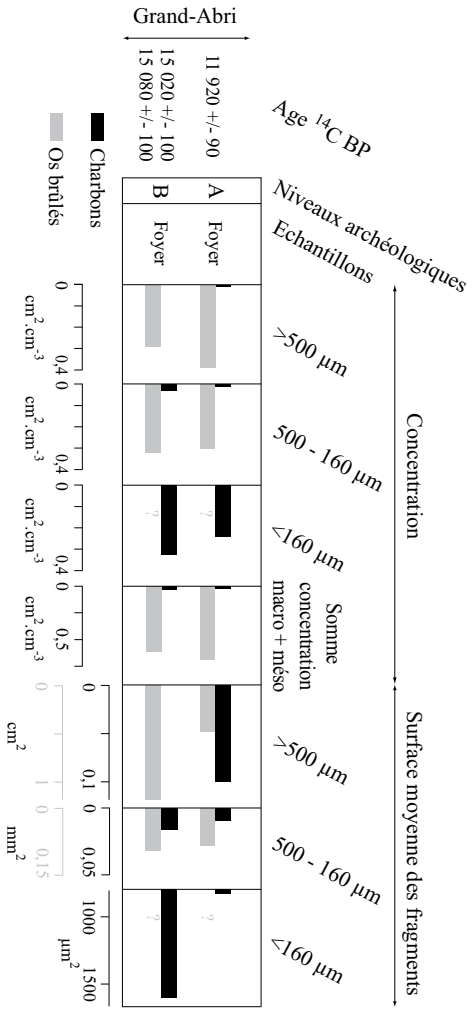

Fig. 7 - Results of the quantifications of combustion signatures (charcoal and burned bone) in the hearths of archaeological levels A and B of the Grand Abri. The micro-fragments of burned bone observed on the pollen slides are not quantified because they are partially altered by the chemical procedure employed in palynology.

influence the preservation of charcoal are the nature of the wood (dead, green or drift wood) (Théry-Parisot, 2001; Théry-Parisot & Texier, 2006), the vegetal species collected and the combustion duration and temperatures related to the functioning of the hearth (Théry-Parisot, 2002a). Dr. Allain (1953) supposed that the near absence of charcoal in the archaeological levels of La Garenne could be due to a nearly total combustion of wood. The presence of bones in the hearths, which increases the combustion duration (Théry-Parisot, 2002a), could have played an important role in the reduction of the macrocharcoal mass, which would partially explain their low frequencies. Post-depositional processes, such as climatic and/or edaphic factors (freeze/thaw, sediment humidity, sediment compaction), biological activities (roots, fungi) and numerous human activities repeated near the hearth (Thinon, 1992; Théry-Parisot, 1998), can favor the "elimination" of charcoals. Charcoals do not appear to be altered by chemical and/or biochemical agents in the soils (Thinon, 1992; Nichols *et al.*, 2000), even if certain authors speak of elements such as oxidation, which could nuance this hypothesis Cohen-Ofri *et al.*, 2006; 2007).

During his excavations, Dr. Allain also noted high quantities of burned bone elements. This second combustion signature, which we have quantified, confirms that this abundance remains constant in the mesoscopic fraction. Burned bones are subject to the same combustion effects and post-depositional processes as charcoal. However, the different physico-chemical constitution of burned bones must be taken into account as burned bone fragments are denser and thus probably more resistant to taphonomic processes than wood charcoal, which is more friable. The quantity of burned bones relative to charcoals could thus increase in function of the intensity of the taphonomic processes.

Conclusion

The procedure of extraction/quantification by image analysis defined experimentally and then applied to the Magdalenian hearths of the Grand Abri has revealed the presence of macrocharcoals (>500 µm). However, since the concentrations are low and the surfaces of the macrofragments are very small, it is impossible to extract them during the archaeological excavation of this site without an adapted procedure. The fact that the entire charcoal signature is present in the very fine sediment fractions (<160 µm) suggests a significant that the wood charcoal was fragmented. The resulting "micro-remains" thus constitute the main source information concerning the presence of combustion residues, and for this reason must be recorded.

