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PAPELES DEL LABORATORIO DE ARQUEOLOGÍA DE VALENCIA

EXTRA – 11

5th INTERNATIONAL MEETING OF CHARCOAL ANALYSIS

The charcoal as cultural and biological heritage

Valencia, Spain, September 5th-9th 2011

ERNESTINA BADAL, YOLANDA CARRIÓN, ELENA GRAU, MIGUEL MACÍAS, MARÍA NTINOU

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5th INTERNATIONAL MEETING OF CHARCOAL ANALYSIS
The charcoal as cultural and biological heritage

INTRODUCTION

The 5th International Meeting of Charcoal Analysis: Charcoal as Cultural and Biological Heritage, held in Valencia (Spain) from the 5th to the 9th of September 2011, is organized by the Department of Prehistory and Archaeology, University of Valencia, and convenes many of the principal specialists in the field.

Natural and human-made fires are the main agents for the deposition of charcolified remains in natural or archaeological sediments. Wood-charcoals produced and deposited by such processes are an important evidence of the flora and vegetation of the past, therefore forming part of the biological and cultural heritage. Wood-charcoal analysis provides precise ethnobotanical and ecological information and for this reason the results of such analysis have become a valuable tool not only for the reconnaissance of the environments of the past but also for a better understanding of the present day ones.

The scope of the 5th International Meeting of Charcoal Analysis: Charcoal as Cultural and Biological Heritage is to introduce current innovative issues and lines of investigation in this field of research and to promote discussion, collaboration and interdisciplinarity.

The Organizing and Scientific Committees have decided to publish this volume you have in your hands with the extended abstracts, where methods and main results of the communications and posters presented in the meeting can be found. The objective is to offer the tools for a suitable citation of the work and original ideas of the authors, even though the proceedings take a long time to be published –which is often the case. However, most of the works presented in the meeting were still in progress at the moment of publication of this volume, so results should be taken with due caution, as some authors point out in their abstracts.

About a hundred contributions are presented in this meeting and prove the current force of Charcoal Analysis. This discipline presents now a great diversity of approaches and generated interesting data that can contribute to a better understanding of the dynamics of natural and anthopogenic landscapes. During the 20th century, most of charcoal analyses were focused in Europe; now, in the 21st century, this discipline crosses ancient boundaries to all the continents: charcoal studies carried out in 29 different countries from Europe, America, Asia and Africa are presented in this meeting.

Five thematic sessions assemble all the fields of interest of Charcoal Analysis. Each session is opened by a keynote speech, the issue of which has been chosen by the speakers in order to expose the brand new topics in Charcoal Analysis:

1st session: Methods, taphonomy, dating. The Keynote conference by Dr. Dominique Marguerie entitled "*Short tree ring series: the study materials of the dendro-anthracologist*" exposes an interesting approach of this line of research. This session consists of nine oral communications and five posters, in which new methods and solutions for the progress of the discipline are presented.

2nd session: Wood and charcoal anatomy. Problems and solutions. The Keynote conference by Werner H. Schoch entitled like the session itself, entails a recent approach to this topic of great interest. This session consists of five oral communications and a poster concerning the botanical identification of wood and charcoal of tropical and subtropical species from the New and Old Worlds.

3rd session: Pedo-anthracology and Pre-Quaternary charcoal. Dr. Antonio Martinez Cortizas opens this session with a conference entitled "*What is natural: the rol of palaeoenvironmental research in reconstructing the history of continental ecosystemes*". Seven oral communications and two posters compose the session and deal with anthracological surveys carried out in soils from North America and Europe.

4th sessión: Archaeological charcoal: natural or human impact on the vegetation. The keynote conference presented by Dr. Isabel Figueiral ─in collaboration with Dr. Laurent Fabre and Dr. Christophe Tardy─ entitled "*Charcoal analysis in Preventive Archaeology: combining culture heritage management with scientific research in the A75 motorway (Clermont l'Hérault - Béziers, Southern France*" will be the prelude to the session with the highest participation in the meeting, with 24 oral communications and 27 posters. These contributions cover many topics concerning charcoal analyses from the Palaeolithic to the Middle Age all around the world.

5th sessión. Ethnographical data of wood and charcoal use. The conference by Dr. Alexa Dufraisse entitled "*Interpretation of firewood management as a socio-ecological indicator*" open the last session of the meeting. In this session there will be seven oral communications and four posters about the uses of wood resources throughout History

This new edition of the International Meeting of Charcoal Analysis is intended as a reflection of the enormous number of researchers involved in the study of charcoal and the interesting data generated by this discipline. Nonetheless, there is still much to discover and to investigate, and much to be done for charcoal to be systematically recovered in all sites. Our aim with the organization of this meeting is to vindicate wood charcoal remains as part of our cultural and biological heritage, since plants are concerned but also humans who lived and used these plant resources. Charcoal remains enclose rich environmental, cultural and chronological information.

ACKNOWLEDGEMENTS

We are grateful to all the institutions that have contributed to the organization of the 5th International Meeting of Charcoal Analysis. The charcoal as cultural and biological heritage:

-Universidad de Valencia

-Facultad de Geografía e Historia de la Universidad de Valencia.

-Departamento de Prehistoria y Arqueología de la Universidad de Valencia

- Centro de Investigaciones sobre Desertificación (CSIC)

- Museu de Prehistoria de Valencia

We are also thankful to all the members of the Scientific and Organizing Committees for their generosity in agreeing to share the task of organizing the conference. Special thanks are addressed to the keynote speakers for their enormous effort. Finally, we are very grateful to all the particicpants for coming from afar, despite the global crisis, to share these days in Valencia with our common goal, the analysis of charcoal as a historical and biological document.

Ernestina Badal and Yolanda Carrión
Technical Secretariat
Valencia 2011

Short tree ring series: the study materials of the dendro-anthracologist

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Summary: *This paper is a review of the recent developments in dendro-anthracology. On large fragments of charcoal, the growth ring width can be measured and, in parallel, the tree ring estimated or even the caliber of the original wood measured. This method can provide fundamental information on the interaction of societies with the environment, such interesting data about palaeoenvironmental conditions, supply area, history of arboriculture... In spite of some method limitations, the dendro-anthracology has a bright future and the ANR DENDRAC is one of the projects likely to popularize this approach.*

Key words: *dendro-anthracology, charcoal, ring width, ring curvature, caliber estimation.*

This paper is a review of the recent developments in dendro-anthracology. When charcoal fragments are large enough, the growth ring widths can be measured and tree ring curvature estimated. This approach was referred to as a « dendrotypological » study by Billamboz (1992), who applied it to large waterlogged woods.

MEASUREMENT OF GROWTH RING WIDTH

Rare are charcoals which present long series of rings. It is generally a fragmented support which suffers the carbonization and taphonomy effects. The study of the radial growth on charcoals thus consists in the calculation of an average ring width. In one sample of charcoals, an average ring width is calculated for each rest with readable and measurable rings. This procedure minimizes the influence of extreme values and reveals trends in the growth of woods.

It is also possible to produce growth curves for large charcoals that contain dozens of rings.

EVALUATION OF TREE RING CURVATURE

The evaluation of tree ring curvature (and the angle of the rays) enables to identify which part of the tree was used. The ring curvature is estimated according to a standard classification: with a constant magnification and using a transparent test card placed on top of or under the fragment (Marguerie, 1992; Carcaillet, 2007; Ludemann and Nelle, 2002). While such an approach reveals trends, it is not a measurement of the diameter of the wood, but merely a characterization.

CALIBER ESTIMATION

A. Dufraisse (2002) continued and adjusted this approach by measuring the diameter of original wood under an image analyzer according to nine classes between 0 and 50 cm. With her, S. Paradis (2007) used the trigonometrical method in an isosceles triangle. This method makes it possible to obtain very good performances with only 9% of measurements presenting a percentage of error higher than 15%. Now the measurements can be taken and treated rapidly with the software *AnthracoLoJ* (Paradis *et al*., in press).

APPLICATION

Palaeoenvironment in north-western France: From the systematic measurement of the average ring-widths of oak charcoals on forty sites in north-western France compared with the number of heliophilic taxa used, we are able to distinguish two states of the forest environment: tree cover remained dense during the Neolithic, but was degraded and varied during the Late Iron Age (Marguerie *et al*., 2010).

Supplies area: At the late Neolithic site of La Hersonnais (France), the different settlement complexes were not contemporaneous. In this case, the increase of the average ring width over the studied time interval reflects forest degradation and the evolution of woodland potential around the site. It seems that a single forest was exploited throughout the occupation of the site. As a result of the decreasing timber availability, buildings became smaller (Bernard and Thibaudeau, 2002).

A dendrotypological classification of long series of rings from large charcoals allows to operate groupings of wood according to the ring width patterns. Charcoals can come from a single tree or from the same stand (Augier *et al*., 2001; Bernard and Thibaudeau, 2002; Carrion, 2003; Marguerie, 2009). Since already a long time, the average growth ring widths were only measured on charcoal samples with a weak curvature of rings (outer rings derived from trunks or large branches, far away from the pith). Now the coupling between wood diameter and radial growth delivers new prospects in the application of the dendro-anthracology (Dufraisse, 2006).

The story of the cultivation of olive trees in Mediterranean region: J.-F. Terral used an eco-anatomical approach with morphometric analyses of charcoals to determine the origin of cultivation of olive trees and grapevines in the western Mediterranean region. In this case, the ring width is one of the parameters taken into account besides of surface of the vessels, the density of vessels and the number of vessels by group (Terral and Durand, 2006).

METHOD LIMITATIONS

Average ring width in case of young stems or twigs: The rings near the pith are always thicker than the outer rings. Serious criticisms may put forward about the method of handling the tree ring data obtained from specimens of young stems with eccentric growth because of the development of reaction wood. The ring widths are thus highly variable on two opposite rays.

Validity of the growth ring width measurement modified by carbonization: The radially shrinkage which varies according to the species and the combustion processes could explain the differences in the variations of the average growth-rings causing problems with a dendrochronological referential established on dry or waterlogged wood. In addition, the vitrification of charcoals, a variable fusion of anatomical constituents within the wood, leading to homogenisation of the structure that makes sometimes series of rings impossible to read. Many stages of alteration by fusion are known (Marguerie and Hunot, 2007). Recently, J.-C. Oillic (2011) got some new results in this field by testing the size of charcoal, the species and some combustion parameters.

PROSPECTS

The next step of dendro-anthracology will be the development and the standardization of some measurements tools. The project DENDRAC (*Development of dendrometrical tools used in anthracology*) supported in France by the ANR (*Agence nationale de la Recherche*) and directed by A. Dufraisse is adapted for that. 28 researchers from 7 laboratories work in it. Three workshops of "measurements methods" will working soon: classical morphometry (curvature and width of rings), multivariate morphometry (population and climatic parameters), quantitative anatomy (caliber/age - climatic parameters).

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Working with WODAN – an online charcoal database

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Summary: *The WODAN charcoal and wood database was launched in 2011, from INSTAR funding received from the Heritage Council in Ireland (Ref. grants 16679, 16705 and AR01042, 2008-2010). The WODAN project aimed to establish an online database for wood and charcoal from archaeological sites and to store published and unpublished literature (when accessible). The database itself may serve a multitude of purposes but first and foremost it is a digital archive. The datasets can facilitate scientific research as well as optimise future sampling strategies. WODAN helps to identify key research agendas for environmental archaeology. This will feed back to other aspects of archaeology, thus facilitating more fully integrated archaeological reports and unlocking data for interdisciplinary research. Another key aim is the national and international standardisation of archaeological wood and charcoal data. This lecture presents the WODAN Project and its results to date.*

Key words: *WODAN, database, charcoal, standardisation.*

INTRODUCTION

In 2007, specialists working on wood and charcoal analysis from Irish archaeological sites came together to form the Irish Wood Anatomists Association (IWAA). Discussions within this group flagged the issue that specialists were using different methodologies for charcoal quantification. Archives of wood and charcoal identifications were being stored in many different ways. Some were on paper as part of site archives, some as excel sheets and others within project based databases. During these meetings, the idea of a centralized database for wood and charcoal results, available to everybody, was born. It was clear also that the recording methods used by the specialists also needed to be standardized.

APPROACH AND DISCUSSION

The WODAN database will hold the accumulation of wood and charcoal data in the form of identifications, wood technology and usage, dating and general site information. This data will be especially useful for reconstructing past vegetation histories and for studying human factors in woodland development, but also in highlighting research areas and demonstrating optimal sampling strategies. The database will form a sustainable and integrated repository of the Irish data, supported by all wood specialists working in Ireland, with a potential to host international data (Stuijts, 2008).

An international dimension was established by collaboration with Dr Otto Brinkkemper (Cultural Heritage Agency, Amersfoort, Netherlands), Dr Mitchell Power (Geography Faculty, Utah, USA), Prof Dr Oliver Nelle (Ecology Center CAU, Kiel, Germany), BIAX *Consult* (Zaandam, Netherlands), ranketing (Kerken-Aldekerken, Germany), Dr Alan Hall (ADS, UK), Dr Vincent Bernard (France), Dr Peter Hambro Mikkelsen (Denmark), Philip Buckland (Sweden), Dr. Robyn Veal (Australia) and the Irish Wood Anatomists Association (IWAA). These contacts have been instrumental in highlighting the differences between methodologies employed on the continent and in Ireland.

One of the first tasks was to evaluate the appetite for the database with relevant parties through a survey. We also compared and discussed our ideas with designers of existing environmental databases to see how they worked and if this was the way we would like to proceed. After this, the WODAN team and the IWAA sat down with the task of reviewing European methodologies and coming to a consensus on the methodology to be used in Ireland. The database aimed to house both the European methods (recording information per single fragment) and the Irish/British methods (recording information per Taxon i.e. wood species). As a result of the WODAN project and ongoing IWAA meetings, a standardised method for charcoal analysis has been developed for Ireland. This varied approach allowed for a consensus to be reached on the methodologies to be used in Ireland and with our partners (Stuijts *et al*., 2008-2009).

A hierarchical system of recording was developed (Figures 1 and 2). The data model employed within WODAN allows users to record information at many levels, from the archaeological site down to individual fragments of charcoal and wood. Where possible the WODAN application also utilizes consistent and standardized terminology for specialists to describe their samples, enabling greater success in comparative analysis within and across archaeological excavations. The construction of the WODAN web application has also, where possible, employed open source software, thus enabling a more sustainable data resource for future researchers to utilize. Help functions which demonstrate how to use the site are online. Templates have also been developed help in recording of site, sample and charcoal fragment information.

Four workshops (International and Irish) introduced the prototype database to specialists and gave people an opportunity to use it. This led to crucial feedback from the intended user community, which was subsequently used to adjust structure and fields of the database.

FIGURE 1. Introduction page to WODAN.

Thoughts in 2010 turned to the accessibility of the WODAN database. Should the results be available to everyone? Who will be allowed to add/adjust results? Instinctively we hoped to have an open policy, which would enable as many people as possible to use the database. Still consideration had to be given to specialists who may not want all their results available online, for example material being used for PhD research or unpublished results. We decided to create a profile for each specialist who is interested in using the database (MyWODAN). They can add their own identifications and thus essentially create a personal archive. The specialist can choose whether or not they want to make results available, on a site by site basis. The results are accessible to be browsed and queried by everybody, except in cases that specialists choose to keep their results from view for their own use (Stuijts *et al*., 2010).

The development of an online database is a fundamental departure from other environmental databases. Its online availability makes the catchment area of the database far greater than any previously designed environmental databases. Internet hosting allows the data to be searchable, easy to upload and always relevant and up to date.

To allow specialists to have maximum use of the database, queries were designed which will allow specialists to search particular fields in the database and also will produce pro-formatted tables for incorporation into reports. WODAN can be further developed, pending funding arrangements (rapid data entry forms).

The database is implemented with Ruby on Rails 2.0. MySQL, Apache and Passenger Phusion are used to manage the persistence and serve the content. The Project is using cloud computing, the database is hosted from the agency Blacknight.

CONCLUSIONS

The WODAN database is online and fully functional at www.wodan.ie. At the time of writing information from 500 sites has been added. The aim for the database is to be a sustainable repository. The next stage is output of results, to interpret data from Ireland and beyond. We would be delighted to collaborate with people who are interested in adding to, or using the database in the future.

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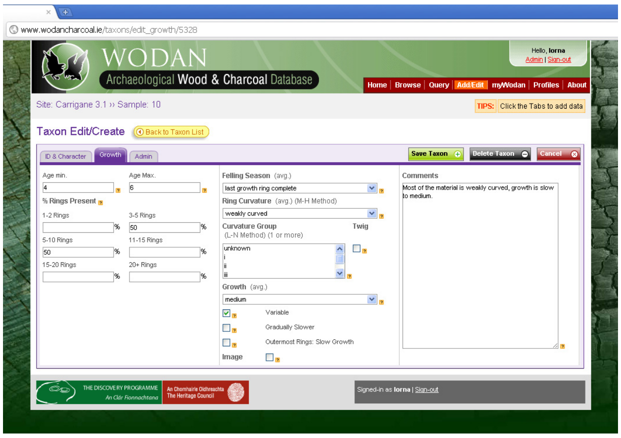

FIGURE 2. Detailed recording of charcoal at Taxon level.

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Vitrification and craft fire in occidental Mediterranean. Describing characteristics, first results and research hypothesis

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Summary: *After analyzing several sets of charcoals sampled from various archaeological and ethnological contexts in western Mediterranean, a scale to evaluate the vitrification phenomenon has been elaborated and applied to archaeological and ethnoarchaeological charred material. Thus, it reveals several marked differences between charcoals and even on the same charcoal. A vitrification description along the transverse wood section has been implemented. The development of an ethno-anthracological approach is essential, because it offers the possibility of collecting and comparing charcoals of the same species, but carbonized into different traditional structures, which means not in the same burning atmosphere.*

Key words: *ethno-anthracology, vitrification, charcoal pit, craft fire, kiln*

INTRODUCTION

Vitrification, named by the glass-like appearance of some wood charcoals, is a phenomenon frequently observed by anthracologists. For several years, various researches have tried to define and explain this phenomenon (Marguerie and Hunot, 2007; Braadbaart and Poole, 2008; McParland *et al*., 2010) but a lot of questions remain unresolved and discussions go on about factors involved in the vitrification process: temperature of carbonization, cooling, wood morphology, green or dry wood, presence of resins or siliceous elements, etc. Recently, analyses lead on charred woods from southern France and northern Africa craft combustion structures of various archaeological and ethnological sites are questioning the exact nature of this phenomenon. They point out how necessary it is to describe and quantify as precisely as possible this phenomenon. The aim of this study is to contribute to a better classification and categorization of vitrified wood charcoal remains. The sites studied date from different periods of time ─from Protohistory till now─ and provide a range of craft traditional structures such as charcoal burning in pits (Martigues and Pourcieux, France) (Durand *et al*., 2010) or in kilns (Méounes-les-Montrieux, France), lime kiln and brick (Sorède, France; Kairouan, Tunisia), or distillation workshops (Djebel Ouslatiya, Tunisia and Ajdir Morocco)

EVALUATING THE WOOD CHARCOALS VITRIFICATION

Visual description of this phenomenon is the starting point of this study. During the anthracological diagnosis of the "Vallon du Fou" material (Martigues, Bouches-du-Rhône, France), recovered from carbonization pits, the glassy appearance of numerous wood charcoals led to elaborate a scale of vitrification in order to better qualify and quantify, in an objective manner, the anatomical observations. Thus, five vitrification degrees were defined and described, from no vitrification at all, to a complete one, that means the total fusion of anatomical elements of wood forbidding taxonomic identification. This vitrification scale has been applied to the wood charcoals recovered from various other archaeological sites. All the analyses reveal the predominant presence of *Erica* sp. as vitrified charcoals, but also *Pinus halepensis-P. pinea*, and *Quercus* (deciduous or evergreen). In Martigues, *Erica* and *Pinus halepensis-P. pinea* charcoals was never vitrified in the same way even in a same pit. In Sorède (Pyrénées-Orientales, France), the scale was applied to charcoals issued from a lime kiln and questioned about the unequal vitrification observed on the same sample and on the same anatomical section. In fact, due to abundant presence of *Erica* sp. twigs and sticks, a new way to apply the vitrification scale was tested and leads to propose new explanation of these differences. Charcoals are systematically vitrified first in the rings surrounding the marrow, an after only in the last rings produced by the cambium near the bark.

STEP TO AN ETHNO-ANTHRACOLOGICAL APPROACH

Researchers try to create this phenomenon in a laboratory (McParland *et al*., 2010), or observe it during archeological experiments (Py and Ancel 2006; Py, 2009). To complete these data, an ethnoarchaeological approach was settled on during field-work in the area of Kairouan (Tunisia) to record traditional gestures, fuel management and burning process developed by lime-burners, brick-makers and rosemary distillers. All these craftsmen use the same fuel to supplement their fire: remnants of distilled rosemary. So, it was possible to sample charcoals both in a limekiln and in a distillation workshop fireplace, and then to compare these samples answering to the question: is vitrification in craft charcoal a result of burning atmosphere? From the same point of view, comparison was established between cedar charcoals sampled from two different distillation processes (charcoal kiln and double pot technique).

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Measuring burn temperatures from charcoal using the reflectance method, first results from an Irish Bronze Age cremation site

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Summary: *Reflectance is a method borrowed from coal studies which can estimate the absolute burn temperature of charcoals. Studies examining the usefulness of reflectance in archaeology are underway in a number of areas. This report details first results from reflectance testing of archaeological charcoals from known Irish Bronze Age cremations, which included calcinated bone. As calcination of bone occurs at 650 °C to ≥ 800 °C (Wahl, 1982), it was expected that the charcoals would reflect this temperature. This was not the case for identified charcoals > 2mm, nor for micro-charcoals of* ca*. 250 µm. Cultural depositional modalities, combustion completeness and taphonomic influences may have all played a part in this result which suggests that the usefulness of reflectance will depend on depositional circumstances and charcoal collection strategies.*

Key words*: Charcoal reflectance testing, taphonomy, micro-charcoals, charcoal collection strategies*

INTRODUCTION

Reflectance testing has been attested as a useful tool for demonstrating approximate burn temperatures of archaeological charcoal (McParland *et al.*, 2009a, b; McParland, 2010). McParland (2010) has in particular, demonstrated the nearly directly linear relationship between reflectance of specially prepared samples of charcoal across a range of wood species, temperatures, and charring times. Extensive testing over a range of archaeological depositional types however, has not yet been carried out, although results from a Roman hypocaust (bath) appeared to confirm the validity of the method. The testing in this study, in which charcoals of a range of size fractions were evaluated, was intended to be a control of the method as cremation temperatures for human bone are known.

ARCHAEOLOGICAL BACKGROUND

Charcoal was derived from excavations of Bronze Age sites along the N8 freeway from Cashel to Mitchelstown in Ireland (Mc Quade *et al.*, 2009), as part of O'Donnell's doctoral research. Soil contexts were bulk sampled and processed by flotation. Reflectance testing was used to address questions of burning temperature from three sites: a flat cemetery at Templenoe, a settlement site at Ballylegan and a *fulacht fiadh* (cooking pit) at Lissava, all excavated in County Tipperary.

In the Irish BA, bodies were either cremated; or burnt in funeral pyres consisting of raised wooden structures that would have ensured adequate air flow from beneath, or may have been sunk into the ground with oxygen being introduced via a series of flues (Buckley and Buckley, 1999: 25). From the site of Templenoe, two samples were selected from cremation pits with well cremated bone (indicated by white colour of remains) which contained *Quercus* sp. (oak) only. A further cremation pit dominated by Maloideae charcoal that included a low level of oak, was also selected. A cremation fill dominated by *Fraxinus* sp. (ash); and a further sample from mixed oak and pomaceous fruitwood pyres (a common occurrence at Templenoe) were also selected for testing. Templenoe is unusual in Ireland in that four possible pyres have also been discovered (in addition to the cremations). Samples from these provided the opportunity to compare burn temperatures of pyre material, with those of cremation pit charcoals. Taxa consisted mainly of *Quercus* sp. and some Maloideae, however, human bone was not actually identified in these contexts. A small number of features at Templenoe were considered to be non funerary pits and these were also tested as a comparison to the funerary contexts. These contained a wide variety of wood taxa and were dominated by *Corylus avellana,* hazel, which was not observed in the funerary contexts. Control samples from a domestic hearth at Ballylegan and from a trough fill at Lissava were also included.

METHOD

Charcoals > 2 mm, once identified taxonomically, were roughly crushed and mounted using one of two methods: cold set, or hot set epoxy resin blocks. The blocks were then ground and highly polished, and inspected under oil and a reflecting microscope for their reflectivity according to McParland (2010). Fifty measurements were taken and averaged for each sample. The hot and cold set epoxy methods have different utility depending on sample size and other factors, but a control test revealed results were not affected by setting method. Testing of samples of individual taxa was made, as well as of mixed taxa. The burn temperature results obtained did not demonstrate the high temperatures expected. Based on McParland's hypocaust work (McParland *et al.*, 2009b), which suggested material of much smaller dimensions would provide higher readings, some of the micro-charcoals from the same contexts, of 250 µm, ranging to 1 mm were further tested (without identification of taxa). Average reflectance measurements for each sample were then calibrated from the known linear relationship between reflectance and temperature (McParland *et al.*, 2009b; McParland, 2010), Figure 1 refers.

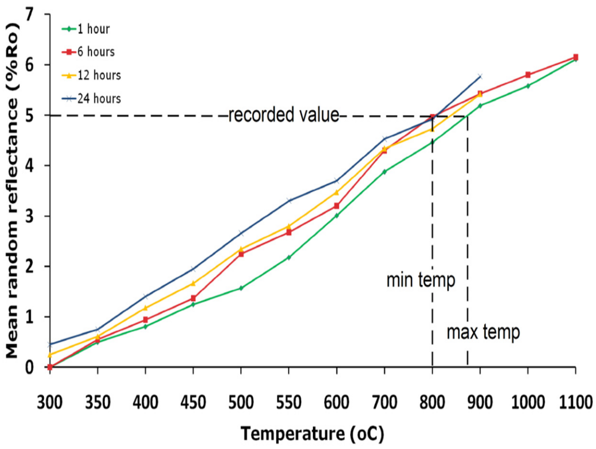

FIGURE 1. Calibration graph of reflectance vs. burn temperature

RESULTS

The average temperature ranges for the tested cremation samples varied from a low of 360-410 °C to a high of 390-450 °C, values well below that expected. Little differentiation in temperature was found for single taxon samples, as opposed to mixed taxa samples, i.e. wood type appeared to make little difference. The smallest fraction samples did show a slightly higher (*ca.* 15 °C) average temperature, and the maximum observed was about 550 °C. The open hearth samples, examined as a contrast, provided similar readings in the high range 390-450 °C.

DISCUSSION

The results show that charcoals collected from archaeological contexts may not always demonstrate the temperatures associated with the known cultural process in question. Because of the presence of the calcinated bone, the temperatures reached in the Bronze Age cremation samples had to have been in the vicinity of 650-800 °C (Wahl, 1982). The fact that no charcoals were measured at any temperature close to this range suggests that remainder archaeological charcoals in this case have not reached these temperatures, and instead reflect incompletely combusted fuel which has been at the periphery of the fire, and/or thrown on late in the cremation. While the smaller, (i.e. 250 µm) charcoals did reveal slightly higher temperatures, the results were not statistically significant. One possibility is that the higher temperatures may have been measureable from even smaller material, but this was not collected. It is not known if ash was deposited, and not collected; or if ash was deposited and lost in the surrounding soils. Combustion, once temperatures reach the high levels expected, may be wholly destructive, and it may not be possible to collect any remnant charcoals which have been exposed to the highest temperatures. However, it should be acknowledged that the flotation process for collecting the charcoals used a 250 µm mesh. Without testing of materials below this size the matter is still open.

CONCLUSIONS

The results suggest that reflectance will need to be applied in a selective manner and results interpreted carefully in terms of cultural burn modalities, combustion processes and taphonomy. Normal field collection of charcoal is by dry sieving over 4 or 5 mm mesh; and/or flotation over 250 µm or larger mesh. Size of charcoals for identification purposes is usually >2 mm. It will be useful in the future to collect un-sieved soil samples of ash and micro-charcoals (where present), and separate out the charcoal by gravimetric or other method for reflectance testing to further resolve this issue.

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Scanning the historical and scientific significance of charcoal production – local scale, high resolution kiln site anthracology at the landscape level

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Summary: *Airborne laser scanning data have been verified, concerning their utilisation in studies of historical charcoal kiln sites. Thousands of such sites are recognizable in hillshade images based on these data. Exact information could be provided on their geographical position and very high kiln site densities could be established. Laser scanning is a valuable tool for kiln site anthracology, facilitating the field work considerably, increasing the efficiency and precision of the site records and highlighting the historical significance of charcoal burning. Moreover, it underlines the outstanding scientific potential of local scale kiln site studies, of which an example is given. The close dependence of charcoal production on the natural local offering of wood and the large number of analysable sites together provide a unique chance to obtain new exact information on the historical forests and the human impact therein with fine spatial resolution at the landscape level.*

Key words: *Black Forest, charcoal burning, forest history, kiln site, airborne laser scanning*

INTRODUCTION

In many regions of the world charcoal burning was an important practice of woodland use in the past. Remnants of charcoal production are widespread in those landscapes. In mountainous areas of western Central Europe sites of charcoal burning (charcoal kiln sites) are by far the most frequent sites we know with scientifically analysable residues of past fuel wood exploitations. These sites are characterized by distinct anthropogenic changes of the ground surface. Moreover, the charcoal macroremains preserved there contain comprehensive information about the historical forests exploited and the human influences therein. Therefore kiln site anthracological studies are a main key, maybe the only one in many regions, for high resolution forest and landuse history at the local stand-scale level of consideration.

Unfortunately, these historical sites generally are not recorded in written sources or in historical maps and they are not visible in the usual aerial photographs. Up to now time-consuming field work was necessary to locate them and to record their exact geographical position. However, a new tool became available for our investigations, airborne laser scanning, offering completely new and innovative options which should be verified for a large pilot area. We want to know in which cases and to what extent the historical kiln sites are recognizable by laser scan technics. Moreover, an example should be given of the scientific value and potential of local scale anthracological investigations of areas with high kiln site density.

STUDY AREA AND METHOD

For this evaluation we choose the southern part of the Black Forest in SW Germany, covering an area of about 2000 km^2. In this area a maximum number of historical kiln sites was already known and an even larger number of new ones was expected. Hillshade images with maximum resolution (DGM1, 1 m-grid; vertical resolution < 0.15 m; LGL 2011) plotted from the laser scanning data were evaluated systematically, focusing on the visibility of these sites. Moreover, the new (potential) sites visible in the plots have been verified by exemplary field surveys.

RESULTS AND DISCUSSION

A large majority of the kiln sites already known indeed is visible at the hillshades, even in forested areas. Moreover, a very large number is recognizable additionally. However, exemplary field surveys give evidence that there are many other kiln sites, which could not be detected at the hillshades, because of:

(1) bad conservation, e.g. by erosion, forest road construction, wood transport etc.,
(2) heterogeneities of the ground surface or vegetation, e.g. dense herb or shrub layer, or
(3) problems with the laser scan data, e.g. flight too late in the spring, when deciduous trees already had developed their leaves.

Consequently and fortunately, field work could not be substituted completely by the scans, but it could be facilitated considerably. Within the region investigated more than 2000 historical charcoal kiln sites already had been recorded in the course of many years of anthracological investigations. However, we were sure that these are only the smaller part of all sites preserved in this area. By using laser scanning the total number of known kiln sites indeed could be doubled within a short time.

Exact information could be provided for the geographical position of thousands of sites. Maximum kiln site densities of more than 150 sites per km^2 could be established, so that the average distance from site to site in such areas comes to less than 90 m.

Several examples of local scale results and of the fine spatial resolution of kiln site anthracology already have been given (e.g. Ludemann, 1994, 2002; Ludemann and Britsch, 1997; Ludemann and Nelle, 2002; Ludemann *et al*., 2004; Noelken, 2005). The sites analysed in these studies range over landscape sections of about one or a few kilometers, covering different ecological conditions, e.g. summit plateaus, slopes of different inclination and exposition, valley floors, etc. (cf., Fig. 1A). The example given here ranges over one square kilometer including 34 kiln sites. Charcoal analysis shows regular spatial patterns of the tree taxa exploited, illustrated by iso-%-lines of the frequencies of the predominant taxa *Abies*, *Fagus* and *Picea*, given in 10-%-classes (Fig. 1B). These spatial patterns can be explained quite well by the different growth conditions (altitude, aspect, inclination, edaphical conditions, etc.) of the forest stands in the vicinity of the sites. A pronounced dependence of charcoal production on the local natural distribution of the tree species is discernible.

CONCLUSION

Airborne laser scanning is a valuable tool for kiln site anthracological studies, facilitating the field work considerably by increasing the efficiency and precision of the site records and providing exact information of the geographical position of the historical sites. Kiln site distribution and density indicate the different local significance of charcoal burning in the past. Moreover, it underlines the outstanding scientific potential of kiln site anthracological studies for forest history and vegetation science at the landscape level. The close dependence of past fuel wood exploitation on the natural tree species composition of the forests exploited on the one hand and the large numbers, wide distribution and high densities of historical kiln sites on the other hand together provide a unique chance to obtain new exact information on the ancient forests and the changes therein with local scale resolution.

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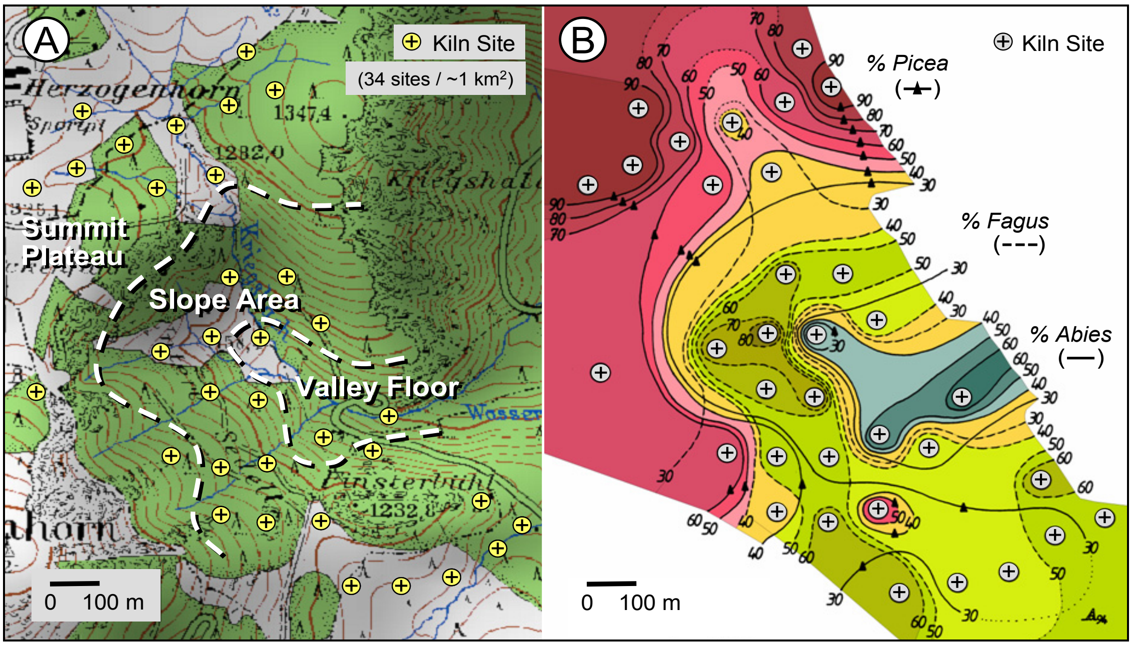

FIGURE 1. Example of local scale kiln site anthracology. A. Site map. B. Taxa frequencies of charcoal samples (Ludemann, 1994, modified). For further explanation see text.

Methodological approaches towards the quantification and identification of charcoal samples retrieved from archaeological sites

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Summary: *The National Roads Authority (NRA) awarded funding to the authors to conduct a PhD research project entitled 'Quantifying woodland resource usage in the Irish midlands using archaeological and palaeoecological techniques'. Pollen cores from a lake and a small hollow as well as charcoal and wood samples from 86 archaeological excavations are being used as indicators of woodland resource usage. There are two main questions addressed. Are we identifying a representative sample set from archaeological sites and are we identifying enough or over- identifying charcoal fragments from each sample in order to determine wood function, wood use and reconstruction of surrounding woodlands? Two charcoal data sets, ranging in date from the Neolithic to the Post Medieval Periods, are currently under investigation where mean saturation points and proportion saturation points of taxa are recorded and graphed. Initial results from the saturation point profiles for taxa diversity indicate that there is little variance in saturation points between time period, site type and short and long term charcoal deposits. Mean saturation points are also lower than expected for most site types evaluated. Further work is on-going using a variety of statistical packages; the data from the 500 samples and these results will be discussed in this paper.*

Key words: *Ireland, woodland resource usage, methods, saturation curves*

INTRODUCTION

This project aims to determine the optimal sampling effort by archaeologists to determine the identity and relative abundance of wood and charcoal samples found during excavations. In this regard there is no definite sampling and identification strategy employed on archaeological excavations and in post excavation analysis in Ireland. Previous studies and recommendations from France (Chabal *et al*., 1999), England (Keepax, 1988; Asouti, 2001) and Pompeii, Italy (Veal, 2009) will be discussed and compared to results from this study.

ARCHAEOLOGICAL BACKGROUND

The charcoal data have been sourced from excavations carried out in the midlands of Ireland along the route of the new 57-km- N6 Kilbeggan–Athlone Dual Carriageway. Archaeological investigation identified over 86 archaeological sites reflecting approximately 6.000 years of human activity in the area (Fig. 1).

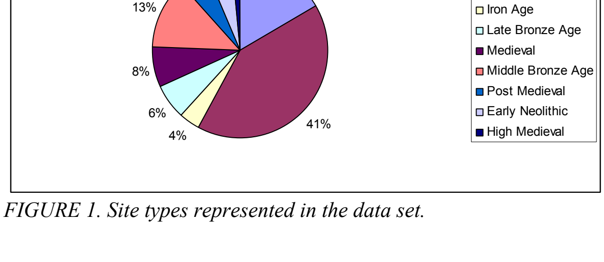

FIGURE 1. Site types represented in the data set.

RESULTS AND ANALYSIS

Two data sets are analysed. Five hundred samples from the first data set have been analysed and up to fifty fragments from each context/sample have been identified, where present (Fig. 2). This data will be statistically analysed to aid in the production of optimal sampling recommendations pertaining to archaeological sites.

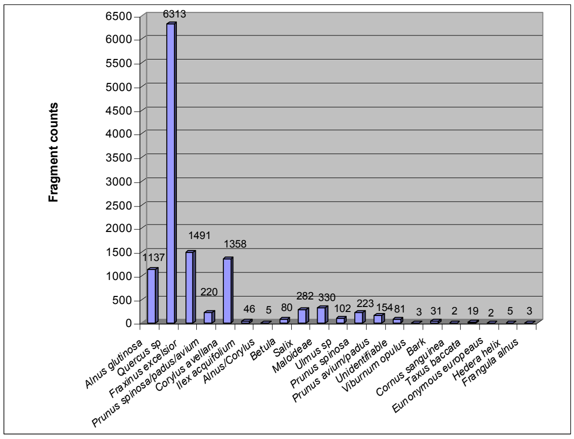

FIGURE 2. Identifications from 500+ samples within the study area. This information will be used to determine optimal sampling procedures.

The second data set which includes the graphing of saturation points (Fig. 3), mean saturation points (Fig. 4) and proportion saturation points of taxa types from 79 samples and 5400 identified charcoal fragments are outlined below. An optimum count of 100 fragments per sample was identified. Results as shown in Figure 3 and

4 records the variation in saturation points across the range of sites/samples investigated. Saturation points range from 1 – 86 after which no new taxa are identified.

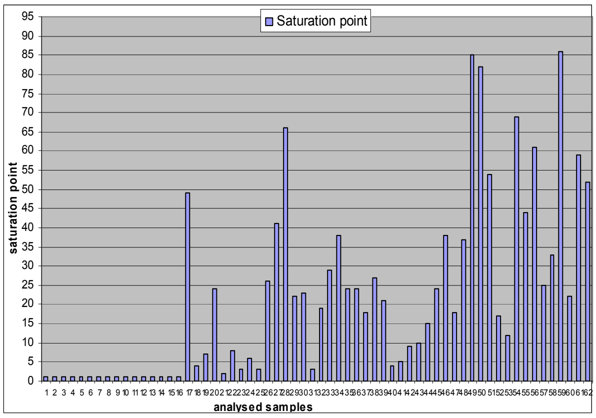

FIGURE 3. Saturation points for all samples analysed for fragment count/taxa diversity analysis.

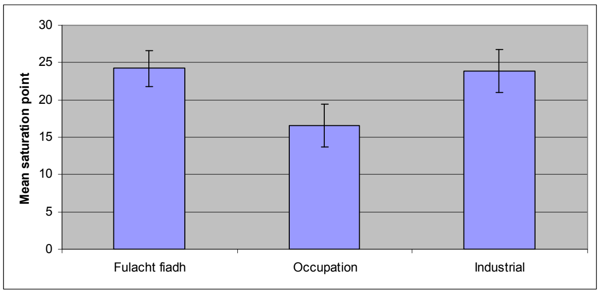

FIGURE. 4. Mean (±SE) saturation points of three site types analysed from the area

Mean saturation points for three site types commonly excavated in Ireland (Fig. 3) are graphed above with standard error bars also denoted (Fig. 4). *Fulacht fiadh* are the most frequent archaeological pre-historic site found in Ireland and may have had varied functions including cooking troughs, sweat house and bathing areas. Occupation sites relate to both Bronze Age habitation sites as well as Medieval dated ringforts while industrial sites include kilns, charcoal production pits and metalworking activity. Results show that mean saturation points for taxa diversity occurs under 25 fragments for all site types analysed.

