An Interdisciplinary Approach to Wood Charcoal Production in the Northwest of the Iberian Peninsula

Une étude interdiciplinare de la production de charbon de bois dans le Nord-Ouest de la péninsule Ibérique

María MARTÍN SEIJO, Andrés TEIRA BRIÓN
GEPN-Grupo de Estudos para a Prehistoria do NW Ibérico
Departamento de Historia I. Faculdade de Xeografía e Historia.
Universidade de Santiago de Compostela. Praza da Universidade 1. 15.782 Santiago de Compostela, Spain
maria.martin.seijo@gmail.com

Abstract – This paper describes an interdisciplinary approach to wood charcoal production in the Iberian Peninsula, which draws on archaeological, archaeobotanical, ethnographic and historical evidence from a chaîne opératoire perspective. For this purpose, several samples from the charcoal kiln of Folgoso (Galicia, Spain) were studied. The archaeological excavation of this site enabled the comprehensive description of the characteristics of the kiln: location, dimensions, characteristics of stratigraphic units, etc. The archaeobotanical analysis of the samples consisted of taxonomic identification, as well as the consideration of other wood anatomical characteristics: part of the plant present (stem, twig, root), minimum diameter, age of plant part, season of cutting, and also different types of alterations related to the combustion process (radial cracks, vitrification, etc.).

Resumé – Cet article est une approche interdisciplinaire de la production de charbons de bois dans la péninsule Ibérique par l'archéologie, l'archéobotanique, l'ethnographie et l'histoire en faisant appel au concept de la chaîne opératoire. Dans ce but on a étudié plusieurs échantillons de la charbonnière de Folgoso (Galice, Espagne). La fouille archéologique de cet endroit nous a permis de découvrir les caractéristiques du charbonnières: emplacement, dimensions, caractéristiques des unités stratigraphiques, etc. L'analyse archéobotanique des échantillons a eu comme résultat l'identification taxonomique ainsi que la considération d'autres caractéristiques anatomiques: la partie de la plante (tige, branche, racine), le diamètre minimum, l'âge de la plante, l'époque de coupe, ainsi que d'autres altérations résultantes du processus de combustion (fissures radiales, vitrification, etc.).

The study of structures and samples linked to charcoal kiln sites provides indispensable information about scrubland and forest related economic activities (Fabre & Auffray 2002; Nelle, 2002; Ludemann, 2006, 2010; Durand *et al.,* 2010; Deforce *et al.*, 2013). Charcoal production was an important economic activity in Northwest Iberia, particularly from the 17th century onward. Wood charcoal was highly valued, both as domestic fuel in the cities and as an industrial fuel for activities such as smelting or forging iron. Heather (*Erica* spp.) was the main wood burnt in these kilns, although oak (*Quercus* sp. deciduous) and other taxa were also used occasionally.

The intensity of this activity had a noticeable impact on the forest, especially in areas where iron-ore was available and where the forges were located1. Although a widespread activity, there is a lack of archaeological information on the process of charcoal production, which was carried out mainly by family units from mountainous areas. Wood was burnt in circular kilns, between 1 and 2 m in diameter, which tend to be of low visibility in the landscape.

The aim of this investigation was to carry out an interdisciplinary approach drawing upon archaeological, archaeobotanical, ethnographical, and historical evidence. This approach enabled the reconstruction of this activity, and the marks it left on the landscapes where it took place. This approach also provided data that facilitated the interpretation of archaeological evidence from charcoal production sites. For this purpose, several samples from Folgoso (Xermade, Lugo, Galicia), a historical charcoal production site, were studied.

The archaeological excavation of this site enabled the comprehensive description of the characteristics of the kiln: location, dimensions, characteristics of the stratigraphic units, *etc*. The archaeobotanical analysis of the samples consisted of taxonomic identification, as well as the consideration of other wood anatomical characteristics and different types of alterations related to the combustion process. The data recovered from the archaeological structures and archaeobotanical samples of Folgoso facilitated the review of other archaeological features, such as those found at A Mourela (As Pontes, A Coruña), which could be interpreted as structures associated with charcoal production (Martín-Seijo *et al.* 2009).

Wood charcoal production process

In order to study the wood charcoal production process in Northwest Iberia, the concept of *chaîne opératoire* was employed to organize all the information recovered from historical and ethnographical sources. The *chaîne opératoire* or operational sequence was defined by Lemonnier (1986:149) "as a series of operations which brings primary material from its natural state to a fabricated state" and involves different elements

1 Schulz Guillermo, «Ojeada sobre el estado actual de la minería del distrito de Asturias y Galicia», Anales de Minas, t. I, 1838, p. 379-397; *La minería en la Región Gallega*, 1928, p. 81.

(energies, tools, gestures, knowledges, actors, materials) that interact during a process which modifies a material system (Lemonnier 2004). The technical choices involved in the wood charcoal production process were woven into a social, economic and ideological tapestry that was, in many ways, unique to a particular place and time (Skibo & Schiffer, 2008: 1-2).

A literature review of historical sources and references to this activity was undertaken, although documentary references to small-scale charcoal production in pit-like structures are rare. Ethnographical and ethnobotanical studies that reference this production process were also examined (Lorenzo, 1983; Blanco, 1996; Fidalgo, 2001; Cerrato, 2002; Carvalho, 2005). In addition, the entire charcoal production process was recreated by a retired charcoal burner (Abelardo Martínez Corral from Piñeiros, Xermade), and recorded by Xosé M. Felpeto Carballeira, following the ethnographic method of participant observation (Atkinson & Hammerley, 1994) (Fig. 1).

The analytical methods of *chaîne opératoire* research help to link the static archaeological and archaeobotanical record to the dynamic social *milieus* in which the techno-gestures were practiced (Dobres, 2010: 129; Dufraisse, 2012; Burri *et al.*, 2013). This concept also allows the integration of interrelated elements that underlie the manufacturing process, such as the individual, the environment, raw material, tools, skills, knowledge, social and economic relations, *etc.*

Five main stages in this process could be distinguished from historical and ethnographical sources:

1. raw material procurement (wood supply: selection and extraction);
2. raw material preparation (trimming branches, splitting the trunk or the roots, etc.);

Fig. 1 – Different stages of the chaîne opératoire of heather charcoal production in a pit-like structure (foia). The recreation of the technical process took place in 2005 during the 1st Conference “Aprendendo cos nosos maiores” (Xermade, Lugo). The participants were Abelardo Martínez Corral, Xosé Seco Hermida and Xosé Manuel Felpeto Carballeira.

