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A new method for facilitating tree-ring measurement on charcoal form archaeological and natural contexts

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ABSTRACT

For the past 20 years, the application of dendrology to charcoal fragments found in an archaeological context has encountered the problem of the fragility of the material for its routine development. Friability and fragmentation are among the reasons for the difficulty of the dendrochronological approach. In order to meet this restrictive element, we present a new method in this article and assess its feasibility. The fixing of charcoal by means of a thermo-shrinking sheath makes it possible to preserve it from the risks of destruction during the various stages from sampling to storage. This constriction using a sheath makes it possible to polish the whole of the transversal plane of a flat surface, thus facilitating measurement of the growth ring characteristics. The feasibility was tested on 95 samples of charcoal, corresponding to eight ligneous taxa sampled in different archaeological contexts. A series of tree-ring widths was measured on 80 pieces of charcoal. The synchronicity between the radii of the same piece of charcoal was excellent, only three samples possessing radii with a Gleichläufigkeit index (Glk) < 70. Of the 14 floating chronologies established on the basis of this data, in eight of them, > 50% of the body demonstrated very good concordance (Glk > 70), making it possible to validate the method on several pieces of charcoal originating from the same context. Thus, thanks to the sheath, the initial condition of the charcoal was preserved and fixed in time. The flat surface created made it possible to take reliable measurements of the rings in the charcoal and these were comparable to the methods normally used in dendrochronology on wood. The ease of manipulation opens up the possibility of applying the dendrological approach to numerous anthracological studies in archaeological and paleo-ecological contexts.

1. Introduction

In the beginning of archaeology the presence of charcoal went largely unnoticed. This is why, early anthracological studies did not make their appearance until the nineteenth century (Heer, 1866; Prejawa, 1896) before developing in France under the impetus of Abbé Breuil (1903). Research into the paleo-ecological significance of collections of charcoal was not initiated until the 1940s when it was instituted by British researchers (Salisbury and Jane, 1940; Godwin and Tansley, 1941), in parallel with the development of methods of applying dendrology and dendrochronology methods to charcoal to analyse the relationship between climate and radial growth (Salisbury and Jane, 1940).

Until the early 1970s, observation of charcoal deposits involved the long and painstaking process of creating thin, three-dimensional sections of the material (Santa and Vernet, 1968). From the 1970s onwards, the development of microscopy techniques reduced the amount of time needed for analysing charcoal (Vernet, 1973). This then made it possible to increase the size and quality of samples, rendering studies of the relationship between man and his environment possible and more reliable (Vernet, 1997; Chabal et al., 1999), especially through statistically testing the structuring of anthracological assemblies (Heinz and Thiébault, 1998). Anthracology then concentrated on the study of functional characteristics linked to the formation of wood conductivity of vessels (quantitative eco-anatomy), so as to be able to infer the history of the cultivation of ligneous plants (Terral and Arnold-Simard, 1996; Terral, 1997; Terral and Durand, 2006), as well as producing a more detailed analysis of paleo-ecological changes (Terral and Arnold-Simard, 1996) and fluctuations in climate (Terral and Mengüal, 1999; Figueiral and Terral, 2002).

The dendroanthracological approach makes it possible to measure the various characteristics of the rings (e.g. width, degree of curvature); it can also be used to estimate the calibre of large charcoal fragments (> 4 mm) (Lundström-Baudais, 1986; Dufraisse, 2002; Nelle, 2002; Dufraisse, 2006; Carcaillet, 2007; Marguerie and Hunot, 2007; Ludemann, 2008; Dufraisse and García-Martínez, 2011; Marguerie,

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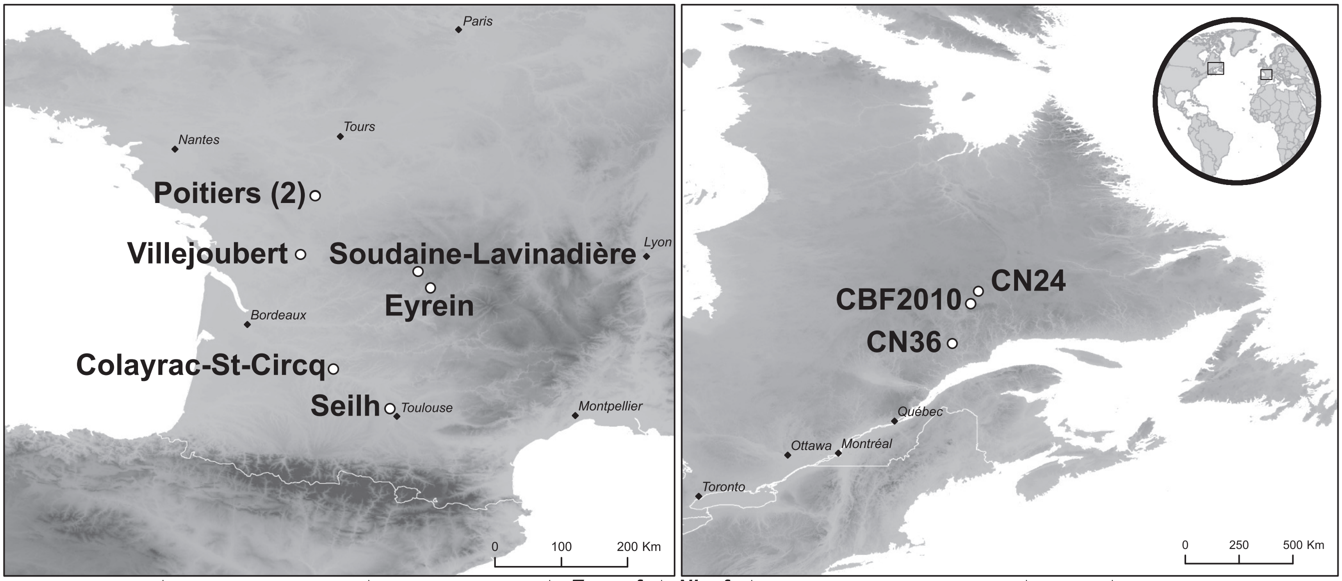