DISCUSSION

When mean saturation points are plotted for site types and time periods a notable consistency between variables is recorded. The mean saturation points centre on 25 fragments which is lower than expected. Current practice in Ireland is to identify 50 fragments per sample where possible. The low saturation points may be related to lower taxa diversity both within the samples and in the surrounding woodlands of Ireland. The results are unexpected when compared with minimum recommended fragment counts from other studies in countries elsewhere (Keepax, 1988; Chabal *et al*., 1999; Asouti 2001; Veal 2009).

Previous studies by Keepax suggest a minimum of one hundred charcoal fragments should be identified to produce a meaningful dataset but this is not always possible or allowable within current budgets. Chabal *et al.* (1999: 66) suggest a minumum of 250 fragments per level, with 400-500 fragments considered as the optimal subsample while Asouti (2001) recommends an intermediatery count at 150 – 200 fragments. Veal's (2009) recent PhD on charcoal quantifications from Pompeii (where 3911 fragments were identified) and where saturation curves were completed suggests that saturation points tended to occur between 60 and 80 fragments before the saturation curves levels out (Veal, 2009: 87). A recurring theme throughout the previous cited studies is that over-identification of individual samples does not compensate for identifying sufficient samples from an archaeological site or level/period therefore further statistical analysis on the analysed 500 samples will provide direction as to the optimal sample analysis per site for the detection of woodland resource use in Ireland. These studies will then be amalgamated with the results from pollen analysis completed from the area for this project.

CONCLUSIONS

Consistent results across all time periods and site types are revealed when the mean saturation points for taxa present within archaeological charcoal samples are plotted.

A further 500 samples and 12,000 charcoal fragments will be statistically analysed to inform researchers and stakeholders alike as to the optimum sampling strategy for a variety of archaeological sites. These issues will be discussed in detail at the conference in September. The results will inform sampling strategies on future road schemes and large infrastructural projects in particular as the NRA is the funding body for this research. These results and recommendations are particularly important within current financial constraints.

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Charcoal as tracer of local tree taxa in the Pleistocene loess field of Central Europe. Which relationship with flora, vegetation, landscape or climate?

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Summary: *Charcoal and pollen records are implemented in order to trace the vegetation and climatic changes from Eastern Europe during the time window 36-26 kyr BP. The present discussion makes comparison between 2 well dated loess sequences with humic horizons that provided pollen and charcoal remains. Some 7 positive climatic oscillations were recorded in this time window which may be correlated with the Greenland ice sequence between GIS 9 and 5b. No significant floristic changes did occur by trees during this period but landscape modifications happened by shifts in the vegetation structure.*

Key-words: *charcoal, pollen, Pleistocene, loess, central Europe*

INTRODUCTION

Charcoal preserved in loess deposits is regarded accurate testimony of the past presence of tree and shrub taxa in the area of natural deposition or archaeological sites. This assertion is valid in certain favorable sites only if some conditions are fulfilled such as the thorough approach of the site stratigraphy, sampling methodology, laboratory treatment of charcoal, identification of the charcoal fragments and careful selection of fragments for radiocarbon dating. Of course the results must be in agreement with a coherent sequence in stratigraphy and chronology. However this assertion may be tempered by various disturbing factors like bioturbation, colluviation, solifluction, reworking, or intrusion by water transport. Only a precise methodology from the field work to the analyses in the laboratory may vouch for the accuracy of the results in chronology and environment. (Damblon *et al.*, 1996; Damblon and Haesaerts, 2002; Haesaerts *et al.*, 2010). Finally the coherence of each assemblage with other stratigraphic and environmental data must be controlled, an evidence which is not always achieved.

The following contribution aims at demonstrating the efficiency of combined stratigraphy, pollen and charcoal investigations with the aim at tracing vegetation changes and climatic oscillations in eastern Europe during the Upper Pleistocene, especially the time window 36-26 kyr BP, well framed by accurate radiocarbon dates on charcoal.

This time span is chosen because it corresponds to a key period that has known the turn from middle to late pleniglacial and the expansion of the Anatomically Modern Humans (AMH) throughout east and central Europe. Although a lot of pollen records come from this area, their chronology is not always accurate and precise. Moreover long well dated sequences mainly originate from the Mediterranean area and their connection with the loess field often remains puzzling.

Here, after a selection of two accurate pedostratigraphic and palaeobotanical records in loess, sequences from Czechia and Ukraine are discussed with the aim to detect the succession of climatic events between 36 and 26 kyr BP and evaluate their extent and impact on the plant environment. The investigation was focused on the archaeological sites of Dolni Vestonice (Czechia, Moravia) and Molodova (Ukraine) which have produced safe pollen records (Pashkevich, 1987; Svobodova, 1991) and were rich in charcoal material well positioned in stratigraphy. Moreover, some parts of the deposits also include pollen and charcoal in natural conditions.

RESULTS

The sequences of Dolni Vestonice and Molodova may be compared owing to their radiocarbon, charcoal and pollen data. The pedostratigraphic succession combined with the radiocarbon dates allow comparing the time slices 28-26 kyr BP in Dolni Vestonice and 33-23 kyr BP in Molodova. Taken together, these sequences include five palaeosols and humiferous horizons which correspond to episodes of climatic improvements that had induced the end of sand or loess input, the stabilization of the ground surface and the formation of humiferous horizons in loess deposits and peaty deposits in bottom valleys.

The low diversity of tree taxa with predominance of boreal conifers such as *Larix*, *Picea* and *Pinus* all along the time window 36-26 kyr BP is attested by charcoal preserved in archaeological sites as well as in natural conditions. *Abies* was also found in Dolni Vestonice (Beresford-Jones *et al.*, 2011). Only pioneer malacophylls like *Salix*, *Betula* and *Alnus* may be ascertained as local or regional trees. On the contrary, temperate angiosperm tree taxa detected in the pollen records and by single charcoal fragments have to be considered intrusive.

The two pollen sequences in the two regions from Moravia and Ukraine point to open landscapes with predominant steppe vegetation on dry grounds and sedge-grass meadows in wetter depression or along the rivers. Such marshes may have been at the origin of the tundra signal in diverse pollen records in central and east Europe. Comparing the charcoal and pollen records from west to east Europe puts some gradient in evidence with damper edaphic conditions to the west and drier ones to the east where charcoal data show boreal conifer trees really favored in central and east Europe. These botanical records also suggest continuity in the vegetation type throughout the 36-26 kyr BP window (MIS 3 - beginning MIS 2) given that pollen and charcoal preserved in tundra-gleys at the end of the middle pleniglacial and the beginning of the late pleniglacial attest the persistence of conifers in a wide steppe context during this transition phase.

CONCLUSION

Finally, it is assumed that the climatic oscillations which characterize the MIS 3 and 2 glacial stages were too short (around one millennium) for allowing revolution of the landscape. The palaeobotanical records rather suggest some local or regional minor changes in a steppe environment with limited expansions of boreal trees that had subsisted in sheltered biotopes linked to the valleys, especially to the east of Europe. Some patches of tundra-like vegetation might have developed as a result of local higher water table.

The above discussed results confirm the lack of temperate malacophyll and sclerophyll temperate tree taxa in the loess area of middle Europe during the stadial and interstadial episodes of the last glaciation. Such temperate taxa were standing in sheltered biotopes of the Mediterranean area and south of 45° N as assumed by recent palaeobotanical syntheses (Fletcher *et al.*, 2010; González-Sampériz *et al.*, 2010; Müller *et al.*, 2011).

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Differential preservation of anthracological material and mechanical properties of wood charcoal, an experimental approach of fragmentation

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Summary: *The question of the fragmentation of archaeological charcoal is particularly interesting, since anthracology relies on a quantitative analysis of identified* taxa. *The undertaking of mechanical compression tests on carbonized wood cubes from ten woody species allows an evaluation of their preservation potential, as well as their possible over- or underrepresentation in archaeological samples. Our tests evidence a differential behavior of the species in what regards mechanical resistance and modalities of fragmentation.*

Key words: *wood charcoal, experimental compression, mechanical properties, fragmentation, taphonomy, archaeology.*

INTRODUCTION

Anthraco-analysis is based on the relative frequencies of taxa, calculated from the number of fragments of each species identified in the sample. Only this quantitative approach allows us to gain access to a structural and dynamic image of the vegetation. In this sense, although the palaeoenvironmental representativeness of charcoal is further proof, the question of fragmentation on charcoal material is of particular importance. Each stage, from the burning of wood through the burial and sampling conditions, take part in the fragmentation process (Chabal, 1994, 1997; Théry-Parisot *et al*., 2010 a, b). However, the behavior of different species when exposed to charring, or the effects of post-depositional processes on the charcoal are poorly known. In the 90's, L. Chabal demonstrated on archaeological material that the fragmentation process of charcoal is the same for all species. According to the author, the fragmentation law is dependent on the archaeological site and the processes that led to its formation. The variety of processes involved, bring to the same level of fragmentation the different species (Chabal, 1997). Most post-depositional processes induce significant mechanical pressure on charcoal (Théry, 2001). Even though experimentation can never be able to reproduce the complexity of these processes, it allows us nevertheless to characterize the physical properties of different species. In this work, we studied the different behavior towards compression of ten common species often found in archaeological contexts: *Acer pseudoplatanus, Betula pubescens, Carpinus betulus, Corylus avellana, Fagus sylvatica, Fraxinus excelsior, Populus alba, Pinus pinaster, Pinus sylvestris, Quercus pubescens*. The production of this raw data allows us to evaluate the potential of preservation of the tested species and their possible under-or overrepresentation.

MATERIAL AND METHODS

For each species, 30 cubes of 2 cm^2 were cut with a band saw and charred in a muffle furnace in the CEPAM laboratory. Each cube was wrapped in aluminum foil and placed in a ceramic crucible and covered with sand to reduce thermal shock and to prevent the cubes of cracking. Carbonization temperatures were determined by considering both the thermal conditions of charcoal formation and the temperature range that can be reached in an open fireplace (charring temperatures: 400, 500 and 750 ° C).

Compression tests were performed on the samples in the CEMEF (Polytech, Sophia-Antipolis) in collaboration with Gilbert Fiorucci and Alexandre Ducom on a tension-compression machine equipped with a hydraulic sensor 10kN. The descent rate was set at 0.1mm/s for 30 seconds from contact with the sample (Ducom, 2010). For all tests, the stress was applied on the transverse face of the cube of charcoal, perpendicularly to the wood fibers. In this direction the material has the greatest strength. Data collected at the end of the tests were used to calculate the stress (force/section of the cube in mm²) expressed in Mega Pascal and the strain (position/height of the cube in mm) expressed in percentages, in order to extract the stress-strain curves, which allow interpreting the mechanical tests (Fig. 1).

The charcoal was placed under the press in small plastic bags so no fragments produced by the compression after the rupture of the material could be lost. We sieved the contents of each package in a column of sieves of 1 mm, 2 mm and 4 mm. The fragments were counted per mesh for each cube with the image analysis software "Image J ". A total of 57,372 fragments for the 315 successful tests were recorded.

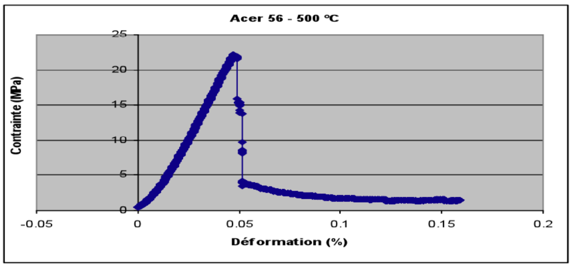

*FIGURE 1: Example of "stress-strain" curve from a compression test of a cube of charcoal (*Acer Pseudoplatanus*).*

RESULTS

Differences in the fragmentation of the species were noticed, which led to the establishment of different groups according to their behavior (Fig. 2).

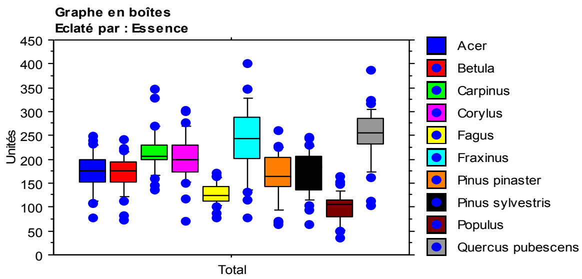

FIGURE 2: Specific variability of the fragmentation.

The temperature of carbonization has obviously an impact on fragmentation. Moreover, if all species produce more small fragments, these do not have the same distribution by size class (Table 1).

Species	>4mm	]2 - 4mm]	]1 - 2mm]	Total
Acer	19	60	94	173
Betula	16	38	117	171
Carpinus	17	44	156	217
Corylus	16	49	137	203
Fagus	17	42	68	127
Fraxinus	18	54	169	242
Pinus pinaster	20	57	89	166
Pinus sylvestris	20	56	96	172
Populus	15	34	50	99
Quercus	35	80	136	251

TABLE 1. Average number of fragments per size class for each species.

Statistical analysis allows determining which factors, among those taken into account, influence most the fragmentation process and its modalities (carbonization temperature, mass loss, density, porosity, anatomical characteristics of species, proximity to the heart of wood, etc.). The identification of influential factors can partially extrapolate our results to other species.

DISCUSSION

As often in experimental studies, our results are not directly transferable to the archaeological material. Several stages are needed to make them suitable:

- New experiments must be carried out to 1) expand the repository of data, 2) simulate other post-depositional processes (freeze-thaw, wetting-drying, shrinkage and swelling cycles of the sediment, diagenesis, biological alterations, etc.). In the same way, the behavior towards fire of the tested species should be taken into account (in particular the number of remains). This will eventually permit to model the preservation potential and "quantitative representativeness" of different species.

- In addition, experimental data does not replace a detailed study of the formation and disruption processes of the archaeological site. A good understanding of the taphonomical processes taking place in the archaeological site crossed with a fine knowledge of the behavior of the species (or type of species) will enable a better evaluation of the potential biases when interpreting anthracological assemblages.

CONCLUSION

Compression tests performed on charcoal from ten woody species showed differences in their mechanical strength and modalities of fragmentation.

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* Caution: the present abstract deals with a work which is still in progress. The results are likely to evolve towards slightly different conclusions. Please cite the definitive publication, when available.March 2011.

Charcoal analysis and wood diameter: inductive and deductive methodological approaches for the study of firewood collecting practices

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Summary: *We present and discuss two approaches for evaluating the diameter of carbonized wood. Results from a theoretical model and its experimental validation shows that the proportions of diameter classes predicted by the model can be recognized. Even though the measured caliber classes do not correspond to the reality of the initial diameters, the measures were sufficiently different and reproductive to be discriminated through factorial analysis. These methods are promising for documenting cultural behavior of past peoples related to firewood use and management.*

Key words: *wood diameter, experimentation, firewood management, modeling*

INTRODUCTION

Since several years, societal questions have been central among anthracological questionings. The development of socio-economic approaches has made it possible to focus on topics related to firewood use and management, which document cultural traits (e.g. type of sites, seasonality of occupation, woodland management and its impact on woodland).

This evolution of the discipline was made possible by the development of new tools and grids for reading the anthracological data (Théry-Parisot, 2001; Dufraisse, 2002, 2006; Chrzavzez, 2006; Marguerie and Hunot, 2007; Paradis, 2007; Ludemann, 2008). In this paper, we present recent methodological developments related to the interpretation of the wood diameter estimated.

METHODS

Methods of estimating tree-ring curvature on charcoal fragments are now well established (Paradis 2007; Garcia and Dufraisse, in this volume). However, these measures only indicate that the fragment is situated within a specific zone in the trunk relatively to the pith. Moreover, in a log of a given size, all the diameters (or diameter classes) can be represented (Fig. 1).

Two approaches, one inductive and the other one deductive are proposed to evaluate the size of carbonized wood. The first approach is inductive (Dufraisse, 2002, 2006). It is based on a mathematical model that consists in establishing the proportion of the different diameter classes for different size of logs. The second approach is deductive (Chrzavzez *et al.*, in press). It is based on the postulate that wood calibers can reflect collecting strategies (e.g. tree felling, dead wood gathering or both).

The aim of experimentation was to test the relation between the calibers of wood prior to burning and the caliber classes resulting from the analysis of their charred products. This method is not a direct inference from situation B (measured charcoals) towards A (initial calibers), but relies on the construction of a discriminating statistical model.

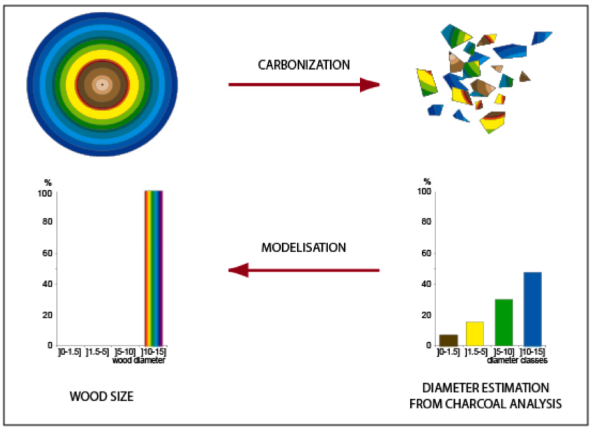

FIGURE 1. Diameter represented in a log (Dufraisse 2002, 2006)

The experiments were conducted in two kinds of structures: (i) in an open fireplace under laboratory conditions allowing limiting the known effects of external factors on the combustion process; (i) in an open-air fireplace, less controllable but closer to the archaeological conditions.

RESULTS

The inductive approach

Experimental studies realized to evaluate the mathematical model indicate that the proportions of diameter classes predicted by the model can be recognized (Chrzavzez, 2006; Paradis, 2007). However, this model has some inherent limits as it cannot correct over-representation of diameter classes. In addition, experimental fires realized with split logs show the absence of the bigger classes.

The deductive approach

In order to verify that charcoal analysis allows discriminating wood batches of different calibers after their combustion, ten experimental combustions of pine wood (*Pinus pinaster*) were undertaken: three fires of big trunk bases (up to 30 cm), 5 fires of medium diameters (10 cm), 2 fires with a complete tree of variable calibers. A total of 4500 charcoals superior to 4 mm were measured with image analysis software. Four classes of calibers have been registered: [0-5 cm], [5-10 cm], [10-15 cm], [> 15 cm]. First, we observed that the results of the replica of a same experiment are comparable. As the profile of the histograms shows, the classes of the measured calibers are represented in the same proportions (Fig. 2). But they don't correspond to the initial diameters of the wood that has been burned. Even though, the measured caliber classes are sufficiently different and reproducible to be discriminated through factorial analysis. This analysis allows discriminating the three experimental batches of wood: small calibers (10 cm), larges calibers (> 30 cm), and the complete tree. This statistical model would allow identifying the calibers of archaeological charcoal.

FIGURE 2. Profiles of histograms from experimental referential.

DISCUSSION AND CONCLUSIONS

Both methods propose a distinct but complementary approach of same phenomena. They both present encouraging results. Nevertheless, these works have been separately developed and the experimental methods have to be homogenized. At present, the experimental referential is enlarged in order to develop a mathematical model including a larger set of situations (ANR DENDRAC, Dufraisse (dir.)).

But the question that remains to consider is how to transpose these results to archaeological samples? Successive archaeological deposits from short-term occupations, fireplace superposing or cleanings and the mixture of charcoal in a same level, tend to interfere with our interpretations. What we regard as the result of one practice is frequently an average representation of multiple practices (Théry-Parisot *et al.*, 2010).

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Assessment of the Holocene fire history of Northern Germany based on various charcoal records, investigated at various spatial scales

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Summary: *The fire history throughout the Holocene was studied for various neighbouring sites in Schleswig-Holstein, northern Germany. Charcoal records from peat sequences with local and regional resolution have been extracted and analysed. Moreover, soil charcoal records sampled on the surroundings of the peat coring places, have been extracted and analysed, providing data in high spatial resolution. Those charcoal records have been quantified, chronologically referenced and compared to each other. Asynchrony of fire signals between the various analysed charcoal records is detected, indicating past fire regime variability, probably in connection to human use of fire.*

Key words: *Fire history, charcoal records, signal spatial resolution, Northern Germany.*

INTRODUCTION

Past fire regime may have had an important impact on the vegetation development, along time, as disturbance event of the ecosystem. Therefore to understand the dynamic of ecosystems it is important to take into consideration the role of past fire occurrences. This has been well investigated for biogeographical domains like Mediterranean areas (Vannière *et al.*, 2008) or Boreal areas (Higuera *et al.*, 2009). But investigation of fire history should not be restricted to ecological systems where fire is described as endogenous factor of dynamics, as natural disturbance event, which is anyway and anywhere an issue of discussion. Only few investigations have been done about fire history in central Europe so far (e.g. Clark *et al.*, 1989; Willis, 2000). And even rarer are the fire investigations dealing with charcoal records from natural archives, specifically analysed, and using recent charcoal records methods (Higuera *et al.*, 2010).

Nevertheless, a general pattern of fire history, at broad scale over Central Europe, has been identified, notably based on charcoal analysis combined with palynological studies (e.g. micro-charcoal counting on pollen slides) providing reliable and important information (Carcaillet *et al.*, 2002; Power *et al.*, 2008).

Based on these investigations, the role of fire occurrence on past dynamics of central Europe ecosystems may be described as considerable. Indeed, despite being less fire sensitive than e.g. Boreal or Mediterranean ecosystems, especially since the mid-Holocene and the establishment of broadleaf woodland, the temperate forest of Central Europe (under oceanic and continental climate) burnt in the past. Human practices (fire ignition and/or fire usage) had played an important role in the past fire regime. Moreover, the increase of fire frequency, since the Neolithic and following the human development, has been identified. This seems to indicate the important anthropic impact on past fire regimes, and consequently on past forest dynamics.

However, the lack of investigations, notably at the local scale, adds to the identified human fire usage 'blurring' the palaeo-records and makes fire history difficult to assess more specifically than the previously general trends. This aspect motivated the research presented in this communication.

METHODS

It has been attempted to reconstruct the fire history on regional and local scale by the analysis of charcoal records from peat sequences of sites with different depositional situation and from different archiving contexts. Comparing fire signal in high spatial resolution (i.e. local scale) to the fire signal in low spatial resolution (i.e. regional scale) may allow identify synchronies and asynchronies in the fire history. This may be a promising approach to formulate at least a hypothesis for the better understanding of the fire palaeo-signal in terms of climate (i.e. more "readable" in low spatial resolution signal) vs. anthropogenic forcing (i.e. more "readable" in high spatial resolution signal).

To investigate and compare precisely low and high spatial resolution fire signals in charcoal records the topographical and geological context of northern Germany provides a relevant and "comfortable" framework, since the young moraine substratum formed a detailed, fine scaled relief variation (i.e. small depressions with lake sediments and/or peat) and also large lakes and peat lands (Nelle and Dörfler, 2008). Therefore, in the northernmost German federal state Schleswig-Holstein, two areas have been selected for sampling. Those include a large open peat land, and nearby small mires in woodland. Moreover, in the surrounding of the cored small mire, soil samples were taken from several soil profiles for soil charcoal analysis.

RESULTS AND DISCUSSION

Peat sequences have been cored with an 'Unsinger piston corer'. From that material, micro- and macro-charcoal records have been extracted and quantified.

From the large mire of 'Kaltenhofer Moor' (Fig. 1) a sequence of more than nine meter length (*ca*. 6.2 m of peat, up to *ca*. 3.4 m of mineral sediment) was cored. The sediment description and the preliminary palynological analysis allows to expect a complete, undisturbed Holocene sediment sequence, providing relevant material to work in high temporal resolution (considering a theoretical linear sediment accumulation/growth, it may be expected a temporal resolution of 13 years per cm along the core). The macro-charcoal analysis, which has been realized so far, indicates that the sequence is quite rich in macro-charcoal pieces allowing postulating regular fire occurrences in the past. Moreover, phases of variable charcoal accumulation value, certainly indicating phases with variable fire frequency, may be observed. This large scale fire signal has been compared to the small scale signal, based on the charcoal record analysed of the small mire peat sequence and to soil charcoal record, both from the Stodthagener forest directly neighbouring the peat bog. These charcoal records allow principally identifying a main fire phase during the Bronze Age, but soil charcoal analysis also allowed identifying fire events during other temporal periods.

FIGURE 1. View of the large peat bog of 'Kaltenhofer Moor' (Picture V. Robin)

This paper aims at the presentation of the methods used in this research project and on the results obtained so far, which however already allow detecting considerable signal variability and asynchrony.

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The ubiquity correction as an alternative method for the quantification of charcoal

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Summary: *The absolute number of charcoal fragments and their relative frequency are the two parameters usually chosen for quantifying taxa in anthracological analysis. Besides, the criterion of ubiquity of taxa in different samples and archaeological features is commonly used (ubiquity analysis). Therefore, a new method that combines these two types of quantification procedures has been devised. This method, called the "ubiquity correction", considers both relative frequency and ubiquity of taxa. In this way, a correction for ubiquity of the relative frequencies of taxa found in different archaeological structures or diverse anthracological samples can be performed. This method also allows verifying if charcoals in various archaeological structures or anthracological samples are uniformly distributed.*

Key words: *methodology, quantification of charcoal, ubiquity correction.*

INTRODUCTION

In anthracological analysis, there are a few methods used to quantify the charcoals. Among these procedures, fragment numbers and weight measurements, together with ubiquity analysis predominate (Chabal, 1988; 1997; Lityńska-Zając, Wasylikowa, 2005). Besides, Chabal (1997) indicated that the results of the fragments' count and weight measurements are highly correlated. Another method was proposed by Kadrow and Lityńska-Zając (1994) and consisted of creating one measurement unit for all the fragments.

This paper presents a new method of quantification of taxa ("ubiquity correction") that combines both relative frequency of taxa based on the absolute number of charcoal fragments and their presence in all samples (*ubiquity analysis*). In this sense, not only the final frequency of taxa in the charcoal assemblage is taken into account but also the distribution of taxa across the samples is considered (Moskal, 2010).

RESULTS AND DISCUSSION

Pits from the Neolithic sites of Polgár-Csőszhalom and Polgár 31 (Hungary) have been used as case studies to test the method (Moskal, 2010). In pit 13, the charcoal fragments come from 7 stratigraphic units/archaeological layers (Table 1). The basis is a usual count of charcoal fragments (N), but the results are presented as relative frequency (%). To obtain the final value of the frequency of a taxon (%U), all its relative frequencies obtained in different stratigraphic units are summed, and then this sum is divided into a total number of stratigraphic units. This can be summarized by the following equation:

$$\%U_t = (a + b + c + d\ldots)/ n$$

In this equation, t is a taxon, while a, b, c, d express its relative frequencies in each stratigraphic unit and n indicates the total number of stratigraphic units. An example that uses the frequencies of hazel shown in Table 1 is presented below.

$$\%U_{hazel} = (3.1 + 2.0 + 1.0 + 5.1)/7 = 1.6$$

In this sense, a mean value of the relative frequency of each taxon is obtained. Also, this method may help to check if the distribution of taxa across diverse stratigraphic units is homogenous. In this case, little discrepancies are observed between relative frequencies obtained from sum of fragments (%) and after the "ubiquity correction" is applied (%U); this means that the same taxa appeared in similar quantities in different archaeological layers (Table 1).

The method can also be applied to different archaeological structures from the same site (Table 2). It is particularly useful when the charcoal assemblages from the entire site are very heterogeneous, as observed in the example from Polgár 31. The differences between relative frequencies based on sum of fragments (%) and after the "ubiquity correction" is used (%U) may confirm that the distribution of taxa at the site varies considerably. Also, it reduces the overrepresentation of some taxa. This may be observed in the case of *Frangula alnus*, which had a large number of fragments only in one of the archaeological pits (Table 2).

CONCLUSIONS

The "ubiquity correction" method (%U) should be usually compared with the relative frequency of taxa (%). If both final values are correlated, the distribution of taxa is rather regular in different units of investigation (samples, archaeological layers, features, etc.). In the opposite case, the correction acts as a homogenization method providing mean values of percentages of taxa. Moreover, this method may serve for the charcoal assemblages characterized by overrepresentation of some taxa.

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POLGÁR-CSŐSZHALOM	**PIT 13**														
STRATIGRAPHIC UNIT	**388**		**433**		**434**	**463**		**492**		**497**	**681**		**TOTAL**		
TAXA	**N**	**%**	**N**	**%**	**N/%**	**N**	**%**	**N**	**%**	**N/%**	**N**	**%**	**N**	**%**	**%U**
Acer sp.		0		0			0	1	1.0			0	**1**	**0.1**	**0.1**
Acer sp. cf. *A. campestre*	1	1.0		0			0		0			0	**1**	**0.1**	**0.1**
Cornus sp.	1	1.0	22	23.4	8	14	9.5	6	6.3	2	5	4.2	**58**	**7.7**	**7.8**
Corylus sp. cf. *C. avellana*	3	3.1		0		3	2.0		0	1	6	5.1	**13**	**1.7**	**1.6**
Euonymus sp.		0	1	1.1			0		0			0	**1**	**0.1**	**0.2**
Fraxinus sp.		0		0			0		0	13		0	**13**	**1.7**	**1.9**
Quercus sp. deciduous	65	66.3	39	41.5	78	124	83.8	62	64.6	75	82	69.5	**525**	**69.6**	**68.4**
Populus sp.		0		0			0		0		2	1.7	**2**	**0.3**	**0.2**
Populus sp./*Salix* sp.		0		0			0	2	2.1		4	3.4	**6**	**0.8**	**0.8**
Prunus sp.		0	2	2.1			0	1	1.0		1	0.8	**4**	**0.5**	**0.6**
Salix sp.	1	1.0		0			0		0	1	1	0.8	**3**	**0.4**	**0.4**
Ulmus sp.	25	25.5	20	21.3	11	2	1.4	19	19.8	7	8	6.8	**92**	**12.2**	**13.2**
Viburnum sp.		0		0		1	0.7	3	3.1	1	1	0.8	**6**	**0.8**	**0.8**
Viburnum sp./*Cornus* sp.		0	3	3.2	1	3	2.0	2	2.1		1	0.8	**10**	**1.3**	**1.3**
Maloideae	2	2.0	7	7.4	2	1	0.7		0		7	5.9	**19**	**2.5**	**2.6**
SUM	**98**	**100**	**94**	**100**	**100**	**148**	**100**	**96**	**100**	**100**	**118**	**100**	**754**	**100**	**100**

TABLE 1. Results of the absolute (N), relative frequency (%) and relative frequency corrected for ubiquity (%U) from pit 13 of the Polgár-Csőszhalom site.

POLGAR 31	**PITS**												
N. OF STRUCTURE	**52**		**733**		**769**		**860**		**862**		**TOTAL**		
TAXA	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**%U**
Frangula alnus	25	22.3		0		0		0		0	**25**	**8.4**	**4.5**
cf. *Frangula alnus*	11	9.8		0		0		0		0	**11**	**3.7**	**2.0**
Pinus sylvestris		0	1	3.7		0		0		0	**1**	**0.3**	**0.7**
Cornus sp.	21	18.8		0		0		0		0	**21**	**7.1**	**3.8**
Corylus sp.	2	1.8		0		0		0		0	**2**	**0.7**	**0.4**
Fraxinus sp.	37	33.0	1	3.7	1	1.9	1	7.1		0	**40**	**13.5**	**9.2**
Prunus sp.		0		0	5	9.6		0	4	4.4	**9**	**3.0**	**2.8**
Quercus sp. deciduous	3	2.7	17	63.0	25	44.2	9	64.3	80	87.9	**132**	**44.6**	**52.4**
cf. *Rubus* sp.	5	4.5		0	10	19.2		0		0	**15**	**5.1**	**4.7**
Salix sp./*Populus* sp.		0		0	2	3.8		0		0	**2**	**0.7**	**0.8**
Ulmus sp.	5	4.5	4	14.8	9	17.3	2	14.3	7	7.7	**27**	**9.1**	**11.7**
Maloideae		0		0	2	3.8				0	**2**	**0.7**	**0.8**
Monocotyledon	3	2.7	4	14.8			2	14.3		0	**9**	**3.0**	**6.4**
SUM	**112**	**100**	**27**	**100**	**52**	**100**	**14**	**100**	**91**	**100**	**296**	**100**	**100**

TABLE 2. Results of the absolute (N), relative frequency (%) and relative frequency corrected for ubiquity (%U) from Polgár 31.

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Dendrochronological study of charred wood at the Cerro Pintado archaeological site (Patagonia, Argentina)

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Summary: *In this work we present the dendrochronological analysis of charcoal from* Austrocedrus chilensis *– cipres de la cordillera – found in a campfire at the archeological site Cerro Pintado in Patagonia, Argentina. Our goals, in the context of a series of studies in Patagonian archaeology, were to compare the charcoals from the campfire with the existing chronologies and to present, based on dendrochronological methods, precise dates for the studied charcoals. Our study represents the first attempt of dating archaeological charcoals using dendrochronological methods in Patagonia.*

Key words: *dendrochronology, charcoal, hunter-gatherers, Patagonia*

INTRODUCTION

In the Patagonian archeological records, the conservation of wood only occurs in exceptional cases. There have been no studies from dendrochronological perspective of the structure of combustion in the eaves or in the open air, where the environmental conditions do not facilitate the wood conservation.

Dendrochronology is the dating of growth rings from woody tree species (Schweingruber, 1996). The comparison between tree rings and climatic records permit the reconstruction of past variations in temperature and/or precipitation. The study of the growth rings in tree species permits us to detect the occurrence of past human activities such as the systematic pruning of branches, which belong to the field of dendroecology. The study of dendrochronology applied on specimens of charcoal found in archeological sites provides a wealth of information, which complements socioeconomic and paleoecological data obtained through conventional charcoal analysis (Carrión, 2003).

In this paper, we present the results of a dendrochronological analysis of charcoal collected in a stove found in a hunter-gatherer archeological site, Cerro Pintado. The objective of the investigation was to initiate studies in the context of Patagonian archeology to date charred wood against master chronologies previously developed for the region. Dating of charcoal will allow inferring past climatic conditions, which existed at the time that the hunter-gather tribes occupied this zone.

DATA AND RESULTS

The archeological site "Cerro Pintado" -42°25´07´´ S and 71°30´34´´ W-, located in the Province of Chubut, Patagonia, Argentina, is situated in an area covered by a mixed forest of *Austrocedrus chilensis* – ciprés de la Cordillera – and *Nothofagus antarctica* – ñire- (Fig. 1). Due to the low rate of deposition of sediments as shown by the low power and low stratigraphic gap between the dated samples (28 cm in approximately 1500 years), and lack of clear stratigraphic levels, the deposit of Cerro Pintado site represents a palimpsest with very low resolution within a time range between 680±60 BP and 1870±80 BP (Bellelli *et al*., 2003).

The state of the combustion structure allowed the recuperation of three fragments of charcoal from the campfire base, radiocarbon dated to 1870±80 BP. The charcoals, identified as *Austrocedrus chilensis*, were dendrochronologically dated. *A. chilensis* is a conifer well-studied in the field of dendrochronology (Villalba and Veblen, 1997, amongst others). It has provided numerous chronologies, which may be used in the future for successive dating of archeological charcoal from this particular species.

Following the dating and measuring of the growth rings from the 3 specimens of charcoal, 4 series were generated, one from each fragment (CP001, CP002, CP003) and an additional series (CP002-03) as a result of the average of CP002 and CP003 time series. By applying the program COFECHA, it was noted that the series CP002 and CP003 cross-dated perfectly after an 8-year displacement in series CP002 in relation to the series CP003, was applied (Fig. 2, left). The correlation reported by COFECHA between these two series is r= 0.714 during the common period. In the case of series CP001, the synchronization was not as precise as that between CP002 and CP003. Due to the fact that series CP001 is very short, problems arose from the dating of this piece of charcoal. With the exception of series CP001, series CP002, CP003 and CP002-03 compared well with a regional chronology, given a correlation coefficient of the order of r= 0.60, during the period 1730 – 1780 AD, which represents a considerably significant value ($p < 0.01$). This leads us to propose that the 2 charcoal fragments of the series CP002-03 cover the period 1733-1785 AD.

FIGURE 1. Left: Archeological site Cerro Pintado, Right: Austrocedrus chilensis *tree.*

CONCLUSION

The dendrochronological dating of charred wood represents an innovative analysis of archeological sites in Patagonia.

The results are not consistent with the radiocarbon dating of the base of the fire (1870±80 BP); this could be due to the formation processes of the archaeological record of Cerro Pintado. The natural and anthropogenic disturbances of the record, coupled with the low rate of sediment deposition, suggest the possibility that the analyzed coals do not belong directly to the campfire base.

Since there are tree-ring reconstructions of temperature and precipitation for the past centuries in the region, they will be used in the future to characterize the climate variability at times of human occupation in Cerro Pintado.

The dendrochronological study shows that the two coals studied cover the period 1733-1785 AD. Presently, logs of *Austrocedrus chilensis* containing rings from this interval have, on average diameters larger than 50 cm, ruling out the possibility that these charcoals belong to current campfires found on the surface of the archaeological site.

To solve the inconsistency between radiocarbon and dendrochronological dates we will conduct radiocarbon dates of the charcoals dated by dendrocronology. This information would corroborate the dendrochronological dates and provide additional information regarding the use of Cerro Pintado archeological site.

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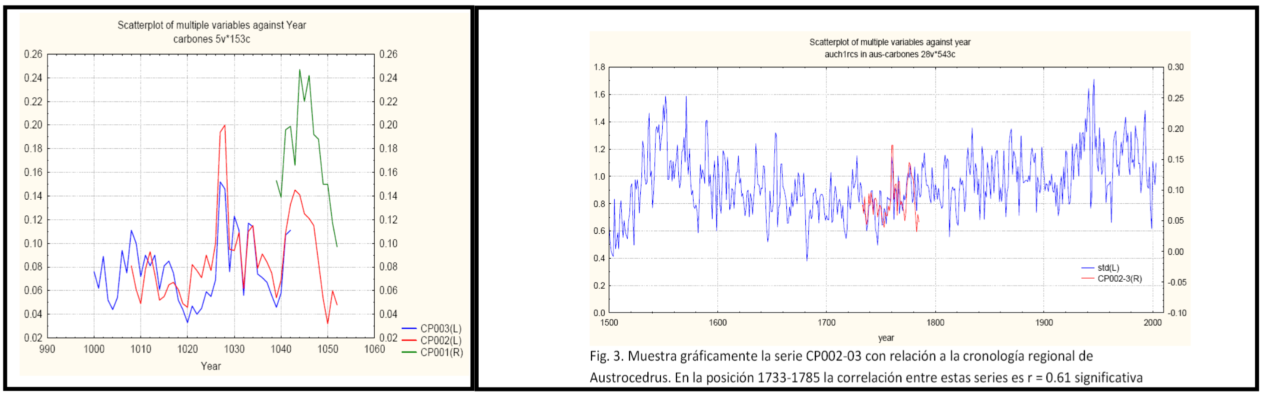

FIGURE 2. Left: Comparison between the 3 series[1]. Right: Graph showing the series CP002-03 with relation to the regional chronology of Austrocedrus chilensis *([1]The year 1000 does not correspond to the actual test date, but was used simply as a random date by which to run the programs).*

Experimentation and combustion properties of Patagonian Andean forest (Argentina)

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Summary: *The information on the combustible properties of native species of the Andean Patagonian Forest is scarce. In research paper we present the results of eight experimental fires, with their analysis and interpretation of shrinkage cracks produced in the wood of two conifers of the southern hemisphere:* Austrocedrus chilensis *and* Fitzroya cupressoides*.*

Key words: *experimentation, Andean Patagonian Forest, Argentina*

INTRODUCTION

With experimentation, is possible to describe the quality that the woody species have as fuel (combustible), and to understand their behavior during combustion (Bazile-Robert, 1982; Théry-Parisot, 2001; Théry-Parisot and Costamagno, 2005). The experimental design, allows the investigator to have a more precise knowledge on the studied phenomenon. Nevertheless, the experiment has certain limitations regarding the difficulty of reproducing the past situations in an identical way

The information about combustible properties of the native species of the Patagonian forests is scarce. The objective of this research paper is expanding our knowledge about the combustible properties of four native species of the Andean Patagonian Forest: *Austrocedrus chilensis* ("Ciprés de la cordillera"), *Fitzroya cupressoides* ("Alerce"), *Nothofagus Antarctica* ("Ñire") and *Nothofagus dombeyi* ("Coihue"). The method used in this investigation is as follows: The combustion was made with green and dry wood of each one of the species and the study and interpretation of shrinkage cracks of the remaining charcoal.

Later one we will develop the experimentations, analysis and interpretation of shrinkage cracks produced on the wood from two species mentioned before: *Austrocedrus chilensis* and *Fitzroya cupressoides*. The *Nothofagus* species are on the final process of experimentation.

DATA AND RESULTS

We realized a total of eight controlled combustions, half of them with wood of *F. cupressoides* and the remaining ones with *A. chilensis*. Each group of each species bonfires was divided in half and made with dry wood and fresh cut wood (green).

The eight combustions were realized under controlled laboratory conditions. All fires were made following a strict protocol. The tree branches were measured and weighed before and after combustion. Temperature, duration of flame and time of the total combustion were registered during the whole process for each one of the controlled combustion (Table 1).

The scars in the remaining charcoal that characterize the kind wood used for the combustion were analyzed using "Image pro-plus" image analyzer software. Over the transverse plane of the charcoal we quantified shrinkage cracks on 25 charcoals extracted from each of the eight fires, therefore a total of 200 charcoals were analyzed.

Experimental fires	Max Tº	Combustion duration	Flame duration	Ashes (in g)
F. cupressoides (DW) 1	583º	1.47hs.	45 min.	37,56
F. cupressoides (GW) 2	522º	1.30hs.	12 min.	15,86
A. chilensis (DW) 1	497º	1.14hs.	25 min.	18,67
A. chilensis (DW) 2	488º	1.20hs.	28 min.	15,26
A. chilensis (GW) 2	464º	1.26hs.	13 min.	19,68
F. cupressoides (DW) 2	459º	1.38hs.	31 min.	18,21
F. cupressoides (GW) 1	441º	1.20hs.	13 min.	55,7
A. chilensis (GW) 1	426º	1.58hs.	12 min.	18,14
(DW) Dry wood (GW) Green wood		1-2: replicate		

TABLE 1. Data obtained from our combustion experiments.