3. structure preparation (selection of kiln location, digging the pit);
4. product preparation (burning of wood inside the kiln);
5. final product (charcoal).

In the geographical area under consideration, two different types of structures were identified – small kilns inside circular or oval pits (*foia, froia*) used in small-scale production, and upright circular kilns (*carboeira*). The current study focused on the former (*foia, froia*), as they correspond most closely to the archaeological feature found at Folgoso, and they are also the most common kiln type in this area. The differences between these kiln types were not only morphological, but also quantitative in terms of the amount of charcoal produced by each firing episode. However, these differences did not extend to the type of wood resources burned in each, as wood from trees could be burned in the small pit structures and shrub wood could be used in the large upright kilns.

According to the sources consulted, the production of wood charcoal was undertaken by family units (Cerrato, 2002). Men, women and children undertook this activity seasonally (2 or 3 months in autumn or winter), complementing their agricultural duties or carried out in parallel with other economic activities, such as herding. It was a family activity, normally carried out by one to three individuals of a family unit, depending on the quantity of charcoal to be produced. Various tools were used during the different stages of the production process, including a hoe to pull up the roots, a draw hoe or a hatchet to cut off the branches and to split the trunk or the roots (the smaller branches could be also broken by hand), and finally a grubber to dig the pit.

Raw material procurement

The historical and ethnographical sources point to a clear correlation between the choice of wood burned and the final use of the charcoal. This selection is evident in the charcoal employed in the different metallurgical processes (reducing, melting or forging), and reflects not only the choice of particular species, but also the location where the wood resources were growing (shady or sunny mountainside). Charcoal obtained from sunny mountainside locations was especially valued by smiths, while charcoal from shadier slopes, which has a higher humidity content (Cerrato, 2002) was used for domestic activities (heating, cooking or ironing).

As reported in historical sources, the fuel used for smelting was charcoal from heather (*Erica* sp., *Erica australis* subsp. *aragonensis*)2 (Blanco, 1996; Cerrato, 2002), although sometimes oak (*Quercus robur*), chestnut (*Castanea sativa*), and strawberry tree (*Arbutus unedo*), amongst others, were used. In forges, the preferred fuel for calcination of the iron-ore was charcoal from oak and chestnut, although other taxa, such as beech (*Fagus* sp.), ash (*Fraxinus* sp.), strawberry tree, walnut tree (*Juglans regia*), cherry tree (*Prunus* sp.) and pine (*Pinus* sp.) could also be burned3. Heather was the fuel burned during the reduction process of the mineral.

Scrubland management practices were applied to facilitate the extraction of the raw material (Cerrato, 2002). The upper part of the shrubs was cut to prepare the soils for extensive cultivation in the mountain areas, and the scrubland was sometimes set alight to facilitate the removal of the roots. Once burned, the heathers were spread on the ground until the end of the summer when the charcoal was made (Fidalgo 2001: 50). These practices also favoured the regrowth of shrubs in the same area.

Charcoal production took place primarily in mountainous areas where wood, from both forest and scrubland, was abundant. The amount of wood needed for charcoal production was very high, and as a result firewood and timber was scarce in the environs of kilns and forges. The deforestation associated with this production process led to the introduction of various laws in the 18th century that aimed to protect trees and forests. These included restrictions relating to the period during which trees could be felled (only a few months each year), as well as proscriptions as to the type of trees that could be cut (dead trees) and the interval between fellings (10-12 years). An example of such regulations is found in the Real Cédula of 1791 for Sargadelos (Lugo).

Raw material preparation

This stage was particularly important in the production of charcoal from heather. The branches of this shrub were cut off using a tool or pulled up by hand, leaving only the stumps and the roots, which were valued for their hardness. After removing the soil, the stumps and roots were transported in bags or baskets to the kiln site, where they were then split into pieces of different size.

Structure preparation

The location chosen for the kiln pit had to have thick and grassy topsoil (Fig. 1.a, 1.b), as the sod was used to cover the pile of wood once it was burning. Pits were commonly reused, and where this happened the structures had to be cleaned prior to reuse. The pits ranged from 1m-2 m in diameter and from 0.40m-0.50m deep.

2 Gómez Núñez Severo, *El general de artillería Don Juan Manuel Munárriz y la siderurgia del siglo XVIII en la región del Bierzo*, Madrid, Publicaciones de la Sociedad Geográfica, 1926

3 Hernández Sampelayo Primitivo, *Memorias del Instituto Geológico y Minero de España. Criaderos de hierro de España, T. IV Hierros de Galicia*, Madrid, I, 1922, II, 1931, III, 1935

When the pit was prepared, similar sized pieces of split wood obtained from stumps and roots were placed inside. The longest pieces of green wood were placed upright in the centre of the structure, and the remainder placed around them to form a cone-shaped structure that would facilitate oxygen circulation (Fig. 1.c, 1.d). The dry wood, the branches and the splinters were used as combustion kindling.

Product preparation

The skills and knowledge of the charcoal producers underpinned the ability to achieve maximum extraction of charcoal from the wood collected. The fire was lit in the centre of the wooden cone-shaped structure, from where it spread outward. When the wood was reduced in volume and red embers produced, the structure was covered (Fig. 1.e). The sods were placed, grass facing downwards, over the embers