Following the numerous taphonomic processes that can modify an archaeological level, the differential fragmentation of wood charcoal and burned bones could

result in an overestimation of the burned bone fragments. However, the total concentrations of charcoal present in all the sedimentary fractions, from the coarsest to the finest, thus integrating the refragmented fractions, remains inferior to the sum of the concentrations of macro- and meso-fragments of burned bones. This suggests that burned bones were indeed abundant in the hearths at La Garenne, on the condition that they were submitted to a rate of refragmentation or disappearance equal to that of the wood charcoal, which is not certain due to their greater mechanical resistance. These first analyses of the microremains of combustion contribute important information and raise numerous questions concerning the presence of residual combustion elements in hearths. It will thus be beneficial to continue, develop and enlarge their application to the ensemble of identifiable residual combustion elements, such as phytoliths, seeds, manures and lignins.

Author

Laurent Marquer

Département de Préhistoire du Muséum national d'histoire naturelle, Paris (France), USM 103-UMR 7194 du CNRS

marquer@mnhn.fr

References

Allain J. 1953 - Foyers et dallages dans le Magdalénien de la Garenne à Saint-Marcel (Indre). *L'Anthropologie*, 57 : 284-294.

Allain J., Desbrosse R., Kozlowski J.K., Rigaud A., Jeannet M. & Leroi-Gourhan Arl. 1985 - Le Magdalénien à navettes. G*allia Préhistoire*, 28 : 37-124.

Asselin H. & Payette S. 2005 - Detecting local-scale fire episodes on pollen slides. *Review of Palaeobotany and Palynology*, 137 : 31-40.

Beaudouin C., Jouet G., Suc J.P., Berne S. & Escarguel G. 2007 - Vegetation dynamics in southern France during the last 30 ky BP in the light of marine palynology. *Quaternary Science Reviews*, 26 : 1037-1054.

Beaulieu de J.L. & Reille M. 1984 - A long upper-Pleistocene pollen record from Les Echets near Lyon, France. *Boreas*, 13 : 111-132.

Beaulieu de J.L. & Reille M. 1992a - Long Pleistocene pollen sequences from the Velay Plateau (Massif Central, France). *Vegetation History and Archaeobotany*, 1 : 233 - 242.

Beaulieu de J.L. & Reille M. 1992b - The last climatic cycle at La Grande Pile (Vosges. France) : a new pollen profile. *Quaternary Science Reviews*, 11 : 431-438.

Cain C.R. 2005 - Using burned animal bone to look at Middle Stone Age occupation and behaviour. *Journal of Archaeological Science*, 32 : 873-884.

Carcaillet C., Bouvier M., Fréchette B., Larouche A.C. & Richard P.J.H. 2001 - Comparison of pollen-slide and sieving methods in lacustrine charcoal analyses for local and regional fire history. *Holocene*, 11: 467-476.

Carcaillet C. 2007 - Charred particles analyses. *Encyclopedia of Quaternary Science* : 1582-1593.

Chabal L. 1992 - La représentativité paléo-écologique des charbons de bois archéologiques issus du bois de feu. *Bulletin de la Société Botanique de France*, 139 : 213-236.

Chabal L. 1997 - *Forêts et sociétés en Languedoc (Néolithique final, Antiquité tardive) : l'anthracologie, méthode et paléoécologie*. Editions de la maison des sciences de l'Homme, Documents d'Archéologie Française, 63 : 189 pp.

Chabal L., Fabre L., Terral J.-F. & Théry-Parisot I. 1999 - L'anthracologie. *In : La Botanique*, Bourquin-Mignot C., Brochier J.-E., Chabal L., Crozat S., Fabre L., Guibal F., Marinval P., Richard H., Terral J.F.& Théry I. (eds) : 43-104.

Clark R.B. 1984 - Effects on charcoal of pollen preparation procedures. *Pollen et Spores*, 26 : 559-576.

Clark J.S. 1988 - Particle motion and the theory of charcoal analysis : source area, transport, deposition, and sampling. *Quaternary Research*, 30 : 67-80.

Clark J.S. & Hussey T.C. 1996 - Estimating the mass flux of charcoal from sedimentary records : effects of particle size, morphology, and orientation. *Holocene*, 6 : 129-144.

Cohen-Ofri I., Weiner L., Boaretto E., Mintz G. & Weiner S. 2006 - Modern and fossil charcoal: aspects of structure and diagenesis. *Journal of Archaeological Science*, 33 : 428-439.

Cohen-Ofri I., Popovitz-Biro R. & Weiner S. 2007 - Structural characterization of modern and fossilized charcoal produced in natural fires as determined by using electron energy loss spectroscopy. *Chemistry European Journal,* 13 : 2306-2310.

Costamagno S., Griggo C. & Mourre V. 1999 - Approche expérimentale d'un problème taphonomique : utilisation de combustible osseux au Paléolithique. *Préhistoire Européenne*, 13 : 167-194.