The total combustion time reached by the fires was 1.30 to 2 hours (approximately). Dry wood of *F. cupressoides* reached the highest temperatures (583ºC), while the lowest was registered using green wood of *A. chilensis* (426ºC). The flame length was higher when dry wood was used, opposite to the fires with green wood (see Table 1).

All the charcoal obtained shown contraction cracks. The variable humidity becomes evident in the charcoal resulting from the eight bonfires. The green wood combustions delivered charcoals with more contraction cracks than the ones made with dry wood. The highest temperature reached during the combustion does not infer to have direct relationship to the amount of contraction cracks observed in the charcoals obtained from the wood of both Patagonian conifers.

CONCLUSION

This stage of development of the experimentation allowed us to know the some properties of native Andean coniferous of the Patagonian Andean Forest used on combustions.

The combustion length, does not infer to have a relationship with the different species used in the experimental bonfires.

All combustions made with fresh cut wood had coals with a higher number of shrinkage cracks compared to the ones from dry wood. As an example an *A. chilensis* green wood bonfires generated 17 % shrinkage cracks opposite to the 6 to 9 % obtained from dry wood.

A relationship between the shrinkage cracks and the highest temperature reached during the combustions was not achieved during the analysis of the obtained coals from *A. chilensis* as well from *F. cupressoides*. However the deeply development of this topic will be restarted, once we conclude the experimental analysis of *Nothofagus antarctica* and *Nothofagus dombreyi* wood. We will deepen in our knowledge working with more dry and green *Nothofagus* wood combustions.

These experiments will allow us to finally found and interpret charcoal indicators of combustible properties on these four native species of the Andean Patagonian Forest - *Austrocedrus chilensis, Fitzroya cupressoides, Nothofagus Antarctica* and *Nothofagus dombreyi*-.

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FIGURE 2. From left to right, the different stages of the combustion experiment

Evaluating methods and results for the application of anthracology to high diversity and high endemism environments: Case study in the Tiwaka Valley, north-eastern Grande Terre of New Caledonia

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Summary: *Although anthracology is nowadays extensively involved in archaeological projects conducted in temperate or dry areas, applications in tropical environments remain rare. Indeed, in such places, anthracologists are facing highly peculiar and diverse flora, as well as poor or inexistent wood anatomy resources which they often have to create themselves. This paper aims at discussing a recent PhD research that applied anthracology to New Caledonia for the first time, as an integrated approach with archaeological analysis of precolonial Kanak landscapes. The strategies and methods used, from sampling to taxonomical identification, will be evaluated. The levels of identification, ratio of unidentified/identified and ecological representation/diversity of the assemblages will be discussed.*

Key words: *Anthracology, tropical environment, archaeology, reference collection, methods.*

INTRODUCTION

Although the methodological developments of anthracology have triggered a diffusion of the discipline in various parts of the world, applications in tropical environments have remained few. The main area where such a work has been realised is Brazil, where R. Scheel-Ybert has been conducting several anthracological research projects (Scheel-Ybert, 2002). In the Pacific, apart from the work of C. Orliac on Rapa Nui, palaeoenvironmental or archaeobotanical studies are mainly produced through palynological research, and they remain a domain to be promoted in the regional archaeology. This is especially true for New Caledonia (South-West Pacific), where our PhD research program was hence set.

DATA AND RESULTS

The first phase of the program was the construction of a wood reference collection on New Caledonia (Dotte-Sarout, 2010; Dotte *et al.,* 2010). Each wood sample was accompanied by a herbarium voucher, and three collections were created to be kept in the three laboratories involved in the project (Paris I-Sorbonne University, now UMR 7209; Australian National University; Institute of Archaeology of New Caledonia and the Pacific). Each wood specimen of the 142 taxa sampled was then charred under controlled conditions and observed under a reflective light microscope, as well as with an SEM when needed, in order to describe the anatomical features of the wood. This information was systematically compiled within a searchable database (under file maker-pro) that also contains pictures of each of the three anatomical sections for each taxon (Dotte-Sarout, 2010).

Given the high diversity an endemism level of the New Caledonia Flora (more than 3.200 indigenous species of vascular plants with 77% endemic), we followed a specific strategy to determine priority taxa that should be included in a first, partial, but most pertinent possible reference collection. Botanical inventories were associated either with botanical sampling or archaeological surveys that aimed at characterizing vegetation types around pre-colonial kanak sites. Systematic lists of species present were made on and around six archaeological sites located in our region, and their analysis integrates general observations made during archaeological surveys and excavations throughout Northeastern Grande Terre. This fieldwork was coupled with a study of botanical references about trees and forest species as well as ethno-botanical and archaebotanical records (Dotte-Sarout, 2010). This enabled us to list 220 taxa to look for in priority during our samplings for the reference collection, defined as: the most widespread species or genus in our region of research; the “leading” species most representative of the main vegetation types; the most important “social” species within the kanak socio-cultural system; and the principal Pan-Pacific species, either “indigenous” or “introduced”.

The ecological representation of the collection and database was then evaluated. It appears to be in accordance with the main ecological conditions found in alluvial valleys of Northeastern Grande Terre: containing 65% of rainforest associated species and the remaining 35% equally divided between species related to wetlands and coastal formations, ruderal or anthropogenic vegetation types, and dry forests (Dotte-Sarout, 2010). Within this general frame, the collection presents a strong emphasis on anthropogenically related plants, regardless of their ecological affiliation. As a result, and in relation to its archaeological and socio-cultural focus, the collection offers an over-representation of non-endemic species: almost half of the taxa have a pan-Pacific distribution.

Archaeological excavations and systematic anthracological sampling on pre-colonial kanak settlement sites constituted the second phase of the research. Test pits were dug on three settlement mounds, from three different kanak precolonial sites, and all sediment excavated was collected. The sediment was then wet-sieved directly in a nearby river and charcoals fragments were hand-picked (>2 mm and >4 mm samples), while flotation revealed to be inefficient due to the clayous nature of the sediment. Referring to previous works in the tropics or in pedo-anthracology (Scheel-Ybert, 2002; Delhon, 2006), our aim was to gather at least 400 fragments to be analysed for each archaeological level, and 100 for non-archaeological levels. This method, together with the use of two other techniques to control ecological diversity, guaranteed that our anthracological assemblages were ecologically representative and our results coherent; especially in the case of a new, inevitably incomplete, reference collection. First, the species-area curves (or taxa-fragments curves) were constructed for each assemblage. Even though they showed a regular and continuous increase in taxonomic diversity (1 new taxon every 3 fragments observed in average), there is a recurrent slackening plateau between 100 and 120 fragments. Second, Pareto Indexes calculated for each assemblage are comprised between 25/75 and 29/71, which can be considered good in relation to the reference of 25/75 calculated for tropical environment by R. Scheel-Ybert (2002). Only two low indexes exist (32/68, 36/64) and are associated with non-archaeological levels from a very diverse environment gathering forests, mangroves and riverine as well as coastal floras. Nearly 2400 fragments were analysed and 2/3 of them identified, (more than 50% down to the genus level at least), which represented 136 different taxa. Unidentified taxa gather 70 different types, most of them being rare taxa only represented in one assemblage and by one or two fragments only. These results showed that the anatomical database and strategic choices made for the constitution of the reference collection were efficient and coherent with our archaeological focus. Moreover, the most frequent taxa of each assemblage were always identified except in the case of one unidentified type, present in 3 of the 8 assemblages in proportions of 0.3% to 9.4% of the identified taxa. 9 taxa were found in more than half of the assemblages, most of the time showing the highest occurrence in proportions of fragments, ranging from 2 to 13% by assemblage in average. All unidentifiable fragments encountered in our samples were either too reflective (vitrification process during burning) or coming from distorted wood parts (knots, etc). The main problems faced for the identification of the charcoal fragments, all due to the very incomplete state of our reference collection in regard to the high diversity of the local flora, were:

- The absence of many rare, endemic species, genus or even families, from our database,
- The question of unknown inter-specific anatomical similarity, requesting more species to be collected and described,
- The problem of intra-specific and individual anatomical variability, requesting several reference samples of the same species from different environment/plant parts to be compared
- The archaic or irregular aspect of the wood anatomy of many tropical/island species, requesting large archaeological charcoal fragments to be observed for variable characteristics to be determined.

DISCUSSION AND CONCLUSION

It is clear from the general coherence of our results that anthracology is a pertinent and promising approach for New Caledonian archaeology. This research also constitutes one more example of the relevant applicability of anthracology in tropical contexts, resulting directly in the creation of a new regional wood atlas. However, several problems arise, all linked to the difficulty of creating rapidly – within a typical research program timeframe of 3-4 years – a reference collection and a database gathering the anatomical description of each taxon collected. Here, we showed how we tried to overcome these difficulties, by defining strategic taxa to be sampled and described, and then by controlling the representativity of our collection as well as of our anthracological assemblages. Still, the main way to secure identifications and interpretations of anthracological samples remains the continuous extension of the reference collection and attached wood atlas. It also implies the acknowledgement that some identification, tentative (cf., family levels) or apparently sure, may be questioned by future descriptions of anatomical variability discovered with the improvement of the reference collection. We believe that such risks can be managed by paying attention to the ethnobotanical, ecological and archaeological context of the anthracological results, in order to control as much as possible the interpretations proposed.

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Wood and charcoal anatomy: Problems and solutions

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Summary: *Anthracology is a part of wood anatomy. The contribution presents possibilities, problems and their solutions for the analysis of charcoal. Careful sampling and the assessment of the overall findings are essential for the interpretation of the results.*

Key words*: wood anatomy, anthracology, archaeobotany, mining*

INTRODUCTION

Very early in the evolution wood was already in use. Animals used it to build nests and the use of branches for digging and poking is known. Right from the beginning of the emergence of the first humans wood demands our attention: the spears from Schöningen in the Landkreis (county) of Helmstedt are the oldest completely preserved hunting weapons of *Homo erectus* so far known and could be about 400,000 years old. The outlines of wood constructions of simple dwellings in Bilzingsleben have been dated to the same period. Yet charcoal has a far better chance of preservation than wood. Charcoal remains from forest fires are found from periods of many millions of years, long before the appearance of the hominids, who left their mark in the form of charcoals as evidence of their use of fire.

MATERIAL AND METHODS

According to the 'Hochschule für nachhaltige Entwicklung Eberswalde' 25,000 to 30,000 wood species exist worldwide. About 5000 of these species would be suitable for commercial use, but only about 1000 are actually traded. 200 to 300 wood species are of commercial importance and for these there are also identification keys available. Therefore, it is obvious that there is often a need to identify wood and wood remains. This seems plain and easy at first, but we soon realise that in this task we are often faced with almost unsolvable problems. Both wood and charcoals have a structure that is specific for the species. There are techniques to make this structure visible: by looking at splitting or breaking surfaces, thin cuts, microphotos or REM images of such samples. For this you need sample collections or good pictures of wood specimens.

In many identification keys there are images taken from just one example. This is not sufficient at all because the structural variability inside one single tree can be great. Differences in the structure of one individual can be greater than between two species from the same family. As there are often only few fragments of charcoal available, there can be no statistical assignment of microfeatures, as it can be done with present day material for comparison.

FIGURE 1: Hippophae *sp. from Tibet. Destroyed structure from the carbonization process.*

The state of the charcoal is vital for the chances of identification. Wood that has been optimally carbonized shows the microfeatures as clearly as a good sample of present day material. Depending on the processes of carbonization, the deposition in the sediment and the accompanying geological and soil chemical processes, structures can be destroyed, changed or overlaid (Fig. 1 and 2). Depending on temperature and available oxygen as well as the composition of the wood, different carbonisation can generate different charcoals. Slow burning of resin rich woods can often lead to a glassy amorphous mass almost without structures, where very tiny parts with identifiable structures can only be found with difficulty. Salts that have been dissolved in the sediment can cristallize inside empty cell spaces and through an increase of volume cause the charcoals to burst. Deposits in vessels and tracheids overlay fine structures and so often prevent us from recognizing diagnostically important features. There are chemicals that can sometimes remove such deposits successfully. But this has to be done with great care, as the fragile charcoals can easily be destroyed.

Carbonized woods can also be used for dendrochronological dating if a sufficient number of tree-rings are available. Possibly one of the most famous pieces of charcoal in this context is the charred log, labeled HH39, found in the settlement of Showlow in Arizona. On June 22nd, 1929, Andrew E. Douglass became convinced that this log closed the gap between the absolute and the floating chronologies. Immediately the famous cliff-dwellings of Mesa Verde and 40 other settlements could be dated absolutely! In alpine regions, for example, preserverd charcoals have often been found that had a connection with mining and smelting processes. In many cases these charcoals show very narrow rings. To be able to measure these rings, thin sections from these charcoals could be cut with a diamond-wire saw.

CONCLUSIONS

The analysis of charcoals produces data for the history of climate and vegetation and fire events and can provide information about the uses of wood. With careful sampling it can provide evidence for a selective use of wood species for building and tool making. The remnants also allow us to identify different crafts and techniques according to the selection of wood species and different burning temperatures.

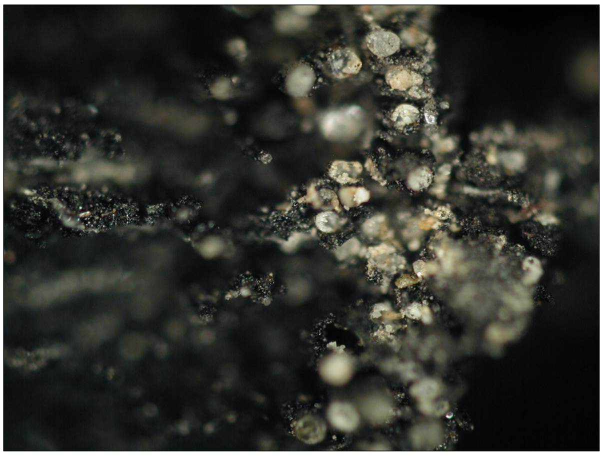

FIGURE 2: Destroyed structure caused by minerals in vessels. Hippophae *sp., Tibet.*

Archaeological charcoal from the African Rainforest. Describing and defining wood types from a diverse environment

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Summary: *Identification of charcoal from species-rich woody environments like the African rainforest is difficult. Obstacles to be encountered are the sheer number of woody species in the region, many of them with similar wood anatomy, and the fact that the wood of many species has not been described yet. To put identifications from regions like these on a sound base, detailed descriptions of charcoal types and discussions on the reliability of their identifications, need to be published and discussed within the scientific community.*

Key words*: charcoal identification, wood types, rain forest, Cameroon*

INTRODUCTION

Our aim is to reconstruct the woody vegetation of the last 2000 years around the site of Dibamba, close to Douala, Cameroon (Oslisly *et al*., 2008). However, using archaeological wood charcoal from the rainforest as a palaeoenvironmental archive entails some problems brought about by the high diversity of woody species.

For West Central Africa there have been some publications referring to charcoal or wood analysis from the end of the 1980s onwards. All of these publications, including our own, have shortcomings. Often information on the data is missing, as for example the number of samples and/or the number of fragments counted. Sometimes it is not clear who actually analysed the charcoal fragments, and often descriptions and/or illustrations of identified types are not included. Consequently, it is not possible to comprehend the identifications and to evaluate the interpretations.

The missing documentation of wood types is an issue, because generally accepted wood types are not established for Central Africa. There are wood anatomy atlases (Normand, 1950-1960; Lebacq, 1955-1963) published before the standardization of features for identification (IAWA Committee, 1989) while IAWA-standard descriptions of some timbers of 25 important timber-containing families have been published recently (Louppe *et al*., 2008; Inside wood, 2004-onwards). Nevertheless, let alone that many taxa are not described anywhere, those that are described are not evaluated concerning diagnostic characters and similarities to other taxa.

These evaluations are important for wood and charcoal identification, because not all characters are useful in the same manner. Some vary within one species (intraspecific variability) and not every species has a distinct wood structure that separates it from all the other species present in the study region (interspecific similarity). In view of these difficulties, it would be important to know, how one can manage to identify charcoals from the African rainforest to species level - as it has been done in the past.

Within this project, designed to identify human impact onto the rainforest of coastal West Central Africa from the Iron Age to colonial time, we have started to tackle the matter of putting identification in West Central Africa on a sound base. As identification is part of the "archaeo/anthracological filter" (Théry-Parisot *et al*., 2010) and may bias the results of the anthracological reconstruction, it is important to start to establish a sound base of wood types described in detail. Results will not be comparable as long as their base is not disclosed.

DATA AND RESULTS

Charcoals from four pits at Dibamba 1 have been screened. Every fragment has been shortly described. Wherever a type was recognized, pictures were made with a SEM. Extended depth of field images were taken after the acquisition of a motorized incident light microscope and multi-focus software. Fragments were grouped according to similarities and the name of a taxon of whichever possible level was assigned to them – provided that taxa with similar wood structure were found in the reference collection or were found to be described in the reference literature.

DISCUSSION

Some wood types it is quite easy to identify and to assign a taxon to them, especially if they have specific characters, like for instance oil-cells, that are not very common. Other wood types propose larger difficulties, e.g. woody types belonging to Fabaceae s.l. or Euphorbiaceae. They are not easily assigned to taxa at a lower taxonomic level than family.

CONCLUSION

An open discussion concerning the identification of charcoals from the African rainforest is needed. It would be desirable that those few anthracologists working in this region share their knowledge and openly discuss the wood types that they have recognized in their assemblages.

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The multipurpose date palm "tree": anatomical identification of modern palm stems and practical application in the archaeological site of Madâ'in Sâlih (Saudi Arabia)

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Summary: *Anatomical characterization of modern palms enables to identify various genera of palms and the different parts of these plants: stem, petiole, lamina and root. Practical application of this anatomical study is employed for the first time at the archaeological site of Madâ'in Sâlih (Saudi Arabia) where charred plants have been found in domestic contexts dating from at least the 2nd century BC until the 7th century AD. Date palm (*Phoenix dactylifera *L.) dominates the assemblage. More petiole remains than stem fragments are testified. Some date palm root and leave remains are also present. These results will be discussed in a large perspective including literary sources and ethnographic observations in order to underline the management of the palm grove and the various uses of the date palm during Antiquity.*

Key words: *Palm, stem, anatomy,* Phoenix dactylifera *L., archaeology. Madâ'in Sâlih*

INTRODUCTION

Since Prehistory the date palm (*Phoenix dactylifera* L.) has played an important role in the economies of the hot deserts of the Middle East. Cultivated for its numerous useful products (fruit for food and fodder; leaves for covering and basketry; fibres for ropes and "wood" for construction and fuel), the date palm also constitutes the main species of oasis agrosystems. Besides seeds, carbonized fragments of ground and vascular tissues are commonly found at archaeological sites in the Arabian Peninsula (Lombard and Tengberg, 2001). Until now they were identified taxonomically without considering if they came from the palm stem or from the woody leaf base (petiole). Yet, the differentiation is important in order to understand practices of date palm exploitation and management of date palm gardens in the past. In this paper we suggest a method for distinguishing between the different parts of the palms on the basis of morpho-anatomy. This method is applied to material from Madâ'in Sâlih (northwest Saudi Arabia) (Fig. 1) and is interpreted in terms of plant use and fuel economy.

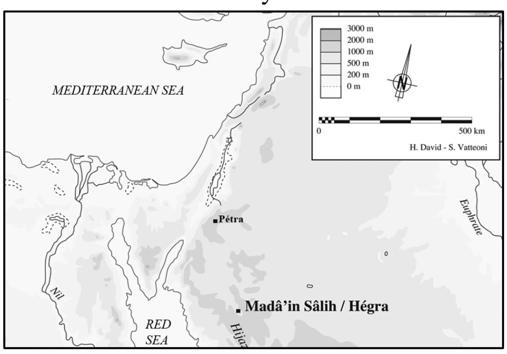

FIGURE 1. Location of the site (after H.David and S.Vatteoni)

ANATOMICAL STUDY OF MODERN SAMPLES

The main descriptors that discriminate palm petioles and stem are based on the fibrous vascular bundles (fvb) (Tomlinson, 1961). Those of the petiole (and thus of the leaf) are made of a well-developed ventral fibrous part (under xylem) and a dorsal fibrous part (above phloem) (Fig. 2D). At the level of the metaxylem, discontinuity between these two fibrous parts is always prominent. Those of the stem have a well-developed dorsal fibrous part. A ventral fibrous part could exist for some genera but is only made of few fibre cells or sclerenchymatous parenchyma cells and it is not as prominent as that of the petiole (as for *Phoenix* L.). Within the stem, discrimination between some genera is possible (Thomas, 2011; Thomas and De Franceschi, *submitted*). Only *Phoenix* and *Hyphaene* Gaertn. are endemic to northwest Saudi Arabia (Fig. 2) (Dransfield *et al*., 2008) with a possible presence of *Nannorrhops* H.Wendl. Fig. 1 A–C shows the differences between their stem fvb.

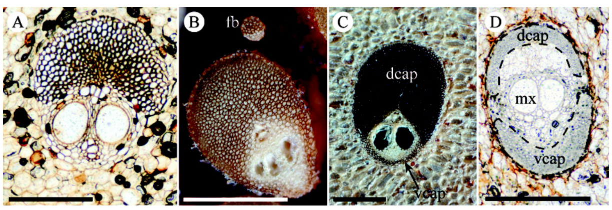

*FIGURE 2. Transverse sections of Fibrous vascular bundles (fvb). **A**. Stem fvb of* Hyphaene thebaica *without vcap and with a Reniforma dcap. **B**. Stem fvb of* Nannorrhops ritchieana *with Reniforma to Lunaria dcap and with an isolated fb. **C**. Stem fvb of* Phoenix dactylifera *with a Vaginata fibrous part (fibres cells all around the fvb). **D**. Petiole fvb of* P. dactylifera *with a small dcap and a well-developed vcap, these two fibrous caps are interrupted at the level of metaxylem (mx). Key to labeling: dcap: fibrous dorsal cap, fb: fibrous bundle, mx: metaxylem, vcap: fibrous ventral part. Scale bar: A–D: 500 µm.*

THE ARCHAEOLOGICAL DATA

The French-Saudi Arabian archaeological and restoration mission of Madâ'in Sâlih started in 2008, directed by Laïla Nehmé (CNRS), Daifallah al-Thali (Saudi Commission for Tourism and Antiquities) and François Villeneuve (University of Paris 1).

Madâ'in Sâlih, the antique site of *Hegra*, is located in a wide desert plain surrounded by mountains (Fig. 1). Arid conditions (± 50 mm of mean annual precipitation) are attenuated by mountain runoff that supplies subterranean groundwater. Today, the natural vegetation is composed mainly by open thorn scrublands.

The site was occupied at least between the 2nd century BC and the 7th century AD. Numerous rock-cut monuments underline various funeral and cultic areas. The excavation of the residential area located in the middle of the town has revealed dense domestic occupations. 1509.8 liters (145 samples) of sediment from fireplaces, refuses and destruction layers were processed by flotation. Palm fragments represent 30% to 50% of the total of wood observed per zone and period. Date palm fruit and seeds dominate the seed assemblages. Among the cultivated plants of the seed or wood corpus, others fruit trees (*Olea europaea* L., *Punica granatum* L., *Vitis vinifera* L.), annual crops (*Triticum aestivum*/*durum* L., *Hordeum vulgare* L., *Lens culinaris* Medik., *Medicago sativa* L.) and textile plants (*Gossypium* sp.) were also identified. Charred seeds and wood of wild plants as *Acacia* spp., *Tamarix* sp. and the *Chenopodiaceae* family are abundant (Bouchaud, 2010).

RESULTS AND DISCUSSION

The observation of specific anatomical criteria on the palm archaeological fragments allows distinguishing petioles, stems, *lamina* and roots. Petioles dominate the palm assemblages. Stem remains are abundant only in few contexts. Root and leaf fragments appear also but in less extend, maybe because of their fragility to fire. Only *P. dactylifera* species was identified among the archaeological stems.

We can assume that date palms were grown during all periods of occupation. This hypothesis is supported by archaeological survey that has revealed agricultural spaces outside the residential area irrigated from wells (Courbon, 2008). Date palm was probably the main crop, cultivated with others species mentioned above.

The dominance of petiole fragments may have resulted from the maintenance of palm groves, notably the pruning practices, as it is shown in ethnographic examples (Battesti, 2005) and classical literary sources (Theophrastus, 1842: II.6.4). Indeed, stems are less likely to be cut.

Use of the date palm as building material seems to be underlined in some destructions layers. Most of the archaeological contexts are fireplaces or refuse layers, which reveal the use of date palm as fuel. Although this is a common practice in oasis regions, however, little is known about it. Modern sources indicate that petioles are considered a good fuel (Munier, 1973), whereas Theophrastus maintains that the "tree" is not appropriate (Theophrastus, 1842: V.9.5) because of its smell.

Our results show that petioles are used for fuel purposes much more than stems. It is very difficult to say if their use as fuel is due to intrinsic properties (better consumption than stems?) or to their availability in nearest environments, as by-products resulting from agricultural management.

CONCLUSION

The present study attempts to underline the scientific potentiality offered by the anatomical characterization of modern palm stems and petioles and its practical application in the archaeological context. Well-defined archaeological layers compared with ethnographic and literary sources bring to light agricultural practices and fuel management.

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Wood anatomy microanalysis for dendrochronological and palaeoenvironmental reconstruction. Prehistoric woody plants from the southeast of the Iberian Peninsula

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Summary: *The prehistory of the southeastern Iberian Peninsula has a main question related to the palaeoenvironment: did argaric and chalcolithic populations overexploit the natural resources? The reconstruction is difficult given the complexity of plant growth in this geographical area. This paper offers a presentation of problems and solutions for archaeobotanical analysis.*

Key words: *charcoal analysis, dendrochronology, human impact, palaeoenvironment, prehistory.*

INTRODUCTION

At present, the most arid region in Europe corresponds to the southeast of the Iberian Peninsula. Large parts of its territory receive less than 300 mm rainfall annually. Nowadays, the remains of natural Mediterranean forest formations only survive on the highest and most marginal mountain ranges, while the Tertiary valleys present highly degraded environments.

In prehistoric times, 3rd and 2nd millennia BC, this territory experienced the emergence of one of the most developed societies in Europe, chronologically and socially distinguished between *Los Millares* (3rd millennium BC) and *El Argar* (2nd millennium BC). Discussion starts on the ability of these societies to transform the landscape in order to guarantee economic sustenance under arid conditions. A new way of resource exploitation caused several changes on the territory and, most important, the beginning of a non-resilient environmental situation.

The main objectives are:

- Understanding of the environmental consequences of different social, economic and political structures under severe aridity and fragile vegetation conditions.

-Studying of deforestation processes, plant exploitation and economic territories.

- Identifying climatic change episodes along the 3rd and 2nd millennia BC.

- Elaboration of the first dendrochronological framework based on charcoal remains from the later Prehistory.

DATA AND RESULTS

Mainly woody species under revision are: *Erica sp, Ficus carica, Olea europaea, Pinus nigra, Pinus sylvestris, Pistacia lentiscus, Pistacia therebintus, Prunus* sp., *Quercus coccifera, Quercus ilex, Quercus suber, Rhamnus* sp., *Rosmarinus officinalis* and *Tamarix* (Schweingruber, 1990; Schweingruber *et al.*, 2006).

The species are individually studied. First of all, it is needed to collect a minimum of 10 samples for each species under study. Each woody plant sample must contain stem, branches and shoots. Once the sample collection is completed, various slides are prepared to observe them on the microscope.

The purpose of this detailed review is to get the growth pattern for each species. Only in that case it will be possible to understand growth response. These differential growths will be registered on a database - through photographs and anatomic feature descriptions.

After the review, the determination on archaeobotanical material will take place. Those optimal samples - equal to highest number of tree rings per sample - will be measured and crossdated between them.

Thanks to the knowledge obtained, it will be able to discern growth patterns (basis for dendrochronology and palaeoenvironment reconstruction) of growth disturbances, and give more precise explanations to ecological changes and species particularities in every charcoal analysis from archaeological contexts.

DISCUSSION

During the last decades a series of hypothesis have been presented concerning the environmental changes and degradation during later Prehistory. A central aspect in the discussion has been the shift of environmental management from *Los Millares* to *El Argar*. Both societies had a very different relation towards natural resources, as well as a distinct social organization.

Shift from an intensive agriculture and diversified subsistence production during *Los Millares*, towards an extensive monoculture based on barley cultivation on the Tertiary plains took place. This agricultural strategy would have resulted in deforestation of previously existing more or less open forest, basically composed by shrubs and underbrush (Castro *et al.*, 1996).

Management of wood resources provides crucial palaeoethnobotanical information. Wood is not used equally in all contexts, or during different phases. The plants used are a reflection of many environmental (Schweingruber, 1996) and social factors: climate, ecology, forest preservation, exploitation strategies and, most important, plant qualities and use knowledge (Badal, 1990; Carrión, 2005; Euba, 2008; Celma, unpublished).

CONCLUSIONS

It will be possible to ensure vegetation changes and overexploitation through the charcoal analysis from different settlement phases (Schoch and Schweingruber, 1982; Rodríguez-Ariza, 1992; Gale, 1999; Rodríguez-Ariza and Esquivel, 2005; Buxó and Piqué, 2008; García-Martínez *et al*., 2008). Thanks to observation and description of tree rings on charcoal we could contribute to a better interpretation of its end and prove real consequences of climate in this society.

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Wood and charcoal anatomy in species of the Brazilian cerrado: effect of carbonization on wood structure

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Summary: *Anthracology is a science already quite well established in Brazil, but there is little information about anatomical modifications due to carbonization in tropical species. In this paper, fresh and charred wood samples from ten Brazilian species were analyzed. Anatomical characters were described and measurements of the main anatomical features of wood and charcoal were statistically compared. The charcoal anatomical structure is closely related to wood anatomy, although some modifications were observed, according to the anisotropic behaviour of wood elements. Reduction of the vessels' tangential diameter was the most evident change. Shrinkage in ray width occurred only in some individuals. The present work supports the identification of charred wood species, contributing to palaeoenvironmental and archaeobotanical studies, as well as to control of charcoal production.*

Key words: *wood anatomy, charcoal, anthracology, cerrado, Brazil.*

INTRODUCTION

Previous works analyzed the structural changes in charcoal prepared at different temperatures, either focusing on mass loss and volumetric shrinkage (e.g. McGinnes *et al*., 1971; Beall *et al*., 1974; Slocum *et al*., 1978), or regarding more detailed anatomical analysis (Prior and Alvin, 1983, 1986; Prior and Gasson, 1993; Kim and Hanna, 2006; Kwon *et al*., 2009; Dias Leme *et al*., 2010). In spite of that, modifications in wood anatomy after charring are still poorly known, especially considering the rich Brazilian tropical flora.

The present study aims to contribute to the comprehension of the anatomical changes in charcoals produced at 400ºC, by the analysis before and after carbonization, as well as to the understanding of the behaviour of different wood types regarding the carbonization process. We also aim to provide information on the wood anatomy of Brazilian native species.

MATERIALS AND METHODS

Three different individuals for each of ten species representative of the cerrado environment were analyzed: *Copaifera langsdorffii* (Leg. Caes.); *Dalbergia violacea* (Leg.Fab.); *Dimorphandra mollis* (Leg. Mim.); *Stryphnodendron polyphyllum* (Leg. Mim.); *Caryocar brasiliense* (Caryocaraceae); *Couepia grandiflora* (Chrysobalanaceae); *Tapirira guianensis* (Anacardiaceae); *Qualea grandiflora* (Vochysiaceae); *Vochysia tucanorum* (Vochysiaceae); *Pouteria torta* (Sapotaceae). The species selection comprises a diversity of wood anatomical types that might be differently affected by the carbonization process.

Samples were collected from an 180ha private reserve of *cerrado* in São Paulo state, Brazil (23º02'55.5" S, 48º31'26.1" W). Three cm-thick discs were obtained from the basal portion of the most developed branches. From these discs, 15-20 µm fresh wood sections were mounted on slides double-stained with safranin and astra blue, and charcoal samples were produced in a muffle furnace at 400 ºC during 40 minutes.

Descriptions and measurements of wood and charcoal anatomy followed the IAWA Committee (1989) recommendations.

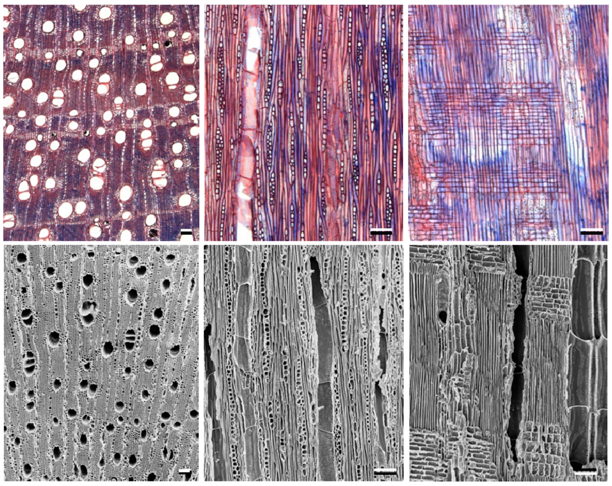

FIGURE 1: Copaifera langsdorffii. *Wood (above) and charcoal (below) micrographs. Bars: 100 µm.*

RESULTS

Detailed anatomical descriptions were elaborated for each one of the studied species. Either in wood or in charcoal samples, the following measurements were taken: tangential diameter of vessels (µm); frequency of vessels (vessels/mm²), tangential diameter of intervessel pit apertures (µm), ray frequency (rays/mm), ray width (µm), and ray height (µm). Statistical tests were applied to wood and charcoal quantitative features aiming to identify possible significant changes due to charring.

DISCUSSION

Vessels were the wood features most affected by charring. A significant reduction in the tangential diameter of vessels was verified in eight out of ten of the analyzed species. The average reduction was of 17%, varying from 2% in *T. guianensis* to 32% in *V. tucanorum*. These results were related to the anisotropic behavior of wood on drying and its conversion into charcoal, with larger contraction in the tangential direction (e.g. McGinnes *et al*., 1971; Prior and Gasson, 1993; Kwon *et al*., 2009).

Some individuals of *D. mollis*, *S. polyphyllum*, *V. tucanorum* and *P. torta* presented a change in vessels' outline from circular to angular after carbonization.

In spite of the significant reduction in the tangential diameter of vessels, there was no significant change in the frequency of vessels. Similarly, no significant difference in the tangential diameter of intervessel pit apertures between wood and charcoal was verified. Ray frequency increased in most of the individuals analyzed, but did not present significant statistical variation.

Significant changes in ray width occurred only in some individuals of *S. polyphyllum, C. grandiflora,* and *V. tucanorum* (narrower rays in charcoal than in wood). In *V. tucanorum* this shrinkage was greater in larger rays, but more studies are still necessary to verify if there is a tendency of greater shrinkage in larger rays.

Ray height did not present significant changes between wood and charcoal either. Our results suggest ray height is a parameter with low significance to evaluate anatomical changes in charcoal, especially because of the great inter- and intraspecific variability of this feature.

Gelatinous fibers were found in 80% of the material. Their analysis did not evidence any considerable change.

CONCLUSIONS

The results here presented confirm that charcoal anatomical structure is closely related to wood anatomy. Wood and charcoal anatomy analyses attest the preservation of qualitative structural features after carbonization at 400 ºC, in spite of the occurence of anisotropic contraction and of small morphometric variations, especially concerning the tangential diameter of vessels. These modifications did not affect charcoal quality, nor do they prevent the correct identification of charcoal taxa.

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Types of ash resultant from burning different vegetation and from varied combustion processes

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Summary: *Some of the physical and chemical properties of ash produced from* Pinus halepensis *collected after a wildfire and* Eucalyptus radiata *burned by a prescribed fire and under laboratory controlled conditions were determined and compared. The ash was found to be different, depending on the combustion characteristics and vegetation type. The different properties of ash will affect the recovery of the ecosystem after fire.*

Key words: *ash, ash properties, fire type, temperature of combustion*

INTRODUCTION

The intensity of a forest fire and the resulting burn severity can be complex and varied. This variability is a function of fuel load, weather, vegetation type, vegetation and soil moisture, slope, fire climate, topography, time since last burned and area burned (Neary *et al*., 1999).

Products of forest fire such as soot, charcoal and ash reflect the characteristics of a fire. Ash, in the broad sense is a solid residue of various sizes that can include both organic and inorganic material. As combustion ceases it is deposited and blankets the soil (Scott, 2010; Moody *et al*., 2009). Depending on the characteristics of the forest fire, ash may have a different colour, organic carbon content, particle size or chemical composition. Therefore ash is an indicator of fire characteristics.

The objective of this work is to compare some physical and chemical properties of different types of ash produced from burning different vegetation and from varied combustion processes.

METHODOLOGY

Four different types of ash were used for the experiment: (i) ash collected after a prescribed fire in a dry Eucalypt forest in Australia, (ii) ash produced by a controlled fire that simulated a low intensity bushfire in dry Eucalypt forest (iii) ash produced by a controlled fire that simulated a high intensity bushfire in dry Eucalypt forest, (iv) ash collected after a low intensity fire in a Spanish Mediterranean forest of *Pinus halepensis.*

In the simulated low intensity fire, mostly fine leaves and branches were used, the leaves had moisture content of 14.5 %. The fire was circular and was ignited from one edge and allowed to spread by wind until all the fuel was burned (Fig. 1a). Three thermocouples connected to a data logger were used to measure the temperature (average = 300 ºC, maximum = 600 ºC). Leaves (3 % moisture content), branches and logs were used to simulate the high intensity fire. The fire was ignited in a barrel (Fig. 1b) and was allowed to burn for a longer period of time than in the previous fire, again temperatures were measured using thermocouples (average temperature = 500 ºC, maximum = 1234 ºC).

The four types of ash were kept in plastic bags and analysed for bulk density, particle density, particle size, water repellency, pH and cation content (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}).

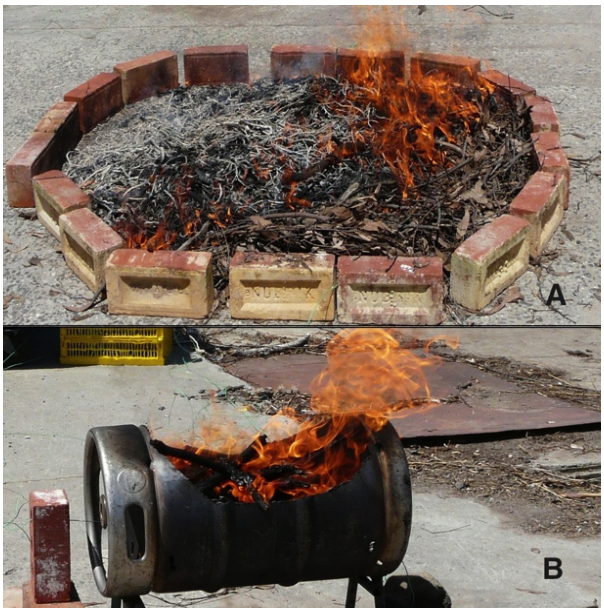

FIGURE 1. Ash produced under controlled conditions a) low intensity fire b) high intensity fire.

RESULTS AND DISCUSSION

The *Eucalyptus radiata* ash collected after the prescribed fire and made by simulating a low severity fire had similar appearance and properties (Table 1). Temperatures of the fire during these two treatments are thought to have been similar. At lower burn temperatures organic material is semi-combusted resulting in the presence of large particles of charcoal. The water repellency of this ash was found to be extreme due to the high content of organic particles (Bodí *et al*., 2011). The ash produced from the more intense controlled fire had a higher particle density, porosity and pH, the particle size of the material was smaller, which is consistent with the findings of Woods and Balfour (2011), and was hydrophilic. At higher temperatures organic material is fully combusted.

Pinus halepensis ash from a low intensity wildfire in the Mediterranean forest is similar to the ash from *Eucalyptus radiata* collected after a prescribed fire in terms of particle size and particle density, probably due to the similar combustion temperature. However, *Pinus halepensis* ash had higher porosity and therefore a lower bulk density and did not exhibit water repellency. The cation content and pH was also higher in the Mediterranean ash possibly due to the difference in species and the underlying basic nature of the lithology in the *Pinus halepensis* burned area (Úbeda *et al*., 2009).

CONCLUSION

Ash produced during a forest fire is different depending on the burn characteristics and the vegetation. These different properties will influence the water quality, soil hydrology, air quality, nutrient cycling and the recovery of an ecosystem after a fire.

Ash properties can provide evidence of fire intensity and the type of vegetation burned. Therefore the study of ash may be a great help in assessing wildfire severity.

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Ash properties	*Ash from Australian dry Eucalyptus forest (Eucalyptus radiata)*			*Ash from low severity fire in a Mediterranean forest of Pinus halepensis*
	Prescribed fire	*Produced in the laboratory simulating a low severity fire*	*Produced in the laboratory simulating a high severity fire*	
Bulk density (g cm^{-3})	0.52	0.38	0.35	0.29
Particle density (g cm^{-3})	1.42	1.35	2.04	1.47
Porosity (%)	0.63	0.72	0.82	0.80
Particle size (%, 2-0.05 mm; 0.05-0.002 mm; <0.002 mm)	60, 38, 2	53, 45, 2	32, 64, 4	73, 26.5, 0.50
Particles > 2 mm (%)	48.24	36.34	43.87	13.64
Water repellency (WDPT -seconds)	3600	3600	<5	<5
pH	7.53	8.87	9.24	9.42
Cation content (mg L^{-1}): Ca^{2+}	24.67	45.04	24.29	58.4
Mg^{2+}	9.68	14.12	1.97	12.2
Na^{+}	6.60	7.5	8.30	28
K^{+}	5.81	5.81	20.42	9.6

TABLE 1. Ash properties.