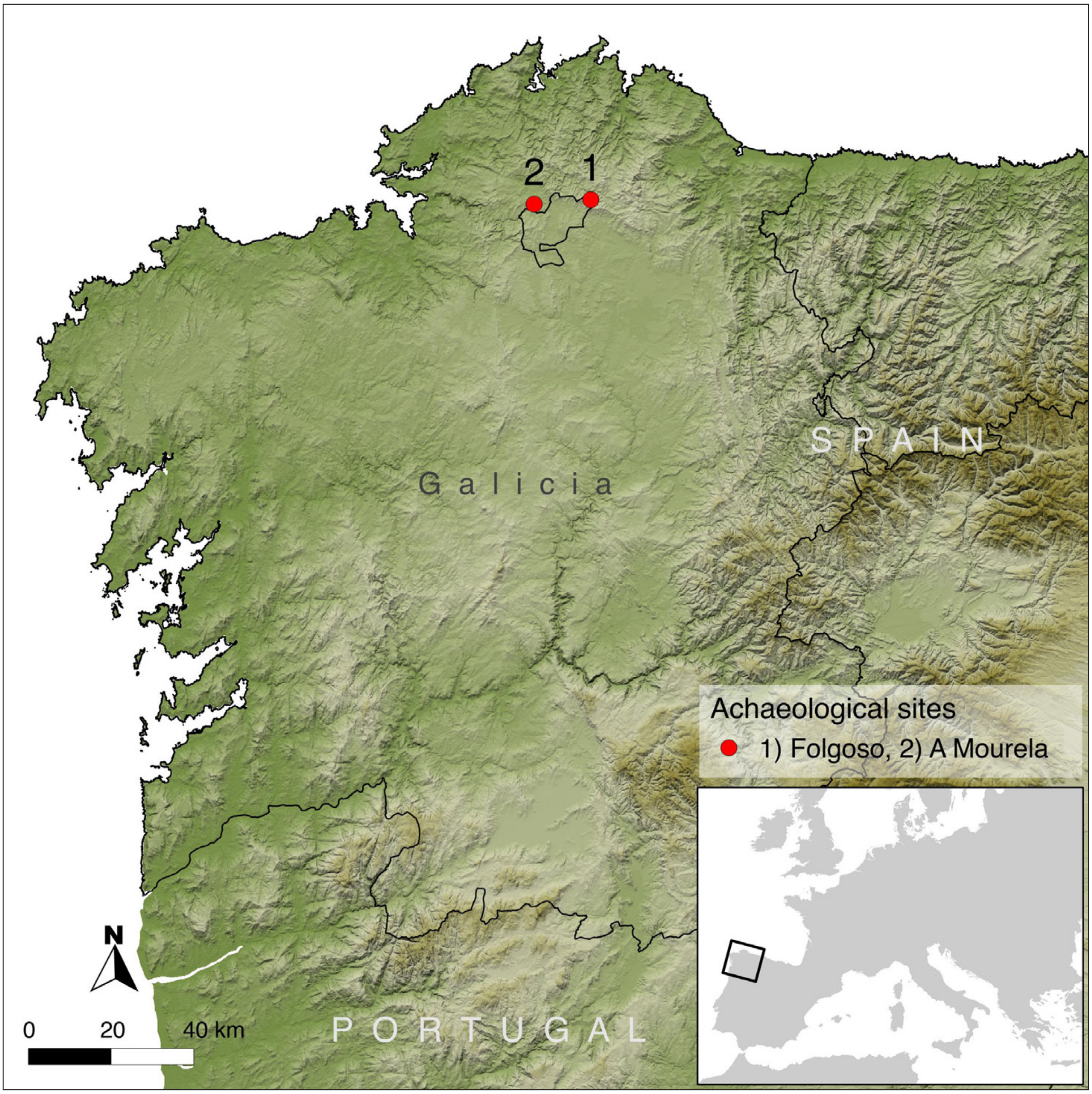

Fig. 2 – Geographical location of the charcoal kilns of Folgoso and A Mourela

(Fig. 1.f). The rest of the soil removed during the digging of the pit was used to cover the kiln (Fig. 1.g).

The combustion process could last from seven/eight hours up to two or three days. During this time, the kiln had to be constantly attended until the charcoal was made. The two main problems that could occur was that (1) the combustion process stopped, and (2) that too much oxygen was drawn in by the kiln, producing complete combustion, with the result that instead of charcoal, only ash would remain. The kiln could not be opened until the fire was extinguished. Once this occurred, the soil and the sod were removed and the charcoal was spread out on the ground (Fig. 1.h). The charcoal was then collected and stored in bags or baskets. The volume of charcoal obtained was approximately a third of the volume of the wood burned.

Final product

The charcoal was classified in relation to its qualities and transported to the point of sale. The higher quality charcoal was obtained from heather stumps and roots, well burned, and was used for specialized activities such as metalworking. The poorest quality charcoal, including little fragments of charcoal and partially burned stumps and roots only (*zocha*), was intended for domestic use.

The charcoal kiln of Folgoso

The site of Folgoso (Xermade, Lugo, Galicia) is located at 650 m.a.s.l. in the Atlantic area, which is under an oceanic influence and characterized by a climate of moderate temperatures and abundant winter rain (Fig. 2). The current vegetation in this area is mixed forest, including oak (*Quercus robur*), holly (*Ilex aquifolium*) and birch (*Betula alba*), and alder (*Alnus glutinosa*) along the river banks. Aerial photographs taken in 1956 show that the vegetation and the relief of the area have not suffered alterations during the last sixty years..

Archaeological features

The charcoal kiln of Folgoso is located near the Rego do Casal stream. The kiln was excavated during the summer of 2013, following on from previous research in the study area that

