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Disentangling human from natural factors: Taphonomical value of microanatomical features on archaeological wood and charcoal assemblages

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ABSTRACT

Archaeobotanical charcoal and wood analyses rely on the observation of different macro- and microanatomical features affecting wood structure to variable extents. These features may result from a wide range of intrinsic and extrinsic factors alluding to different stages of the wood's taphonomical history: initial growth conditions, human selection, transformation/use and discard, post-depositional processes and archaeological sampling strategies. Papers in this volume address taphonomy in this broad sense, through recent methodological work mainly based on experimentation and case studies from a variety of chrono-cultural and geographical contexts. The authors present a number of tools available to wood and charcoal analysts and discuss their archaeological relevance to characterize anthropogenic and/or natural processes. The presented approaches are complementary and well reflect the extent to which wood and charcoal remains provide new insights into past human practices and social dynamics.

1. Introduction

Since the beginning of systematic charcoal analysis or anthracology, increasing attention has been given to different types of micro-anatomical features to advance the discipline's theoretical, methodological and interpretative framework (Vernet, 1992, Thiébault, 2002; Badal, 2004; Damblon, 2013; Fiorentino and Magri, 2008; Badal et al., 2012; Ludemann and Nelle, 2017; Théry-Parisot et al., 2010; Dotte-Sarout et al., 2015; Kabukcu, 2018). In the early stages of anthracology, research was focused on sampling and quantification methods and potential representativeness biases such as fragmentation and mass reduction, which led to establishing the methodological basis of the discipline (Chabal, 1982, 1988, 1992, Chabal, 1994, 1997; Chabal et al., 1999; Krauss-Marguet, 1981; Badal García and Heinz, 1991; Badal, 1992; Pernaud, 1997). The development of an accurate method for charcoal analysis allowed to compare data between sites and to establish reliable paleoecological records (Asouti and Austin, 2005). Beyond these aspects, analyses of microanatomical features on charcoal advanced in two main directions. First, the study of anatomical features to reconstruct firewood management, especially in Paleolithic and Mesolithic contexts for which a systemic interpretative framework was needed (Théry-Parisot, 2001; Henry and Théry-Parisot 2014a; Vidal-Matutano et al., 2017). Secondly, the study of anatomical features to identify aspects related to woodland management and paleoecological reconstructions (Terral and Mengüal 1999; Marguerie and Hunot, 2007; Ludemann and Nelle 2002; Dufraisse and García-Martinez, 2011; Dufraisse et al., 2018).

Macro- and microanatomical features visible within the ligneous cellular structure depend on different intrinsic and extrinsic factors alluding to various stages of the wood's taphonomical history: initial growth conditions, human selection, transformation/use and discard, post-depositional processes and archaeological sampling strategies. Initial growth conditions can be reflected by distinguishable anatomical variations of the wood structure resulting from intrinsic or extrinsic natural factors or human activities such as deforestation, pruning or domestication/irrigation (Schweingruber, 2007; Dufraisse, 2006; Terral, 2000; Limier et al., 2018). The identification of the features related to these processes sheds light on woodland management practices and environmental effects on woody plants. Human selection is a major topic in anthracology where the study of anatomical features allows going beyond the taxonomic identification to analyze charcoal assemblages, as aspects related to socio-economical behavior can be approached through studies aiming at reconstructing minimal diameters and state of the wood (green, seasoned, decayed) used. Indeed, the latter are additional indicators of firewood acquisition modalities (woodcutting vs. gathering) and have different implications in terms of heat requirements and fire use (Moskal-del Hoyo et al., 2010; Théry-Parisot and Henry, 2012; Henry and Théry-Parisot, 2014b; Mallol and Henry, 2017; Vidal-Matutano et al., 2017). Transformation/use and discard involve different processes subjected to variable archaeological visibility according to the studied material; macro- and microtraces on worked wood allow reconstructing manufacture processes and uses, whereas in the case of charcoal assemblages the combustion constitutes an additional taphonomy filter. Burning induces wood fragmentation and mass reduction, alters the cell walls and can produce specific microanatomical alterations such as cracks and vitrification, in relation to the initial fuel characteristics (Chabal et al., 1999; Théry-Parisot et al., 2010; Théry-Parisot and Henry 2012; McParland et al., 2010). Post-depositional processes and preservation of charcoal or wood in archaeological or natural contexts are diverse. In the course of their depositional or post-depositional history, charcoal particles can be fragmented or hyper fragmented. Anthracological remains are affected by processes indicating the action of mechanical, biological or climatic factors (Chrzazvez et al., 2014). In the case of wood, its preservation

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generally implies specific depositional and post-depositional conditions. Finally, archaeological sampling strategies and recovery methods can have a significant impact on assemblage fragmentation and, more generally, representativeness, which stresses the importance of the traceability of excavation and laboratory methods (Vidal-Matutano, 2017; Arranz-Otaegui, 2017).