What is natural: the role of palaeoenvironmental research in reconstructing the history of continental ecosystems

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Summary: *Here I argue that palaeoenvironmental research is one the few tools available to decipher the complex evolution of continental ecosystems and the role played by humans. For this purpose, there is a wealth of archives and proxies that can be integrated to obtain information on the history of ecosystems. Some examples from Spain are given, as the reconstruction of atmospheric metal pollution -due to mining and metallurgy since prehistory- and its coupling to changes in forest cover, and soil degradation (erosion and acidification). But also on induced changes that shifted some specific habitats into a state that is of present priority protection. From this long-term perspective the questions of what and when is natural are less relevant than understanding the complex coupling between environment and humans.*

Key words: *environmental change, archives, multi-proxy research, human-environment interactions.*

There seems to be a consensus on the fact that we are facing a situation of global environmental change, in which human transformations may play a critical role. For some, the degree of human alteration of the "*natural*" biogeochemical cycles is so large that the term "*Anthropocene*" has been proposed to indicate that in the last few centuries we entered a human-dominated, geological epoch (Crutzen and Stoermer, 2000). The awareness of such a situation has also led to increased concern in developing mitigation and conservation measures/strategies. The later have seldom incorporated time perspectives longer than a few decades, or a century at most. But it is well known that changes in continental ecosystems functioning occur at different time scales, and a long-term perspective is needed for a proper understanding of the timing and drivers of the changes. Palaeoenvironmental research is one of the few tools that can provide a valuable long-term perspective on the dynamics of ecological systems (Willis and Birks, 2006).

There is a wealth of archives (i.e. marine sediments, glacier ice and snow, lake sediments, colluvial soils, peat) and proxies (i.e. biotic: fossil pollen, non-pollen palynomorphs, seeds, tree rings, charcoal, animal remains, etc.; and abiotic: chemical elements, isotopic composition, organic compounds, etc.) that enable the reconstruction of environmental changes. In regard to human transformations, a major aim is to identify and separate the so called "*natural*" and "*anthropogenic*" signals, thus to determine what is natural. But this is intimately linked to the question: when is natural? That is to say, to determine the earliest evidence of human transformation as a significant driver of biogeochemical cycles. One such example is the reconstruction of atmospheric metal pollution initially linked to mining and metallurgy, and later to fossil fuel combustion (coal and petrol), waste incineration, etc. For Spain, for example, the use of metal concentrations, enrichment factors and isotopic composition (mainly for lead) resulted in detailed chronologies for the last few centuries (Martínez Cortizas *et al*., 2011) and also for the last 8000 years (Kylander *et al*., 2005). Although for Pb the start of significant anthropogenic contributions started 3000 years ago (Kylander *et al*., 2005), recent investigations based on isotopic composition have pushed back the first evidence of metal contamination in N Spain to the earliest metallurgy, almost 5000 years ago. Comparisons between records of different heavy metals also revealed phases of polymetallic contamination (like the Roman period or the Industrial Revolution) and periods when only one or a few metals dominated (as for example Ni in the Bronze age). The records from distant areas like Galicia (references mentioned above) and Catalonia (Camarero *et al*., 1998, Serrano *et al*., 2011) also showed the presence of general as well as local patterns –linked to the history of particular areas.

Since metal pollution is an indication of mining/metallurgy, and these reflect economic activities demanding other resources, it was not surprising to find that the combination of geochemical and palynological records for the same archives (i.e. peat cores) revealed that pollution was synchronous with the fate of the forests (Martínez Cortizas *et al*., 2005), forest cover decreasing when pollution increased.

Human activities were also involved in landscape changes at longer time scales. In N Spain, for example, the interaction between human activities and the environment were expressed as modifications of the vegetation cover, the elimination of the soil resource (by erosion) in many places and its concentration (by resedimentation) in more localized, control-demanding areas, as well as the progressive acidification of continental ecosystems (Fig. 1). But in some specific situations, human induced changes also produced shifts in the structure of former habitats that lead to a present state labeled as "priority protection" in the European legislation (as the Natura 2000 network). A good example of this has been recently described by López-Merino *et al*. (2011). They found that the palaeocological history of La Molina mire demonstrates that human intervention (by inundation of the former fen in Roman times) promoted a rapid evolution to an ombrotrophic bog, declared at present as Site of Community Importance.

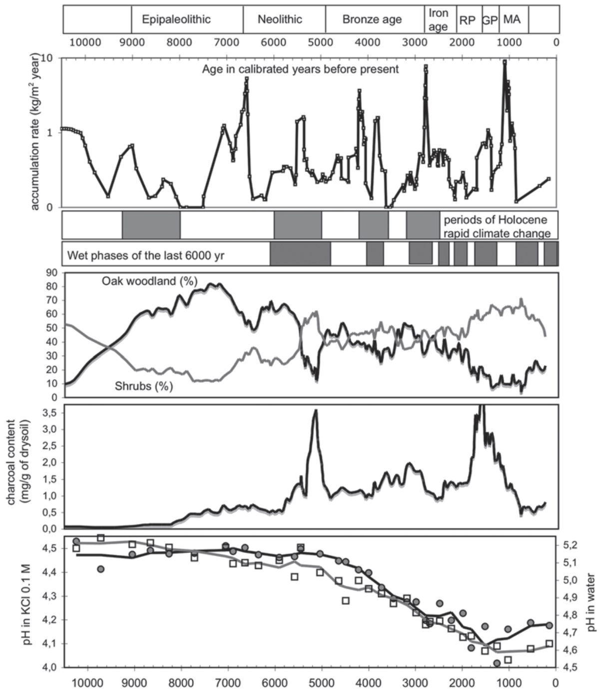

FIGURE 1. Holocene changes in soil erosion/accumulation rates (log scale), vegetation change, charcoal content and soil reaction (pH) in Campo Lameiro (Pontevedra, NW Spain). Taken from Martínez Cortizas et al. *(2009).*

In conclusion, in Spain and many other parts of Europe the long and intricate history of human transformations of the environment has resulted in the conformation of present cultural landscapes. Palaeoenvironmental research can provide information on pre-impact states of ecosystems, trajectories of prehistoric and recent changes, and complex system behaviour (Dearing *et al*., 2006), which is critical for the understanding of our past, for ecological modeling and to develop proper conservation strategies. As the time perspective is enlarged, the questions of what and when natural fade away is, and human-environment interactions appear as the result of coupled complex systems.

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Evidence from charcoal of fire regimes in the Cretaceous of Alberta, Canada

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Summary: *Charcoal is recorded from late Cretaceous sediments of Dinosaur Provincial Park, Alberta, Canada and represents the first documented observations of charcoal at this locality despite over one hundred years of research. Abundant charcoal deposits have been recorded throughout the 1.7 million year sediment sequence indicating multiple fire events within this locality. Fire appears to be a major influencing factor within this Cretaceous ecosystem and may have affected the life of the inhabiting dinosaurs. The occurrence of charcoal allows reconstruction of the burned vegetation at multiple locations within Dinosaur Provincial Park. The charcoal assemblage is comprised of gymnosperm wood only, which may be a reasonable representation of the local vegetation; however it could be the result of a taphonomic bias. The absence of additional plant types within the charcoal assemblage may also be due to certain species being preferentially burnt owing to a more fire prone nature.*

Key words: *wildfire, charcoal, gymnosperm, wood, Cretaceous*

INTRODUCTION

Fire plays a major role in modern ecosystems, greatly influencing plant communities (Bowman *et al.*, 2009). The anatomical preservation of charcoal makes it a highly useful tool that allows reconstruction of plants, and therefore the vegetation of specific localities. Charcoal is often overlooked in ancient sediments, potentially due to a lack of recognition (Scott, 2010). Charcoal deposits found in Cretaceous sediments globally indicate that fire was an important ecosystem process during this Period, however, there is still little knowledge regarding fire-prone vegetation within the Cretaceous. Current research being carried out in Dinosaur Provincial Park, Alberta, Canada aims to address this through sedimentological and palaeobotanical analyses, enabling vegetation reconstruction to be undertaken.

SEDIMENTOLOGY OF DINOSAUR PROVINCIAL PARK

Dinosaur Provincial Park covers an area of 72 km^2 and contains well exposed mid-late Campanian sediments (Currie and Koppelhus, 2005). Despite the area having been extensively researched for over one hundred years, due to the abundance of both articulated and disarticulated dinosaur remains, charcoal deposits had never been reported. Two formations are exposed within the park, the Oldman Formation and the Dinosaur Park Formation, which represent a 1.7 million year interval of the mid-late Campanian. The Oldman Formation is comprised of very fine sandstones, mudstones and shales that can be interpreted to represent palaeochannels. The Dinosaur Park Formation is comprised of medium grained sandstones, mudstones and shales interpreted to represent the lateral accretion of point bars from a meandering river (Thomas *et al.*, 1987).

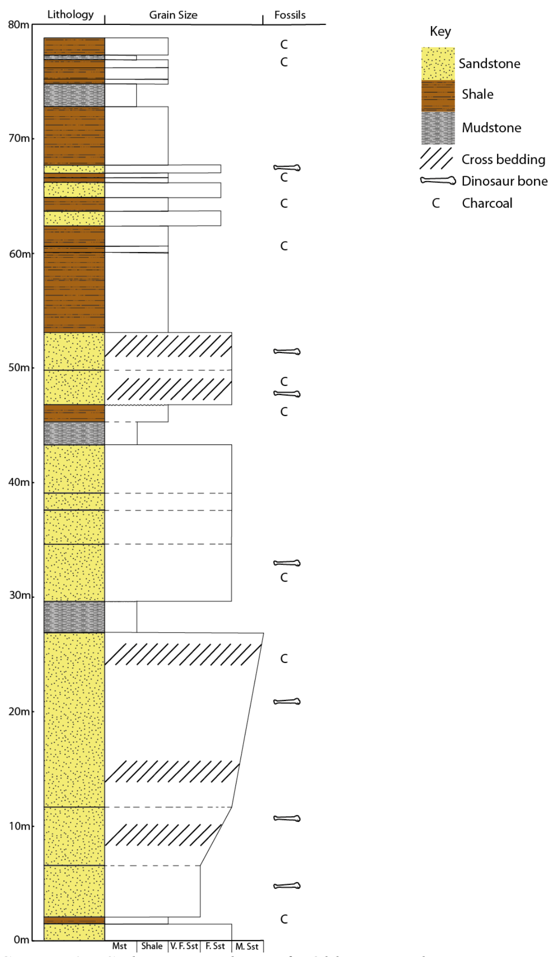

FIGURE 1. Sedimentary log of Oldman and Dinosaur Park Formations showing abundant charcoal presence.

CHARCOAL OCCURENCE

Charcoal has been observed to be highly abundant throughout Dinosaur Provincial Park, and represents the first documented observation at this locality. Sampling was undertaken throughout the Park, at ten different locations, with abundant charcoal observed in each. Figure 1 indicates the presence of charcoal throughout both the Oldman and Dinosaur Park Formations from one locality within Dinosaur Provincial Park. The charcoal is comprised of gymnosperm wood only, some of which displays growth rings (Fig. 2).

There is no correlation between the charcoal abundance and the sediment type in which it is contained. Currently there does not appear to be a relationship between the amount of charcoal within a sedimentary unit and its stratigraphic position.

IMPLICATIONS FOR VEGETATION RECONSTRUCTION

The presence of only gymnosperm wood charcoal is of particular interest, as this would not be expected when compared with the palynological data. Angiosperms were present at Dinosaur Provincial Park at this time in the Cretaceous, with the palynology indicating multiple species and a high abundance. The absence of angiosperms poses an interesting question as to whether this was a gymnospermous dominated environment with weedy angiosperms and ferns only present in minor numbers, or whether there is a preservational bias in charcoal favouring gymnosperm wood.

Initial results indicate a bias within the charcoal record, as with a gymnosperm dominated environment additional organs, such as leafy shoots and cone scales, would be expected to occur. Dinosaur Provincial Park was a fluvially dominated system during the Campanian, which may have resulted in some abrasion to the charcoal causing it to fragment and may result in some of the smaller charcoal size fraction being transported outside the boundaries of the field area; however this would be highly unlikely to remove all angiosperm, fern and additional gymnosperm organs.

CONCLUSIONS

The presence of abundant charcoal throughout the sedimentary succession in multiple localities throughout Dinosaur Provincial Park provides the first record of charcoal within this dinosaur rich environment, and indicates that wildfire played a major role in this ecosystem during the Campanian. This charcoal record is highly important as it not only allows vegetation reconstruction in this area, but also indicates that wildfire, due to its abundance, would have impacted on the inhabiting dinosaurs.

The charcoal composition may reflect the local vegetation, however it is possible that a true reflection of the ancient vegetation may not be preserved posing a problem for vegetation reconstruction. It is, however, evident from the data that gymnosperms were an important component of the flora at this time. The presence of growth rings on some larger charcoal pieces enables tentative comments to be made regarding seasonality within Alberta during the late Campanian. The charcoal data also suggests that there is no increase in wildfire abundance throughout the Campanian.

ACKNOWLEDGEMENTS

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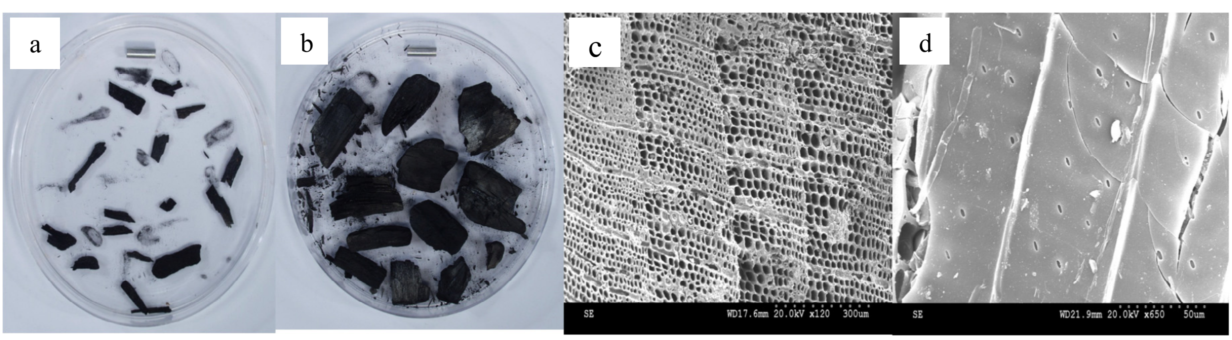

FIGURE 2: Examples of charcoal from Dinosaur Provincial Park. a. Charcoal sample containing a small size fraction. b. Charcoal sample containing a large size fraction. c. SEM image of gymnosperm wood displaying growth rings. d. SEM image of gymnosperm wood.

Evidence of fire regimes in the Pleistocene of the California Islands

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Summary: *Charcoal has been recovered from a range of late Pleistocene sites both in Santa Cruz Island and Santa Rosa Island, belonging to the California Channel Islands. Sediments have been dated using radiocarbon measurements based on wood charcoal, fungal sclerotia, glassy carbon and fecal pellets and are given as calendar years BP. Charcoal assemblages from samples dating from* 24,694 to 12,900 *years are dominated by coniferous wood charcoal. Little angiosperm charcoal was recovered in any of the samples. Fungal sclerotia are frequent in a number of samples from a range of ages both on Santa Cruz and Santa Rosa. Fecal pellets are common in most samples and abundant in others. Some of the fecal pellets have hexagonal sides and are likely to represent termite frass. The sediments are fluvial in origin and the distribution of charcoal is irregular. The charcoal records a significant record of fire before the earliest documented human arrival on the islands and there is no evidence for a catastrophic fire triggered by a cometary impact at the onset of the younger Dryas, 12,900 cal years BP.*

Key words: *wildfire, charcoal, conifer, coprolites, human.*

INTRODUCTION

The California Channel Islands exposes Pleistocene sediments dating from around 24,000 years ago. These islands are significant as they record the first arrival of humans in to North America, around 15,000-13,000 cal BP (Pinter *et al*., 2011). The sequence of sediments exposed in both Santa Cruz Island and Santa Rosa Island are fluvial in origin and the nature of the sedimentation changes through the sequence. In Santa Cruz Island some of the earliest Pleistocene sediments (16,000 cal BP) contain large coniferous trees and are associated with charcoal. In the Holocene sequence from Santa Rosa Island there is little charcoal reported and palynological data support a change in vegetation to one dominated by angiosperm dominated herbaceous vegetation (Anderson *et al*., 2010). The climate dried and by 6900 cal BP grasslands are significant. In this paper we report on the charcoal assemblages recovered from the pre- Younger Dryas sequences on the islands.

SEDIMENTOLOGY OF THE ARLINGTON CANYON SECTION, SANTA ROSA ISLAND

The sediments exposed on the Islands belonging to the late Pleistocene show significant variation. The sediments include fluvial channel sands and over-bank silts and muds. However, coarse fan sediments including extensive conglomerates occur sporadically through the sequence. Charcoal (Scott, 2010) occurs throughout the sequence both as scattered fragments, lenses and as thin discontinuous layers (Fig. 1). We have noted a change in sedimentation style as the climate dried and the vegetation switched from a forest-dominated system to one dominated by herbaceous plants and grasslands. In the lower part of the sequences sediments are dominated by a range of muds, silts and sands that often contain charcoal.

However, plant compression fossils are generally absent and palynomorphs are often poorly preserved or absent. In the younger part of the sequences there are a number of prominent dark horizons. These do not contain any significant organic material, so their age is difficult to determine. They may represent paleosol horizons.

CHARCOAL OCCURRENCE AND IDENTITY

Charcoal occurs abundantly in many parts of the sedimentary sequence. Most of the samples were dominated by wood charcoal and are of coniferous origin (Fig. 2b). While many samples predominantly contain only charred wood fragments some also include uncharred wood fragments (Fig. 2a). Reflectance microscopy on the charcoal fragments give low reading, usually less than 2% Ro. This implies temperatures of less than 500 ^{o}C and may indicate predominantly surface fires. Many of the samples also contain both fungal sclerotia (Scott *et al*., 2010) and arthropod fecal pellets (Scott *et al*., 2010) (Fig. 2c, d). Such pellets may be abundant and dominate assemblages. In some cases coprolite assemblages contain charred, partially charred and uncharred specimens (Fig. 2a).

IMPLICATIONS FOR WILDFIRE INTERPRETATION

Dating of the oldest charcoal, associated with large coniferous trees suggests that wildfire was a natural part of the ecosystem before the arrival of humans on the islands. There is evidence of regular small surface fires with a limited amount of post-fire erosion and deposition through the sequence. We do not find evidence of 'mass wasting' following intensive fires at the 12,900 horizon as claimed by other authors (e.g. Kennett *et al.*, 2008) as part of their Younger Dryas impact theory (Firestone *et al.*, 2007). Quantification of charcoal as claimed by other authors in these sediments is difficult as many of the sediments contain pebbles from fan deposits so successive samples are not comparable. This is also made difficult because of the intermittent occurrence of the charcoal. While it is possible to imagine that there is an increase in fire through the early part of the sequence it is not possible to determine if this is human or naturally caused.

FIGURE 1. Sediments exposed along Arlington Canyon, Santa Rosa Island. Charcoal occurs as discontinuous layers as well as on the cross-set of sandy units and scattered in the sediments

CONCLUSIONS

Fire was an important element of the ecosystem on the islands from at least 24,000 cal BP. Fires were dominated by surface fires through coniferous woodland as evidenced by the common occurrence of conifer wood charcoal that has been exposed to low temperatures. There is also evidence that at least some litter was charred, transported and deposited into the river systems from the common occurrence of fungal sclerotia, but particularly from termite frass. Fire systems changed as the vegetation changed and little wood charcoal is found after 12,900 cal BP at the beginning of the Younger Dryas. We see no evidence for the occurrence of a cometary impact at 12,900 cal BP (see Pinter *et al.*, 2011 for a review of this issue).

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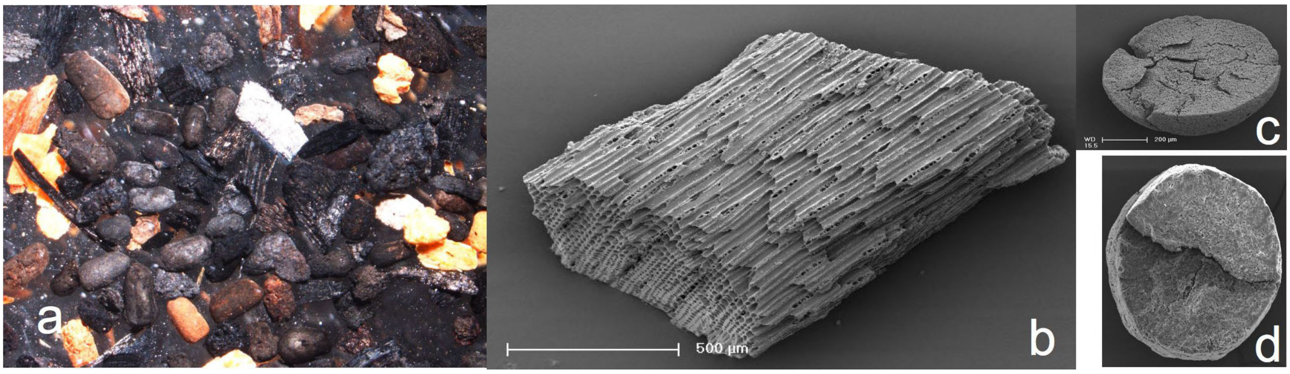

FIGURE 2. Examples of charcoal from the late Pleistocene of the California Channel Islands. a. Typical charcoal assemblage with charred and uncharred wood and fecal pellets, Arlington Canyon. b. SEM of charred conifer wood, Santa Cruz Island. c. SEM of Broken fungal sclerotium, Santa Cruz Island. d. SEM of section through charred termite pellet, Santa Rosa Island.

Main data and general insights of recent soil charcoal investigations on nine sites in Central Europe

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Summary: *Soil charcoal analyses were performed on nine sites in Central and Northern Germany. The main results, discussion and interpretation are presented here, based on the overall extraction of 330 g of charcoal from 45 soil profiles, and the taxonomic analysis of ca. 11,200 charcoal pieces. Soil charcoals are recorded in various site contexts (soil, altitude, etc.), providing diverse soil charcoal quantities, varying in mg.kg-1 proportion from 1 to more than 3000. The identified taxonomic assemblages, combined with the radiocarbon AMS dating of 67 single charcoal pieces, allowed to postulate that the Central European forests, including broadleaf temperate forests, burned in two main phases since the last glacial phase, one during the late Pleistocene/early Holocene and another during the late Holocene. The human vs. climatic forcing of that past fire history is discussed.*

Key words: *soil charcoal analysis, soil analysis, radiocarbon dating, fire history, forest changes.*

INTRODUCTION

The Holocene vegetation history of Central Europe has been well investigated, leading to a global consensus about the main aspects of forest tree temporal and spatial development since the last glacial phase, and the respective roles of climate and humans on the ecosystems dynamics (e.g. Kalis *et al.*, 2003). Nevertheless, several issues are still the subject of discussion, as a result of new data, closing some gaps, and/or new ways of investigation, such as interdisciplinary (Nelle *et al.*, 2010). Important questions remaining concern the assessment of the Holocene forest/woodland structure and the role of 'mega-herbivores' on those, during the late Pleistocene and the early Holocene (Vera, 2002). Other questions involve human activities, which are known to have an increasing influence on the dynamics and structures of forests/woodlands since the mid-Holocene at least and with human cultural development. Those factors influenced, directly or indirectly, the forest history as important disturbance factors (Pickett and White, 1985). Among those disturbances factors, the occurrence of fire is important.

The role of fire on the dynamics of ecosystems has been well documented for several bio-climatic domains (e.g. Vannière *et al.*, 2008; Higuera *et al.*, 2009). However, the fire history in Central Europe is still barely documented. Fire history reconstructions based on charcoal records from natural archives are especially rare. Nevertheless, some work has shown that forests of Central Europe were burned during the Holocene period (Clark *et al.*, 1989), as a result of human and/or climatic control. That last aspect of the main control of the past fire regime in Central Europe remains little discussed so far, notably in the light of recent insights about the Holocene climatic variability.

It is in this framework that fire history and related forest dynamics of Central Europe were investigated. To take into account the possibly important heterogeneity in fire history at a local scale (forest stand) due to local use of fire by humans, this investigation has been based on soil charcoal records (i.e. pedoanthracological approach). Despite the fact that soil charcoal analysis does not allow one to obtain strictly chrono-stratified palaeo-records, as from lake sediments, this approach allows one to reconstruct single occurrences of fire events. Moreover, using the same investigation material, it has been possible to identify the type of vegetation burned.

MATERIAL AND METHODS

This investigation was done on nine sites, grouped in two large investigation areas in Central and Northern Germany, with the intention to include a larger range of forest systems (Fig. 1). Soil samples were taken from forest sites under oceanic and subcontinental climate contexts, from 50 to 1140 m asl, and from various types of soils, such as sandy to clay rich soil, and also from sedimentary materials (colluvial layers). At each of the investigation sites, a multi-sampling strategy, with a repeatable protocol, was used, following Carcaillet and Thinon (1996) and Bork and Lang (2003).

Soil charcoal assemblages (with charcoal pieces larger than 1 mm) were extracted and analyzed in the laboratory. They were quantified in charcoal concentration by weight of samples, and partly analyzed taxonomically (90 charcoal pieces per layer of sampling). To obtain chronological information, radiocarbon dating was performed on some charcoal pieces for each site.

The charcoal investigations were combined with soil analysis to identify the context of sampling and to assess some aspects of taphonomical issues, which is important for the interpretation of soil charcoal assemblages.

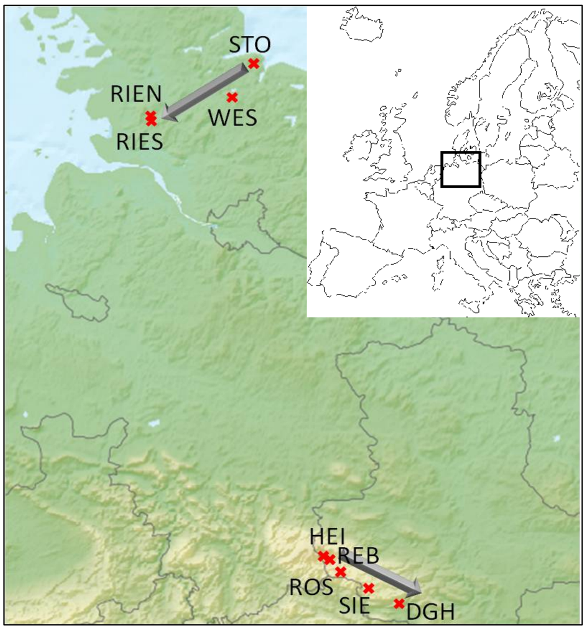

FIGURE 1. Map of localization of the nine investigation sites. Investigation sites in Northern Germany: RIEN (Riesewohld North); RIES (Riesewohld South); WES (Westensee); STO (Stodthagener Wald); Investigation sites in Central Germany: HEI (Heinrichshöhe); REB (Renneckenberg); ROS (Rosentalskopf); SIE (Sieben Gemeinde Wald); DGH (Die Grosse Holz).

RESULTS AND DISCUSSION

Based on an extraction of about 330 g of charcoal, from more than 1700 kg of soil samples and on the taxonomic analysis of more than 11,000 charcoal pieces, the observations are as follows:

Despite a large variability in the soil charcoal concentrations, there are charcoal pieces in any type of investigated soil, from various elevations, latitudes, topographic contexts, etc. This indicates that, in any kind of investigated site contexts, the forest burned several times during the Holocene period. The charcoal records have been formed because of these forest fires. Moreover, the extracted and quantified soil charcoal records have provided, in any investigated sites, enough suitable material for relevant palaeo-environmental reconstruction. The large heterogeneity of the soil charcoal concentration seems to indicate a considerable variability in past fire regimes at the local scale. This might be due to the influence of human use of fire, increasing the past fire regime heterogeneity from site to site.

The taxonomic identification allows one to point out that broadleaf temperate forests burned, since the soil charcoal assemblages of several sites are dominated by *Quercus* and/or *Fagus* pieces, while such temperate forest species are not ‘easy flammable’ fuel. Further, chronological data indicates ancient occurrences of fire events. The overall radiocarbon date distribution (about 67 AMS C14 dates) indicates two main periods of fire occurrence, one during the late Pleistocene/early Holocene period and another one in the late Neolithic period and younger, with many more dated fire events. The overall dataset supports the hypothesis of an important and increasing human impact on past fire occurrences since the Neolithic period, and highlights the important role of fires at the local scale, regardless of the ignition factor. With regard to the late Pleistocene/early Holocene period, the fire events also have been dated, with a relatively high number of occurrences on various sites, probably related to climatic forcing, in regards to the burned forest fuel.

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Soil charcoal analysis: a tool to investigate non-linear abrupt changes in ecosystems

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Summary: *Soil charcoal assemblages' constitution and archiving happens connected to the stratigraphical record from non-linear erosion events in a changing ecosystem. Those events are enabled by a change in vegetation cover, for example due to fire events. The resulting deposits are charcoal enriched. They form the here discussed sediment material from case studies used to show that the combination of geomorphological and soil charcoal analysis provides a promising approach to reconstruct non-linear abrupt changes of ecosystems dynamics.*

Key words: *soil charcoal analysis, geomorphology, erosion/deposit, non-linearity, fire event*

INTRODUCTION

Since its establishment as a new palaeoecological approach (Thinon, 1978), soil charcoal analysis (i.e. pedoanthracology) has been increasingly developed over the last decades. However, most of the works done so far deal with particular localized issue and/or with particular investigation areas, especially where fire occurrence is well known as a natural component of the ecosystem dynamic change through time (Ohlson and Tryterud, 2000; Vernet, 2006). However, it can be observed that 'there are charcoal pieces everywhere, in any type of soil'. This observation combined to the palaeoecological insight which possibly can be drawn from this approach (i.e. fire history and past forest vegetation reconstruction) at local scale (i.e. 'mega-charcoal' records), makes the soil charcoal investigation relevant for reconstructing ecosystem dynamics, especially in interdisciplinary approaches (Nelle *et al.*, 2010). However, an important aspect is limiting the interpretation of soil charcoal assemblages: Palaeoecological investigations are based on 'well' established chronological frameworks like chronologically stratified sediments, archiving several types of palaeo-indicators. Such materials allow establishing with a reduced number of dating a temporal framework for the palaeo-data, notably by depth/age modelling. This is very difficult to be obtained from soil charcoal assemblages. Indeed, the quantitative and qualitative analysis of the soil charcoal assemblages is delicate to be chronologically interpreted, since soils are a dynamic archiving context (Carcaillet, 2001). But this does not mean that soil charcoal analysis is out of interest to reconstruct the history of past ecosystems.

The research presented in this communication aims to illustrate how relevant and reliable the strong correlation of soil charcoal and geomorphological analysis is to the reconstruction of non-linear abrupt changes in ecosystems.

DISCUSSION BACKGROUND

Soil formation processes, and especially those implicating the mixing of soil materials soil materials, have an important role in the charcoal pieces vertical distribution. Trees uprooting is an important example. This process possibly mixes important volumes of soil, along a considerable depth in the soils (Šamonil *et al.*, 2010). Additionally, bioturbation processes are to be mentioned, probably as the main soil mixing factor, mainly due to earth worm activity (Jégou *et al.*, 1998). Because these processes are not linear ones, the charcoal incorporation in *in situ* formed soil is not occurring linearly through time. The charcoal incorporation into the soil matrix seems to be more a 'mixing' process. So, to obtain a reliable chronological framework from soil samples it would be necessary to date all the extracted charcoal pieces, to establish the chrono-stratigraphy of the palaeo-indicator itself, instead of the archiving context. This is of course not realistic. Nevertheless, soil charcoal analysis is a relevant and reliable tool to detect and analyze non-linear abrupt changes in ecosystem dynamics: once embedded in the soil matrix, erosive intermittent events might transport the charcoal over variable distances and subsequently deposit a mix of charcoal and transported sediment. These deposits constitute an interesting archiving context to soil charcoal records, and in general to many types of biotic indicators (Bork and Lang, 2003). Like the processes of soil formation, those erosive events are not linear and non-predictable events since they are often a result of a changing vegetation cover, which itself does not follow linear and predictive processes: land cover change is a consequence of ecosystem disturbance, which is an unpredictable event of total or partial destruction of the biomass of the ecosystem, over various temporal and spatial scales (Pickett and White, 1985). However, climatic cycling is an important driver of erosive phases on longer temporal scale, by inducing natural change in vegetation land cover when causing forest canopy retreat. And even at the scale of an interglacial stage like the Holocene, such climatic cycles ('Bond events') can cause a natural change in vegetation cover and eventually erosional processes.

Nevertheless, during the Holocene most of vegetation cover changes are due to human activities (e.g. land use changes), with an increasing impact concomitant to human society development. These changes of land vegetation cover and their consequences on soil erosion are strictly not predictable and not linear. In the process of human induced and natural vegetation cover change fire has been, and still is, the reason for a drastic, abrupt, change of vegetation cover (e.g. forest opening). A strong correlation is established between a fire event, producing charcoal, and the happening of an erosive event, caused by the total or partial vegetation cover destruction (Fig. 1). This 'chain effect' is crucial to both: the constitution of most of the soil charcoal assemblages, and consequently of the soil charcoal record interpretation.

FIGURE 1. Charcoal flow in burnt catchment. Australia 2009.

Soil charcoal analysis must therefore be strongly correlated to soil historical and geomorphological perspectives because i) soil analysis and geomorphological approaches may provide crucial support to the soil charcoal assemblage interpretation by detecting soil horizon resulting from erosion/deposit events, like alluvial or colluvial sediments, and ii) the chrono-stratigraphical record (established by archaeological/OSL/14C dating) enables a chronology, which can support the dating of the charcoal record. Consequently, charcoal assemblages extracted from sedimentary layers could be correlated to the chronological frame obtained, and evermore charcoal pieces may serve to the dating, as very relevant and reliable datable material. Also a soil charcoal dataset including taxonomical and quantitative data of charcoal concentration serves soil historical and geomorphological investigation by providing an insight into the burnt land cover vegetation types.

CASE STUDIES

Two examples from Central and Northern Germany illustrate that the sedimentologically reconstructed and dated non-linear erosive events reflect a consequent soil charcoal quantity and local vegetation composition. At each of these sites, palaeoecological investigations have been done about past soil history with the identification, dating, and in some case the quantification (i.e. sediment budget) of colluvial layers, in soil sequences (i.e. profiles). From those colluvial layers soil charcoal assemblages have been extracted to investigate past fire history (i.e. fire regime) and past forest composition (i.e. the burnt material), based on soil charcoal quantification (i.e. concentration) and wood charcoal taxonomic identification.

These illustration cases support the great interest and perspectives of the combined approach of soil charcoal and geomorphologic analysis to palaeoecological reconstruction.

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Charcoals in dunes – an example from Northern Germany

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Summary: *Dunes are palaeoarchives hitherto rarely investigated for charcoal. Here we present a study of charcoals from an inland dune complex in Northern Germany. The charcoal assemblages were analyzed as part of a project which aims at the reconstruction of historical wind erosion in high spatial and temporal resolution. Different layers can be separated, containing considerable amounts of charcoals, which were taxonomically identified. Oak (*Quercus*) is dominating the spectra, and together with significant proportions of Ericaceae-charcoals (probably heather,* Calluna vulgaris*) indicate the presence of semi-open or open heathland, which was managed by fire. In the upper, younger sand layers a greater diversity of* taxa *was found, with dominating* Quercus*, and other species like* Fagus*,* Alnus*,* Betula*,* Corylus*,* Fraxinus*,* Salix*,* Populus-Salix*-type, as well as some Ericaceae. This diversity might indicate that the charcoals were blown in together with the sand from the surroundings, and do not represent the local vegetation on the dunes. The differences in the charcoal assemblages and the thus possible correlations of layers support the stratigraphical correlation made by the geomorphologists.*

Key words: *dune development, wind erosion, geoanthracology, charcoals origin, heather*

INTRODUCTION

Since the beginning of human-made deforestation and the rise of agriculture erosion became important for soil as well as landscape development. In Northern Germany sandy soils are very common. With the opening of the forest wind erosion and consequently sand drifts are resulting in the formation of inland dune complexes.

The research here presented focuses on a dune complex, Kurharder hill, in the vicinity of Joldelund (Schleswig-Holstein, Germany, Fig. 1). The Kurharder hill covers an area of around 2 ha and belongs to an inland dune field of about 80 ha. The Holocene dune development is the subject of a PhD project by U. Lungershausen who studies soil-sediment-sequences and ancient dune surfaces along several exposures made by an excavator. In this project's context, archaeological and historical records are considered and the analysis of palaeo-botanical material, especially charcoal, is carried out.

Main questions for charcoal analysis are spectra and possible origin of the charcoal.

MATERIAL AND METHODS

49 soil samples were taken from the dune profiles for charcoal analysis. Samples were dry- and/or wet-sieved in the lab, and the very small charcoals (1 to several milimeters, very rarely up to 1 cm) were analysed with a stereo lens (magnification 7.5-112.5x) and an incident light microscope with 100x, 200x and 500x magnification. For each sample it was tried to analyse at least 30 pieces but due to the sometimes low charcoal content this was not possible for every sample.

RESULTS

In total we determined 1085 charcoal pieces. The spectrum contains 14 species and is dominated by oak (*Quercus*). Further common species are the family Ericaceae (most probable *Calluna vulgaris*) and beech (*Fagus*). Birch (*Betula*), alder (*Alnus*), hazel (*Corylus*), poplar-willow type (*Populus*/*Salix*), ash (*Fraxinus*), pine (*Pinus*), maple (*Acer*), lime (*Tilia*), and apple subfamily (*Maloideae*) occur in several samples.

Five different layers can be found in the profiles (Fig. 2). Layer 1 is the older soil (formation before sand erosion started). Layers 2 and 3 are humus rich whereas Layers 4 and 5 are primary sandy, and are the upper, thus youngest layers. For layer 1 just one soil sample is available, with *Betula*, *Populus*/*Salix*, and *Pinus* charcoals. The other layers are dominated by *Quercus*. In some samples of layer 2 and 3 Ericaceae have high values, other species just occur as single pieces. In layers 4 and 5, the appearance of Ericaceae is less significant and other species like *Fagus*, *Betula* and *Alnus* reach higher values. The samples contained between 1 and 7 taxa (mean: 3.2±1.7). The assemblages of layers 4 and 5 are taxonomically more diverse than the others.

DISCUSSION

The charcoal seems to originate from different times and sources. For layer 1 we estimate that this layer was formed during the Late Allerød / Younger Dryas (which is confirmed by one AMS date). The high values of *Quercus* and Ericaceae in layer 2 and 3 indicate an open or semi-open landscape with *Calluna* heather which was burned during medieval times, probably due to fire management by humans. After the clearance of the semi-open landscape wind erosion took place and formed the dunes. Layers 4 and 5 contain charcoal from the surrounding of the dune, but it is not clear yet how far the charcoal can be transported with the sand due to wind erosion. The bigger "catchment area" might explain a more species-diverse charcoal spectrum. We assume that a couple of the species found, especially species of wetlands, did not grow on the dunes, but were transported by wind from the surroundings.

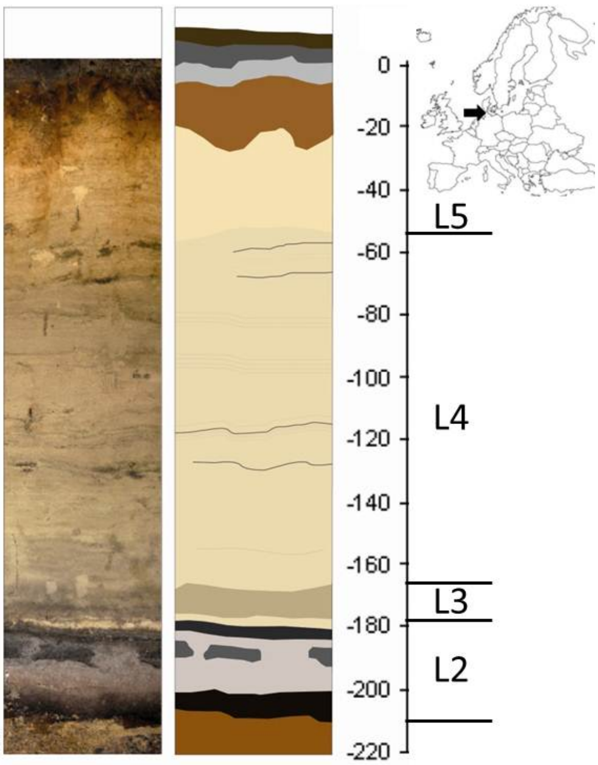

FIGURE 1. Photo and schema of a profile of the Kurharder hill with different layers (U. Lungershausen); on the right top: Map of Europe, arrow pointing at Joldelund.

CONCLUSION

The different layers of the dune are formed due to different processes were erosion plays an important role during medieval times. Charcoal analysis helps to interpret the origin of the material which formed the dune. The understanding of the formation of such dune complexes is improved by the cooperation of several disciplines. Anthracology can support stratigraphical interpretation of sediment profiles, while the investigation of these dune complexes by soil scientists and geomorphologists gives access to palaeoarchives like dune complexes, hitherto rarely explored by botanists.

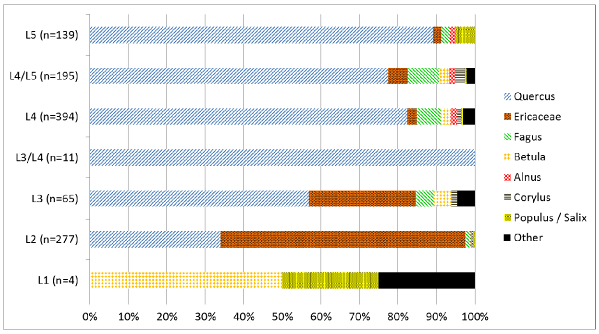

FIGURE 2. Charcoal spectra from the five different layers, when two layers are named (e.g. L3/L4) the soil samples were taken at the border between both layers. Other includes Fraxinus, Pinus, Acer, Tilia, Maloideae, Sorbus *and* Lonicera.