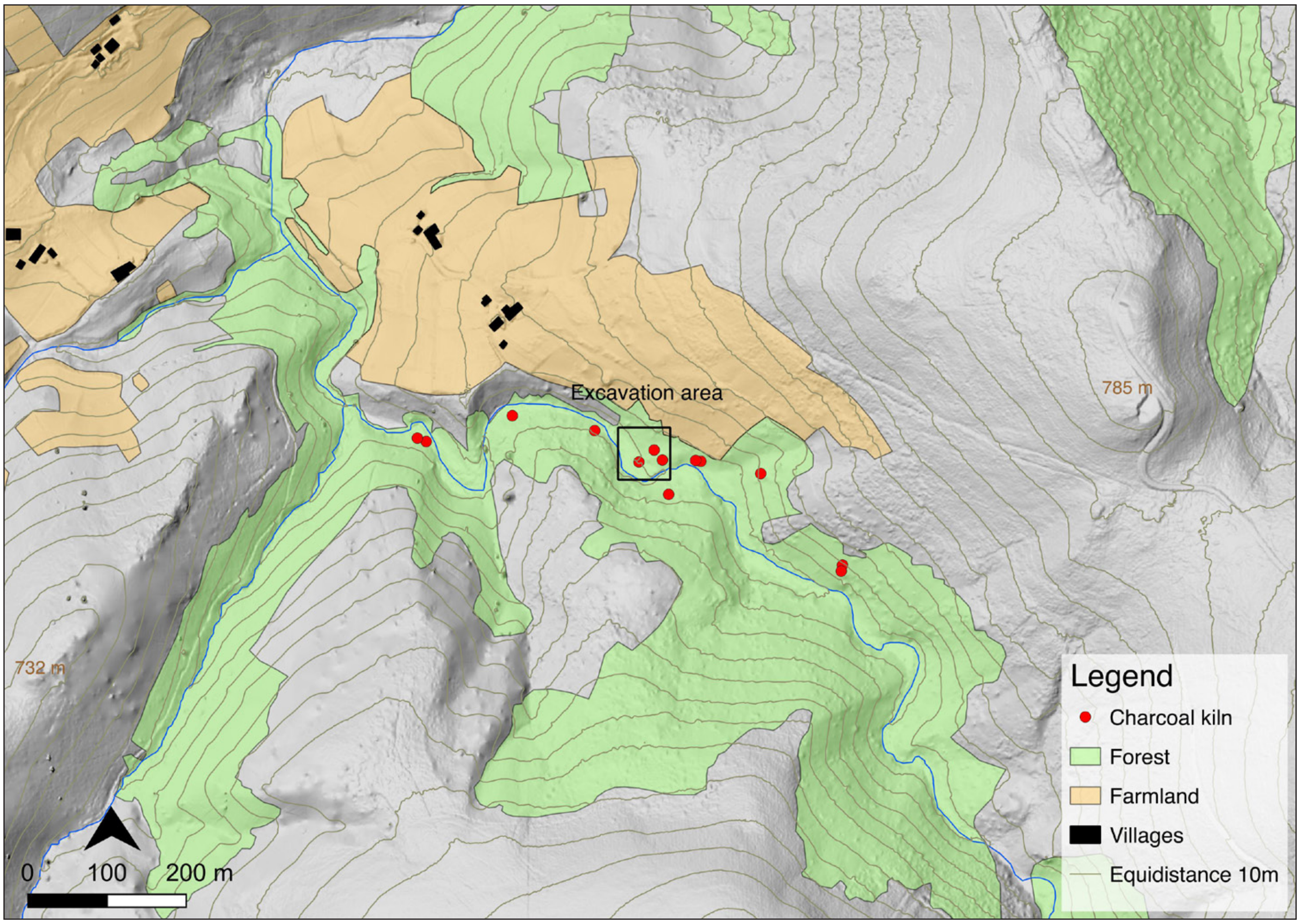

Fig. 3 – Digital terrain model indicating land uses in Folgoso during the 1950s, showing the charcoal kilns distribution and their immediate surroundings

identified and recorded historical kiln sites which were known by oral references. Other similar features were identified in the bottom of the river valley, although exhaustive recording of all the structures could not be undertaken at this stage (Fig. 3).

The charcoal kiln was built at some point between 1940 and 1959. It was a circular pit-like structure, 1.89 m in diameter and 0.58 m deep (Fig. 4). Excavation revealed four stratigraphic units within the pit (SU003 to SU006) and another deposit (SU002) in its immediate surroundings. All of these stratigraphic units were related to charcoal production and had a high content of wood charcoal remains – fragments with sharp edges and lengths ranging from 0.4cm to 10cm. Five sediment samples were collected, four of which were subsampled (SU002: 2 litres; SU0062: 2 litres) and processed by water sieving using 2.1 mm and 0.5 mm meshes.

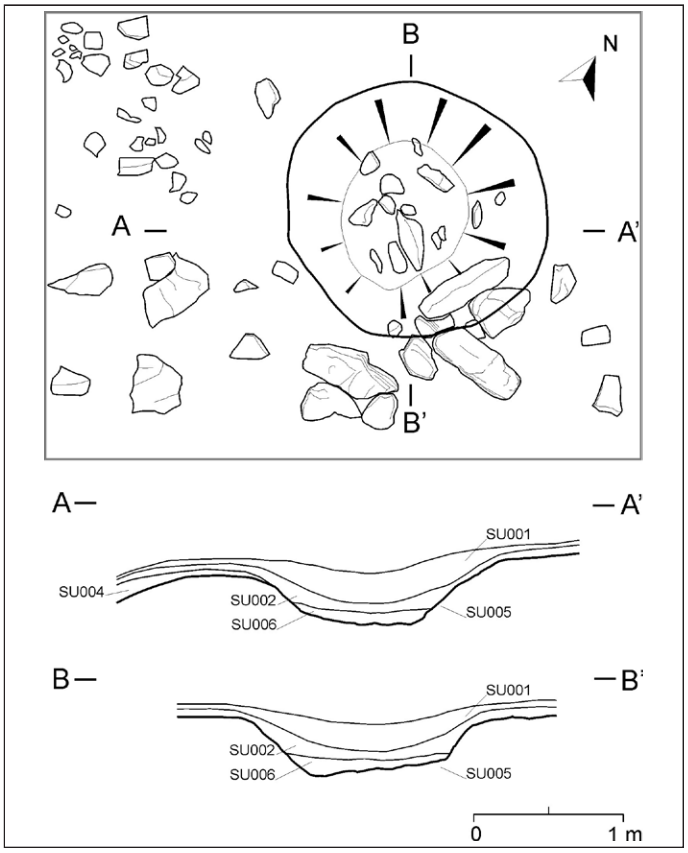

Fig. 4 – Charcoal kiln of Folgoso: plan and section of the archaeological structure

Archaeobotanical data

Two samples from the stratigraphic unit located outside the structure (SU002) were selected for charcoal analysis. The other sample came from SU006, located inside and in the bottom of the kiln. These charcoal samples represent the latest use of this structure. The results are discussed together as both samples represent evidence of charcoal production in this structure, although it cannot be known if they correspond to the same or to different moments of use of the kiln. 250 charcoal fragments were analysed – 150 from SU002 and 100 from SU006.

The charcoal samples were observed in an Olympus CX-40 reflection light microscope with objectives of 2x, 4x, 20x and 40x. The taxonomic identification was carried out by manually fracturing the charcoal according to the three anatomical sections of wood: cross, longitudinal tangential and longitudinal radial. Dendrological features of the charcoal were also recorded, considering several anatomical characters and alterations (Théry-Parisot, 2001; Marguerie & Hunot, 2007; Marguerie *et al.,* 2010; Théry-Parisot *et al.,* 2010). The aim of recording these features was to characterize the exploitation of wooden resources, registering where possible the ring curvature (strong, medium, weak) (Marguerie *et al.*, 2010: 327), the part of the plant consumed (stem, twig, round wood, root) and/or the part of the stem (heartwood or sapwood) identified by the presence of inclusions such as tyloses. Other alterations that could provide information about the combustion process (radial cracks, vitrification, cell wall collapse, etc.), growth conditions (scars, compartmentalization, alterations of growing rhythm, etc.), and taphonomic processes (fragmentation, erosion, etc.) were also registered. All the archaeobotanical data were recorded in a Spatial Data Infrastructure (SDI) which includes both a database and GIS application (ArcInfo).