To understand processes and classify different features several methods have been applied relying overall on experimentation and ethnoarchaeology (Ntinou, 2002; Théry-Parisot et al., 2009; Henry et al., 2018; Théry-Parisot et al., 2016; Picornell Gelabert et al., 2011; Dussol et al., 2017; Caruso-Fermé et al., 2015; McParland et al. 2010; Dufraisse et al., 2018). Accurate observations of the materials and efforts in understanding the processes involved in the formation of microanatomical features have provided interpretation keys of anthracological materials that are currently at different stages of development.

For the Paleolithic and, more generally, temporary hunter-gatherer occupations, specific questionings related to taphonomy issues and wood-related human behavior in terms of fire management systems are widely being developed. These questionings concern mainly fuel selection and acquisition modalities from an environmental, territorial and functional perspective (Théry-Parisot, 2001; 2002; Théry-Parisot et al., 2010, 2018; Allué 2002, Allué et al., 2009; Henry and Théry-Parisot, 2014a; Vidal-Matutano, 2017; Vidal-Matutano et al., 2015, 2019; Alcolea-Gracia, 2018; Allué & Mas, this volume; Martínez-Varea et al., this volume). These specific chrono-cultural contexts have also led researchers to investigate more in depth the impact of depositional and post-depositional processes in order to contribute to reconstructing on-site taphonomic conditions (Théry-Parisot, 2001; Carrión-Marco and Badal, 2004; Chrzazvez et al., 2014; Marquer et al., 2015; Vidal-Matutano et al., 2017; Vidal-Matutano, 2017). With increasing anthropogenic pressure from the Neolithic onwards and within more recent, generally better preserved contexts, the development of dendroanthracological tools and multi-proxy approaches have allowed significant advances in the knowledge of past woodland management and agricultural systems (Ludemann and Nelle, 2002; Carrión-Marco, 2005; Delhon et al., 2009, Dufraisse 2006; Terral and Durand, 2006; Delhon et al., 2008; Paradis-Grenouillet and Dufraisse, 2018; Marguerie et al., 2010; Dufraisse and García-Martinez, 2011; Dufraisse et al., 2018; Out et al., 2013). Finally, exceptional contexts such as waterlogged sites where non-charred ligneous materials are preserved allow the adoption of a wider perspective regarding wood uses, from techno-functional and cultural approaches of ligneous materials and artefacts to the reconstruction of woodland management and economies (Carrión-Marco and Rosser, 2010; Chabal and Feugère, 2005; López-Bultó and Piqué, 2018; Zhilin et al., 2018; Klooß, 2014; Martín-Seijo and Carrión, 2012; Mertens, 1998).

2. Case studies presented in this special issue

The case studies presented in this volume cover a wide geographic range from Eurasia to South America. The archaeological contexts are also diverse, with a chronological span from the Middle Palaeolithic to historical periods. There is a broad application of new approaches to traditional anthracology that definitely contribute to a better understanding of anatomical features and, more generally, of the anthracological record. These approaches are intended to solve particular issues regarding specific human activities related to wood uses and to understand natural and anthropogenic processes affecting anthracological assemblages.

As previously mentioned, the Paleolithic has traditionally been the most studied period from a taphonomical perspective, probably because many processes related to charcoal aging and decay make evident the need for a deep taphonomic analysis. In this special issue, two papers focus on this period from different perspectives. Martínez Varea et al. (2020) present two case studies, Abrigo de la Quebrada and Cova de les Cendres (Spain) to analyze the taphonomical characteristics of charcoal remains affected by post-depositional processes. The authors analyze preservation conditions involving different type of contexts and human occupation patterns. Allué and Mas (2020) present an overview of microanatomical features observed on *Pinus sylvestris* type charcoal from Paleolithic sequences in Iberia. As the values provided by the microanatomical features are difficult to interpret in terms of human behavior, they are used as a comparative proxy between archaeological sequences. However, the advance in the description of these features and an accurate classification will allow in the future a better understanding of the meaning of these results with broader implications for wood uses during the Paleolithic.

Charcoal quantification and floristic representativeness of the anthracological spectra (floristic diversity and proportions between taxa) is an important issue in anthracology. The main variables identified as affecting the reliability of charcoal assemblages are the recovery methods used during the excavation, the number of analyzed fragments, the study of different contexts and the origin of the samples (dispersed vs concentrated charcoal assemblages) (Chabal, 1988; 1992; 1997; Chabal et al., 1999; Badal, 1992). The general validity of these premises, mainly built around protohistorical to historical case studies, is reexamined by Henry et al. (2020) for a Mesolithic cave occupation. The objective was to understand the respective contributions of different size classes (2–4 mm and $>$ 4 mm) and sampling contexts (dispersed vs. concentrated charcoal) on the floristic results of Escabasses Cave (France). The fact that the floristic results vary more according to size class than to sampling context goes against previous observations and invites taking fragment size more systematically into account. Furthermore, this specific situation may have paleothnographic implications regarding the way in which small mobile Mesolithic groups managed fireplaces in a confined space.