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Pedoanthracology and dendroecology: two complementary approaches applied to old forest history

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***Summary**: This paper deals with the combined use of pedoanthracology and dendroecology for the study of forest dynamics. Two forests were studied and compared: the mixed larch/arolla pine subalpine forest of Praroussin (Queyras, French Southern Alps) and the mixed beech/oak mediterranean forest of The Sainte Baume (Var, France). First results reveal the role played by arolla pine (Praroussin) and oak (Sainte Baume) in the past. These species will also play an important role in the future.*

***Key words**: pedoanthracology, Sainte Baume forest, subalpine forests, forest dynamics, dendroecology*

INTRODUCTION

There is increased interest in natural or semi natural forests in Europe due to their high biodiversity. Dendroecology and pedoanthracology were applied to decipher Holocene forest history and dynamics. Two forests were studied and compared: the mixed larch/arolla pine subalpine forest of Praroussin (Queyras, French Southern Alps) and the mixed beech/oak mediterranean forest of The Sainte Baume (Var, France). The aims of this study are: (i) to understand the dynamics that led to the installation these forests, (ii) to assess their current dynamics, and (iii) to enable the future modification of composition and structure of these forests. Results presented here are still preliminary and very incomplete.

STUDY AREA AND METHODS

Beech forest of the Sainte-Baume (43°20'00" N – 5°46'38" E) consists of beech (*Fagus sylvatica*), yew (*Taxus baccata*), holly (*Ilex aquifolium*), mapple (*Acer opalus, Acer campestris*), lime (*Tilia platyphyllos*), and oak (*Quercus pubescens*) (Molinier *et al*., 1959). The Praroussin forest is located on the western slope of the Guil valley at *ca.* 1950 m (44°45'44' N – 6°59'54" E). In this forest many of the larches (*Larix decidua*) and arolla pines (*Pinus cembra*) are several hundred years old. Understorey consists of bilberries (*Vaccinium uliginosum, V. myrtillus*), juniper (*Juniperus sibirica*), and alpenrose (*Rhododendron ferrugineum*).

Pedoanthracology. Five evenly distributed pits 60 to 80 cm deep were dug across the two plots of Praroussin while two pits 40 to 50 cm deep were dug within the three plots of the Ste Baume. Samples were taken at 10 cm intervals from all of the soil profiles. Charcoal was extracted employing protocols as described by Carcaillet and Thinon (1996). Only charcoal fragments larger than 1.25 mm were sorted, weighed and identified.

Dendroecology. In each plot, all trees, saplings, snags, logs, stumps and branches were listed (species, circumference 50 cm high) and spatialized. In order to study the regeneration, each sapling is referenced according to its species, its base circumference and its height. The measurements useful to evaluate the dead wood volumes on the ground were performed on logs, branches and stumps. So as to study the age structure of the plots, we have cored all trees at a height of 50 cm, to maximize the rings' number by core. Because of counting errors related to missing rings, the age structure was built in 10 years age-classes (Payette *et al*., 1990). In order to estimate tree ring/climate relationship, 15 trees were selectionned in each plot. From each tree two increment cores were taken with Pressler's borer.

RESULTS AND DISCUSSION

Praroussin

Pedoanthracology. Arolla pine was present in this area from *ca*. 7600 cal BP (Table 1) to 1500 cal BP. Our results suggest the establishment of larch from *ca*. 6000 cal BP, whereas other studies have indicated an earlier arrival, dating back to 8000 cal BP in the southernmost Alps (Ortu *et al*., 2005). The presence of fir at *ca*. 5900 cal BP, at 1980 m asl on a western-facing slope, confirms that its ecological requirements were less restricted than commonly believed (Ozenda, 1985). There is no doubt that fir had a mid-Holocene distribution that was wider than we had once assumed (Carcaillet and Muller, 2005). The charcoal spectra suggest that the larch forest was mixed comprising larch, arolla pines and isolated firs. The occurrence of willow and small leaf trees indicates that this mixed forest was open enough to allow the expansion of a shrubby understorey.

Pit	Material	Depth (cm)	Species	Age BP	Age cal. BP (2 σ)
PRA I 1	charcoal	50-60	*Pinus cembra*	1655 ± 30	1510-1627
PRA I 2	charcoal	40-50	*Larix decidua*	2595 ± 30	2705-2771
PRA I 1	charcoal	20-30	*Pinus cembra*	2930 ± 30	2973-3167
PRA I 3	charcoal	40-50	*Larix decidua*	5265 ± 35	5934-6123
PRA I 2	charcoal	20-30	*Pinus cembra*	6750 ± 40	7566-7673
PRA II 2	charcoal	20-30	*Larix decidua*	905 ± 30	742-911
PRA II 4	charcoal	10-20	*Pinus cembra*	915 ± 30	764-919
PRA II 2	charcoal	0-10	*Larix decidua*	965 ± 30	795-888
PRA II 4	charcoal	10-20	*Pinus cembra*	985 ± 30	895-959
PRA II	charcoal	OS	*Pinus cembra*	1590 ± 30	1408-1539
PRA II 4	charcoal	30-40	*Larix decidua*	1595 ± 30	1409-1542
PRA II 2	charcoal	20-30	*Abies alba*	5065 ± 35	5734-5908

TABLE 1: Praroussin. List of radiocarbon dates (OS = off site, uprooted tree) (Touflan et al., *2010).*

Dendroecology. On plot 1, the ages vary between 23 and 607 years. All classes are represented in the distribution up to 200 years. For stone pine, the median age is 55 years and the oldest individual is 158 years old. All classes up to 160 years are represented. On plot 2, the ages vary between 9 and 565 years. All classes up to 190 years are represented. Any stone pine exceeds 159 years old and its age structure is shared among 4 ages-groups (10-40, 50-80, 100-130, 140-160 years)

Ste Baume

Pedoanthracology. Preliminary results of charcoal are presented in presence/absence. The beech occurs in all the pits, except one, that was dug in the oak-dominated part of the forest of Ste Baume. The "absence" of beech thus is to be interpreted with caution because work still in progress.

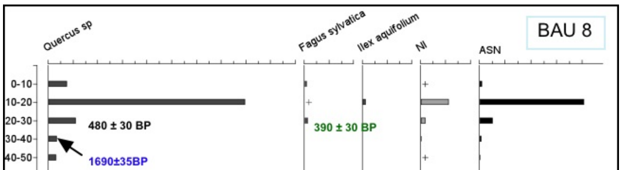

FIGURE 1: Example of pedoanthracological diagram. Bau 8 (Plot 3, beech dominated?).

Charcoals of oak are present in every pit, which would attest the past extension of the oak grove beyond the surface that it occupies today (Fig. 1). Four radiocarbon dates came from *Quercus* deciduous, four from *Fagus sylvatica* and one from *Taxus baccata*. The radiocarbon dates indicate Late Antiquity to Middle Age fire events. The oldest dates come from *Fagus* (778 – 903 AD) and *Quercus* (311 – 422 AD). Other dates range between *ca.* 780 and 1500 AD. In the preliminary results, no fire events have been thus recorded since almost 500 years.

Dendroecology. Trees are *ca*. 182 yrs old. Their installation dates the beginning of the 19th century. This period coincides with the stop in 1815 of the important cuttings made during revolutionary period (Guinier, 1944). Some trees older than 256 years could have played a major role in the natural regeneration of the forest. But beeches could also have been planted. The stand structure is characterized by two dominant classes, very young and old trees.

CONCLUSION

Pedoanthracology and dendroecology bring new light on the forest dynamics. Episodes of fire have taken place for a long time in the studied forests, particularly in the subalpine forest. The study of subalpine forest dynamics (dendroecology) shows that arolla pine will play a major role in the future, as it was already the case in past (pedoanthracology). In the forest of beech, the importance of oak charcoal reveals the past importance of this species and corroborates the results of the dendroecology study. The regeneration of beech is not ensured and is finally going to favor the expansion of oaks.

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Subalpine forest history and dynamics in the French Alps (Queyras)

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Summary: *In the context of global change, the assessment of the species and forest past dynamics at timberline is essential to improve knowledge about the present landscape and its evolution. Several paleoecological approaches are simultaneously used for reconstructing past landscape and its evolution. The dynamics of subalpine forest are subjected to natural disturbances most particularly fires. By the end of the Atlantic period, human perturbations by agro-sylvo-pastoral practices became an important factor that explains the landscape dynamics and the dominance of some ligneous species. First results of the pedoanthracology approach reveal an early recolonization by stone pine and larch following the last glaciation. In the past, the timberline was higher than nowadays. Considering the present change, particularly the abandonment of human practices, current conditions at high altitude might potentially allow forest establishment. The poor frequency of shrubs in charcoal samples raises question about their status and possible presence in past understoreys and their settlement conditions.*

Key words: *high altitude ecosystems, Queyras, pedoanthracology forest dynamics, species history*

INTRODUCTION

High-altitude forest dynamics are considered to be of special interest with respect to global changes and are frequently investigated in ecological and palaeocological studies. To date, paleoecological data from Queyras (southern French Alps) have been provided mainly by pollen sequences (de Beaulieu, 1977; David, 1995; Nakagawa *et al.*, 2000). Apart from data from small peat bogs, these studies have generally reported vegetation dynamics on a regional scale. However, studies based on charcoal found in soils (pedoanthracology) are of high interest to specify forest dynamics at local scale (Talon *et al.*, 1998; Talon, 2010; Touflan *et al.*, 2010). These local vegetation variations are most often imprecisely recorded by pollen sequences. Consequently, in order to understand local vegetation dynamics, history of the species and treeline variation in response to climatic and/or human pressure, it is important to carry out studies based on charcoal in natural soils.

DATA AND RESULTS

The study area is located in the Natural Park of Queyras in the inner French Alps comprising a massif centred on the Guil Valley. The woody vegetation is composed of woodlands spreading between 1700 and 2400 m asl, and is dominated by *Larix decidua*, *Pinus cembra* and *Pinus uncinata*. The understorey is dominated by *Rhododendron ferrugineum* L., *Vaccinium uliginosum* L. (mostly on north-facing slopes), *Arctostaphylos uva-ursi* (L.) Spreng. (on south-facing slopes) and *Juniperus communis* L. The tree line on the north-facing slopes is formed by a mosaic of *L. decidua* woodlands, spreading up to 2400 m asl. On the south-facing slopes, traditional land use has been devoted mainly to livestock grazing (mostly sheep), resulting in large areas of meadows and heathland slopes, where trees are absent above 2000 m.

Six sites were investigated following previous studies and current forest composition. At each site two or more pits were dug along an altitudinal gradient: at least one at the uppermost limit and one in the forest. The sampling strategy was based first on the observation of the soil profiles and on the subsequent soil description. Undisturbed soil samples were collected at 10 cm intervals from all of the soil profiles. Approximately 10 kg of soil material were collected per soil horizon. Charcoal was extracted using protocols described by Carcaillet and Thinon (1996). Only charcoals larger than 1.25 µm were identified, weighted and sometimes dated.

About 3000 fragments were identified and weighted. *Pinus cembra*, *Larix/Picea* and *Pinus sylvestris uncinata* (i.e. *Pinus sylvestris/uncinata*) were the most represented species with respectively 28%, 24% and 8.5% (Fig. 1). Pine species are well represented at mid to high altitude, while larch fragments are more frequent at mid-altitude. Both shrubs and *Abies alba* charcoals are present in relatively small quantities compared with other species. Shrubs and vitrified fragments are more often present in high altitude soils.

Species distribution in soils varies between sites and within the profiles. Results of the correspondence factor analysis performed (Fig. 2) on number of fragments per species per soil profile show neither significant difference between sites for larch nor for pine forests. Both fir forest and grassland sites seem to reveal different dynamic or history.

Currently, 6 fragments issued from 5 different sites were dated (Table 1). The radiocarbon dates obtained indicate mid- to late- Holocene fires. The oldest date involves *Pinus cembra* (8702-9024 cal BP) in Jal3 and corresponds to the earliest date for this species.

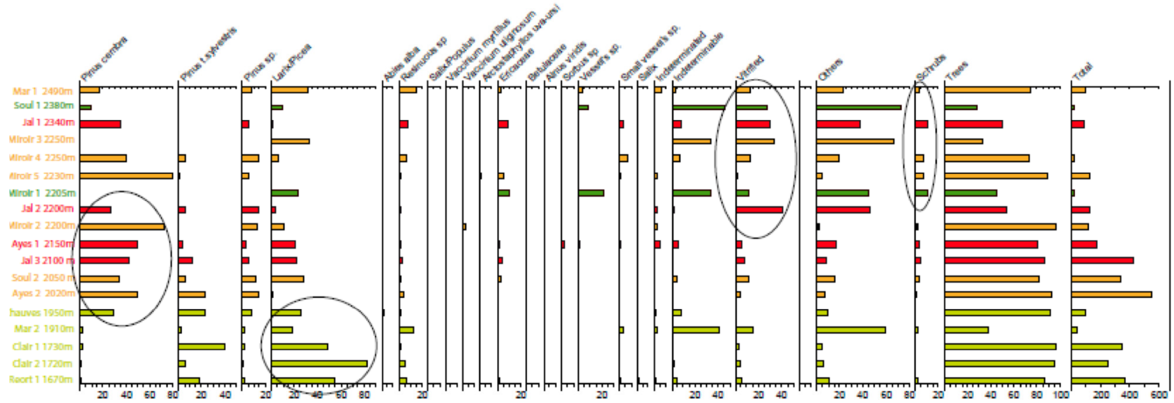

FIGURE 1. Species frequency in soils following altitudinal gradient. Colours correspond to ecosystems types: light green for Fir forest, orange for Larch forest, dark green for grassland and red for Pine forest.

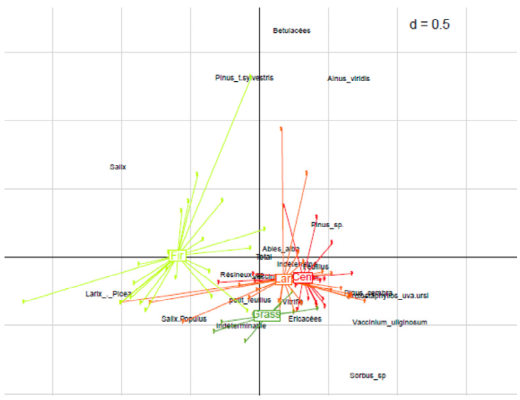

FIGURE 2. Correspondence factor analysis on soil profiles grouped following current vegetation.

Nomination	Profondeur	Peuplement	Espèce	Age 14C (BP)	Age calibré (BP)
Jal3A	40-50	cembraie	*Pinus cembra*	8020 ± 50	8702-9024
Jal3B	40-50	cembraie	*Pinus t.sylvestris*	4295 ± 30	4827-4891
Ayes2	40-50	cembraie	*Pinus cembra*	7560 ± 40	8315-8427
Miroir2	5-15	mélèzin	*Pinus cembra*	1060 ± 30	927-1009
Miroir4	10-20	mélèzin	*Pinus cembra*	2110 ± 30	1995-2152
Clair1	20-30	sapinière	*Pinus t.sylvestris*	2380 ± 35	2339-2491

TABLE 1. List of radiocarbon dates.

DISCUSSION

Radiocarbon dates confirm results from another study carried out in the inner French Alps where Touflan *et al.,* (2010) evidenced an earlier colonisation by larch (8213-8105 age14C BP) and pine following the last glaciation. Other radiocarbon dates are in progress in the aim of providing information about the history of fir and Ericaceae species. To date, in the Queyras area, there is a lack of archaeological studies that could bring essential knowledge about human installation.

The large representation of pine fragments at mid to high altitude could reveal a long-lasting pastoral exploitation of these sites. The current presence of larch at mid-altitude in closed-forest environment also evidences a long sylvo-pastoral system involving larch stands. The low charcoal frequency in grassland soils could attest a long past history of open ecosystems related to pasture land exploitation.

Vitrified charcoals are more present at high altitude sites, which raises questions about the local environment conditions (specific environment, specific type of fire, taphonomy).

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Soil, charcoal, vegetation dynamics and agro-pastoral activities since Neolithic in the medium mountain of Mont Lozère (France)

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Summary: *Pedoanthracological and pedological analyses on soils of Nardus stricta area of the Mont Lozère (France) have been carried out in order to understand the origin of this plant community, which develops in the uppermost part of the Mont Lozère, just above the beech forest. A palaeoenvironmental multi-disciplinary approach (palynology, archaeological and sedimentary charcoal analysis, dendrology, geochemistry, geoarchaeology) combined with landscape, pastoral and mining archaeological evidence demonstrate the impact of different human activities in this landscape. Soil and soil charcoal study carried out at a high resolution permits to determine the evolution of the Ranker soil and the relationships between this type of soil and the vegetation dynamics since the Neolithic. What is the role of fire (natural or anthropogenic fire) in the construction of this open landscape?*

Key words: *soil, charcoal,* Nardus stricta *grassland, geochemical analyses, agro-pastoral activities*

INTRODUCTION

The study area is the Mont Lozère, located in the Massif Central (France). This medium mountain, which has revealed a lot of human ancient activities (metallurgy, farming, pastoral activities and forest exploitation), can be considered as a reference model to understand the relationship between human practices and vegetation dynamics since the Neolithic period.

We present the first results from soil charcoal analyses and pedological descriptions applied in the same pits on the uppermost part of the Mont Lozère. The study site, characterized by an open landscape composed by *Nardus stricta, Ericacea, Vaccinium myrtillus,* etc., is situated above the remains of beech forest located in the lower part of the north slope (maximum altitude at 1350 m), and shows a sporadic re-colonization of conifers. A combined study of the charcoal-burning platforms (Allée and Paradis, in press) located in the west part of the Mont Lozère and palynological analysis of the peat bog "Amourous" (Servera Vives, oral communication) located near the pedoanthracological pits demonstrates the presence of beech forest at 1450 m altitude during the High Middle Ages. Today, beech tree is absent from the study area.

The aim of the study is to shed light on the dynamic of the *Nardus stricta* grassland, which has been considered as natural for a long time. In addition, the evolution of the Ranker soil (AFES 2009) located in a pastoral landscape will be taken into account in its relationship with past forest and agro-pastoral practices. Another objective of this research is to determine the maximum elevation reached by treeline as well as its evolution since the Neolithic.

METHODOLOGY

A test-pit performed in September 2010 has revealed the presence of charcoal fragments in all soil horizons. After this first survey, 10 pits were dug along an altitudinal transect from 1350 m asl up to 1560 m asl in the northern slope with a high altitudinal resolution of about 25 m.

The identification of charcoal from soil and the radiocarbon dates from charcoal fragments permit to reconstruct the dynamic of the vegetation over a long time. Pedoanthracological samples have been taken every 5-10 cm, from the bedrock towards the surface of the pit, after having made pedological descriptions of the soil horizons (Baize and Jabiol, 1995; Carcaillet and Thinon, 1996; Bal *et al.,* 2010; Talon, 2010). Any colluviums or bioturbation traces have also been noted.

RESULTS AND DISCUSSION

The pedological profile of "La Bourassade" shows 3 horizons. The upper one is a humiferous A horizon (15 cm deep). The second one is 60 cm deep and presents a silty sand texture and some granules. Both of them have a crumb macro-structure. The third one (between 75 and 105 cm deep) is also a silty sand horizon and contains medium and large stones. This succession could correspond to a rankosol, but the profile is deep and the second horizon does not contain numerous stones. So, the classification of this soil and a better characterization of the horizons could be clarified thanks to the different chemical analysis and the micromorphological study.

The test-pit conducted in September 2010 (Fig. 1) has revealed the presence of charcoal in all soil horizons. The medium size of the charcoal is 0.8 mm and some of them present altered anatomical structure, which makes difficult the identification. The 35 charcoal samples identified are all *Genista* genus (Schweingruber, 1990). For this test it was impossible to date the charcoal according to the size and the height of the fragment. These first results reveal an open landscape in the entire sampled sequence and suggest that human management of these grasslands included repeated burnings.

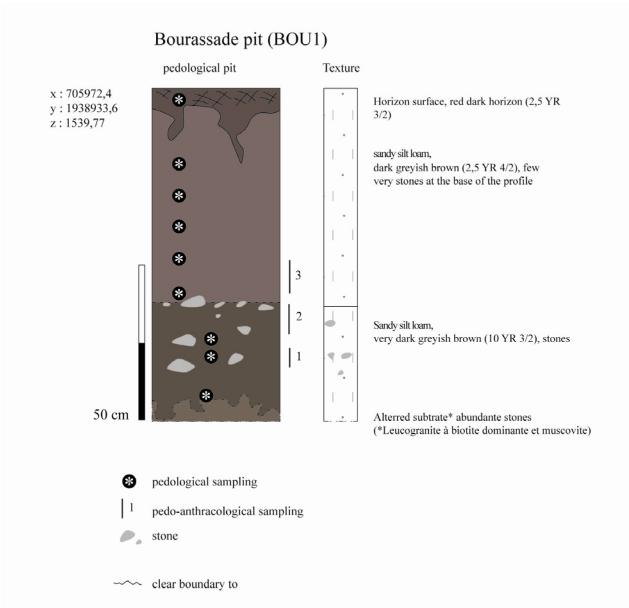

FIGURE 1. Pedological description of the pit in the Amourous area (M. Liard)

CONCLUSION

This pedoanthracological study is part of a multi-disciplinary project including archaeological survey and a multi-proxy palaeoenvironmental approach with the aim of studying the interactions between agro-pastoral activities and cultural landscape shaping.

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Holocene environmental reconstruction in Southern Calabria (Italy): an integrated anthracological and pedological approach

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Summary: *A multidisciplinary approach based on anthracological and pedological analysis on soil profiles is used to reconstruct past environment in two archaeological sites of Calabria (South Italy): Cecita Lake and Palmi. The soils of Cecita span from late Neolithic/early Eneolithic to Greek and Roman ages. The second site includes a late Neolithic to late early Bronze Age to undifferentiated historical succession. Pedological analysis show the occurrence of clay coatings in the Neolithic soils from both sites, suggesting a climate with high moisture availability and some seasonal contrast, enhanced by warm-humid conditions during the late early-middle Holocene climatic optimum. The post-Neolithic soils show more abundant short-range order minerals than phyllosilicates and no clay coatings, indicating a transition towards prolonged humid conditions. Between these climatic phases severe land degradation is recorded, testified by human impact and soil erosion, well-documented by pedoanthracological results at Cecita. Here, charcoal fragments from Neolithic soils are dominated by deciduous oak-forest, whereas a transition to a mountain pine forest is recorded in the Roman soils. A stable oak forest characterizes, instead, the landscape at Palmi from the Neolithic onward.*

Key words: *pedoanthracology,* Quercus *deciduous type,* Pinus *group* sylvestris*, Cecita Lake, Palmi*

INTRODUCTION

Multidisciplinary research is an essential tool in reconstructing past environment and landscape. In this poster we present the application of archaeoanthracological analysis, together with pedoanthracology and pedology, for understanding environmental changes in two different areas of Calabria (South Italy).

THE STUDY AREA

The two studied sites are Cecita Lake and Palmi, situated in north-central inland and south-western coastal Calabria, respectively. Cecita Lake is an artificial lake located on the Sila Massif at about 1130-1140 m asl in a tectonic depression filled up, probably since late Early-Middle Pleistocene through Late Pleistocene, by fluvial-lacustrine sediments related to a palaeo-lake. The main vegetation is composed by beech (*Fagus sylvatica*) and oak forest (*Quercus cerris*). The high mountain belt is made of conifers dominated by pine (*Pinus laricio*) and fir (*Abies alba*). Human occupation along lake shores from late Neolithic to early Eneolithic (5800-5350 years BP) and from Greek time (6th to 3rd century BC) to the Roman Age (3rd – 1st century BC to 5th – 6th century AD) is documented by settlements and archaeological finds. The excavation close to Palmi (Piani della Corona site) is situated on a wide terrace at about 500 m asl, along the southern Tyrrhenian coast of Calabria. A pedostratigraphic succession already described by Bernasconi *et al.* (2010) is present, including late Neolithic settlements and artifacts (about 6500-5800 years BP). They are partly truncated and buried by anthropogenic disturbance, that displays repeated ploughing traces of undifferentiated historical epochs, separated by a late early Bronze Age paleosurface (about 4000-3700 years BP). This surface is in turn affected by marks of archaeological structures and ploughing.

MATERIALS AND METHODS

The methodology has envisaged a first geomorphological and pedological characterization and description of the soil profile and the subsequent collection of soil samples for pedological and anthracological analysis. In the case of Cecita Lake only late prehistoric and Roman soils were sampled. They all consist of surface A horizons, in places affected by repeated prehistoric to modern ploughing traces (Ap). In the Neolithic soil the A horizon exhibits scarce clay coatings in pores and overlies a Bw horizon. At Palmi the upper profile was sampled: the deep argillic (Btb) horizon dated to late Neolithic, the late early Bronze Age paleosurface (Ab) and, above this Bronze Age paleosurface, the upper stratigraphic succession consisting of brown anthropogenically disturbed organic-mineral (Ap) horizons, archaeologically not well dated because of their reworking for agricultural practices (Bernasconi *et al.*, 2010). The deepest part of the soil profile is going to be dated by AMS dating to have the most ancient chronological limit. The samples were water-sieved with mesh sizes of 2, 1, 0.5 and 0.25 mm. Charcoal fragments with > 2 mm size were sorted; the taxonomical determinations have been made by a stereo lens and an incident light microscope at magnification 100x, 200x and 500x, using wood anatomy atlases and reference collections of wood.

RESULTS AND DISCUSSION

Soils from both sites partly developed on volcanic ash and display variable Andisol-like features related to formation of some amounts of short-range order minerals. Ash composition, the pedostratigrahic position and some radiometric dates suggest a provenance from late Pleistocene/Holocene explosive eruptions of the Aeolian Islands (Scarciglia *et al.*, 2008; Bernasconi *et al.*, 2010). Micromorphological observations performed in thin sections prepared from undisturbed soil samples highlighted the occurrence of clay coatings in the Neolithic layers of both sites, and their relict significance (e.g. Kemp, 1998). These features suggest climatic conditions characterized by high moisture availability and some seasonal contrast, enhanced by a warm-humid climate. Therefore, main soil development may have occurred during the late early-middle Holocene climatic *optimum* (Scarciglia *et al.*, 2008; Bernasconi *et al.*, 2010; Pelle *et al.*, 2010). The post-Neolithic soil horizons show more abundant short-range order minerals than phyllosilicates and no or very rare clay coatings, suggesting climatic changes towards overall prolonged humid (and probably cooler) conditions. Between the two distinct climatic phases identified during and after the Neolithic, severe land degradation is also recorded, testified by human impact and soil erosion. Archaeo and pedoanthracological data from Cecita give good evidence of it. In fact, charcoal fragments from Neolithic soils are dominated by deciduous oak forest (mainly *Quercus* deciduous type), whereas a transition to a mountain pine forest dominated by *Pinus sylvestris* group is recorded in the Roman soils. Preliminary soil charcoal data from Palmi, instead, suggest a stability of forest cover characterized by a deciduous oak forest; in fact this *taxon* is present both in the Neolithic and in the post-Bronze Age horizons. It is noteworthy the presence of *Abies,* belonging today only to mountain vegetation, identified in a Neolithic horizon. It cannot be ruled out that also some effects of climate drying (e.g. Mayewski *et al.*, 2004; Di Donato *et al.*, 2008) could have enhanced land degradation after the Neolithic climatic *optimum*, as also coherent with above decrease or interruption of clay illuviation in younger soils. However, in the mountainous area of Cecita Lake, the decline of the deciduous oak forest could mainly be caused by the human overexploitation of the forest resource. To better determine the significance of climate or human influence in this area two new soil profiles from Cecita Lake are going to be analyzed pedoanthracologically, with the aim to have a more detailed chronological succession and a more accurate date for the shift from the deciduous oak forest to the mountain pine forest. New AMS dating is going to be done. AMS dating is required also for both data concerning the silver fir and post Bronze Age oak found at Palmi.

CONCLUSIONS

The anthracological and pedological analysis carried out in Palmi (south-western Calabria) suggest a stability of forest cover form Neolithic to the post-Bronze Age. At Cecita Lake (north-central Calabria) the data shows a transition from a deciduous oak forest dominant in the Neolithic soils to a mountain pine forest characterizing the Roman soils. In the mountainous area of Cecita Lake, this shift could be mainly caused by the human overexploitation of the forest resource. New analyses are going to start to clarify this aspect.

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Charcoal analysis in Preventive Archaeology: combining culture heritage management with scientific research in the A75 motorway (Clermont l'Hérault - Béziers, Southern France)

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Summary: *The drawbacks and advantages of preventive archaeology and the implications for archaeobotanical studies are assessed based on the example of work carried out prior to the construction of the A 75 motorway in southern France. The main results obtained in sites destined to be rapidly destroyed are presented. They provide a large scale insight on human settlement and land exploitation from the Middle Neolithic to the height of the Roman Empire.*

Key words: *preventive archaeology, southern France, charcoal analysis, human settlement, vegetation*

INTRODUCTION

According to the Collins Dictionary of Archaeology (Bahn, 1992) Rescue Archaeology or Public Archaeology is a British generic expression applied to the work carried out on sites prior to their destruction by modern developments. This term is synonymous with the North American Salvage Archaeology or Cultural Resource Management and with the French "Fouilles de sauvetage", which was replaced in 2001 by 'Fouilles préventives' (preventive archaeology), in an attempt to reverse the drawbacks of traditional rescue archaeology. In Rescue archaeology 'archaeologists run behind the bulldozers' trying to make the best of the unpleasant job of rapidly destroying our history; in Preventive archaeology 'archaeologists precede the bulldozers' (Demoule and Landes, 2009) safeguarding our history via the excavation, study and publication of uncovered remains.

This is the aim of INRAP (Institut National de Recherches Archéologiques Préventives), which possesses both the infrastructures required for large scale survey/excavation and the will to promote high quality research.

During field work an effort is made to recover as much information as possible. However, our ability to study the archaeobotanical remains recovered from the sediment samples is limited by time and financial resources. Clear research priorities must therefore be established in order to obtain reliable datasets. This negative aspect is compensated by the opportunities opened by the work in linear projects such as motorways, railway lines, gas works, which allow us to visualise patterns of human settlement and subsistence adaptation through time and on a regional scale, crossing a large range of ecological habitats. The work carried out prior to the construction of the A 75 motorway between Clermont-l'Hérault and Béziers (Hérault, Southern France) is a good example of this (Fig. 1).

FIGURE 1: The site of Montferrier (Antiquity) prior to the construction of the A 75 motorway (photo M. Compan).

RESULTS AND DISCUSSION

Based on the assessed importance of remains uncovered during the survey phase ('diagnostique' in French), more than 30 locations were selected for subsequent major excavation and study, covering the period Neolithic - Middle Ages.

Concerning charcoal analysis, particular attention was paid to sites with particularly interesting structures:

- Middle/Late Neolithic settlements (Pirou, Roquessols, Barreau de la Devèze) characterized by the large number of pits uncovered (more than 300 just in the first site). The abundance of heliophilous plants, colonisers of empty spaces suggest a long last occupation / exploitation of the area. Significant frequencies of *Pistacia lentiscus*, which usually grows on the dry and stony areas of the Mediterranean' garrigue', raise questions concerning its significance this early in time.

- Delimited fields covered with plantation pits (vine plantation and orchards) during the gallo-roman period (Champ Redon, Aire de Repos de Valros) allowed us to test the type and the paleoenvironmental reliability of the information obtained from this type of structure. The taxonomic diversity recorded by the identification of the charcoal fragments recovered suggests that the remains of domestic wood fuel were recycled (at least partly) and used as a fertiliser in agriculture. This impression has been confirmed by the study of terrestrial molluscs (S. Martin in Figueiral *et al*., 2010a).

- Roman burial ensembles (Renaussas, Vigne de Bioaux, Cresses Basses, Peyre Plantade, Soumaltre) provided information on the wood-fuel used to cremate the bodies and showed that, in general, no particular selection was carried out. The diversity of woody plants exploited testifies to the absence of any restrictive rules. However, certain activities linked with the burial ritual (ex: fireplace associated with tombs) may have favoured the sporadic choice species, such as *Cupressus*. The use of branches of small calibre may be explained by the technical requirements of the cremation process.

Lined wells were excavated obeying strict safety procedures and rewarded us with a remarkable wealth of material and information concerning the Roman period (Montferrier, Rec de Ligno, Mazeran), especially concerning the levels preserved under anoxic conditions. The quantity and diversity of plant material vary from one well to the other. Although some of the debris might have fallen naturally or been lost accidentally, it is clear that most of them result from the use of wells as a rubbish dump. The most relevant charcoal analysis data were obtained in the first well and provide a clear image of the major biotopes exploited by the local population - the mixed oak woodland, the alluvial forest and the cultivated fields. The identification of present-day exogenous species (*Fagus*, *Abies*, *Larix*/*Picea*) may result either from trade or from their sporadic survival in favourable lowland locations as shown by previous studies (Chabal 1997; Durand 1998; Puertas 1998, among others). The abundance of monocotyledonous stems (*Arundo*) is more difficult to explain in terms of local ecology alone and may result from specific activities carried out in the vicinity (Figueiral *et al*., 2010a and b).

CONCLUSIONS

A complex picture of human occupation and activities is drawn. This is an area where the different ecological and cultural influences from the Hérault and the Orb valleys converge. Preventive archaeology allowed us to show the importance of recognizing chrono-cultural disparities in order to understand their influence in the establishment and evolution of vegetal landscapes. Concerning Pre-History, the question of the early anthropogenic impact may be linked with the presence and confrontation of “Ferrières” or “Vérazien” populations in this buffer zone. The ecological influence of the Hérault valley and the coastal plain is also detected. This ecological pattern is also identified later on, during Antiquity, with influences from both the “Clermontais” an area of passage and exchanges, and urban centres, such as Béziers. The problem of the small and medium sized gallo-roman agrarian establishments has also been considered, in association with the diversity of their economy and grape vine exploitation. The “A 75 experience” has also highlighted the importance of a scientific coordination for the paleoenvironmental studies, to provide rapid guidance, to deal with strategic choices in terms of sampling, to assess the potential of remains in terms of research projects, and to ensure that specialists are kept informed of developments during field work.

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The fire of Iberian Neanderthals. Wood charcoal from three new Mousterian sites in the Iberian Peninsula

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Summary: *Three archaeological sites with Middle Palaeolithic sequences are currently under excavation in the Iberian Peninsula. The stratigraphic deposits in Gruta da Oliveira (35-70 ka BP), Cueva Antón (35-45 ka BP) and Abrigo de la Quebrada (40-50 ka BP) provided the wood charcoal for the analysis, whose first results are presented here. Our work offers a preliminary view of the local flora used by Neanderthals and contemporary climatic conditions in three regions of Iberia.*

Key words: *wood charcoal, Neanderthal, fire, palaeoecology,* Pinus.

INTRODUCTION

In this paper we present preliminary results of wood charcoal analysis from three caves in the Iberian Peninsula, Gruta da Oliveria in Portugal and Cueva Antón and Abrigo de la Quebrada in Spain (Fig. 1A). Our main aim is to provide new information concerning the use of wild plants by the Neanderthals during the Upper Pleistocene. The analyses of wood charcoal should provide a picture of the surrounding flora and the ecological conditions at the time. Moreover, through the analysis of wood charcoal we have tried to understand the importance of post-depositional processes in the palaeoecological interpretation.

Archaeological wood charcoal is a material that provides abundant and variable information: ecological, ethnographic, taxonomic, chronological, etc. Although some of the methods used to obtain this information are destructive, if the sequence of analyses is coordinated in an adequate manner none of the information is lost. The analysis of wood charcoal should follow this sequence: botanical identification should be conducted first and afterwards the material can be sent to the radiocarbon laboratory, where it will be dated and destroyed. Such a procedure, which emphasises the history of species and the detection of taphonomic problems (Carrión *et al*., 2010), was followed in the Mousterian sites presented here. The radiocarbon dating results obtained are presented in Table 1.

THE SITES

Gruta da Oliveira is located in the Almonda karstic system in central Portugal (39°30'23" N, 08°36'49" W, 115 m asl). The bioclimatic conditions are thermomediterranean and woody flora is dominant. The most abundant species are: *Olea europaea var. sylvestris*, *Rhamnus alaternus*, *Pistacia terebinthus*, *Pistacia lentiscus*, *Myrtus communis*, etc. In the areas with deeper soils *Pinus pinaster* and *Quercus* sp. evergreen grow.

The Middle Palaeolithic sequence (layers 7 to 19) is dated to ca. 35-70 ka BP (Angelucci and Zilhão, 2009).

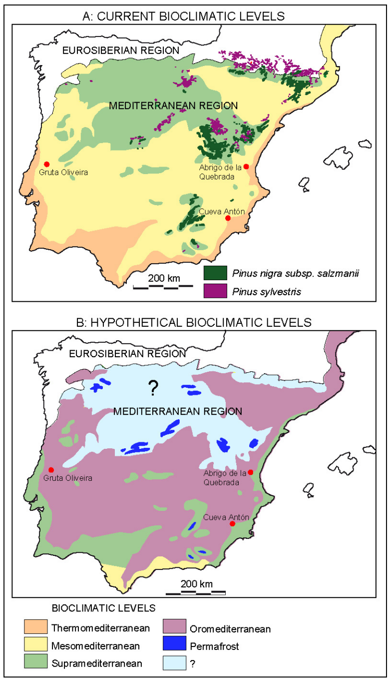

FIGURE 1. Location of the Middle Palaeolithic sites. A) In the current bioclimatic map of Iberia and distribution of Pinus nigra *and* P. sylvestris*. B) In hypothetical bioclimatic levels during the Middle Palaeolithic.*

Cueva Antón is a rockshelter opened into the base of an E-W, 25-30 m high, Eocene limestone escarpment located towards the tail end of the La Cierva reservoir, on the Mula River (01°29’43” W, 38°03’56” N, 380 m asl). The current bioclimatic conditions are thermomediterranean semiarid and the vegetation is xerophytic scrub with xeric grasses as *Stipa tenacisima*, *Lygium spartium* and some scattered *Pinus halepensis*.

Excavations at Cueva Antón have exposed levels of Middle Palaeolithic occupation in the stratigraphic sequence. Abundant artefacts organized around hearth features are present in the lower levels of the sequence, but occupation remains are scarce toward the top (Zilhão *et al*., 2010).

The Abrigo de la Quebrada (39º48'25" N, 01º00'49" W, 708 m asl) is located in a narrow canyon where bioclimatic conditions are meso-momediterranean dry. Pine (*Pinus halepensis* and some *P. pinaster*) forests are dominant over most of the area. This large rockshelter presents an important stratigraphy for the regional late Mousterian.

Site	Context	Laboratory	Species	Radiocarbone date (BP) and method
Cueva Antón	I-i	OxA-20115	*Pinus halepensis*	98±23 (ABOx-SC)
Cueva Antón	I-k/II-d	OxA-20881; OxA-21244	*Pinus* sp.	31150±170 (ABA); 32890±200 (ABOx-SC)
Cueva Antón	I-k	OxA-20882	*Pinus nigra*	31070±170 (ABA)
Cueva Anton	II-hi	OxA-18672	*Juniperus* sp.	39650±550 (ABA)
Gruta da Oliveira	8 (intrusive)	GrA-29384	*Olea* sp.	6055±45 (ABA)
Gruta da Oliveira	12 (unacceptable)	GrA-24408	*Pinus* sp.	26940/+270/-250 (ABA)
Gruta da Oliveira	13	GrA-24410	*Erica* sp.	39540/+490/-410 (ABA)
Gruta da Oliveira	14	GrA-22024	*Pinus sylvestris*	42800/+2300/-1800 (ABA)
Gruta da Oliveira	14 (unacceptable)	OxA-13137	*Pinus sylvestris*	27850±550 (ABA)
Gruta da Oliveira	14	Beta-183537	*Pinus sylvestris*	40900±1100 (ABA)
Gruta da Oliveira	15 (unacceptable)	GrA-24407	*Pinus sylvestris*	37520/+380/-330 (ABA)
Abrigo de la Quebrada	C-5	Beta-244002	*Pinus nigra/sylvestris*	43930±750 (ABA)
Abrigo de la Quebrada	C-5	Beta-244003	*Pinus nigra/sylvestris*	40500±530 (ABA)

TABLE 1. Radiocarbon dates on wood charcoal from the Middle Palaeolithic sites.

MATERIAL AND METHODS

With variants, subsurface sampling of the sites took place in two phases. At Quebrada, for example, each unit was excavated in 10 cm levels and all sediment was screened through a set of nested dry screens of 5 mm, 2mm, and 1mm in size. Artifacts and charcoal were collected from these screens. Additionally, 2-liter sediment samples were collected from each level of each excavation unit for flotation and water screening to separate the coarse fraction with microartifacts from the fine fraction with organic materials. The average size of the wood charcoal pieces identified is less than 2 mm. Wood charcoal was scattered in variable densities throughout the excavated deposits; only at Gruta Oliveira does part of the charcoal come from hearth features, one in level 14 and another in level 21.

We used a Nikon Optiphot-100 dark/bright field incident light microscope for taxonomic identification of wood charcoal. The specimens were identified with the aid of specialized plant anatomy bibliography and a reference collection of modern charred woods. At this stage of analysis, we only work with the presence of taxa, but in the future we will apply the appropriate statistical calculations. Photographing and detailed observation of microorganisms and minerals was carried out with a Hitachi S-4100 Field Emission Scanning Electron Microscope and the EMIP 3.0 (Electron Microscope Image Processing) software.

RESULTS

The flora used by Neanderthals is characterized by conifers and a few angiosperms. Among the conifers, pine and juniper contributed most of the wood charcoal recovered. Although not all the pines could be identified to species level, of those pieces that could the great majority are *Pinus sylvestris* in Gruta da Oliveira and *P. sylvestris* or *P. nigra* in the other sites.

The pine/juniper-dominated charcoal assemblages reflect a very similar ecological context in all three sites. These trees are well adapted to the dry-cold climate that prevailed in the Iberian Peninsula at the time. Pines, in particular, can store considerable water in their trunks to help them survive long periods of drought. The driest conditions are denoted at Cueva Antón by the predominance of *Juniperus* sp. associated with *Ephedra* sp. This combination suggests an open, steppic landscape with scattered mountain pine stands.