Costamagno S., Théry-Parisot I., Brugal J.-P. & Guibert R. 2005 - Taphonomic consequences of the use of bones as fuel. Experimental data and archaeological applications. *In* : *Biosphere to Lithopshere. New studies in vertebrate taphonomy*, T. O'connor (ed). Actes du 9° Colloque de l'ICAZ, Durham, août 2002. Oxford, Oxbow Books : 51-62.

Cour P. 1974 - Nouvelles techniques de détection des flux et des retombées polliniques : étude de la sédimentation des pollens et des spores à la surface du sol. *Pollen et Spores*, XVI : 103-141.

Daniau A.L. 2008 - *Variabilité des incendies en Europe de l'Ouest au cours du dernier cycle climatique : relations avec le climat et les populations paléolithiques. Etude des microcharbons préservés dans les carottes marines*. Thèse de doctorat, Université de Bordeaux I, 238 pp.

Despriée J., Rigaud A., Vialou D. & Gageonnet R. 2004 - Le Paléolithique de la vallée moyenne de la Creuse: le coteau de « la Garenne », Grand Abri et Grotte Blanchard, Saint-Marcel (Indre). *Bulletin de l'Association pour la Sauvegarde du Site Archéologique d'Argentomagus et Amis du Musée*, numéro spécial, 119 pp.

Faegri K. & Iversen I. 1989 - *Textbook of pollen analysis*. London, John Wiley and sons, 328 pp.

Guiter F., Andrieu-Ponel V., Beaulieu de J.L., Cheddadi R., Calvez M., Ponel P., Reille M., Keller T. & Goeury C. 2003 - The last climatic cycles in Western Europe : a comparison between long continuous lacustrine sequences from France and other terrestrial records. *Quaternary International*, 111 : 59-74.

Hounslow M.W. & Chepstow-Lusty A. 2002 - Magnetic properties of charcoal rich deposits associated with a Roman bath-house, Butrint (Southern Albania). *Physics and Chemistry of the Earth*, 27 : 1333-1341.

Hounslow M.W. & Chepstow-Lusty A. 2004 - A record of soil loss from Butrint, southern Albania, using mineral magnetism indicators and charcoal (AD 450 to 1200). *Holocene*, 14 : 321-333.

McDonald G.M., Larsen C.P.S., Szeicz J.M. & Moser K.A. 1991 - The reconstruction of boreal forest fire history from lake sediments : a comparison of charcoal, pollen sedimentological, and geochemical indices. *Quaternary Science Reviews*, 10 : 53-71.

Marquer L., Nespoulet R., Chiotti L., Otto T. & Théry-Parisot I. 2008a - Etudes sur la taphonomie des charbons de bois au cours des occupations du Paléolithique supérieur de l'abri Pataud (Dordogne, France). Colloque international Q6: « *Biodiversité au Quaternaire: Climats, Environnements et Peuplements* », 166 pp.

Marquer L., Pomel S., Abichou A., Schulz E., Kaniewski D. & Van Campo E. 2008b - Late Holocene high resolution palaeoclimatic reconstruction inferred from Sebkha Mhabeul, Southeast Tunisia. *Quaternary Research*, 70 : 240-250.

Marquer L. 2009 - Apports des signaux polliniques et charbons à la reconstitution des paléoenvironnements et à la connaissance des relations homme/milieu au Pléistocène dans le bassin de la Loire moyenne (France). Thèse du Muséum national d'histoire naturelle, 233 pp.

Marquer L., Despriée J., Otto T., Migaud B. & Renault-Miskovsky J. sous presse - Apport de l'étude des microcharbons dans la compréhension de la taphonomie des macrorestes végétaux brûlés sur le site magdalénien du coteau de « la Garenne » (Indre, France). *Cahiers d'archéologie romande*.

Naughton F., Sanchez Goñi M.F., Desprat S., Turon J.L., Duprat J., Malaizé B., Joli C., Cortijo E., Drago T. & Freitas M.C. 2007 - Present-day and past (last 25000 years) marine pollen signal off western Iberia. *Micropaleontology*, 62 : 91-114.

Nichols G.J., Cripps J.A., Collinson M.E. & Scott A.C. 2000 - Experiments in waterlogging and sedimentology of charcoal: results and implications. *Paleogeography, Paleoclimatology, Paleoecology*, 164 : 43-56.

Patterson W. A., Edwards K.J. & Maguire D.J. 1987 - Microscopic charcoal as a fossil indicator of fire. *Quaternary Science Reviews*, 6 : 3-23.