Combustion processes entailing wood carbonization have major implications in different aspects affecting archaeological charcoal assemblages. Some work has already been done using experimental archaeology to understand specific processes such as mass reduction, wood anatomy changes and fragmentation (Slocum et al., 1978; Chrzazvez et al., 2014; Gonçalves et al., 2012; Théry-Parisot et al., 2010). Among the alterations resulting from combustion, vitrification is one of the most recurrent, even though it rarely affects the entire assemblage. This glassy and refractive aspect of the wood anatomical cell structure has no accurate explanation yet, even though most of the studies agree that this alteration results from – but cannot be only explained by - the combustion process. Different parameters have been tested and analyzed by several researchers, such as type of combustion process, temperature or initial state of the wood (Théry-Parisot, 2001; McParland et al., 2010; Henry, 2011). Courty (2017) proposed that this alteration results from wood flash-pyrolysis induced by aeroplasma. In this special issue, Courty et al. (2020) present research focused on vitrification affecting different kinds of charcoal remains. The authors present new evidence based on modern burning assemblages and their identification and a detailed process inducing vitrified charcoal. One of the strengths of the study is to provide insights on fuel qualities and pyrotechnology, showing that there are different degrees, and probably different processes, leading to the production of vitrified charcoal components. Vidal-Matutano et al. (2019) present a multi-approach study based on the spatial analysis of charcoal and burned faunal remains to understand the causes of vitrification in an anthracological assemblage from the pre-Hispanic site of Chasogo (Tenerife, Spain). In this study, abundant vitrified wood charcoal fragments seem to be spatially related to the combustion structures and the burnt bones suggesting the relationship of this phenomenon with specific combustion conditions, allowing the discussion of some working hypotheses for future analyses.

Wood management has become an important issue based overall in dendroanthracology, with diameter estimates used for drawing paleoeconomical but also paleoenvironmental hypotheses regarding woodland structure (Carrión, 2005; García-Martínez and Dufraisse,

2011). Dufraisse et al. (2020) present new methodological developments for the analysis of wood diameter estimation using the Pith Location Tool (PLT). This method, based on trigonometry, was applied to seven different taxa, constituting an important reference dataset. The strengths of this research are to provide measurement protocols and guidelines for an accurate dendroanthracological analysis, as well as an R-function for wood and charcoal fragments allowing a wide use of this tool among the research community.

Caruso-Ferme and Thery-Parisot (2020) apply for the first time an evaluation of the minimal wood caliber to a Patagonian hunter-gatherer site, Cerro Casa de Piedra 7 (Argentina). They propose a comparison between diameters measured on charcoal vs. wood fragments of *Nothofagus*, the most abundant taxon in this archaeological context. The results show completely different patterns between firewood and wood diameters used at the site throughout time, which has interesting implications regarding wood acquisition strategies of these Patagonian societies.

López-Bultó (2020) presents the famous Neolithic waterlogged wood assemblage of La Draga (Spain), from which he analyses woodworking debris and formless pieces of wood. Indeed, in sites with exceptional preservational conditions, this last category is often left aside in xylological studies. This study confirms the necessity to take them into account, as they allow the discussion of key aspects of wood economies such as raw material selection, transport and manufacturing processes (e.g., Caruso Fermé 2012; Taylor et al. 2018).

Finally, post-depositional processes can be studied from a wide perspective including pedoanthracology as an approach to understand soil formation processes in natural contexts (Scott and Damblon, 2010). Ponomarenko et al. (2020) present a multidisciplinary study based on sedimentology, palynology and pedoanthracology. The study is focused on the discrimination of natural versus anthropogenic causes of erosion phases during historical times in the Middle Volga region. According to the data, different land uses and cultivation techniques are clearly recognizable in the sedimentary profiles of the investigated area. The authors conclude that human practices related to livestock and deforestation are the main cause of erosion.

3. Concluding thoughts

Anthracology is a relatively young research field that is still expanding thanks to new analytical methods based on experimental work and actualistic reference datasets in general. Ongoing approaches range from the macroscopic to the molecular levels, with a whole new world of possibilities opening up for a better understanding of both natural and anthropogenic processes. The articles in this SI only represent partially what is going on out there, but in our opinion, they well reflect the fact that charcoal and wood analyses tend to diversify around multiple topics. As shown in this volume, these topics go from paleoenvironmental reconstructions and land-use patterns to very specific questions regarding firewood and wood management, while methodological developments and questionings are still at the heart of the discipline. Much is still left to do to be able to characterize, understand and interpret the many signatures identifiable within the charcoal record, and their relevance for the study of different taxa, archaeological levels, sites and periods. Taphonomic issues are often treated laterally in papers focused on other topics, which often makes it difficult to follow the progress made. In this sense, this volume aims to be a meeting point for the definition, evaluation of archaeological relevance and general discussion of microanatomical signatures observed in archaeological charcoal and wood.

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