When we compare the present day distribution of *Pinus nigra* and *Pinus sylvestris* in the Iberian Peninsula with the location of the Mousterian sites we may observe that during the time that the caves were used the sequence of bioclimatic levels would have been displaced approximately 1000 m in altitude and the temperature would have been 10 ºC lower (Fig. 1B).

The botanical identification of wood charcoal was followed by the selection of specimens for radiocarbon dating. The explanations for the results falling outside the expected range for the Middle Paleolithic are: (a) the *Olea europaea* var. *sylvestris* from Gruta da Oliveira comes from a burrowed area in the uppermost level of the sequence, and confirm that the taxon should be ascribed to the Holocene flora (Carrión *et al*., 2010); (b) the *Pinus halepensis* from Cueva Antón dates the inundation silts deposited over the site after construction of the La Cierva dam in the early 20th century; (c) the couple of age determinations for *Pinus sylvestris* from Gruta da Oliveira that are too young reflect incomplete decontamination of very small samples, not intrusion from non-existent Upper Paleolithic levels.

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Environment and plant economy during the Mesolithic in the Haut-Quercy (Lot, France): anthracological and carpological data*

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Summary: *This paper presents and discusses the results of the analyses of the charred wood and seed remains from three Mesolithic sites: les Fieux, les Escabasses and le Cuzoul de Gramat (Lot, France). Charcoal analysis shows quite original results, i.e. the early disappearance of softwoods in favour of pre-forest vegetation dominated by* Prunus *type* mahaleb/spinosa *in which deciduous* Quercus *forest develops progressively. Such environments produce a variety of edible fruits, which do not seem to have been exploited significantly for alimentary purposes.*
These results raise several questions linked to the palaeological representativeness of our charcoal assemblages and the palaeoeconomic significance of the carpological remains, both of which could have been biased by cultural factors (selection, site function, activities…) and/or taphonomic conditions.

Key words: *firewood, palaeoethnobotany, Mesolithic, south-western France.*

INTRODUCTION

The Causses of the Haut-Quercy, located between the Pyrenean and the Massif Central mountain ranges, offer contrasted landscapes that must have been attractive to prehistoric hunter-gatherers, according to the great number of sites dotting the Causse de Gramat, center of our study area. However, only few palaeobotanic studies have been carried out in this region unfavourable to the conservation of sporopollinic and other non-charred plant material. In order to obtain a picture of the local environment and its exploitation during the Mesolithic period, this paper presents and discusses the results of the charred wood and seed remains from the sites of les Fieux, les Escabasses and le Cuzoul de Gramat.

THE SITES

These are all located on the limestone plateau Causse de Gramat, at an altitude of 250 to 300 m asl. The present-day vegetation is located in the supra-Mediterranean level and consists of more or less degraded *Quercus pubescens* woodlands.

The stratigraphic sequences dating from the Mesolithic comprise layers dated between *ca.* 9500 and 5500 BP: Fieux cave has yielded early Mesolithic layers (Champagne *et al.*, 1990), whereas Escabasses cave and Cuzoul de Gramat rockshelter were reoccupied throughout the middle and late/final Mesolithic (Valdeyron, 2000; Valdeyron *et al.*, 2011).

MATERIAL AND METHODS

Sampling, sorting and identification were performed in concordance with the classic methodology of each discipline (Chabal, 1991; Marinval, 1999). In order to represent and to discuss the evolution of the ligneous vegetation on the plateau, data from 5 sites were integrated in a factorial analysis.

RESULTS

The layers dating from the end of the early Mesolithic (Les Fieux cave) showed very homogeneous anthracological results, which indicate the presence of well-established forest vegetation dominated by deciduous *Quercus*.

As for the middle Mesolithic, the charcoal analysis of les Escabasses showed a strong dominance of *Prunus* type *mahaleb/spinosa* (around 8000 BP) whereas the study of Cuzoul led to results that were closer to the charcoal assemblages from Les Fieux (however, no radiocarbon dates are available yet).

Finally, the anthracological spectra resulting from the analysis of the layers of the late Mesolithic of those two sites converge: supramediterranean woodland dominated by *Quercus* and its associated species, as well as the appearance of slightly more hygrophilous taxa, reflect probably an increase in humidity related to the climatic evolution of the Atlantic period.

The dominance of *Prunus* type *spinosa* in one site led to question the palaeological representativeness of our spectrum: are we dealing with pre-forest type vegetation or have other factors led to the distortion of our results?

As in most temperate dry Mesolithic sites, carpological data are extremely scarce and plant material consists mainly of hazel pericarps, although sometimes fragments of acorns or Fabaceae were recovered. Nevertheless, first results obtained for the site of Cuzoul seem promising; the excavation is only beginning, and 3 taxa (*Corylus*, *Quercus* and *Cornus*) have already been identified in a single hearth.

But to what extent do these results reflect the reality of plant exploitation by Mesolithic groups? Our palaeoeconomic interpretation cannot be made regardless of taphonomic or societal issues such as site function or season of occupation.

DISCUSSION

Our anthracological results, as well as their comparison with data from other sites, allow us to discuss the palaecological evolution of the plateau, but also to consider the possibility of a taphonomic impact on the material of Escabasses cave.

A comparative study of different sizes of charcoal shows that *Quercus* is underrepresented among the charcoals superior to 4 mm in the layers where *Prunus* is dominant, and overrepresented in the late Mesolithic layers where *Quercus* becomes the main taxon. Therefore, differential fragmentation can hardly be considered as a distortion factor. These results are in concordance with previous work by Chabal (1982, 1991) and Badal-García (1990).

In addition, the taxa list and proportions obtained for the middle Mesolithic layers of Escabasses cave are very similar to present-day fruticeae *Prunetalia spinosae* Tüxen, the only difference being the persistence of this formation throughout the centuries, whereas nowadays this kind of vegetation is more quickly invested by forest taxa when the land is unexploited.

This recurrent pattern through several layers of the Escabasses, as well as similar situations encountered in other sites from the middle Mesolithic, make the hypothesis of a human preference for Rosaceae prunoideae difficult to support.

As regards the carpological results, it is well known that hazel represents an important food resource throughout the Mesolithic, but even this is difficult to conclude for our sites, since estimations show that the recovered fragments correspond to a very reduced number of entire nuts.

It is interesting to notice that this amount remains low regardless of the season of occupation i.e. regardless of the fact that nuts (but also other edible fruits) were available around the sites. Hazel, which has a high nutritional value and is often seen as an emblem of the Mesolithic period, seems to be particularly suitable for transportation; therefore, different scenarios of acquisition and consumption can be proposed.

CONCLUSION

The review of some potential causes of distortion of our anthracological data leads us to speak in favour of their palaeoecological representativeness. The specificity of the studied region seems to reside in the early disappearance of softwoods in favour of a pre-forest vegetation dominated by *Prunus* type *mahaleb*/*spinosa* in which deciduous *Quercus* forest develops progressively, though in a locally and temporally contrasted way.

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* We would like to inform the reader that this work is still in progress: therefore, the results are likely to evolve towards slightly different conclusions. Please cite the final publication, when available. March 2011.

Vegetation dynamics, human impact and exploitation patterns in the Paris Basin through the Holocene: palynology *vs*. anthracology.

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Summary: *The comparison between the palynological and the anthracological records of the Paris basin during the Holocene provides congruent pictures. This, despite some differences related to the nature and origin of the investigated samples (e.g., from archaeological contexts or paleochannels). At basin level, both analytical approaches similarly record the taxa characterizing the four principal environmental phases of vegetation history. The first phase, which is uniquely documented on palynological ground, is associated to the presence of extended pine woods between 9200 and 8200 cal BC. The second (8200-6800 cal BC) corresponds to the emergence of hazel woods and to the first development of pioneer plant species of deciduous oak woods at the expense of pine woods. The third phase, corresponding to the long time period 6800-800 cal BC, witnesses the full development and diversification of deciduous oak woods. Finally, the last phase, characterized by an increasing anthropic impact since* ca. *800 cal BC, is dominated by deciduous oak-beech woods. However, despite their usual congruence, the palynological- vs. anthracological-based pictures also show some punctual differences, notably in the local representativeness of some woody taxa. At the archaeological site level, these discrepancies may allow a better understanding of the human-related environmental exploitation patterns.*

Key words: *Paris basin, Holocene, palynology, anthracology*

INTRODUCTION

During the last two decades, the development of rescue archaeology in the Paris basin has led to a significant refinement of the archaeobotanical record (Pernaud, 1997; Leroyer, 2004, 2006; Leroyer and Allenet, 2006). While a synthetic picture for the Holocene of this area has been independently provided on palynological and anthracological grounds respectively, so far a direct comparison of the scattered results from these two analytical approaches has not been conducted.

MATERIAL AND METHODS

The present analysis relies upon the anthracological evidence from 44 sites and 91 palynological sequences constrained by a total of 148 radiocarbon (^{14}C) dates. The anthracological material comes from archaeological sites located both on the plateau (the majority) and the valley bottom (a few), while the palynological record exclusively refers to valley bottom sequences from humid environments, not necessarily related to the archaeological sites.

RESULTS AND DISCUSSION

The palynological picture (Fig. 1) summarizes the Holocene vegetation history through the assessment of seven regional pollen zones (PAZ IV to IX). Zone IV (Preboreal) is constrained between *ca*. 9200 and 8200 cal BC by 15 radiocarbon dates; zone V (Boreal) between *ca*. 8200 and 6800 cal BC by 10 dates; zone VI (early Atlantic) between *ca*. 6800 and 5000 cal BC by 17 dates. Zone VII (late Atlantic), when evidence of an anthropic impact is only recognizable nearby the archaeological sites, is constrained by 28 dates between *ca*. 5000 and 3500 cal BC. Zone VIII (Subboreal), when systematic agro-pastoral activities are traceable, is constrained between *ca*. 3500 and 800 cal BC by 31 ^{14}C dates. Zone IX (early Subatlantic), between *ca*. 800 and 50 cal BC (10 dates), testifies a nonlinear increase of the anthropic pressure on the landscape. Finally, zone X, which is constrained by 37 dates, basically documents an increase in the agro-pastoral activities punctuated by episodes of decay following abandonment.

The anthracological picture (Fig. 1) summarizes the vegetation history through three regional zones (BP1 to 3). The anthraco-zone BP1, chronologically constrained between Boreal and early Atlantic, corresponds to Mesolithic levels. Zone BP2, covering from the late Atlantic to most of the Subboreal, is associated to archaeological levels spanning from the early Neolithic to the middle Bronze Age. Finally, zone BP3, which covers the late Bronze Age, the Iron Age, the Classical Antiquity, and the Middle Age, corresponds to the Subatlantic.

Based on the substantially converging evidence from the independent palynological and anthracological records summarized above, four main evolutionary phases can be identified in the vegetation history of the Paris basin through the Holocene (Fig. 1). The first one is uniquely attested on palynological ground (PAZ IV) and corresponds to the presence in the region of extended pine woods. The second phase, recorded by both disciplines (PAZ V et BP1), is associated to the emergence of hazel woods and to the first development of pioneer plant species of deciduous oak woods at the expense of pine woods, between *ca*. 8200 and 6800 cal BC. The third phase (PAZ VI, VII and VIII, and BP2), when the first effects of anthropization can be found, covers the long period from 6800 to 800 cal BC. It corresponds to the full development and diversification of deciduous oak woods (*Quercus*, *Tilia*, *Fraxinus*), where the still sporadic but growing presence of *Taxus* and *Fagus* also marks the progressive spread of more humid forest *facies* towards the end of this period. The fourth phase (PAZ IX and X, and BP3), testifying an increasing anthropic impact since *ca*. 800 cal BC, is dominated by deciduous oak-beech woods.

In spite of their globally congruent pictures, the palynological and anthracological independent records also show differences in the proportional representativeness of some woody taxa. Notably, while palynology emphasizes the role of *Ulmus*, *Tilia*, *Corylus*, and *Alnus*, the anthracological figures underline the relative role played by Rosaceae, *Quercus*, *Acer*, *Fraxinus*, and *Fagus*. Such differences likely reflect: the heterogeneous proportion in the analysis of contexts sampled on the plateau and the valley bottom, respectively; the random effects of pollen production and spread; the combustion-related taphonomic effects; the anthropic selection of woody taxa according to their fire and/or timber properties; the variable distances of the settlements from the procurement areas. In this framework, as it clearly results from the subtle analysis of the archaeological contexts where both kind of records are available - such as the sites of Paris "Bercy", Varennes "La Justice", Villiers-sur-Seine "Le Gros Buisson" - the impact of the anthropic factors on the vegetation dynamics appears proportionally relevant.

CONCLUSION

In conclusion, certainly at the archaeological site and local level, the discrepancies punctually shown by our large scale comparative analysis between the palynological and the anthracological records currently available for the Holocene of the Paris basin, point to their value as reliable source of information for the assessment of the human-related environmental exploitation patterns.

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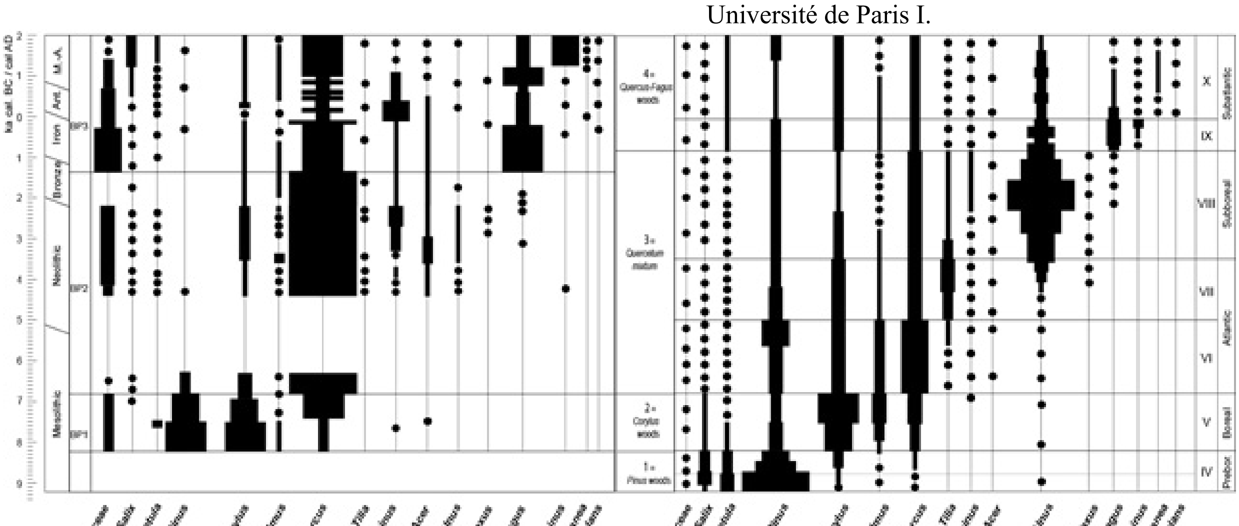

FIGURE 1. Synthetic diagram of the palynological (right) and anthracological (left) records for the Holocene of the Paris Basin.

Fire history in southern Sweden during the past 11500 years: relationships with climate and human impact, and the role of fire in forest dynamics

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Summary: *Three bog sites in the province of Småland, S. Sweden, were studied for macrocharcoal and microcharcoal with the aim to reconstruct the Holocene fire history of the study region. In parallel, the local forest/vegetation histories at the three sites were inferred in quantitative terms (in percentage cover of plant taxa within the relevant source area of pollen RSAP) using the Sugita's Landscape Reconstruction Algorithm (LRA). Additional information on the fire history was obtained from findings of fire-dependant coleopteran, charred plant remains and identified large charcoal fragments. A synthesis of the results, complemented by a study of fire scars (1600-1900 AD) at one of the sites, provides detailed information on the regional and local fire history in terms of long-term trends in fire activity and, for some periods, fire frequency, intensity, and size. We also examined the importance of the vegetation composition as one of the causes behind differences between local fire histories at different locations. Moreover, archaeological records and earlier studies of past climatic conditions in the study region were used to discuss the role of human activities vs. climate characteristics. The results and conclusions from these studies were compared to similar investigations in Europe.*

Key words: *Holocene, fire history, Landscape Reconstruction Algorithm, human impact, climate, southern Sweden.*

INTRODUCTION

It is well recognised that studies of past fire regimes and their causes (human and/or climatic) are useful to understand the long-term ecological effects of fire on vegetation communities (Whelan, 1995). Further, information on the long-term fire history and its effect on forest dynamics and insect fauna may provide useful insights for forest management aiming at maintaining biodiversity in these ecosystems of the boreo-nemoral zone of NW Europe.

There are only two studies of long-term fire history for the entire Holocene in southern Sweden, i.e. the charcoal records at Stavsåkra and Storasjö in the province of Småland (Greisman and Gaillard, 2009; Olsson and Lemdahl, 2009, 2010; Olsson *et al.*, 2010). Additional information on the fire history was obtained from findings of fire-dependant coleopteran, charred plant remains and identified large charcoal fragments. The synthesis of results, complemented by a study of fire scars (1600-1900 AD) at one of the sites, provided detailed information on the regional and local fire history in terms of long-term trends in fire activity and, for some periods, fire frequency, intensity, and size (Olsson *et al.*, 2010). These studies suggested different fire histories at the two sites separated by only *ca.* 50 km. Therefore, a third site close to the western study site, Notteryd, was selected with the aim to check whether the fire history at Stavsåkra was representative of the region N. of Växjö and to further study the variability of long-term fire regimes in time and space. These studies also had the goal of improving our understanding of long-term fire ecology. In order to assess the relationships between fire and vegetation/plant composition, we used the Landscape Reconstruction Algorithm (LRA) of Sugita (2007) to infer percentage cover of the plants involved. The study of Notteryd is not finalized yet. It will be presented at the conference and published elsewhere.

RESULTS AND DISCUSSION

In this paper, we briefly present the long-term fire history at the two sites Stavsåkra and Storasjö, the comparison of the two fire records, and the information provided by the application of the LRA. The methods are described in Figure 1 that compares the records of macro- and micro-charcoal with the LRA-based reconstruction of local plant abundance (main taxa) and the record of dated clearance cairns (Skoglund, 2005). The two Holocene micro- and macro-charcoal records indicate that fire was more frequent during the Early and the Late Holocene periods. Moreover, frequent fire activity during the Late Holocene was mainly related to human land-use as shown by forest clearances from *ca.* 1500 cal BC (Late Bronze Age) (Fig. 1) (Greisman and Gaillard, 2009; Olsson *et al.*, 2010; Olsson and Lemdahl, 2009, 2010).

During the Mid Holocene, fire activity was higher at Storasjö than at Stavsåkra, which was most probably related to the higher abundance of pine at Storasjö during that period (Fig. 1). The coleoptera data indicate that species dependant of fire were present during the periods of high and frequent fire activities. Findings of a coleoptera species dependant of grazed *Calluna* heaths confirm that *Calluna* heaths developed from 1500 cal BC (Fig. 1) and were maintained until recently (*ca.* 1850 AD). There is a good correspondence between the periods of fire activity inferred from the macrocharcoal record at Storasjö from *ca.* 1400 AD and the reconstruction of fire regimes from the study of fire scars (Wäglind, 2004; Marlon *et al.,* 2010). According to the study of fire scars and the identification of the macro-charcoal found in the peat (mainly grasses and other herbs), the fire regime was obviously human-induced to improve fodder for grazing animals in the pine forest. This is shown by the fact that 1) fires were relatively small in area, but very frequent (a mean interval between fires of *ca.* 20 yrs) and 2) no macro-charcoal from trees was found (Olsson *et al.*, 2010).

CONCLUSIONS

Fire (both climate- and human-induced) obviously played an important role in the Holocene forest dynamics of the boreo-nemoral zone of southern Sweden and in the long-term maintenance of floristic and coleopteran diversity. The general trends in the fire history of southern Sweden are strikingly similar to the pattern inferred from the Global Charcoal Database (Power *et al.*, 2008). The application of the LRA (Sugita, 2007) provided additional information that neither pollen percentages nor pollen accumulation rates could offer. It showed that pine was significantly more abundant at Storasjö than at Stavsåkra during the entire Holocene, which explains the different local forest histories.

ACKNOWLEDGEMENTS

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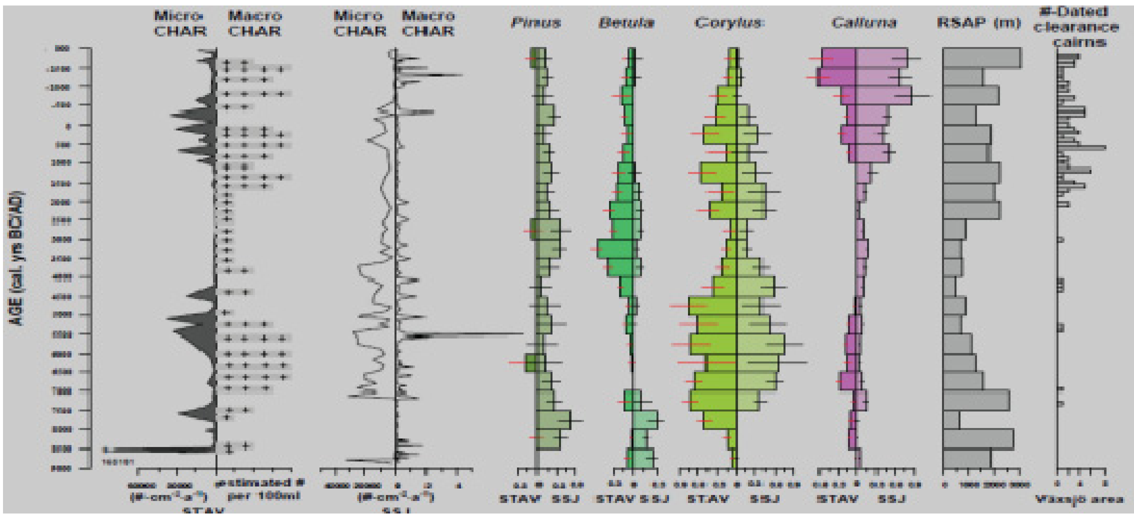

FIGURE 1. Records of macroscopic and microscopic charcoal from Stavsåkra (STAV) and Storasjö (SSJ), and LRA-based estimates of local abundance of main taxa (with Standard Errors) within the relevant source area of pollen (RSAP; Sugita, 2007), i.e. varying between 500 and 3500 m radius during the course of the Holocene; the grey bar chart on the right side shows the number of dated clearing cairns per 100-a interval in the Växjö region (Skoglund, 2005), indicating extensive forest clearing in the region of the Stavsåkra study site. The number of macrocharcoal fragments (≥0.25 mm) per 100ml were estimated at Stavsåkra as follows: +=0-10, ++=10-100; +++=100-1000; ++++=≥1000. At Storasjö, a continuous macrocharcoal analysis following the method developed in Australia (see references and description in Olsson et al., *2010) was performed and provides the number of macrocharcoal per cm*^{2} *and year.*

Neolithic wood usages: examples from the lowlands of Germany

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Summary: *Five Neolithic archaeological sites in the lowlands of Germany were studied for their wood usages by humans. At all sites generally the available wood of the surroundings was used. The charcoal spectra are representing the individual site conditions like for example adjoining wetlands. Besides the reflexion of the natural forest composition, the impact of the human activity on the landscape is visible in the spectra. Light demanding species like* Corylus *and Maloideae are reaching very hight values indicating an opening of the landscape by Neolithic farmers.*

Key words: *natural development, human impact, Maloideae, archaeoanthracology, Neolithic*

INTRODUCTION / SITES

Changes in Neolithic subsistence strategy – like the rise of agriculture and the onset of constant settlements – resulted in changing land usages. At the same time the natural development of the environment occurred due to immigration processes, which resulted in the appearance, increase and decrease of woody species. Both factors together – human activity and natural development – affect the wood usage by humans.

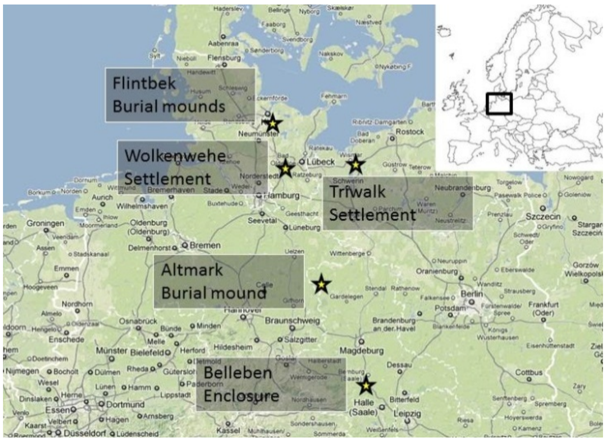

FIGURE 1. Map with the five investigated sites (source Google maps).

Charcoals from five archaeological sites (Fig. 1) were taxonomically identified; including diameter and growth ring analysis. Excavations of the grave mound field of Flintbek (1977-1996) yielded archaeological charcoal material for the time span from the Neolithic until the Iron Age. During the Neolithic more than 25 grave mounds were built. Fire was used for construction (for example for the preparation of the chamber ground), thus charcoals were found in several layers. Furthermore, a neolithic grave mound (so-called Königsgrab) near Lüdelsen (Altmark, excavation in 2009/10) was analysed. The grave was build during the funnel beaker time but human usages are detectable until the Iron Age. The third site, the neolithic station Wolkenwehe (excavation from 2006 until 2009, Mischka *et al*., 2007) of hitherto unknown function was located in the center of a river fen mire complex and was probably used as a temporary site. The fourth site is a settlement, which was located nearby Triwalk and which was excavated in the 1990s in the course of a motorway construction (A20). In both settlements/stations wood was mainly used as firewood, but also for construction. The last site is an enclosure with a round extension of about 90 m in diameter near Belleben in Sachsen-Anhalt, which has been excavated since 2005. The function of these enclosures is still a matter of investigation.

RESULTS

From the five sites a total of 2588 charcoals were determined (Fig. 2). The number of species range between 8 and 15 (per site). Generally, the spectra are dominated by oak (*Quercus*) followed by hazel (*Corylus*). In the three northern sites (Flintbek, Wolkenwehe and Triwalk) the wetland species alder (*Alnus*) and ash (*Fraxinus*) are frequent. Striking are the very high values of wetland species at the settlement site of Wolkenwehe. In contrast, these species are nearly missing in the two southern, more climatically continental sites (Altmark and Belleben). Instead, pine (*Pinus*) has a higher proportion there. The subfamily Maloideae (which includes apple/*Malus* and hawthorn/*Crataegus*) reaches up to 15% at the sites Belleben, Flintbek and Triwalk.

DISCUSSION

Based on the theory that for firewood supply the least necessary effort was chosen we think that the charcoal spectra represent the woody environment of the neolithic sites. The values of *Alnus*, *Fraxinus* and *Pinus* are in accordance with the natural settings of the concerned places. The site of Wolkenwehe is situated in a mire complex, thus mainly wood from the alder carr vegetation of the mire with ash and hazel was used, and the people did not go beyond the surrounding carr for greater proportions of their fuel wood supply.

Due to the size of the mire we estimate that most of the wood used comes from a maximal distance of 500 m from the site. This reconstructed resource exploitation radius also shows that the carr vegetation was sufficient for their needs.

The values of light demanding species (*Corylus* and Maloideae) are indicating an opening of the landscape around the sites. *Corylus* may just profit from the land use of humans; however, the explanation of the high Maloideae values is more difficult (Kreuz, 1992, Damblon *et al*., 2001/2002). Because the anatomic differentiation between *Malus* and *Crataegus* (Schweingruber, 1990) is not feasable two different scenarios are possible: 1) *Crataegus* was fired because it was growing as a pasture weed or 2) *Malus* trees were used for food production near the sites and the wood was used for domestic and/or ritual fires.

CONCLUSION

In the charcoal spectra of the neolithic period two different influences concerning species usage appear: 1) The spectra represent the natural conditions of the sites like moisture conditions, 2) The influence of humans is clearly visible in the charcoal spectra due to high values of the light demanding species (especially Maloideae).

ACKNOWLEDGEMENTS

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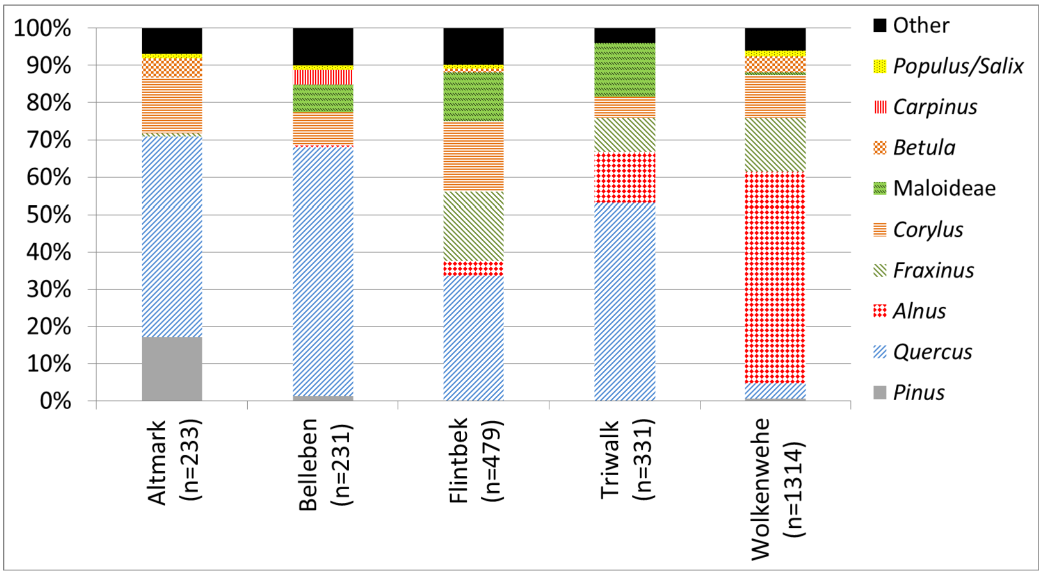

FIGURE 2. Charcoal spectra from the five archaeological sites. Other includes Acer, Fagus, Ulmus, Prunus, Tilia, Cornus, Sorbus, Rhamnus, Hedera, Berberis *and* Ericaceae

Woodland and its use in central Bosnia during the late Neolithic. Results from anthracological investigations in the Visoko-basin

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Summary: *The multi-disciplinary research-project "Tell in the woods? Anthracological investigations in SE Europe and Turkey" deals with the woodland-management of Neolithic and Chalcolithic societies. As part of this project charcoal samples from several sites from a settlement-region in Bosnia and Herzegovina were investigated. First results show an open landscape with manifold vegetation. The investigation of different sites allows the tracing of vegetational differences on a micro-regional scale. High amounts of Maloideae in the charcoal assemblages suggest a special treatment of this group of plants. The occurrence of* Pinus *raises questions for potential stands of pine in the neolithic vegetation. In comparison with archaeological and macro-botanical analyses a differentiated picture of the exploitation of woodland can be suggested.*

Key words: *Late Neolithic, southeast Europe, wood use, vegetation.*

INTRODUCTION/BACKGROUND

To gain a better understanding of neolithic societies and their reception of the environment, anthracological investigations provide information about the wood use and the exploitation of woodland. The interdisciplinary PhD-project "Tells in the woods? - anthracological investigations in South-East Europe and Turkey" aims at tracing exploitation strategies for woodland vegetation developed by tell inhabiting societies and raises the question for the beginning of an intentional management of wooden resources.

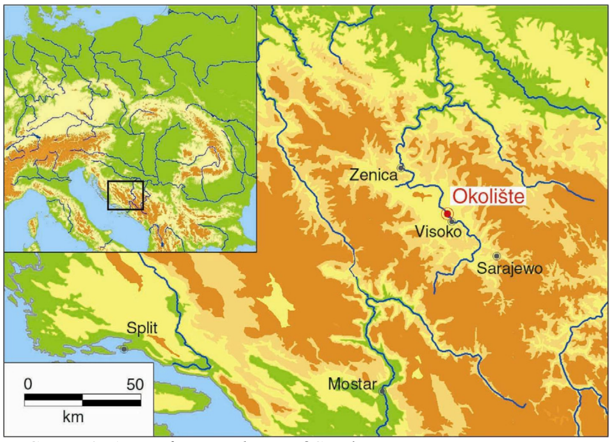

FIGURE 1. Area of research NE of Sarajevo.

Excavations in the Visoko-basin, Bosnia and Herzegovina, in the years 2002-2008 provided the opportunity to investigate charcoal samples from three sites dating to the time span between 5300 and 4500 cal BC. During the late Neolithic people of the Butmir-group settled in central Bosnia, around 20 km from the todays state Capital Sarajevo (Fig. 1). They erected structured settlements with several rows of parallel houses. The inhabitants maintained connections with the Adriatic and the Danube area as indicated by pottery decoration patterns and the occurrence of obsidian tools (Hofmann *et al*., 2007).

Climate data from the eastern Mediterranean suggest a slightly drier climate than today (Roberts *et al*., 2011) and the present-day potential natural vegetation is in the transition between the central European mountain beech forests and the central European mixed deciduous forests (Horvat *et al*., 1974).

MATERIAL AND METHODS

During the field campaigns every archaeological feature was sampled for macro-botanical investigation. All samples were processed directly by flotation. All charcoal pieces with an edge-length of more than one millimetre were handpicked. The charcoals were determined under a reflected light microscope and detected on genus level. Per sample 30 pieces were identified, if possible.

RESULTS

More than 120 samples with over 2500 pieces of charcoal were investigated. 17 taxa could be documented (Table 1). The charcoal spectra from different sites, located in various parts of the Visoko-basin differ noticeably (Fig. 2). Near the Bosna-river in the valley, riverine vegetation (*Alnus, Fraxinus* and *Ulmus*) is dominant in some areas. In the broad valley bottom mixed deciduous forests (*Quercus* and *Carpinus/Ostrya*) seem to dominate the neolithic vegetation. Growing percentages of mountain species (*Abies*, *Acer* and *Fagus*) are recorded in a steeper side valley. High amounts of light demanding species

(*Cornus*, *Corylus* and Maloideae) in parts of the settlement region indicate at least a partly opened landscape.

	Okolište 738 pcs.	Kundruci 771 pcs.	Zagrebnice 403 pcs.
Abies	7	91	12
Acer	13	111	9
Alnus	18	13	7
Carpinus/Ostrya	7	7	2
Cornus	26	20	40
Corylus	49	51	17
Euonymus	3	0	0
Fagus	36	108	16
Fraxinus	11	45	44
Maloideae	99	116	14
Pinus	123	36	116
Prunus	3	1	0
Quercus	241	115	85
Sambucus	4	0	0
Ulmus	6	18	27
Viburnum	10	4	0
Cf. *Populus*	1	0	0

TABLE 1. Taxa identified in the investigated settlements and their absolute numbers.

Internal analyses suggest the use of pine and oak for timber. More species were found in the space between houses and in fireplaces (*Euonymus*, *Sambucus*, *Prunus,* etc). In addition, one of the documented houses offers an assemblage of taxa, differing from the other houses in the use of elm and the absence of pine.

DISCUSSION

The intra-site analysis led to the distinction of timber and fuel wood, indicated by differences in the charcoal spectra found in archaeologically identified house contexts and, contrasting these, hearths and open areas. A preference in the use of pine and oak for timber is documented, whereas the fuel wood record shows rich and diverse vegetation in the surroundings of the investigated settlements. The characteristic combination of taxa in the charcoal record of one of the houses can be interpreted as an indication for exclusive use of single wood species in exceptional contexts, which is also suggested by the archaeological finds. The comparison of fuel wood spectra derived from several settlements accounts for the identification of different ecosystems used by the neolithic population.

The high amounts of light demanding species suggest the preferential treatment of single species. Especially in combination with the macro-botanical analyses, it can be assumed that hazel, cornelian cherry and possibly apple trees were pollarded regularly. The stands of these plants may be located in edge situations in the manifold landscape. The occurrence of *Pinus* raises the question of transportation of wood versus changes in site conditions in the Visoko-basin since the Neolithic.

CONCLUSIONS

For the first time, vegetation data are available for the Visoko-basin and provide insights in the mid-Holocene vegetation of central Bosnia. The dispersal of charcoal assemblages within the settlements can be used to distinguish timber and fuel wood. In combination with the archaeological data it seems possible to trace cultural restraints or at least exclusive use of single taxa. The comparison of fuel wood assemblages shows the exploitation of different ecosystems by the Neolithic population and suggests an open landscape. The high percentages of Maloideae, *Corylus* and *Cornus* are the result of human influence on the vegetation and let us think of a careful management of fruit bearing trees and shrubs.

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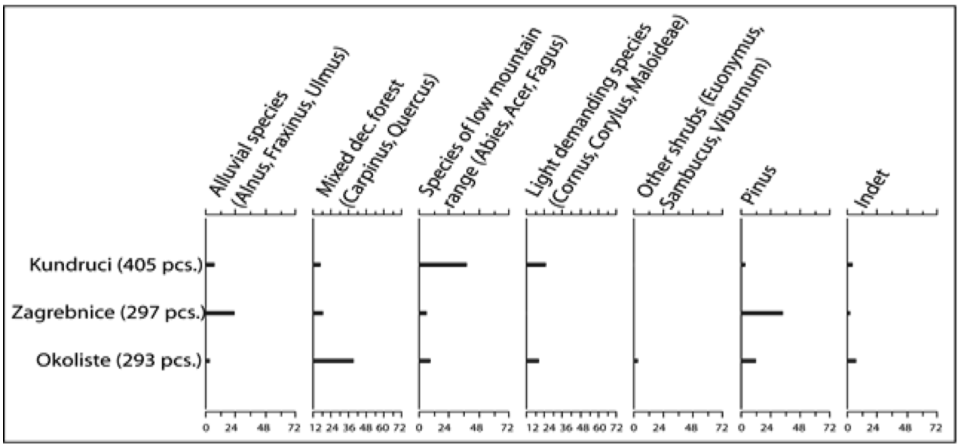

FIGURE 2. Fuel wood assemblages from the different settlements in the Visoko-basin.

Charcoal analysis for the Neolithic of the Ionian Islands, western Greece: the case of Drakaina Cave at Poros, Kephalonia

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Summary: *The paper presents the results of wood charcoal analysis from Drakaina Cave for the Neolithic and the Chalcolithic period. The site is located at Poros Gorge, Kephalonia Island, Greece. According to the wood charcoal analysis, a rich environment would have existed in the gorge where both evergreen and deciduous species as well as some conifers would have grown. Among these* Phillyrea *and both evergreen and deciduous oaks would have been the most abundant. No significant changes occurred in the vegetation of the area from the Late Neolithic to Chalcolithic. The microenvironments of the gorge would have played their role in preserving the dynamic and rich ecosystems but the critical factor would have been the specialized, discontinuous use of the cave.*

Key words: *Neolithic, Chalcolithic, vegetation, microenvironment, specialized site.*

INTRODUCTION

Drakaina Cave is located in the south-eastern part of Kephalonia Island in the Ionian Sea, Western Greece (Fig. 1a). The cavity lies at an altitude of *ca.* 70 m in the steep-sloped Poros Gorge (Fig. 1b). At present, Drakaina forms a rock shelter extending over an area of approximately 90 m^2.

The site has been systematically excavated between 1992-1996, 1999-2002 and 2004-2005 by the Hellenic Ministry of Culture and Tourism – Ephorate of Palaeoanthropology-Speleology of Southern Greece (Chatziotou *et al.*, 1995; Stratouli, 2005). Human activity on-site started at about the mid 6th millennium cal BC and continued up to the beginning of the 4th millennium cal BC, based on radiocarbon dating. During the Early Bronze Age the cave hosted cultural activity only periodically and later on from the late 7th century BC to the beginning of the 2nd century BC it became a place of cult activity.

The earliest chrono-cultural periods attested at the sequence of the cave, i.e. Late Neolithic (Late Neolithic I: *ca.* 5600/5500 – 4900/4800 cal BC) and Chalcolithic (= Late Neolithic II: *ca.* 4800 – 3700 cal BC) (Fig. 1c) have been the focus of intensive research that has revealed the following aspects (Stratouli, 2005):

- Construction and special care of/for a series of lime plastered floors, overall an unusual practice for cave sites.
- Lack of evidence of grain storage and limited food preparation on site.
- Consumption of various foodstuffs on site at intervals, probably during formal or other feasts and by no means during routine visits.
- High fragmentation of pottery pointing to the practice of deliberate breakage.
- Transportation into the site of various local and imported to the island artifacts and raw materials.
- On site pigment processing.

These characteristics may be read as a system of signs of particular meaning that attribute a symbolic significance to the cave for the Neolithic community in the region. This idea may be also supported by the specific location of the cave in the Poros Gorge, which links the coastal zone with an interior basin of fertile farming land.

At Drakaina Cave, well-organized and systematic sampling of the excavated prehistoric deposits for environmental data has yielded great amounts of wood-charcoals. The wood-charcoal material on which this presentation focuses represents the majority of the excavated squares and the totality of the Neolithic stratigraphic sequence of the Cave, comprising two major chrono-cultural phases, i.e. Late Neolithic and Chalcolithic, as well as a possible intermediate phase, i.e. Late Neolithic/Chalcolithic.

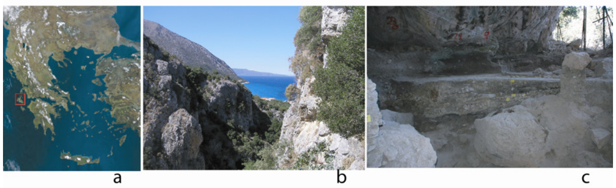

FIGURE 1. Location of Drakaina Cave: a. Kephalonia Island, western Greece, b. the gorge of Poros, c. the stratigraphy of Drakaina Cave.

DATA AND RESULTS

A total of 2793 wood-charcoal pieces have been analyzed and they have produced a rich plant list, which shows that a large number of both evergreen and deciduous species as well as some conifers would have grown in the gorge (Table 1). Among the identified taxa we can distinguish between those that would have probably grown to form the tree level of the formations, the components of the understorey (bushes and shrubs) and possible climbers. The qualitative and quantitative wood-charcoal results are presented as assemblages corresponding to each one of the three major chrono-cultural periods mentioned above.