The results obtained from the charcoal analysis of these samples showed that the main taxa for charcoal production in this structure were oak (*Quercus* sp. deciduous) and heather (*Erica* sp. and *Erica arborea/australis*). The morphotypes *Erica* sp. and *Erica arborea/australis* were distinguished by the following anatomical characteristics. *Erica arborea/australis* was identified by the presence of uniseriate rays up to 8-11 cells high composed of upright cells, and multiseriate rays up to 8 cells wide and up to 35-40 cells high, composed of upright cells at the margins and of square and procumbent cells in the centre (Queiroz, 1989). *Erica* sp. included species with rays between 3 and 6 cells wide, such as *Erica multiflora*, *Erica scoparia*, *Erica umbellata* or *Erica vagans* (Queiroz, 1989). Other taxa were sporadically identified, such as *Salix* sp./*Populus* sp., Rosaceae/Maloideae, *Arbutus unedo* and *Quercus* sp. deciduous/*Castanea sativa*.

The percentages of the different taxa varied between SU002 and SU006 (Fig. 5). In the archaeological deposit located outside the kiln (SU002), a higher percentage of *Quercus* sp. deciduous was indentified, while in the deposit inside the structure (SU006) there was an absolute predominance of *Erica* spp. (*Erica* sp. and *Erica arborea/australis*).

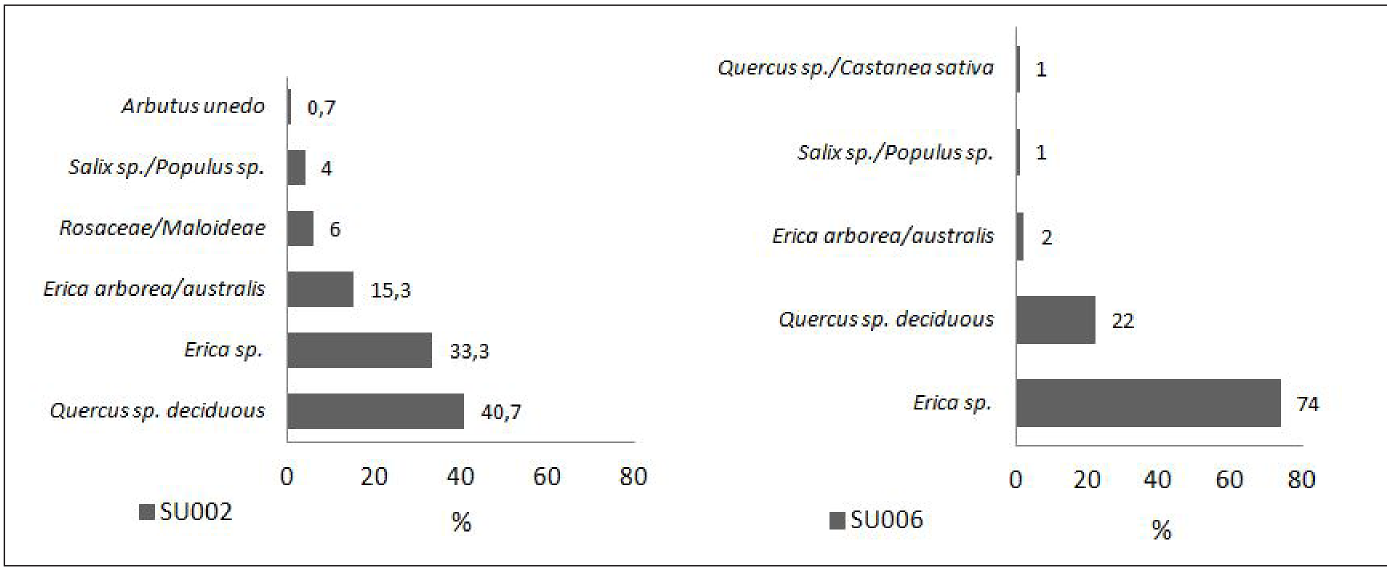

Fig. 5 – Results of charcoal analysis.

These differences could be related to depositional processes. The charcoals recovered from both stratigraphic units could be the discarded fragments that were left inside the structure and its surroundings after the kiln was opened and the charcoal removed and classified according to quality. The higher proportional presence of *Erica* spp. in SU006 is consistent with the role of this taxon as a main fuel and probably these charcoal fragments remained *in situ* in the last batch. The charcoal recovered from SU002 could be related to the processes of charcoal removal, classification, and packaging outside the structure, or might represent a mixture of charcoal from inside the kiln and from the covering layer of soil. The higher percentage of *Quercus* sp. deciduous in this deposit could reflect the fracturing of large individual elements of oak (branch, trunk), which may result in an over-representation of this taxon.

The differences previously observed between the stratigraphic units in terms of taxonomic composition are also reflected by the differences that are observable in the analysis of the type of ring curvature (Fig. 6). The fragments with weak curvature in both deposits were all of *Quercus* sp. deciduous, while the fragments with strong and medium curvature included *Quercus* and the other taxa. The exploitation of trunks or large branches of oak could explain the high proportional presence of *Quercus* sp. deciduous and the predominance of fragments with medium and weak curvature in SU002. The fragments with strong curvature identified in SU006 could correspond to the exploitation of branches and twigs of heather.

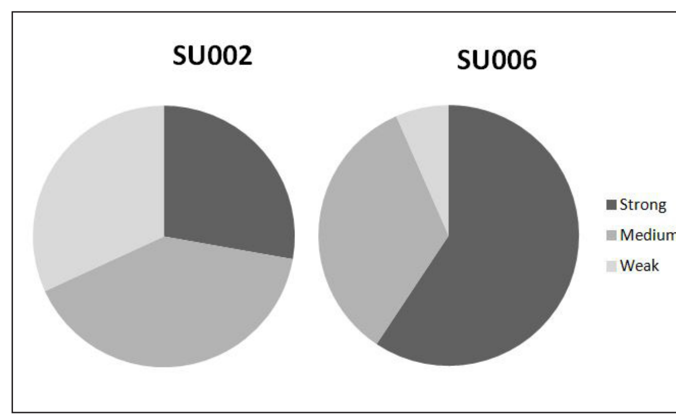

Fig. 6 – Results of the ring curvature registered during charcoal analysis

The length of each charcoal fragment was measured, and slight size differences were recorded between these two stratigraphic units (Fig. 7). The charcoal recovered in the surroundings of the kiln was more fragmented (71.3 % of them between 0.3 cm and 1 cm) than that recovered inside it (64 %).