Perlès C. 1977 - *Préhistoire du Feu.* Paris, Masson, 174 pp.

Reille M. & Beaulieu de J.L. 1988 - History of the Würm and Holocene vegetation in western Velay (Massif Central, France) : a comparison of pollen analysis from three corings at lac du Bouchet. *Review of Palaeobotany and Palynology*, 54 : 233-248.

Reille M. & Beaulieu de J.L. 1990 - Pollen analysis of a long upper Pleistocene continental sequence in a Velay maar (Massif Central, France). *Palaeogeography, Palaeoclimatology, Palaeoecology*, 80 : 35-48.

Rhodes A.N. 1998 - A method for the preparation and quantification of microscopic charcoal from terrestrial and lacustrine sediment cores. *Holocene*, 8 : 113-117.

Stiner M.C., Kuhn S.L., Weiner S. & Bar-Yosef O. 1995 - Differential burning, recrystallization, and fragmentation of archaeological bone. *Journal of Archaeological Science*, 22 : 223-237.

Théry-Parisot I. 1998 - *Économie du combustible et Paléoécologie en contexte glaciaire et périglaciaire, Paléolithique moyen et supérieur du sud de la France (Anthracologie, Expérimentation, Taphonomie)*. Thèse de doctorat, Université Panthéon-Sorbonne de Paris, 500 pp.

Théry-Parisot I. 2001 - *Économie des combustibles au Paléolithique, Anthracologie, Expérimentation, Taphonomie*. Editions CNRS, Dossier de Documentation Archéologique, 20, 195 pp.

Théry-Parisot I. 2002a - Fuel management (bone and wood) during the Lower Aurignacian in the Pataud Rock Shelter (Lower Palaeolithic, Les Eyzies de Tayac, Dordogne, France). Contribution of experimentation. *Journal of Archaeological Science*, 29 : 1415-1421.

Théry-Parisot I. 2002b - The gathering of firewood during Palaeolithic time. *In* : *Nouvelles approches méthodologiques, histoire de la végétation et des usages du bois depuis la Préhistoire*, Thiébault S. (ed). Actes du second colloque international d'Anthracologie, BAR international series, 1063 : 243-250.

Théry-Parisot I. & Costamagno S. 2005 - Propriétés combustibles des ossements. Données expérimentales et réflexions archéologiques sur leur emploi dans les sites paléolithiques. *Gallia Préhistoire*, 47 : 235-254.

Théry-Parisot I. & Texier P.J. 2006 - L'utilisation du bois mort dans le site moustérien de la Combette (Vaucluse). Apport d'une approche morphométrique des charbons de bois à la définition des fonctions de site, au Paléolithique. *Bulletin de la Société Préhistorique Française*, 103 : 453-463.

Théry-Parisot I., Costamagno S., Brugal J.-P., Fosse P. & Guilbert R. 2005 - The use of bone as fuel during

the Palaeolithic, experimental study of bone combustible properties. *In* : *The zooarchaeology of fats, oils, milk and dairying*, J. Mulville & A.K. Outram (eds). Actes du Colloque de l'ICAZ, Durham, août 2002. Oxford, Oxbow Books : 50-59.

Thevenon F. 2003 - *Les résidus carbonés de feux dans les sédiments lacustres et océaniques intertropicaux : Implications méthodologiques, climatiques et anthropiques*. Thèse de doctorat, Université de Droit, d'Économie et des Sciences d'Aix-Marseille III, 127 pp.

Thinon M. 1992 - *L'analyse pédoanthracologique : aspects méthodologiques et applications*. Thèse de doctorat, Université de Droit d'Économie et des Sciences d'Aix-Marseille, 297 pp.

Vannière B. 2001 - *Feux, Agro-Pastoralisme et Dynamiques Environnementales en France durant l'Holocene. Analyse du signal incendie, approches sédimentologiques et études de cas en Berry, Pyrénées et Franche-Comté.* Thèse INA-PG/Université de Franche-Comté, 327 pp.

Villa P., Bon F. & Castel J.C. 2002 - Fuel, fire and fireplaces in the Palaeolithic of western Europe. *Review of Archaeology*, 23 : 33-42.

Yravedra J., Baena J., Arrizabalaga A. & Iriarte M.J. 2005 - El empleo de material óseo como combustible durante el Paleolítico Medio y Superior en el Cantábrico. Observaciones experimentales. Museo de Altamira. *Monografias*, 20 : 10-38.

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