The frequency of occurrence of the identified taxa shows that *Phillyrea* and both evergreen and deciduous oaks would have been the most abundant. Oaks and sporadic Aleppo pines would have constituted the tree-level of the formations. A rich understorey is represented by a large number of smaller trees and shrubs among which strawberry tree, turpentine tree and the almond hold a special place. Riverside vegetation would have grown at the bottom of the gorge and along the watercourse. Some indication of this may be seen in the presence of poplars, elms and ash.

DISCUSSION AND CONCLUSIONS

The wood-charcoal assemblages show a rich plant environment that may have been the result of: a) the geographical and latitudinal location of Kephalonia that receives a mean annual rainfall between 750-1000 mm and has mild winter temperatures (January average 10-15 ^{o}C) (Polunin, 1980, 14-19), and b) the microenvironments existing within the gorge.

The qualitative and quantitative results of the wood-charcoal assemblages do not show significant changes from the Late Neolithic to the Chalcolithic (Table 1). The above-mentioned climatic and environmental parameters might have played their role in preserving the dynamic and rich ecosystems. However, we believe that the main reasons should be looked for in the frequency, continuity and intensity of human presence in the gorge and the type of activities that the cave accommodated. The characteristics of the vegetation for over a millennium of human presence at the cave indicate that either its use as a habitat was discontinuous and quite sporadic or that it was used for specialized activities other than animal keeping, which seems improbable since it would have caused some changes to the vegetation. In the case of specialized hunting actions, social gatherings and feasting or a ritual combination of them, the abundant use of firewood for e.g. meat processing and food preparation would have been required. However, such activities would have been periodical and spaced in time and therefore, no matter how large quantities of firewood would have been needed in each occasion they would have caused overall little alteration to the surrounding vegetation.

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	LN		LN - CH		CH	
TAXA	**n**	**%**	**n**	**%**	**n**	**%**
cf. *Abies cephallonica*	3	0.30			1	0.12
Acer sp.	5	0.50				
Angiosperm	24	2.40	27	2.81	42	5.20
Arbutus unedo	64	6.39	128	13.32	62	7.68
Carpinus/Ostrya	2	0.20	1	0.10		
Cistus sp.	3	0.30	2	0.21		
Cistaceae	3	0.30	1	0.10	1	0.12
cf. *Clematis* sp.	2	0.20				
Conifer	4	0.40	1	0.10	6	0.74
Erica sp.					3	0.37
cf. *Erica* sp.	1	0.10				
Ficus carica	1	0.10			2	0.25
Fraxinus sp.	1	0.10				
Juniperus sp.	35	3.50	10	1.04	14	1.73
cf. *Juniperus* sp.	1	0.10				
Labiatae	3	0.30	4	0.42	1	0.12
Laurus nobilis			2	0.21		
Leguminosae	1	0.10			3	0.37
Maloideae	9	0.90	19	1.98	3	0.37
Monocotyledon	1	0.10				
Olea europaea	8	0.80	1	0.10		
Phillyrea/Rhamnus alaternus	257	25.67	285	29.66	179	22.18
Pinus halepensis	1	0.10	11	1.14	5	0.62
cf. *Pinus halepensis*	3	0.30	1	0.10	2	0.25
Pinus halepensis/Pinus pinea type					1	0.12
Pinus nigra			1	0.10		
Pinus sp.			7	0.73		
cf. *Pinus*	1	0.10				
Pistacia terebinthus	25	2.50	43	4.47	46	5.70
Pistacia lentiscus			2	0.21		
Pistacia sp.	7	0.70	5	0.52	2	0.25
Populus sp.	2	0.20	1	0.10		
Prunus amygdalus	24	2.40	33	3.43	46	5.70
Prunus amygdalus/Prunus spinosa type	5	0.50	5	0.52	11	1.36
Prunus amygdalus/Prunus webbii type	2	0.20	2	0.21	3	0.37
Prunus spinosa type			2	0.21	2	0.25
Prunus webbii	4	0.40	1	0.10	6	0.74
Prunus sp.	4	0.40	4	0.42	17	2.11
Quercus sp. deciduous type	144	14.39	124	12.90	80	9.91
Quercus sp. evergreen type	240	23.98	150	15.61	118	14.62
Quercus sp.	103	10.29	86	8.95	149	18.46
Ulmus/Celtis	1	0.10				
Undetermined I			1	0.10		
Undetermined II	1	0.10				
Undetermined III	1	0.10				
Nut shell	3	0.30	1	0.10	2	0.25
Bark	2	0.20				
Sub-total	**1001**	**100**	**961**	**100**	**807**	**100**
Non identifiable	13	1.28	6	0.62	5	0.62
TOTAL	**1014**	**100**	**967**	**100**	**812**	**100**

TABLE 1. Qualitative and quantitative results for the wood charcoal assemblages of the Late Neolithic, the Late Neolithic-Chalcolithic and the Chalcolithic periods.

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On the distribution of deciduous oak in the second half of the Holocene in northern Syria

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Summary: *This presentation will summarise anthracological results from northern Syria for the second half of the Holocene. A combination of methods will be used to investigate the relative impact of people and climate on the vegetation.*

Key words: *Syria, deciduous oak, human impact on the vegetation, climatic impact on the vegetation*

INTRODUCTION

Today oak park woodland is absent in northern Syria (Fig 1). However, recent charcoal analysis at the sites of Tell Mozan (3rd and early 2nd millennium BC), Tell Leilan (3rd millennium BC), Tell Hamoukar (4th millennium BC), Tell Halaf (first millennium BC till second millennium AD), Tell Jerablus (4th and 3rd millennium BC) and Tell Shioukh Tahtani (late 4th till second millennium BC) indicates a more southward distribution of deciduous oak through the second half of the Holocene in Northern Syria (see also partially in Deckers and Pessin, 2010).

FIGURE 1. Photo from present day Tell Mozan that shows the lack of trees in the surroundings

METHODS

In this presentation, ancient woodland exploitation will be investigated through GIS land use modeling, diameter measurements on deciduous oak charcoal fragments and charcoal-to-seed ratios. Besides determining the human impact on the vegetation through time, climatic impact on the vegetation will also be investigated. This will amongst other things be undertaken by evaluating the *Pistacia/Quercus* ubiquity ratio, stable carbon isotopic values and ring-widths on deciduous oak.

PRELIMINARY RESULTS

Our GIS-calculations for the Upper Khabur Basin for example indicate that even with population densities of between 200 and 400 persons/ha there was still some room for oak park woodland vegetation in the third millennium BC (Deckers and Riehl, 2008). Moreover, preliminary diameter analysis results on oak charcoal fragments indicate that mostly small branches were used during that period, thus that the whole tree was not cut down, but instead coppicing was practiced. Furthermore, charcoal-to-seed ratios from Tell Mozan indicate that dung was probably an important component of the fuel used at this site. The regular use of dung as fuel there may indicate that the park woodland was rather open in the surroundings of Mozan. However, it cannot be discounted that people used dung by preference, for example, for specific purposes (Deckers, in press).

Quercus/Pistacia ubiquity ratios for the third to second millennium BC indicate that the “boundary” of the oak park woodland with the *Pistacia* woodland (steppe) shifted northwards over time. This is probably related with climatic drying (Deckers and Pessin, 2010). Within this paper, the location of the “boundary” of the oak park woodland with the pistachio woodland steppe will be investigated over longer time periods.

The climatic interpretations will be backed by stable carbon isotopic research and ring-widths of oak fragments. This research is still in process at the time of the abstract writing.

ACKNOWLEDGEMENTS

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Environmental and social changes recorded in the charcoal remains of Arslantepe (Anatolia) from 3350 to 2000 years BC

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Summary: *Charred wood remains, coming from the Turkish tell of Arslantepe (Malatya), have been studied to reconstruct the vegetation history and the palaeoclimate features of the site. Considerable amounts of charcoal remains from five different archaeological periods, since 3350 years BC to 2000 years BC, have been analyzed. The anthracological investigation provided a rather short list of woody* taxa *(11 in all), with important changes along the five investigated periods. Both human choices and environmental causes can be advocated to explain increase/decrease of key* taxa*. The interpretation of* taxa *has permitted to recognize two different landscapes, one mainly characterized by woody steppe elements, the other by riparian vegetation ones. The first and the last of the investigated archaeological periods, occurring between 3350-3000 and 2500-2000 years BC respectively, show important similarities, with overwhelming presence of hygrophilous* taxa*. In the central three periods woody-steppe landscape has been evidenced by wood remains. As a matter of fact these periods are considered to have been rather unstable from a climatic point of view in the Near East. The $^{13}C/^{12}C$ ratio in fossil plants allows reconstructing palaeoclimate, giving the possibility to exclude problems related to the human selection of wood.*

Key words: *charcoal, eastern Anatolia, isotope analysis, Late Chalcolithic, Early Bronze Age*

INTRODUCTION

The site of Arslantepe (*Arslan* = Lion, *Tepe* = mound) is located in the Malatya plain (Turkey). Today is a hill, 30 m high (Fig. 1), formed by a series of settlements built and abandoned/destroyed in five thousand years of almost uninterrupted occupation (Table 1).

FIGURE 1. The Arslantepe hill and the archaeological excavations.

Excavations of "La Sapienza" University of Rome at the site have been carried out uninterruptedly since 1961, bringing to light extraordinary remains of past prehistoric and protohistoric cultures of Eastern Anatolia. The excavation is still in progress, the oldest archaeological level dates back to the 7th millennium BP, the youngest is of Byzantine times. The amount of archaeobotanical remains is extraordinary both in quantity and importance.

As shown in Table 1, five different populations featured the archaeological periods analyzed. They are characterized, as indicated by the archaeological evidence by different cultures and social organizations.

The most ancient period analyzed is called VI A. The excavation has brought to light both public monumental buildings as the palace with temples and storage areas in which economic, religious and administrative activities were performed, and also élite residences. They are the evidence of the emergence of the first states. A big fire destroyed the whole settlement. After that, the whole 3rd millennium BC was characterised by a continuous occupation with superimposed villages, some of which fortified and more permanent (e.g. VI D), whilst others more seasonal and ephemeral (e.g. VI B1).

Chronological sequence	Period of Arslantepe	Calendar years BC	Contemporary civilization in Mesopotamia
Early Bronze Age III	VI D	2500 - 2000	Protodynastic III b, III Ur dynasty
Early Bronze Age II	VI C	2750 - 2500	Protodynastic II - III a
Early Bronze Age I	VI B1/VI B2	3000 - 2750	Period of Jemdet Nasr and Protodynastic
Late Chalcotithic 5	VI A	3350 - 3000	Late Uruk Culture

TABLE 1. Chronology of Arslantepe

METHODS

The identification of charcoals was carried out at the reflected light microscope and then, for detailed wood identifications, a Nomarski microscope (phase contrast microscope with differential interference contrast) was used.

Carbon isotope analysis was carried out to evaluate environmental changes on two selected *taxa*, deciduous *Quercus* and *Juniperus*. According to Farquhar *et al.* (1989) the stable carbon isotope contained in plants depends on several environmental factors. So the comparison of isotopic ratios from different periods can be related to changes in humidity (Hall *et al*., 2008; Riehl *et al*., 2008). $^{13}C/^{12}C$ ratio analyses were performed by combustion in an Elemental Analyser coupled with isotope ratio mass spectrometer.

DATA AND RESULTS

All the investigated periods have included charred remains of woods, seeds and fruits. Eleven different wood *taxa* and one monocot taxon have been recognized (Table 2); the majority of charcoals have been identified at the genus level.

Period of Arslantepe	Chronological sequence	List of *taxa*
VI D	Early Bronze Age III (2500 – 2000 BC)	deciduous *Quercus* *Populus* sp. *Alnus* sp. *Pinus sylvestris/montana* gr. *Juniperus* sp. *Ulmus* sp. *Fraxinus* sp. *Pistacia* Rosaceae Cf. *Arundo*
VI C	Early Bronze Age II (2750 – 2500 BC)	deciduous *Quercus* *Populus* sp. *Alnus* sp. *Pinus sylvestris/montana* gr. *Juniperus* sp. *Fraxinus* sp. Cf. *Arundo*
VI B2	Early Bronze Age I (2900 – 2750 BC)	deciduous *Quercus* *Populus* sp. *Alnus* sp. *Juniperus* sp. *Ulmus* sp. *Fraxinus* sp. *Pistacia* *Tamarix*
VI B1	Early Bronze Age I (3000 – 2900 BC)	deciduous *Quercus* *Populus* sp. *Alnus* sp. *Juniperus* sp.
VI A	Late Chalcotithic 5 (3350 – 3000 BC)	deciduous *Quercus* *Populus* sp. *Alnus* sp. *Pinus sylvestris/montana* gr. *Juniperus* sp. *Ulmus* sp. *Fraxinus* sp. *Rosaceae* Cf. *Arundo*

TABLE 2. List of taxa *(in order of abundance) found at Arslantepe.*

The assemblages found indicate that wood resources were mainly exploited from two local ecological communities, the woody steppe (composed by deciduous and semi-deciduous oaks with rosaceans) and the riparian vegetation. The last is from wet environments, including both hydrophilous (mainly alders and poplars with a slow amount of tamarisks) and possibly hygrophilous (elms and ashes) *taxa*. A considerably minor contribution is from mountain *taxa* (pines and junipers). The comparison of the relative *taxa* abundances in the single periods indicates that woodland-steppe elements are very abundant for half a millennium, during the Early Bronze Age, from 3000 to 2500 years BC (VI B1, VI B2 and VI C periods). On the contrary hydrophilous elements are quite important during the Late Chalcolithic (VI A) and at the end of the Early Bronze Age (VI D), while woodland-steppe elements and mountain ones show opposite values in these two periods.

The isotope data confirms the results of traditional archaeobotanical analysis, suggesting that periods with higher amount of trees of wet environments were more humid. Moreover, they show instability of climate during the Late Chalcolithic according to palaeoenvironmental proxy.

The modern samples have more negative values than the archaeological ones. This indicates that present day climate conditions are drier than the past ones.

DISCUSSION AND CONCLUSIONS

At Arslantepe, during more than one millennium a number of important changes in timber use are found. Preliminary investigations suggest that also the isotope carbon ratios from selected *taxa* underwent important changes.

Further analyses will make clearer the climatic trends that occurred from the Late Chalcolithic to the Early Bronze Age (Masi *et al*., work in progress). By means of charcoal studies, it becomes evident that only using a multidisciplinary approach it will be possible to discern among natural and anthropic factors in the shaping of past plant landscape.

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Evolution and management of humid landscapes in Northern Dauphiné (Rhône valley, France): contribution of charcoal and wood studies*

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Summary: *The humid plains of the lower Dauphiné area, located at the foothills of the northern French pre-Alps, between Grenoble and Lyon, are made of a complex of glacial and fluvial morphologies that have been occupied during a major part of the Holocene by marshes. In the framework of two programs funded by the* Ministère de la Culture et de la Communication *and the* Agence Nationale de la Recherche*, "*PCR Peuplement et Milieu en Bas-Dauphiné (Isle Crémieu), de l'apparition de l'agriculture à l'époque moderne*"(J.-F. Berger dir.) and "*PaléohYdroloGy and huMAn–cLimate-envIronment interactiONs in the Alps*" ("Pygmalion", F. Arnaud dir.) and thanks to numerous archaeological operations previous to various building works, we had the opportunity to study the management of these peculiar landscapes by human societies since the Neolithic. A dozen of sites, mainly "natural" sequences and palaeohydrological structures (palaeochannel and drainage/irrigation ditches), but also "real" archaeological occupations, have provided wood charcoal and/or imbibed wood remains. It appears that vegetation changes recorded by charcoal and wood assemblages are mainly related to local changes (soils, local humidity) and triggered by human management of the swamps.*

Key words: *charcoal analysis, humid landscape management, hydrological systems, vegetation, Bas Dauphiné*

INTRODUCTION

The humid plains of the lower *Dauphiné* areas are located at the foothills of the northern French pre-Alps, between Grenoble and Lyon. Colluvio-alluvial and/or lacustrine sedimentation progressively filled the glacial basin during the first part of the Holocene, before the development of peats during the Neolithic (Berger *et al.*, 2008). In spite of its being occupied by marshes during the major part of the Holocene, the area has been intensively used by human societies since prehistoric times (Bernigaud *et al.*, in press).

Thanks to numerous archaeological operations previous to various building works, we had the opportunity to study the management of these peculiar landscapes since the Neolithic. A dozen of sites (Fig. 1), mainly "natural" sequences and palaeohydrological structures (palaeochannel and drainage/irrigation ditches), but also "real" archaeological occupations, have provided wood charcoal and/or imbibed wood remains.

Charcoal from archaeological sites gives information on the wood gathered for fuel, which is usually collected in the surroundings (Chabal, 1997). Charcoal from hydraulic structures and fluvial archives witnesses either natural vegetation fire or anthropic activities, such as bank cleaning or agricultural fires (Delhon, 2005). Finally, imbibed wood remains have been found in peaty deposits, where they deposited and preserved in situ, or in the infilling of hydraulic structures and rivers palaeochannels.

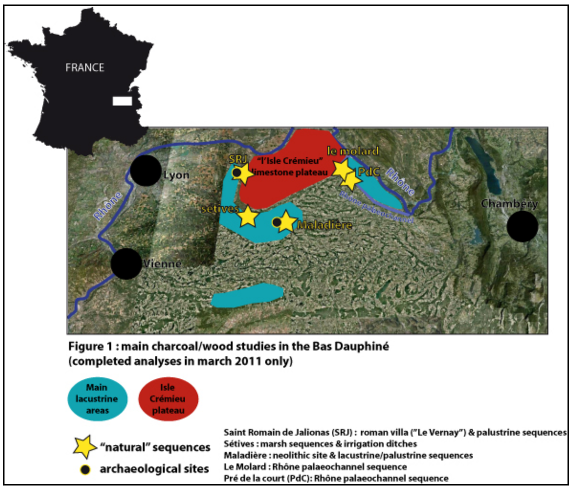

Figure 1 : main charcoal/wood studies in the Bas Dauphiné (completed analyses in march 2011 only)

RESULTS AND DISCUSSION

It appears (Fig. 2) that vegetation changes recorded by charcoal and wood assemblages are mainly related to local changes (soils, local humidity) and triggered by human management of the swamps. They also document human practices (cleaning of the river banks, agricultural practices), and climate impact seems to have only a secondary importance in local vegetation changes. Nevertheless, occurrences of mountain species (fir: *Abies alba*) or Mediterranean species (sclerophyllous oak: sclerophyllous *Quercus*) have been recorded and could have a climatic meaning.

ACKNOWLEDGEMENTS

This study is part of the programe "PCR Peuplement et Milieu en Bas-Dauphiné (Isle Crémieu), de l'apparition de l'agriculture à l'époque moderne », funded by the french Ministère de la Culture et de la Communication and of the program « Pygmalion » funded by the ANR. Most of the 14C dates were done thanks to the « Artemis » program.

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* Caution: the present abstract deals with a work which is still in progress. The results are likely to evolve towards slightly different conclusions. Please cite the definitive publication, when available. March 2011.

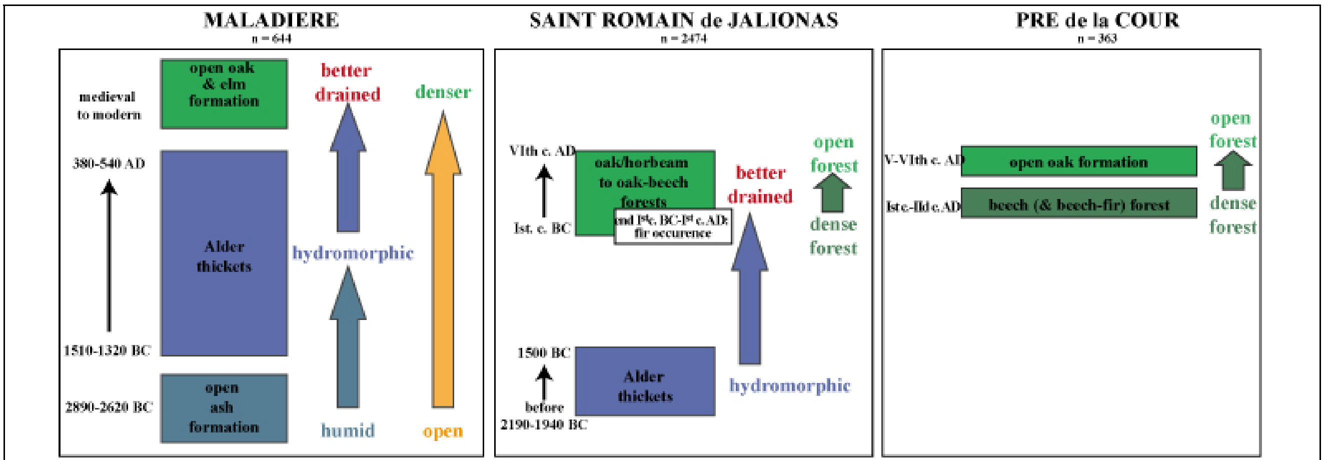

Figure 2: First synthesis of the evolution of the vegetation in the *Bas Dauphiné* humid areas, based on anthracological and xylological data from: Maladière (Néolithic site + trenches), Saint Romain de Jalionas (roman and medieval site + trenches) and Pré de la Cour (trenches).

People and woodlands: an investigation of charcoal remains as indicators of cultural selection and local environment in Bronze Age Ireland.

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Summary: *The recent Celtic Tiger boom in Ireland resulted in a huge increase in housing and infrastructural developments throughout the country. In turn, this generated the highest number of archaeological excavations the country has ever seen. Road scheme and Gas Pipeline developments in particular provided the opportunity to examine a ribbon of sites, cutting a broad swathe through the landscape. These allowed the unprecedented chance to examine environmental material from a long, narrow line across the country, facilitating a landscape archaeology approach to interpreting charcoal results. One of these road improvement schemes (N8 Cashel to Mitchelstown) was taken by the author as a case study for a PhD, to use charcoal analysis to provide an insight into Bronze Age people's relationship and use of their available woodland.*

Key words: *charcoal, Ireland, Bronze Age, cremation.*

INTRODUCTION

There are three main types of site that date to the Bronze Age in Ireland, settlement, funerary and *fulachta fiadh,* all of which were found along the study route of the N8 (Mc Quade *et al*., 2009) (Fig. 1). *Fulachta fiadh* are large troughs, which were sunk into wet areas or filled manually with water. They were used for cooking or bathing. Charcoal was sampled and analysed from thirty nine sites, securely dated to the Bronze Age. Complimentary plant remains and bone results are available for all of the sites, and were used to provide an interdisciplinary assessment of the way people interacted with their local landscape. The thesis was undertaken to examine cultural, functional and random reasons for the selection of trees for different purposes in Bronze Age Ireland.

FIGURE. 1 Segment of the N8 roadscheme (Warner Corporate photography).

DATA AND RESULTS

Over 17,000 charcoal fragments were identified from the road scheme, including fourteen wood taxa. The results are dominated by oak (*Quercus)*, followed by pomaceous fruitwood (Maloideae) and hazel (*Corylus avellana*).

The largest Bronze Age flat cemetery ever excavated in Ireland was found at Templenoe, Co. Tipperary within the study area (Fig. 2). It was composed of 76 cremation pits, 54 of which contained cremated bone and three possible pyres. This site was fully sampled, to examine temporal and spatial changes in charcoal throughout the cemetery. This provided an exciting opportunity to examine the use of fuel for the process of cremation.

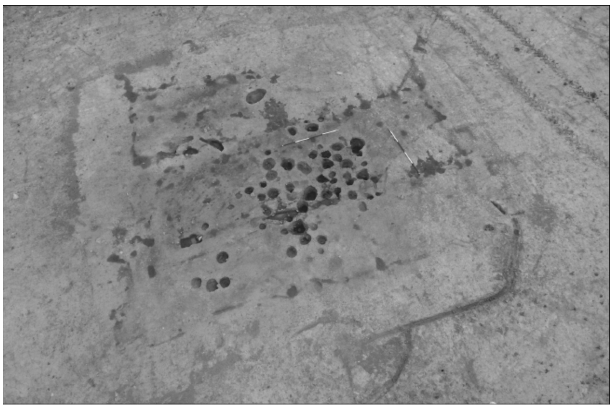

FIGURE 2. Early/Middle Bronze Age flat cemetery at Templenoe, Co. Tipperary (After Doody, 2008 Plate 1).

Charcoal analysis demonstrated that a very particular charcoal signature was evident in the cremation burials, a mixture of oak and pomaceous fruitwood. This was statistically significant and different to charcoal results from either the settlement or *fulachta fiadh* contexts. This particular pattern has been seen before in Ireland, from excavations along the Gas Pipeline to the West (Grogan *et al*., 2007).

Charcoal was compared with osteological results from the same contexts, to examine if wood taxa selection affected the burning process (if cremated bone is blue/black in colour it was badly cremated, in contrast to white bone which was successfully cremated). The demographic profile of the cemetery was also compared to the charcoal results, along with the stratigraphic evolution of the cemetery. Overall, the charcoal results remained extremely homogenous, appearing to be unaffected by time period, human demographic or the level of success of the cremation.

Charcoal from the entire road scheme was analysed through a specially adapted GIS system (Fig. 3). The results were also statistically examined using the statistical packages PC ORD and SPSS, the first time these have been applied to charcoal fragments from archaeological sites in Ireland. Charcoal data indicates that oak-hazel-ash (*Fraxinus*) woodlands were prevalent in the area during the Bronze Age.

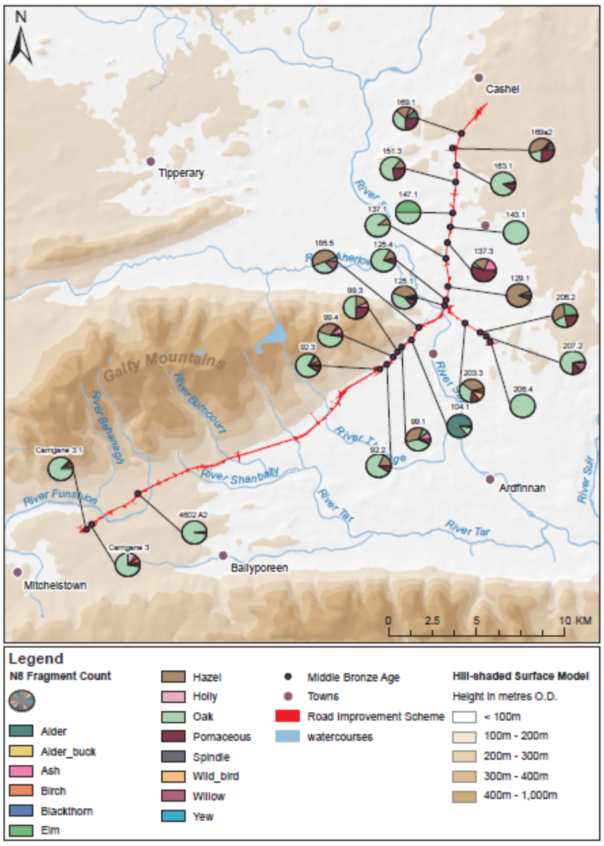

FIGURE 3. Charcoal results mapped through GIS.

CONCLUSIONS

Charcoal data from the N8 Cashel to Mitchelstown indicates that oak-hazel-ash (*Fraxinus*) woodlands grew in the area during the Bronze Age. The analysis has demonstrated the importance of oak in many contexts- structurally, as fuel and for funeral pyres. Hazel was also often selected for wattle or fuel.

The recognition of a specific wood 'trend' within cremation burials may be very useful in the future in the identification of 'blind burials' or cenotaphs. These are contexts, which appear to all intents and purposes as cremation burials, but have no human bone remaining. If the charcoal present has a 'typical' wood taxa of oak and pomaceous fruitwood, commonly associated with cremation pits which are inclusive of human bone, then it would be easier to interpret these as actual cenotaphs.

The level of charcoal varies considerably between cremation deposits, suggesting that charcoal was deliberately included in the secondary rite of burial in a cremation pit in some cases, and not in others. Its collection from pyres and inclusion within cremation pits indicate its importance in the cremation ritual. Furthermore, the general consistent presence of charcoal in cremation pits suggests that people did not hand pick bone out for burial, but rather shoveled or scooped up a mixture of pyre and bone for burial. This provides us with further evidence on the rather elusive nature of the actual process of Bronze Age cremation.

ACKNOWLEDGEMENTS

The N8 Cashel to Mitchelstown road scheme was excavated by Margaret Gowen & Co. Ltd, with funding provided by the National Roads Authority, Ireland.

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Integrated archaeobotanical studies in a protohistoric settlement of Central Spain: El Llano de la Horca (Santorcaz, Madrid)

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Summary: *This paper presents a series of archaeobotanical analyses (pollen, charcoal and seed/fruits) carried out in central Spain at the site known as "El Llano de la Horca", a protohistoric settlement with Bronze Age (BA) and Late Iron Age (LIA) occupations. Archaeobotanical data was integrated to relevant information concerning settlement patterns and economy of similar sites in the study area.*

Key words: *archaeobotany, El Llano de la Horca, central Spain, Bronze Age, Late Iron Age.*

INTRODUCTION

El Llano de la Horca is located in the north-eastern part of Madrid, Central Spain (Märtens *et al*., 2009), on the top of a plane hill at 879 m asl. It covers virtually all the 14 ha of the hill, stressing a defensive function and the visual control of the surrounding territory (Fig. 1).

FIGURE 1. General view of El Llano de la Horca and its exploitation territories.

High moorlands and plateaux with deep slopes and edges, plains, shelves and valley bottoms characterize the area, showing a clear-cut partitioning of the landscape. *Juniperus thurifera* formation proliferates in the northern exposures whereas *Quercus ilex* vegetation formations are more characteristic in the southern exposures and areas with more developed soils. *Quercus faginea, Acer monspessulanum* and river bank vegetation formations are located in valleys, shady slopes and hollows (Blanco Castro *et al*., 1997).

Extended digs are nowadays concentrated in an extensive area covering 1500 m^2 (Sector I) where the most complete stratigraphic sequence was recorded. The oldest occupation (3600±80 BP) corresponds to a BA smaller settlement. The Carpetanian settlement (LIA) is found over this stratum. Four occupation phases were recorded, covering a period between the 3rd and 1st centuries BC. (Märtens *et al*., 2009). All the archaeobotanical samples were recovered from this sector.

RESULTS AND DISCUSSION

Pollen analysis indicated an open landscape dominated by NAP taxa, *Juniperus* and an important representation of NPM *Glomus fasciculatum* related to deforestation processes. Pollen results were regrouped according to their ecological affinities and human activities. Several kinds of land-use were observed along the LIA occupation phases of this settlement: a strong herding character is dominant during phases I-II, whereas it decreases during phase III to become dominant again during phase IV.

Anthracological studies (Fig. 2) revealed *Juniperus thurifera* and *Quercus ilex* as main the arboreal taxa managed, indicating an alternation between the exploitation of northern and southern exposures of plate hills during the LIA occupation phases. *Pinus sylvestris-nigra*, *P. pinaster-pinea* were also present in very low amounts. Charcoal analysis also revealed relevant amounts of *Quercus faginea* and the presence of *Fraxinus angustifolia* suggesting the frequentation of valleys and thereby the exploitation of the nearby alluvial territories. *Quercus suber*, *Erica* sp. and Fabaceae appeared only in the Carpetanian period (LIA).

Carpological analysis evidenced mainly cereals with some sporadic legumes and weeds. Naked wheat was dominant followed by hulled barley in minor amounts, and some erratic occurrences of hulled wheat.

MAIN CONCLUSIONS

Archaeobotanical data was correlated with the geographical setting and archaeological context of the site (Märtens *et al*., 2009). The evolution of settlement patterns in Central Spain (Urbina, 2007), as well as the economy of other Carpetanian sites (Cerdeño *et al*., 1992; Quero *et al*., 2005), was also considered to evaluate territory management regarding vegetal resource potentiality since the Bronze Age (BA). Changes were expected as a consequence of different socio-economic realities in this site, especially when the settlement became an important Carpetanian *oppidum*.

The combined results pictured a subsistence system based on cereal agriculture. Furthermore, livestock breeding and metalwork activities seemed to have resulted in an important deforestation in order to gain place for crop fields and cattle feeding to cope with the needs of the Carpetanian growing community.

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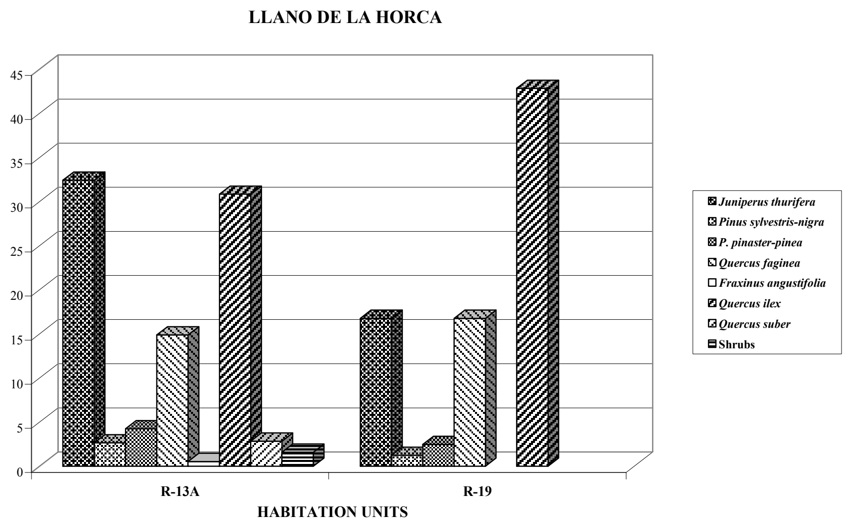

FIGURE 2. Anthracological data obtained in the Bronze Age (R-19) and Late Iron Age (R-13A) occupations phases of the settlement.

Vegetal roofs analysis from *Las Paleras* fortification. Human impact during IX-Xth centuries AD (Alhama de Murcia, Spain)

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Summary: Las Paleras *site preserves several vegetal roofs collapsed above the occupation levels from many rooms. Thanks to a thorough excavation of these layers, a large number of dendrological remains have been recovered. First charcoal analysis results show a low diversity of species used for the construction of these roofs, focused mainly on* Pistacia lentiscus*.*

Key words: *Alhama de Murcia, charcoal analysis, dendrology, human impact,* Pistacia lentiscus*.*

INTRODUCTION

Las Paleras site is located on the top of Cerro del Castillo hill at 368 m high overlooking the present town of Alhama de Murcia. (Ramírez and Baños, 2004; Baños and Ramírez, 2005; Baños, 2006).

Since April 2010 it has started a systematic collection of archaeobotanical samples at the site of *Las Paleras*. The aim is to obtain data of forest exploitation and ethnological knowledge from IX-X centuries AD.

The fortress area has been excavated much of the compound. This area is currently expanding with the emergence of a new housing area. For now, here are the first results of E8 and E26 rooms.

FIGURE 1. Room E26. Example of vegetal ceiling collapsed above occupation levels (see the darker spots). The remains consist of small-caliber branches (M. Celma).

DATA AND RESULTS

The *taxa* determined for Cerro de las Paleras site are: *Pistacia lentiscus, Pinus nigra, Punica granatum, Teucrium* sp. and other herbs like *Stipa tenacissima* (Schweingruber, 1990; Schweingruber *et al.*, 2006).

The most interesting result is specific *P. lentiscus* study. It offers information about vegetal roofs construction. Transverse section shows acquisition of this woody plant in the beginning of spring. The branches measure from 15 to 40 mm of diametre. The maturity of the wood used is variable, from 3 to 25 years old, indicating a selection of young shoots to lighten the roofs.

At the moment, laboratory excavation and dendrological remains determination are still on. It will be completed during next months.

DISCUSSION

There are no so many sites from this chronological period with archaeobotanical analysis done. It is needed to increase the remains from different archaeological sites to compare uses and forest exploitation forms. Does political change mean different exploitation forms in medieval times?

On the other hand, exhaustive and individualized analysis of the samples offers new data of local ecological changes.

CONCLUSIONS

Quite often, collapsed levels are not excavated properly. Sometimes these layers are containing the best remains for dendrological analysis to determine which woody plants were used for construction. In this case is presented an example of revaluation of its importance in a site with low sediments for occupation layers (20 to 70 cm). *Las Paleras* charcoal study is an opportunity to know the environment and vegetation for Sangonera valley during IX-Xth centuries AD. The next results will provide a pattern of forest exploitation and the specific use of wood in different rooms of the site.

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We would like to thank to the Alhama de Murcia city hall for giving to us an opportunity and sharing archaeobotanical remains from *Las Paleras*.

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Iron Age and Roman woodworking in the Northwest of the Iberian Peninsula

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Summary: *This article presents data on wood-working on settlement sites and specialist production sites during the Iron Age and the Roman period in Northwest Iberia. These archaeobotanical remains were preserved in a variety of ways, including saturation by water or humidity, carbonisation, and occasionally mineralisation, as well as indirect preservation through negative impressions in clay. The artefacts consist of structural elements, domestic objects or related to specialised activities. Their study allows us to characterise the technical process of woodworking.*

Key words: *woodworking, charcoal and wood analysis, Iron Age, Roman Period, NW of the Iberian Peninsula.*

INTRODUCTION

This article discusses the artefacts and wooden structures recovered in Iron Age and Roman sites in the northwest of the Iberian Peninsula.

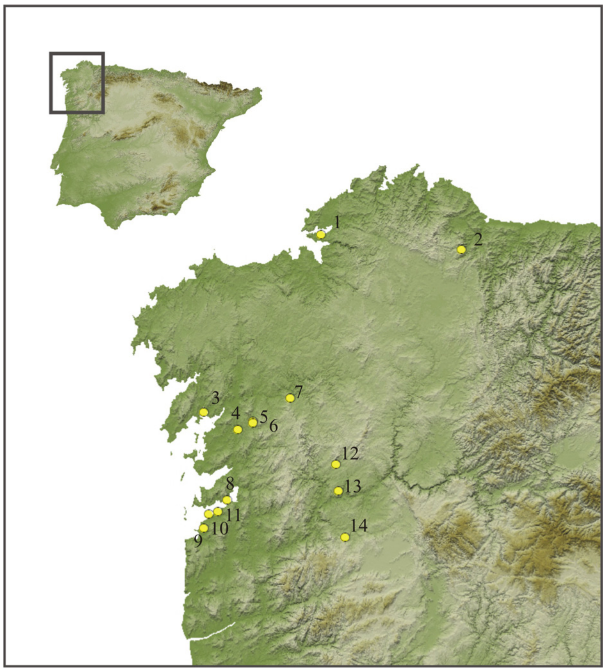

FIGURE 1. Site location. Iron Age: 2. Zoñán, 3.Neixón Grande, 5. Alto do Castro, 6. Castrolandín, 7. Castrovite, 8. Montealegre, 9. Nabás, 10. Punta do Muíño, 12. Coto do Mosteiro, 13. O Castelo, 14. Castromao. Roman period: 1. Noville, 4. Caldas, 11. Areal.

Samples from two types of sites were analyzed. Most of the sites were habitation sites, which during the Iron Age correspond to fortified settlements (*castros*), and during the Roman period to a *vicus* and a *villa*. The majority of the pieces, however, come from a site associated to specialized production: a marine saltern.

The study of these pieces of wood provides a greater understanding of how this raw material was used in the manufacturing of products. While the preservation of these types of objects and structures is rare in archaeological contexts, wood was used in many different ways in the daily life of past societies.

MATERIAL AND METHODS

The most common type of preservation of the analysed samples was through water or humidity saturation, followed by carbonization and occasionally mineralization. There was also indirect evidence for construction with wood from the impressions of branches in clay.

During the microscopic study the samples were first identified taxonomically, with the anatomical patterns of the wood samples identified on the three sections (cross, tangential, radial). In the case of waterlogged samples, thin sections were used, while for carbonised or mineralised samples a marginal zone was removed. The dendrological and taphonomic characteristics of the samples were observed and registered.

At the macroscopic level, the technological study of these wooden products was based on the description and registering systems used in a number of publications (Pugsley, 2003; Pillonel, 2007). A morphometric analysis was first undertaken, which included an overall description, graphic registering (photography and illustration) and measuring of the object. Following this, the different stages of the *chaîne opératoire* identifiable in the piece were described: acquisition, surface preparation, processing, manufacturing and finishing process.

DATA AND RESULTS

Waterlogged wooden pieces corresponding to three stages of the *chaîne opératoire* were studied: manufacturing wastes, preforms and finished objects/structures. The state of conservation of the pieces varied in relation to the type of preservation and to the contexts in which they were found.

Fragments of carbonized wood, from episodes of burning at some sites or from fuel, and a fragment of mineralised wood were also analysed, providing information on the species and techniques used in the construction and elaboration of objects.

The *chaîne opératoire* of woodworking begins with the acquisition of the raw material: the selection of the species and of the part of the plant to be used. The identified taxa used in manufacture from the Iron Age samples were: *Quercus* sp. deciduous, *Corylus avellana, Fraxinus* sp., *Alnus* sp., *Ilex aquifolium* and *Quercus* sp. evergreen. The samples from this period consisted of carbonised or mineralised pieces, which in the majority of cases were fragmented. The samples from the Roman period presented a greater taxonomic variability, favoured by the preservation of wood in humid contexts: *Quercus* sp. deciduous, *Castanea sativa*, *Quercus* sp. evergreen, *Quercus suber*, *Alnus* sp., Rosaceae/Maloideae, *Pinus* tp. *sylvestris/nigra*, *Fraxinus* sp., *Juglans regia*, *Prunus* sp., *Salix/Populus* and *Frangula alnus*.