Location	*Site*	*Period*	*Type of context*	*Nb of charcoal*	*Taxa*	*Case(s)*	*Reference(s)*
Poitiers	Notre Dame la Grande	Late Antiquity / Middle Ages	House fire	26	Quercus deciduous / Abies sp. / Tilia sp.	1 and 2	Boissavit-Camus (1992) ; Poirier (1999)
Poitiers	Calvaire	Early roman period	Latrine	6	Quercus deciduous / Populus sp.	2 and 3	Poirier (1999)
Villejoubert	Castrum Andone	Early / Middle Ages	Occupation	3	Quercus deciduous / Acer sp.	3	Poirier (2009)
Soudaine-Lavinadière	Le Prieuré du Saint Sépulcre	Modern period	Smithy	2	Castanea sp.	3	Conte (2007)
Eyrein	Champ de Brach	Iron Age	Hearth	18	Quercus deciduous / Alnus sp.	2 and 3	Beausoleil et al. (2007)
Colayrac-St-Circq	Naux	Late Middle Ages	House fire	5	Quercus deciduous	3	Ballarin et al. (2007)
Seilh	Château Percin	Middle Neolithic	Hearth	6	Quercus deciduous	3	Pons (2011)
CN24	Côte-Nord 24	Modern period	Forest Fire	17	Larix / Picea	3	Unpublished results
CBF2010	Côte-Nord John	Modern period	Forest Fire	9	Larix / Picea	3	Unpublished results
CN36	Côte-Nord 36	Modern period	Forest Fire	3	Larix / Picea	3	Unpublished results

Fig. 1. Location and characteristics of sites.

2011; Paradis-Grenouillet, 2012; Paradis et al., 2013) and to study the use of environments and resources (Backmeroff, 2001; Deforce and Haneca, 2015), as well as dating and estimating the length of time during which there was human activity (Dieudonné-Glad, 2000; Ballarin et al., 2007; Fermé and Villalba, 2011). The approaches used hitherto, however, did not make it possible to generalise the application of dendrochronology to charcoal found in archaeological and paleo-ecological contexts (Marguerie, 2011). That is because, unlike wood, which is rare in an archaeological context since its preservation normally requires anaerobic conditions (Kuniholm, 1996; Billamboz, 2003), charcoal is an abundant material frequently found in most excavations. It is generally much better preserved than wood over time since carbonisation stops the material from rotting and offers more sites for study than does wood.

Despite the fact that charcoal shrinks about 12–20% (radial) and 7–13% (longitudinal) during the carbonisation process its major disadvantage, however, is fragmentation and friability (Schweingruber, 1982; Blondel et al., 2018). Indeed, in its original condition, it remains difficult to preserve between the time it is excavated and when it is analysed and stored in a collection. The result of this fragmentation, which is due to taphonomy or the collection method, frequently results in the collection of only small pieces of charcoal, the number of rings being limited per fragment. This renders the synchronization of growth patterns and the establishment of long chronologies more difficult. Furthermore, it is necessary to obtain a transversal, perfectly even, absolutely horizontal plane in order to be able to perform reliable and unbiased quantitative measurements. Without a flat surface, it is hard to reproduce an analysis of the rings and this can result in significant errors. It is very difficult to maintain charcoal under optimal conditions during handling especially in the case of large fragments. Several authors mention the precautions to be taken in different contexts for sampling and preserving charcoal fragments until they are ready for analysis (Hall Jr, 1946; Scantling, 1946; Kuniholm, 1996). This is how the method of using plaster strips was developed and how Acryline Paraloid B72 resin came to be used (Blondel et al., 2018). Yet details of the preparation of samples for performing dendroanthracological analysis and, more especially, measurement of the width of the rings, is often scarce or lacking (Dieudonné-Glad, 2000; Backmeroff and Di Pasquale, 2001; Marguerie and Hunot, 2007; Marguerie, 2011). Blondel et al. (2018) illustrate two other methods. The first consists in freezing the charcoal so as to be able to achieve a flat surface by using a razor blade (Le Digol et al., 2007; Marguerie et al., 2010). The second consists of smoothing the charcoal with fine sandpaper (Blondel et al., 2018). While these methods make it possible to render the rings readable, they have several disadvantages. Firstly, freezing can result in the possible distortion of the width of the rings and secondly, the method cannot be used on friable charcoal samples (Blondel et al., 2018). In view of the disadvantages of these methods, the generalisation of dendrochronological studies on charcoal and its preservation remains difficult due to the constraints involving the material.

To resolve problems linked to the preservation of charcoal fragments, we offer a new method making it possible to fix the charcoal by means of a thermo-retractable sheath. This makes it possible to manipulate the charcoal, smooth it and store it. Smoothing makes it possible to obtain a flat, polished surface in cross-section and consequently, the reading, measurement and analysis of the tree rings. This method facilitates the rolling out of standardised and reproducible dendroanthracological measurements. The following is a presentation of the