The most significant percentage of anatomical alterations were those related to the combustion process, such as radial cracks and vitrification (Fig. 8). Their presence was significant in both archaeological deposits (SU002 and SU006), although the presence of radial cracks and vitrification was higher in *Erica* sp. in SU006 and in *Quercus* sp. deciduous in SU002.

The season of plant death was registered in three cases, two fragments of *Quercus* sp. deciduous in the SU006 and one of *Arbutus unedo* in the SU002 (Table. 1). In both stratigraphic units the latewood formation had finished, coinciding with autumn or winter.

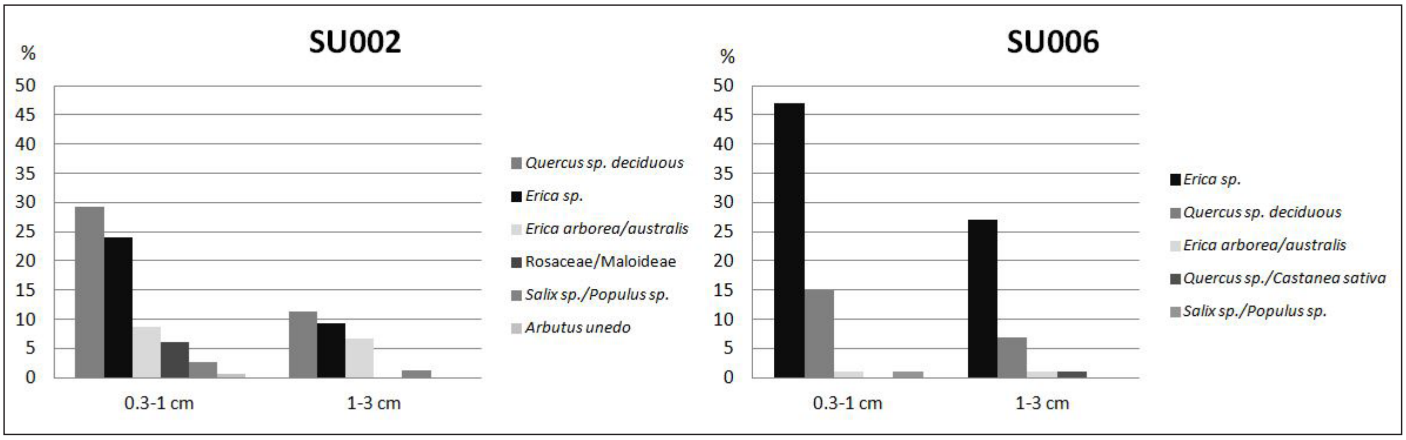

Fig. 7 – Length of each fragment registered during charcoal analysis

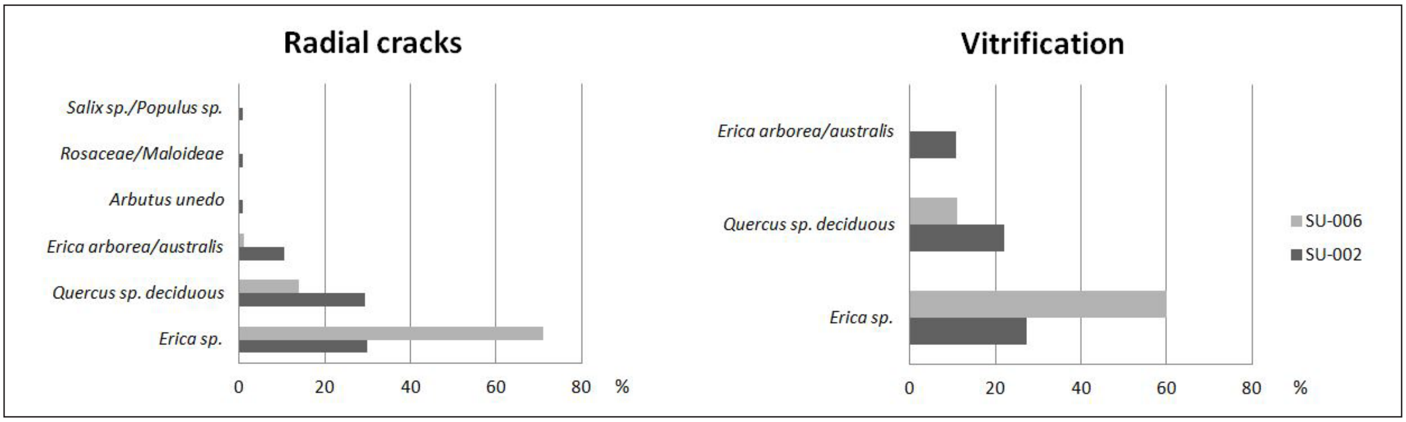

Fig. 8 – Anatomical alterations related to the combustion process registered during charcoal analysis

Table 1 – Season of plant death

Taxa/ Season of plant death	SU002		SU006	
	Earlywood	Latewood	Earlywood	Latewood
Quercus sp. deciduous				2
Arbutus unedo		1		

Discussion

The majority of anthracological studies of wood charcoal production sites that have developed in several forest areas of Europe focus on the study of upright circular kilns, structures that are frequent and visible in the mountainous landscape (Fabre & Auffray, 2002; Nelle, 2002; Ludeman, 2010; Euba, 2010; Ludeman, 2012; Deforce *et al.*, 2013). Other less evident kiln structures, such as the small pit-like structures related to the exploitation of small shrubs and linked to local and family production, are less well known (Bonhôte *et al.*, 2002), although recently kilns dating to the Late Bronze Age have been recorded and their anthracological data re-evaluated (Durand *et al.*, 2010).

The existence of this kind of pit-like kiln in Northwest Iberia was reported in ethnographical sources (Lorenzo, 1983; Cerrato, 2002). These structures were used until several decades ago in relation to the exploitation of the scrubland resources for charcoal production. The data compiled about the different stages of the *chaîne opératoire* of the wood charcoal production process greatly helped in the interpretation of the archaeological and archaeobotanical data.

The location of the charcoal kiln of Folgoso was conditioned by different factors:

1. the presence of woody resources (*Erica* spp. and *Quercus robur*);
2. the proximity of a water source;
3. the area selected was the property of the familiar unit that produced the charcoal. However, the ethnographical sources indicate that usually the charcoal production sites were placed on communal lands (Cerrato, 2002).

In the charcoal kiln in Folgoso, the morphological characteristics described in the sources (Lorenzo, 1983; Fidalgo, 2001; Cerrato, 2002) coincided with those registered in the archaeological record. These sources also helped in the interpretation of the formation processes of the stratigraphic units registered during the archaeological excavation. The charcoal recovered from SU002 could represent remains related to the spreading of the charcoal outside the kiln prior to collection and storage. In the case of SU006, the charcoal recovered came from the base of the structure, suggesting that it probably remained *in situ* and was not collected. The archaeobotanical data support this hypothesis, because the taxonomical composition was very similar, although there were variations in the percentage of presence of each taxa, and the presence of *Erica* spp. (including *Erica* sp. and *Erica arborea/australis*) was higher in the base of the structure. The season of plant death in autumn or winter concurred with the data recovered from the historical and ethnographical sources (Lorenzo, 1983; Fidalgo, 2001; Cerrato, 2002).

The archaeological characteristics described in the sources and recorded in Folgoso were very similar to those of the pit-like structure documented in A Mourela (As Pontes, A Coruña, Galicia) and dated to cal AD 772-1048 (Beta-230718) (Martín-Seijo *et al*. 2010). The taxa identified during the charcoal analysis of the samples were also comparable, with wood from *Erica* sp., cf. Rosaceae/Maloideae and *Quercus* sp. deciduous recovered. Vitrification and radial cracks were present in a high percentage of the charcoal fragments recovered from inside the kilns in both Folgoso and A Mourela. Occasionally the vitrification of the tissues was so high that it prevented their taxonomical identification.

The presence of vitrification is common in charcoal recovered from historical charcoal kilns (Théry-Parisot, 2001: 71; Vaschalde *et al*., 2011). The cause of the presence of this alteration still unknown, as experiments carried out showed that vitrified charcoals do not result from high temperature charring or from the use of green wood (McParland *et al*., 2010). The samples from Folgoso showed how the presence of both radial cracks and vitrification was higher in heather charcoal than in other taxa. The physical and chemical properties of heather may influence the presence of this alteration. The burning of small branches documented by the presence of heather charcoals with strong curvatures could also be related to vitrification, which often affects small pieces of wood such as twigs (Marguerie & Hunot, 2007). In addition, the conditions in which combustion developed could also be a factor.

The exploitation of scrubland wood resources (*Erica* spp.) as raw material for charcoal production indicates the importance of reassessing the management and exploitation of the scrubland in mountain areas, probably since early times, as well as the role of fire in spreading these shrubs and facilitating their extraction.

Acknowledgements

The excavation of the charcoal kiln of Folgoso was carried out with support from Grupo de Estudos para a Prehistoria do Noroeste Ibérico-GEPN, in addition we thank Concello de Xermade and Asociación El Porvenir de Lousada for their help during the field work. We also kindly acknowledge the archaeologists (Aldara Rico Rey, Israel Picón Platas) and volunteers (Ermitas Vérez Mouriño, Ramón Otero Otero, José Gacio Orosa, Vicente Pernas Pernas) who participated in the excavations. We also want to thank Darío Peña Pascual for preparing the digital terrain model (Fig. 3) and Cliodhna Ní Lionáin for reviewing the English text of the final manuscript. We are particularly grateful to Manuel Pernas Gómez and his family, Antonio Riveira Requeijo and Xosé M. Felpeto Carballeira for their essential collaboration in this project.

References

Atkinson Paul, Hammersley Martyn, «Ethnography and participant observation», dans Denzin Norman K. & Lincoln Yvonna (eds.) *Handbook of qualitative research*, Sage Thousand Oaks, CA., 1994, p. 248-261.

Blanco Emilio, *El Caurel, las plantas y sus habitantes. Estudio etnobotánico de la Sierra del Caurel (Lugo). La importancia de las plantas para nuestros antepasados*, A Coruña, Fundación CaixaGalicia, 1996, 203 p.

Bonhôte Jérôme, Davasse Bernard, Dubois Claude, Izard Véronique, Métailié Jean-Paul, «Charcoal kilns and environmenta history in the eastern Pyrenees (France). A methological approach», dans Thiébault Stephanie (ed.) *Proceedings of the 2nd International Meeting of Anthracology.* BAR International Series, 1063, Oxford, 2002, p. 219-228

Burri Sylvain, Durand Aline, Py Vanessa, Vaschalde Christophe, « Les outils pour acquérir et transformer la matière ligneuse dans les chaînes opératoires techniques des artisanats forestiers en Provence et Haut-Dauphiné au Moyen Âge », dans Anderson P.C., Cheval C. et Durand A. (dir.) *Regards croisés sur les outils liés au travail des végétaux. An interdisciplinary focus on plant-working tools. XXXIIIes rencontres internationales d'archéologie et d'histoire d'Antibes,* Ed. APDCA, Antibes, 2013, p. 397-414

Cerrato Ángel, «Carboneros de las sierras del Sureste de Orense», *Revista de Folklore*, nº 256, 2002, p. 123-132.

Deforce Koen, Boeren Ilse, Adriaenssens Sara, Bastiaens Jan, Keersmaeker Luc De, Haneca Kristoff, Tys Dries, Vandekerkhove Krys, «Selective woodland exploitation for charcoal production. A detailed analysis of charcoal kiln remains (ca. 1300-1900 AD) from Zoersel (northern Belgium)», *Journal of Archaeological Science*, vol. 40, 2013, p. 681-689

DOBRES Marcia-Anne, «Technology's Links and Chaînes: The Processual Unfolding of Technique and Technician», dans PRENCEL Robert N. et MROZOWSKI Stephen A. (eds.), *Contemporary Archaeology in Theory. The New Pragmatism*, Hoboken, Wiley-Blackwell, 2010, p. 156-169.

DUFRAISSE Alexa, «Firewood and woodland management in their social, economic and ecological dimensions. New perspectives», dans BADAL Ernestina, CARRIÓN Yolanda, MACIÁS Miguel, NTINOU María (coords.), *Wood and charcoal evidence for human and natural history, Saguntum Extra* 13, 2012, p. 65-73.

DURAND Aline, DUVAL Sandrine, VASCHALDE Christophe, «Le charbonnage des Éricacées méditerranéennes : approches croisées archéologiques, anthracologiques et historiques», dans DELHON Claire, THÉRY-PARISOT Isabelle et THIÉBAULT Stéphanie (dir.), *Des hommes et des plantes. Exploitation du milieu et gestión des resources végétales de la Préhistoire à nous jours. XXX*[es] *recontres internationales d'archéologie et d'histoire d'Antibes*, Antibes, Éd. APDCA, 2010, p. 323-331.

EUBA Itxaso, « L'exploitation des ressources végétales dans les Pyrénées Orientales durant l'Holocène: analyse anthracologique des structures d'élevage, de fours et de charbonnières dans l'Alt Urgell (Chaîne du Cadí) et la Vallée du Madriu (Andorre) », *Quaternaire*, vol. 21, (3), 2010, p. 305-316.

FABRE Laurent, AUFFRAY Jean-Christophe, «An anthracological method for the study of charcoal kilns in relation to historical forestry management», dans THIÉBAULT Stephanie (ed.) *Proceedings of the 2*[nd] *International Meeting of Anthracology.* BAR International Series, 1063, Oxford, 2002, p. 193-199.

FIDALGO Xosé Antonio, *Os saberes tradicionais dos galegos*, Vigo, Ed. Galaxia, 2001, 292 p.

GONZÁLEZ PÉREZ Clodio, *A producción tradicional do Ferro en Galicia. As grandes ferrerías da provincia de Lugo*, Lugo, Deputación Provincial de Lugo, 1994, 266 p.

LEMONNIER Pierre, «The study of material culture today. Towards an anthropology of technical systems», *Journal of Anthropological Archaeology,* 5, 1986, p. 147-186.

LEMONNIER Pierre, « Mythiques chaînes opératoires », *Techniques & Culture. Mithes. L'origine des manieres de faire*, 43-44, 2004, p. 2-15.

LORENZO Xaquín, *Os oficios*, Vigo, Ed. Galaxia, 1983, 349 p.

LUDEMANN Thomas, «Anthracological Analysis of Recent Charcoal-Burning in the Black Forest, SW Germany», dans DUFRAISSE Alexa (ed.) *Charcoal Analysis: New Analytical Tools and Methods for Archaeology. Papers from the Table-Ronde held in Basel 2004.* BAR International Series, 1483, Oxford, p. 61-70.

LUDEMANN Thomas, «Past fuel wood exploitation and natural forest vegetation in the Black Forest, the Vosges and neighbouring regions in western Central Europe», *Palaeogeography, Palaeoclimatology, Palaeoecology*, vol. 291 (1–2), 2010, p. 154–165.

LUDEMANN Thomas, «Airborne Laser Scanning of Historical Wood Charcoal Production Sites – a New Tool of Kiln Site Anthracology at the Landscape Level», dans BADAL Ernestina, CARRIÓN Yolanda, MACIÁS Miguel, NTINOU María (coords.), *Wood and charcoal evidence for human and natural history, Saguntum Extra* 13, 2012, p. 247-252.

MCPARLAND Laura C., COLLINSON Margaret E., SCOTT Andrew C., CAMPBELL Gill, VEAL Robyn, «Is vitrification in charcoal a result of high temperature burning of wood?», *Journal of Archaeological Science*, 37, 2010, p. 2679-2687.

MARTÍN-SEIJO María, ALLES María José, ABAD Emilio, «Análise dos carbóns arqueolóxicos», dans BONILLA Andrés et FÁBREGAS Ramón (eds.), *Círculo de engaños: Excavación del cromlech de A Mourela (As Pontes de García Rodríguez, A Coruña),* Santiago, Ed. Andavira, 2009, p. 163-175.

MARGUERIE Dominique, BERNARD Vincent, BÉGIN Yves, TERRAL Jean-Fréderic, « Dendroanthracologie », dans PAYETTE Serge, FILION Louise (éds.), *La dendroécologie - Principes, méthodes et applications*. Québec, Presses de l'Université Laval, 2010, p. 311-350.

MARGUERIE Dominique, HUNOT Jean-Yves, «Charcoal analysis and dendrology: data from archaeological sites in north-western France», *Journal of Archaeological Science*, vol. 34, 2007, p. 1417-1433.

MEIJIDE Antonio, *La antigua minería del cobre en el valle de Valdeorras*, Sada, Ed. do Castro, 1985, 129 p.

MUÑOZ Emilio, MORLOTE José Manuel, MONTES Ramón, «La ferrería medieval de El Pendo (Escobedo, T.M. de Camargo) ». *Altamira. Revista de Estudios Montañeses*, vol. 65, 2004, p. 141-158.

NELLE Oliver, «Charcoal burning remains and forest stand structure – Examples from the Black Forest (south-west-Germany) and the Bavarian Forest (south-east-Germany)», dans THIÉBAULT Stéphanie (ed.) *Proceedings of the 2*[nd] *International Meeting of Anthracology.* BAR International Series, 1063, Oxford, 2002, p. 201-207.

PINTO CARVALHO Ana María, *Etnobotánica del Parque Natural de Montesinho. Plantas, tradición y saber popular en un territorio del Nordeste de Portugal*, Thèse de Doctorat, Madrid, Universidad Autónoma de Madrid, 2005, 456 p.

QUEIROZ Paula F., «Wood Anatomy of Iberian Ericales», *Revista de Biologia*, vol. 14, 1989, p. 95-134.

SKIBO James M., SCHIFFER Michael B., *People and Things: a behavioral Approach to Material Culture*, New York, Springer-Verlag, 2008, 170 p.

THÉRY-PARISOT Isabelle, *Économie des combustibles au Paléolithique*, Antibes-Paris, CÉPAM-CNRS, 2001, 195 p.

THÉRY-PARISOT Isabelle, CHABAL Lucie, CHRZAVZEZ Julia, «Anthracology and taphonomy, from wood gathering to charcoal analysis. A review of the taphonomic processes modifying charcoal assemblages, in archaeological contexts», *Palaeogeography, Paleoclimatology, Palaeoecology*, vol. 291, nº 1-2, 2010, p. 142-153.

VASCHALDE Christophe, DURAND Aline, THIRIOT Jacques, «Vitrification and craft fire in occidental Mediterranean. Describing characteristics,first results and research hypothesis», *Saguntum Extra-11. 5*[th] *International Meeting of Charcoal Analysis. The charcoal as cultural and biological heritage*, 2011, p. 19-20.