The objects identified from the Iron Age were vessels made from *Alnus* sp. and *Fraxinus* sp., agricultural implements, weapon or tool handles in *Quercus* sp. deciduous and *Corylus avellana,* and the handle of an indeterminate object in *Alnus* sp. For structural elements (planks, laths, wedges, joinery pieces, *etc*.) the species selected were *Quercus* sp. deciduous, *Corylus avellana, Fraxinus* sp. and *Quercus* sp. evergreen. Manufacturing waste was of *Quercus* sp. deciduous and *Ilex aquifolium.*

At some sites branches of small diameter of certain taxa like *Corylus avellana* or *Salix/Populus* were identified. They were probably selected for the elasticity of their young branches, and used in the construction of frameworks (roofing, walls); although other shrub species, such as heather and legumes, were also being used. Obtaining long straight poles necessary for this type of construction was achieved through pruning/coppicing of the plant, although the secondary branches of trunks of high quality wood (e.g. *Quercus*) felled for the elaboration of other structural elements could also have been used.

DISCUSSION AND CONCLUSION

The analysis of these samples provides information on the use of wood during the Iron Age and the Roman period in the northwest of the Iberian Peninsula. The analysed data reveals that species were being selected for their physical and mechanical properties responding to the necessities of the object in question, e.g. high quality trunks for structural elements, flexible branches for frameworks, or fine-grained wood for more finely worked objects. It appears that these requirements were met by local resources, since the taxa identified were characteristic of the landscapes of northwest Iberia during the Iron Age and Roman period (Desprat *et al.,* 2003) and the use of "exotic" wood is undocumented.

The most frequent type of objects among the structural elements or those connected with construction, are planks – variable in size-, joinery pieces, and frameworks of poles. There is a degree of continuity in the wooden construction techniques during the two time periods analysed. Despite the fact that during the Iron Age iron nails used for the joining of wooden pieces have been documented, wooden joinery pieces continued to be used into the Roman period.

The wooden frameworks indicate the presence of forestry management practices related to the production of large, straight and flexible branches. The observation of the cutting season through the presence of bark on the branches indicates that felling took place during various seasons: we propose the use of green branches for their great flexibility for frameworks, discounting storage, but it could also be connected to the existence of repairs to the structure in various seasons of the year.

This type of wooden remains presents an elevated incidence of alterations like the action of entomofauna or the presence of hyphae. In waterlogged wood this could be the result of contamination after use, a result of taphonomic processes, while in the structural elements it could have occurred during its period of use through exposure to the open air or to ground humidity.

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Woodland transformation under palaeogeographic constraints and fuelwood use on a coastal lagoon during the Antiquity, according to charcoal analysis (The Prés-Bas *villa* and Le Bourbou, Loupian, Hérault)

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Summary: *Charcoal remains from the* villa *of Prés-Bas and the pottery workshop of Le Bourbou reveal that, during Antiquity, the mixed oak woodland and the alluvial plain vegetation were both exploited for fuelwood. Based on local ecology, these results illustrate the long term opposition between the northern and the southern shores of the Thau lagoon.*

Key words: *Roman* villa*, Antiquity, palaeobotany, coastal environment, effects of human activities.*

INTRODUCTION

The margins of the Thau lagoon, occupied since the early Neolithic, provide abundant archaeological, palaeobotanical and palaeogeographic information. Our palaeoenvironmental study is based on charcoal analysis carried out at the roman *villa* of Prés-Bas. Long term coastal morphological evolution and vegetation history are used as reference to distinguish the role of physical conditions and human incentive.

A PROSPEROUS GALLO-ROMAN *VILLA*

The *villa* of Prés-Bas (Loupian, Hérault) located in the Narbonnaise, 1.2 km away from the lagoon of Thau, was occupied from 50 BC to 600 AD. Built first as a modest farm it was later transformed into a rich patrician domain with *thermae*. The cellar, with a capacity of 1500 hl bears witness to an economy based on viticulture. The amphorae for the *villa* were produced by the lagoon in the port and pottery workshop of Le Bourbou, active between 50 and 425 AD. During the 5th century the *villa* was transformed into a magnificent residence with mosaic floors (Bermond and Pellecuer, 1997).

CHARCOAL SAMPLING AND RESULTS

Charcoal was sampled from the domestic deposits of the *villa*, the *praefurnium* and the pottery kilns by dry sieving (4 mm mesh), to ensure the reliability of data, their palaeoenvironmental representativity and the correct identification and interpretation of the area targeted for wood collecting (Chabal, 1997). Charcoal analysis provided a large plant spectrum with 33 species, at least. The study of 4600 charcoal fragments from domestic residues sampled in the *villa* (Fig. 1), shows that Quercus *ilex* dominated woodland during all the occupation. The abundance of *Olea europaea* and the presence of *Vitis vinifera* and *Juglans regia* are particularly noted. *Cupressus*, probably introduced in France and rarely identified during the Antiquity, is present. Data from the *praefurnium* (300/375 AD) also reveal the use of diverse species (9 taxa/540 charcoal fragments). *Quercus* (deciduous), *Quercus coccifera-ilex* and *Ulmus* predominate; their frequencies vary slightly according to the 8 sampling areas. The potters from the Bourbou (3500 charcoal fragments) used 23 species, at least; fragments of *Quercus coccifera/ilex* and associated species predominate. Wood calibre and humidity seem important factors to take into account for this activity, while the species used seems to be of no consequence (Chabal, 2001).

DISCUSSION AND CONCLUSIONS

Quercus coccifera/ilex (certainly the holm oak) and associated species are the main components of fuelwood used both in the *villa* and in the pottery kilns. The wood supply must have been a well organised activity. Based on the species identified (cultivated species and plants from the alluvial plain) it appears reasonable to think that the supply area must have included the very near proximity. Inside the *villa*, differences between the domestic spaces and the *praefurnium* are observed and must be explained. Intentional choice appears as an unlikely explanation, as the three main species identified in the *praefurnium* are hardwoods, with similar behavior during combustion. Moreover, deciduous *Quercus* and *Ulmus* could have been the dominant species of the ancient woodlands situated close to the northern shore of the lagoon. At present, *Ulmus* and *Fraxinus* still survive further west, as residual groves on alluvial soils. Therefore, our hypothesis is that the differences observed may reflect different supply areas. Coppices of holm oak, providing most of the fuelwood, could have been exploited on the hills behind the *villa*, beyond the cultivated areas, and even further away. A more reduced area of ancient woodland could have provided a separate provision of fuelwood for the *praefurnium*. Can we guess why? This mixed or alluvial woodland, older than the oak coppices, could have provided wood of larger calibre, more appropriate for the slow and continuous heating of the hypocaust.

The ecological connotation of this interpretation is supported by our knowledge of the long term transformations of the coastline. Some studies highlight the complex palaeogeographic evolution of the littoral area during the Holocene (Court-Picon *et al*., 2010). Abundant organic remains (wood, charcoal, seeds and fruits) have been recovered from the Late Bronze Age dwellings built on the shores of the lagoon, when the sea level was –2m asl. On the southern shore, the majority of the agrarian activities and wood cutting took place in the xero-thermophilous areas of the 'lido' and Mont St-Clair. On the northern shore, two contrasting habitats are noticed: the alluvial/mesophilous areas, with deciduous *Quercus*, *Ulmus*, *Fraxinus*, *Juglans* and the drier areas colonised by *Quercus ilex* (Bouby *et al*., 1999; Chabal *et al*., 2010).

During the Antiquity, sea level was *ca*. 1.5 m higher. In the northern shore, the alluvial plain may have been partially submerged. The mesophilous forest may also have been cleared for agriculture during the Iron Age. Then, oak dominated areas may have become the main available woodlands. In mixed woodland, the exploitation of wood would quickly favour *Quercus ilex* over *Quercus pubescens* (Chabal, 1997). People living in the *villa* exploited the drier areas of the low hills, as well as the more humid areas/older stands. This was complemented by a more opportunistic supply (pruning of cultivated trees). Our perception of local woodlands based on fuel used during the Antiquity is in conformity with the ecology characterising the northern shore of the lagoon; it also reflects the differences noted since the Bronze Age, taking into account the rise of sea level.

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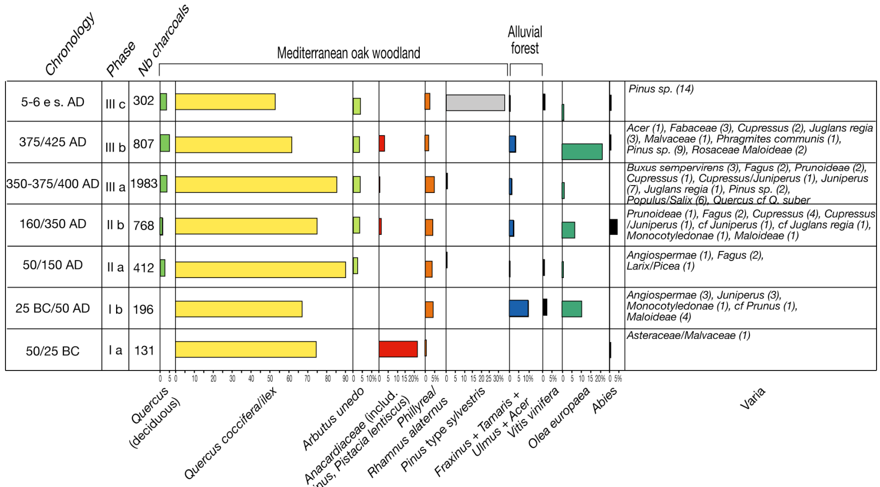

FIGURE 1. Charcoal analysis diagram of the villa *of Prés-Bas (Loupian, Hérault).*

Charcoal analysis from Lixus (Larache, Morocco)

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Summary: *The aim of this paper is to present the results of charcoal analysis from the site of Lixus (Larache, Moroco) during three key moments of human settlement.*

Key words: *Moroccan anthracology, landscape, firewood management, charcoal and wood analysis*

INTRODUCTION

Lixus (Larache, Morocco), the ancient city of Mauretania Tingitana, was settled by the Phoenicians during the 7th century BC. It gradually grew in importance and later came under Carthaginian domination. After the destruction of Carthage, Lixus fell to Roman control and became an imperial colony that reached its zenith during the reign of Emperor Claudius I.

This study addresses the management of the Lixus forest by analysing 5595 charcoal fragments during three key moments of occupation.

RESULTS

Seventeen wood taxa were identified: *Erica arbórea, Fraxinus* sp., *Juniperus* sp., *Leguminosae* sp., Monocotiledonea sp., *Olea europaea, Pinus pinea, Pistacea lentiscus, Populus* sp./*Salix* sp., *Quercus ilex, Quercus ilex-coccifera, Quercus suber, Rhamnus* sp., *Rosaceae* sp., *Tamarix* sp., and *Ulmus* sp. (Grau Almero, 2005; Grau Almero *et al.,* 2001, 2010a, 2010b, 2010c).

DISCUSSION

The flora identified in Lixus's Phoenician levels indicated the existence of a mosaic of biotopes which provided wood used for various activities carried out in Lixus.

The Phoenicians would collect firewood from ash, poplar, willow and elm trees in riparian communities. However, despite proximity to the Lucus River, the low presence displayed by this species indicates that this may not have been the place where the wood was collected.

The type of vegetation growing around Lixus is also reflected in palynological studies carried out in the Sakha-Sokha Oued bog, near Larache (Ballouche et *al*., 1986), where cork oak species were better represented in an open landscape with sun-loving herbs.

Other taxa came from areas with good limestone soils where oak formations grew. There would have been well-developed kermes oak formations as well as wild olive trees, mastic, leguminous plants, etc., in the underbrush of these oak forests.

Therefore, there were areas that contained various vegetation types of trees and shrubs near the site. Plants that were used for firewood such as cork, oak and heather grew in acidic soils within the area. The pine wood remains could have been either from the oak or cork forest areas.

During the Punic period, the relative frequency of all types of the evergreen *Quercus* decreased considerably. This would indicate an increased clearing of oak forests, cork trees and shrubs in order to provide wood for fuel furnaces and ovens. The persistence of anthropogenic pressures on the environment favoured the degradation of sclerophyllous oak forests and their replacement by scrub bushes and pine-covered areas.

During the Mauritanian period, wood resources from areas with acidic, wet and sandy soils found on the left bank of the Lucus River declined in comparison to previous phases. This could be interpreted as a relocation of the harvesting area of the wood used in combustion structures to zones where calcareous soils with Kermes oak bushes and mastic and leguminous plants were present at the expense of oak trees. At this point, the vegetation of the original forest could have begun to change, and forest management in Lixus would have varied depending on the evolution of the vegetation and changing resource priorities. Burning and clearing forests in order to obtain farmland and pastures caused these shifts in the evolution of the vegetation.

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Preliminary anthracological study of the Taza site (Western Algeria)

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Summary: Preliminary anthracological and wood study of the Taza site concerns a period stretching from antiquity to the 19th century. This study outlines the characteristics of the palaeoenvironnment and the ethnobotany (interaction of man with the vegetable world) at different periods of time around this site and tries to differentiate the occupation of layers.

Key words: *Taza, antiquity, medieval, anthracology, timber, environment, ethnobotany.*

INTRODUCTION/BACKGROUND

Taza site is situated at the south-east of Miliana (Fig. 1), on the mountain of Matmata. The Lambert coordinates of localization are X: 434-434.5, Y: 3968.5-3969. The settlement is one of the establishments (Bourouiba, 1983) founded by the Emir Abd-el-Kader[1].

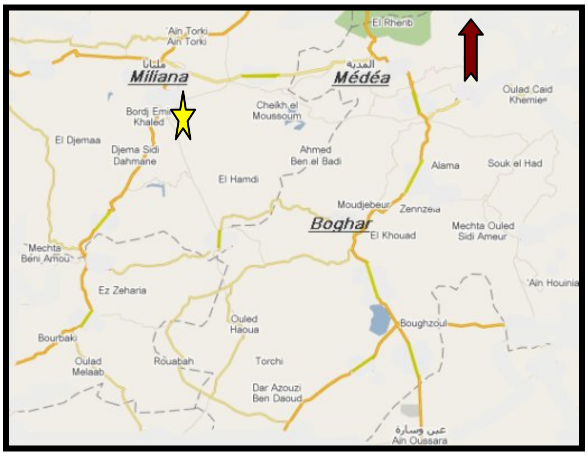

FIGURE1: Taza geographical localization

The site was discovered in 1974 and after several visits by researchers (Bouyahiaoui *et al.*, 1998), Professor Bouyahiaoui carried out a prospection in 2001 and in 2002 he launched systematic excavations (Bouyahiaoui, several years) which continued until 2010 (Fig. 2).

The archaeological vestiges discovered in Taza attest to the presence of several deposits (from the older to the most recent): Roman, Almohades and the Emir Abd-el-Kader level. The rich and exceptional materials discovered are under detailed study.

FIGURE 2: View of the site after the 2009 excavation

MATERIALS AND METHODS

The charcoals and wood (natural and timbers) from Taza were collected during the excavations, precisely during the 2003, 2004, 2006 and 2008 field seasons (Table 1). The majority of samples were retrieved from the Emir level and only one sample comes from the Roman level occupation.

Site discovered	Sector	Area	Nature
Taza	04	03	Wood (Fig. 3 A, B)
Taza 14/07/2003	01	02	Charcoal fragments
Taza 19 07 2004	A B	1 /	Charcoal fragments + Wood (Fig. 3 D)
Taza 21/7/2004	/	A	Charcoal fragments
Taza 18/07/2006	1 /	6	Charcoals of the Roman level (Fig. 3 C) Timber/ Tool? L-19cm, l. 2 (Fig. 3 E).
Taza 2008	4	3	Charcoals, Timber (Fig. 3 F)
Taza 2008	03	/	Barks, Needles, Ashes with Charcoal
Taza	/	/	Tool? L : 10,5 ; l : 2,5 (Fig. 3 G, H)

TABLE1: Samples from Taza site

[1] Abd-el-Kader: Algerian philosopher and politician (1808-1883), founder of a first Algerian State.

The identification (three anatomical section views) was accomplished by photonic reflex microscope and the use of Schweingruber's atlas (1990).

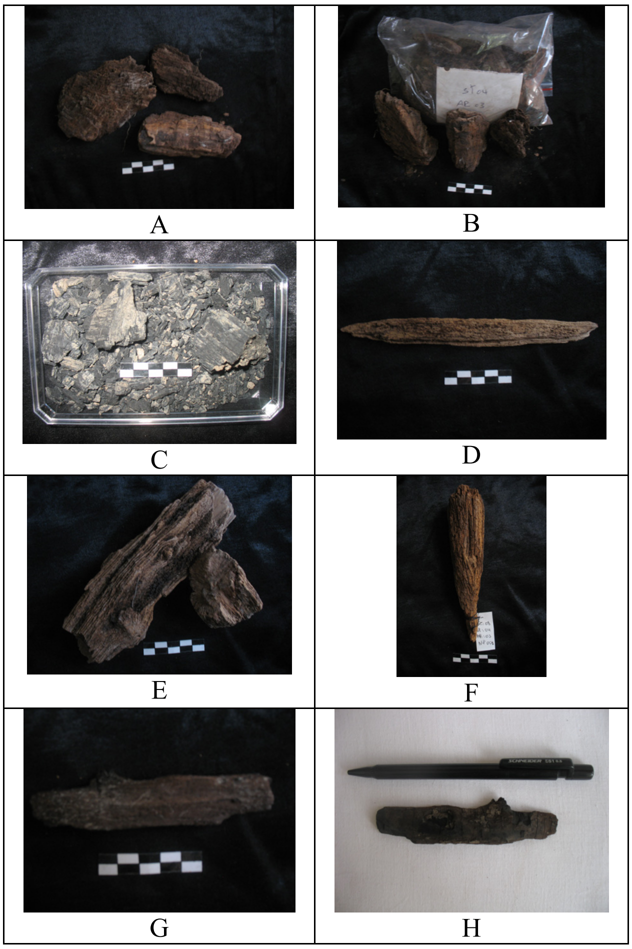

FIGURE 3: Charcoal and wood from Taza

RESULTS AND DISCUSSIONS

The charcoal analysis is under development. On one hand, the preliminary results of species listing allow making a positive analytic study; from an ecological point of view we will certainly reach conclusions concerning the image(s) of the local environment in several levels. On the other hand, some information obtained by the analysis (wood and charcoals from the Emir occupation) could be interpreted in two perspectives: palaeoethnological and palaeoecological.

CONCLUSION

A conclusion from the identification of the charcoal, the wood and timbers has not been reached yet. The variability of the samples' nature will allow obtaining information concerning the vegetation, the environment, the climate and especially the activities practised during different occupation periods. Consequently, we will be able to raise conclusions concerning the environmental evolution in the surroundings of the site and the activities practiced in the different architectural structures during the occupation of the site.

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Vegetation history over the last 2500 years: a multi-site approach in Maremma (Tuscany, Italy)

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Summary: *The aim of this work in progress is to study vegetation and forest cover changes in a large area in Southern Tuscany (Central Italy) by means of charcoal analysis with an innovative multiple site approach. Charcoal remains come from six archaeological sites, dated between the 6^{th}-5^{th} c. BC to the 15^{th} c. AD, from Etruscan period to Middle Age. The sampled contexts were carefully selected since only dispersed charcoals represents a long term collecting of the wood, and is therefore more likely to reflect the local vegetation. Establishing the changes in the vegetation cover, with a high resolution in detecting human impact, this approach allows to determine a reasonable diachronical spatial pattern.*

Key words: *dispersed charcoals, forest cover changes, Mediterranean vegetation, human impact.*

INTRODUCTION

In Southern Tuscany (Italy), in spite of the abundance of archaeological excavations, few studies dealing with charcoal analyses were carried out; attempts to reconstruct vegetation history are mainly carried out by means of pollen analysis, above all from the lake deposits. The interdisciplinary studies of the sediments of Lago dell’Accesa (Magny *et al*., 2006; Drescher-Schneider *et al*., 2007; Magny *et al*., 2007) and of the Ombrone alluvial plain (Biserni and van Geel, 2005), involving both sedimentologists and palaeobotanists, provided a record of vegetation and climatic change spanning over 15,000 years, until 2500 BP.

The Holocene vegetation inferred from pollen data of Accesa Lake is characterised by alternating dominance of deciduous oaks and *Quercus ilex* (Drescher-*Schneider et al*., 2007). A low resolution in detecting human impact was achieved from these data, due to the difficulties in distinguishing between changes in the vegetation cover induced by man from those caused by climatic changes in the Mediterranean region (Drescher-Schneider *et al*., 2007). Human impact seems to start during the Neolithic period, and increases in the Early Bronze Age. Afterward, the human impact in Iron Age and Etruscan period is detected by the increasing values of arable crops and of species of the secondary forest canopy with a declining deciduous oak forest (Biserni and van Geel, 2005; Drescher-Schneider *et al*., 2007). Finally the last 2500 years were poorly represented in very few upper centimeters of the cores and were not studied in these works.

MATERIALS AND METHODS

The human presence was continuous in the Southern Tyrrhenian Tuscany: Etruscan, Roman and Medieval settlements follow one another in the area and several archeological sites have been excavated during the last ten years and a lot of charred botanical remains have been available. Thus, despite pollen have been until now the most studied remains, charcoal analysis could provide a better spatial resolution and a finest identification level.

The aim of this work is to study vegetation and forest cover changes in a large area of Maremma in the Southern Tuscany, from Etruscan period to Late Middle Age. To determine a reasonable spatial pattern, charcoal analysis is carried out with an innovative multisite approach. Charcoal remains come from six archaeological sites, dated between the 6^{th} -5^{th} c. BC to the 15^{th} c. AD, located along 100 km of the Tyrrhenian coast (Fig. 1).

The analyzed sites are, from north to south, the Castle of Donoratico, dated from Late Roman Age to 15^{th} c. AD, the Acropolis of Populonia, dated from 2^{th} c. BC to the third quarter of 1^{th} c. BC and from 9^{th} c. AD to 13^{th} c. AD, the Roman building of Vignale, dated from 3^{th} c. BC to 5^{th} AD, the Roman harbour of Spolverino near river Ombrone, from 2^{nd} c. AD to 5^{th} c. AD, the Roman temple area of Lo Scoglietto, from 1^{th} c. AD to 6^{th} c. AD, the Etruscan residence “Casa delle Anfore”, dated 6^{th} c. BC-5^{th} c. BC.

FIGURE 1. Map of the research area: location of the archaeological and main sites cited in the text. 1. Castle of Donoratico; 2. Accesa Lake; 3. Acropolis of Populonia; 4. Roman building of Vignale; 5. Grosseto; 6. Ombrone alluvial plain; 7. Roman harbour of Spolverino near river Ombrone; 8. Roman temple area of Lo Scoglietto; 9. Etruscan residence “Casa delle Anfore” (Marsiliana-Manciano).

The sampled contexts were carefully selected since only dispersed charcoals represents a long term collecting of the wood, and is therefore more likely to reflect the local vegetation; these contexts are living layers, waste pits, silos, collapses, furnaces, fireplaces, fills layers. Adequate volumes of sediments were collected in order to obtain enough charcoals to analyse. In addition, the living layers were sampled using a grid (1x1 m2), the pits were sampled by means of uniform sized cuts and fireplaces and concentrated charcoals were totally collected. Identification is still in progress, at least 250 charcoals will be studied for each context, the lower amount of charcoal in some layer will be taken into account for the interpretation of the data.

EXPECTED RESULTS

We expect that this multiple site approach and the large time interval spanned by our sites will allow some open questions to be resolved:

- to establish if the present evergreen vegetation can be referred to degradation of a deciduous forest or if, according the map of the potential vegetation by Mondino (1998), these sites are located in the zone of holm's oak wood and macchia vegetation;
- to detect the beginning of extensive Olive cultivation;
- to asses the human impact in terms of deforestation through all the investigated period.

The first available data seems to show a strong relationship between the vegetation features and the historical background of the sites (Fig. 2); at Populonia, for example, the mixed deciduous forest increase when human presence is lower and thus indicating that evergreen vegetation can be considered as the degradation of a deciduous forest. Concerning the history of olive cultivation, few data comes from Populonia, where the extensive cultivation begin in Medieval time.

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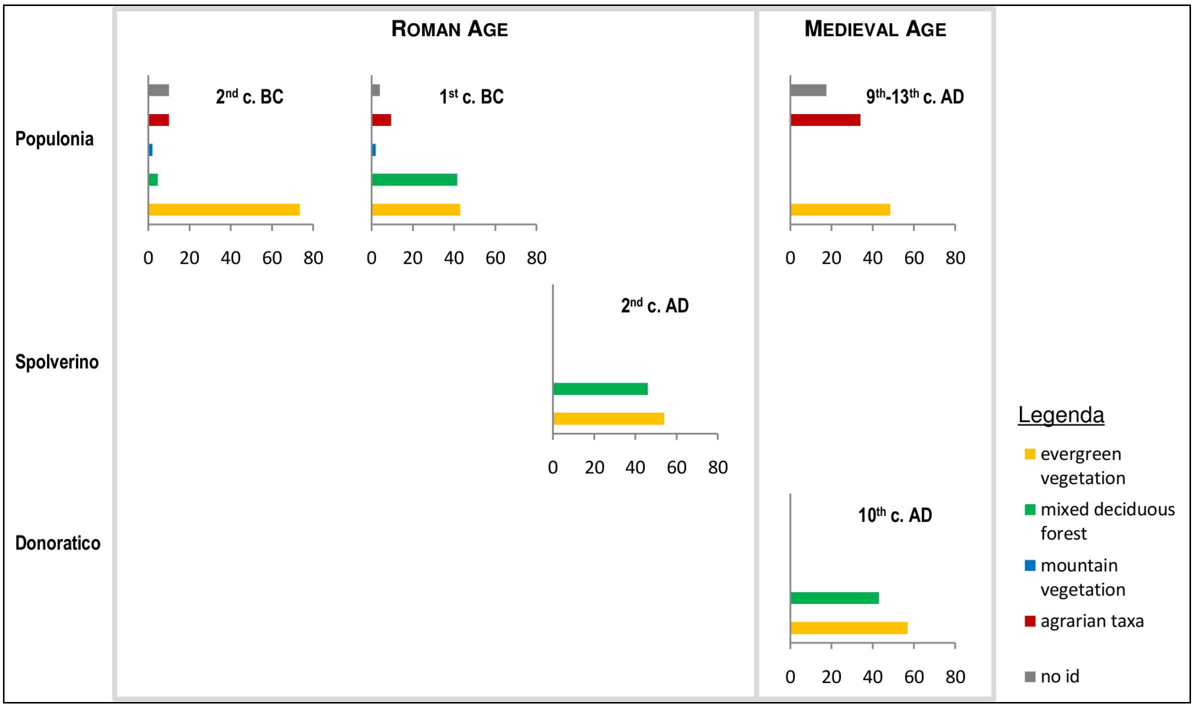

FIGURE 2. Charcoal data from acropolis of Populonia, Roman harbour of Spolverino and Castle of Donoratico. Bars represent the percentage of main vegetation types calculated as sum of the relative single taxa.

The Romans, the wood and the forest: state of the art and new data from the Vesuvius area (Naples, Italy)

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Summary: *The Vesuvius area (Naples, Italy) is one of the richest regions in archaeological findings of the Roman Age. A huge quantity of vegetal material was preserved by the 79 AD eruption. Unfortunately, because of the early beginning of the archaeological investigation in this area, huge parts of the archaeobotanical remains are now completely destroyed and not available any more for modern research. Nevertheless, the analysis of the last charred and wooden remains of structural elements from* Herculaneum *and from the Poppaea's Villa at* Oplontis *is started. Silver fir and cypress are the most used taxa. The identification of these trees, together with other taxa as chestnut and walnut, gives us new information about these outstanding trees in this part of the Italian peninsula and allows us to better understand the use of wood and the utilization of forest resources during Roman times. This will also contribute to the reconstruction of the ancient landscape of this region of the Roman Empire.*

Key words: *charcoal analysis,* Abies alba*,* Cupressus sempervirens*,* Herculaneum*, ancient landscape*

INTRODUCTION

The area surrounding the Vesuvius volcano, with its famous cities of *Pompeii*, *Herculaneum* and *Neapolis* and its numerous villas, was one of the most important and vital places of the Roman Empire. The 79 AD eruption allowed the preservation of entire cities and villas, giving to the posterity the possibility to investigate every aspect of the social and economic life and of the artistic and architectural production. The eruption allowed also the preservation of the vegetal material: timber used for structures, garden plants, remains of meals and stored foodstuffs were found in huge quantities since the first excavations.

STATE OF THE ART: ARCHAEOBOTANICAL RESEARCH IN THE VESUVIUS AREA

Unfortunately, the aim of the researches in this area that started in 1738 with a first investigation in *Herculaneum* was to bring to light the precious artistic objects found in the villas and not to understand the material culture of the daily life. Because of this approach, and because of the scant attention paid both by the classical archaeologists and the Italian botanists and ecologists to the archaeobotanical findings, the most part of the vegetal remains discovered during these first investigations were not studied in a systematic way and not published. Up to now, although on the one hand pollen analysis was applied in several contexts (e.g. Mariotti Lippi, 2000) together with carpological investigation (e.g. Ciaraldi and Richardson, 2000), on the other hand the studies of charcoal and wood remains are not widely applied yet. The few available data mostly concern the archaeological contexts investigated by Jashemski (1979), together with unsystematic research carried out in *Herculaneum* and in *Pompeii* (e.g. Mols, 2002). Thus, the big amount of vegetal material found by the several investigations taken up during the last 250 years in the most important archaeological contexts of the Roman world, is today almost completely lost or destroyed and risks to be unavailable any more for modern research. However, it is important to mention that the Vesuvius area still today is the richest place concerning archaeological wood, constituting a unique chance to analyze the use and technology of wood during the Roman Age and to reconstruct the past landscape of this important region.

HERCULANEUM AND *OPLONTIS*: NEW DATA

In this perspective, a PhD project is started, in the range of a wider work aimed to analyze all the evidence of the use of this material in the Vesuvius area. The investigation regards different archaeological contexts: from the so-called "Villa of Augustus" at Somma Vesuviana and the bath complex at Pollena Trocchia (Di Pasquale *et al*., 2010) both on the northern slope of the Vesuvius, to the shipwrecks found in the *Neapolis* harbor (Allevato *et al*., 2010). In this paper we present the first new data from the analysis of the charred and wooden structures of the Poppaea's Villa at *Oplontis* and of *Herculaneum*.

MATERIALS AND METHODS

The methodology has envisaged the sampling of all the wooden and charred elements pertinent to the structures, and the furniture still present in the two archaeological contexts. The taxonomic determinations have been made with a stereo lens (magnification 7.5-112.5x) and an incident light microscope (100x, 200x and 500x), using wood anatomy atlases and reference collections of wood.

RESULTS AND DISCUSSION

The two main *taxa* used in the Poppaea's Villa are *Cupressus sempervirens* and *Abies*, indicating the preference of coniferous wood for building. This situation is confirmed by the analysis of the charred structures at *Herculanuem*, where *Abies* is the most represented *taxon*, followed by *Cupressus sempervirens. Castanea sativa* and *Juglans regia* are also present. The results are very interesting since they give us information about the history and the use of some outstanding trees of this part of the Italian peninsula during the Roman Age. Regarding the two main *taxa*, of great interest is the attestation of *Abies* at both sites. Based on the morphological features of the wood it is not possible to distinguish between the different species of the genus *Abies*, nevertheless the attribution of our fragments to *A. alba* seems the most reliable due to the wider distribution of this species in the Italian peninsula. Silver fir is frequently found in archaeological sites of the Mediterranean Italy dated to Roman times. Nowadays in Italy *Abies alba* is common on the Alpine chain and, with scattered small populations, along the whole southern Apennine chain above 800 m asl. The nearest population to our study area is located at about 70 km from Mount Vesuvius. The archaeobotanical data available for ancient Campania seem to prove, instead, a wider diffusion of fir during the Roman time and to ascribe its decline to the forest exploitation for timber (Quézel and Médail, 2003). Pollen data from the Sele basin area (60 km south of Naples), moreover, show the fir decline only at the end of the Medieval Age (Russo Ermolli and Di Pasquale, 2002). The whole set of these data is in contrast with the hypothesis of an Alpine provenance of the fir timber found at *Herculaneum* and *Pompeii* (Kuniholm, 2002). Also the identification of cypress timber is interesting. Cypress has probably been cultivated on the Italian peninsula since the Etruscan times (Quézel and Médail, 2003) and gradually it has become a key element of the cultural landscape of Mediterranean Italy, assuming during the Roman Age a strong symbolic-ritual value (Meiggs, 1982). Anyway, cypress had also a certain economic significance: this plant was also used in woodworking and as building timber, as the archaeobotanical data available for ancient Campania, and in particular for *Oplontis* and *Herculaneum*, clearly show. Chestnut and walnut wood was used as building timber. Together with other evidence available for ancient Campania (Di Pasquale *et al*., 2010), these results suggest a not exclusive cultivation of these trees for their fruit during the Roman Age, as it is commonly thought. Most probably in this area Romans exploited small forests of chestnut present *in loco* for the timber, and the diffusion of this tree on a large scale took place only from the 5th – 6th century AD when the big interest on its fruit started.

CONCLUSIONS

The analysis shows the prevalent use of coniferous wood for building. Among conifers *Abies*, probably *A. alba*, and *Cupressus sempervirens* are the predominant *taxa*. The massive use of silver fir timber in building is probably the main cause of its almost total disappearance from the forests of southern Italy. Regarding cypress, we can hypothesize its cultivation for timber production. Finally the data can indicate the good level of knowledge in wood use and technology reached by the Romans.

ACKNOWLEDGEMENTS

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Forest management and territorial practices during the Early Middle Ages in the medium mountain of Mont Lozère (France). A combined approach of charcoal and palynological analyses.

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Summary: *Mont Lozère is located in the Massif Central (France). The area presents a wide diversity of long-term shaped landscapes, which result from complex strategies in natural resources management: farming, agro-pastoralism, forest exploitation, metallurgy… What is the relation between spatial and temporal variability in land-use patterns and the high landscapes diversity? The ongoing project uses a paleo-environmental multi-disciplinary approach (palynology, charcoal analysis, geochemistry, geo-archaeology) combined with landscape, pastoral and mining archaeological evidences in order to find an appropriate answer to these questions. This paper focuses on multi-proxy palaeo-environmental studies (charcoals, pollen, non-pollen palynomorphs). These studies have been undertaken at high spatial and temporal resolution both in natural sequences (peat bogs) and archaeological records (charcoal burning platforms). The results lead to the reconstruction of the vegetation dynamics and, more specifically, to the co-evolution of the vegetation assemblages and the territorial practices. The integration of all data linked together mainly from the High Middle Ages enables to map the forest's distribution.*

Key words: *Charcoal-burning platforms, palynology, landscapes evolution, Massif Central*

INTRODUCTION

Mont Lozère, located in the Massif Central (France), presents a wide diversity of long-term shaped landscapes, which result from complex strategies in natural resources management farming, agro-pastoralism, forest exploitation and metallurgy. In this sense, archaeological surveys have listed nearly 80 lead-ore smelting sites, more than 230 charcoal-burning platforms and 18 agro-pastoral sites (Fig. 1). Most of sites date back from the High and Late Middle Ages.

This paper aims to trace human management and landscape shaping in a middle mountain area during the 11th to 15th centuries. To achieve this, we use a combined approach based on both charcoal burning platforms and palynological data.

MATERIAL AND METHODS

Comparison of charcoal and palynological data allows a further understanding of landscape dynamics. Charcoal-burning platform location let us map the medieval forest distribution (Fig. 1), because of wood exploitation next to the platforms (Davasse, 2000). The charcoal analysis gives local botanical information (determination of the species and the diameter of the burnt wood) (Ludemann, 2010). Besides, the radiocarbon dating of charcoal burning platforms corresponds to a short lapse use (11th-15th centuries).

Otherwise, palynology provides local and regional landscape information in a diachronic way (since the Neolithic period); additionally it informs about the complementarity of human practices, particularly enabling to decipher agropastoral activities (Miras *et al*., 2010). Ten charcoal burning platforms have been analysed in order to determine the taxonomic classification and the diameter estimates. For every charcoal burning platform the surface and depth horizons were systematically studied, so we could evaluate the evolution of the exploited woods. For each layer, nearly 150 charcoals are determined to obtain at least 60 measures of radius curvature. The measurements were realised with AnthracoLoJ application (Paradis-Grenouillet *et al*., 2010).

Palynological analyses have been carried out on two peat bogs: "Countrasts" and "l'Amourous"; dated back from 1960±25 BP and 6930±25 BP respectively. These records have been chosen, following a combined microregional and regional strategy and the location of the charcoal burning platforms and other archaeological elements, in order to obtain a data correlation (Ejarque *et al*., 2010). High resolution pollen analyses have been performed with a sampling resolution narrowed to 2-4 cm. A combination of other biological proxies such as non-pollen palynomorphs, stomata and pollen clumps furnished more local information.

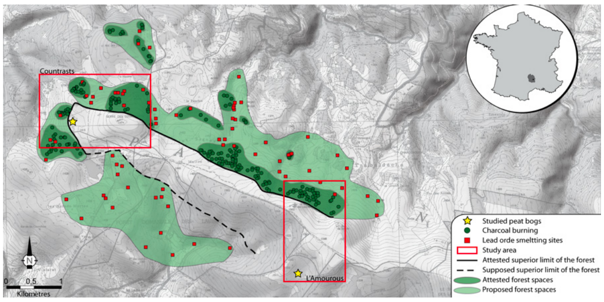

FIGURE 1. Location of archaeological sites and peat bogs studied. Reconstruction of the proposition for the medieval forest.

RESULTS AND DISCUSSION

The charcoal analyses show the exclusive exploitation of beech for the medieval period while palynological data from "Countrast" peat bog confirms the presence of a local beech forest. Examination of the burnt wood diameters show a dominance of small diameters (lower than 10 cm), while the pollen diagram shows a slight increase of beech values (Fig. 2). This could be interpreted as a short lapse coppicing with an accurate managing of the beech forest. During the High Middle Ages, an expansion of pastoral activities is underlined by pastoral pollen indicators and non-pollen palynomorphs. This is concomitant with a decline of annual crops and with the maximum of metallurgical activities. Furthermore, pastoral enclosures, not dated for the moment, have been reported in this area.

All this data suggests a territorial distribution of human activity based on charcoal production and metallurgical activities on the slopes, while agropastoral practices were located on the upper mountain areas.

The end of charcoal production and metallurgical activities (14th-15th centuries), coincides with an increase of arboreal pollen, mainly of beech value, and a decline of anthropogenic pollen indicators. It should be interpreted as a reconquest by the forest following the end of the metallurgical works.

CONCLUSION

The combination of paleo-environmental and archaeo-historical data indicates that the cultural landscape of this area is due to the heterogeneity and complexity of long term human micro-regional and local practices. Such an approach gives us a better knowledge about territorial organization during the medieval period between agro-pastoral and metallurgical activities. Nevertheless the combination of such approaches with other environmental proxies (sedimentary charcoal analyses, geochemistry, isotopic studies, sedimentology) and archaeo-historical data, will allow studying the origin of vegetation dynamics (territorial practices, climatic or environmental events...) since the Neolithic.

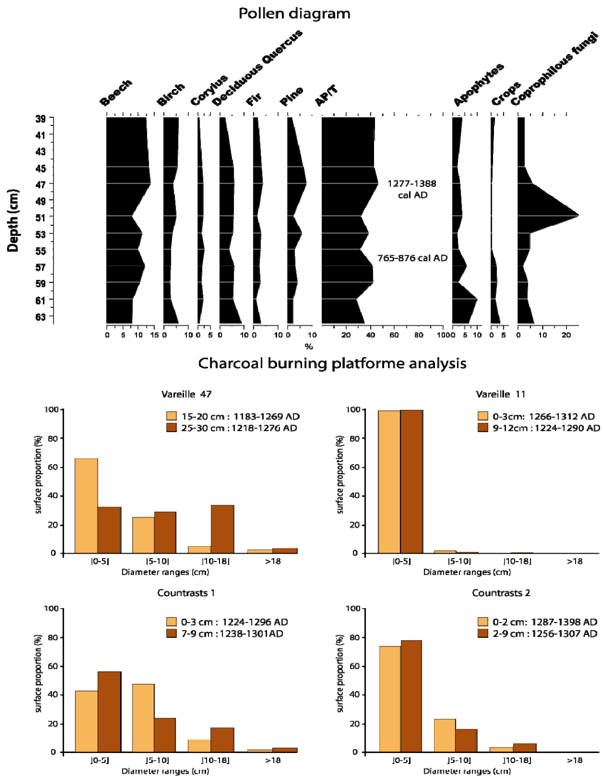

FIGURE 2. Pollen diagram of the Countrasts peat bog (above) and the radius curvature proportion in 4 charcoal burning platforms located in the vicinity of the peat bog (below).

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Classic period wood use at monumental centers in northwestern Mesoamerica

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Summary: *For over 50 years, researchers have suggested that increased regional rainfall allowed for the colonization of the highland deserts of the northwestern frontier zone of Mesoamerica by farmers during the Classic period (200-900 AD). Drought is hypothesized to have later provoked abandonment of the region by 900 AD. However, very little research has been carried out in the zone to detect evidence of this proposed climate change. I present preliminary results from the first comparative study of wood charcoal from the northwestern frontier, focusing on three Classic sites that span the region's north-south gradient of intensifying aridity. The results indicate that the strongest evidence of environmental degradation is found in the south (where average annual rainfall is the highest), while the sites located farther north demonstrate more stable use of wood resources.*

Key words: *Mesoamerica, anthracology, wood charcoal, resource management, human impact.*

INTRODUCTION

Scholars have proposed that increased precipitation and subsequent drought were key factors in the development and collapse of agricultural societies in the northwestern frontier of Mesoamerica (Palerm and Wolf, 1957; Armillas, 1964). The frontier zone was occupied during the Classic period (200-900 AD), with the peak of growth from 600-800 AD. After a regional collapse by 900 AD, the area did not see large-scale agricultural settlements again until after the Spanish Conquest in the early 1500's. However, the few paleoenvironmental studies carried out in the region do not provide evidence of Late Classic drought (Brown, 1992; Frederick, 1995; Trombold and Israde-Alcantara, 2005; Elliott *et al*., 2010).

FIGURE 1. Map of the northern frontier zone of Mesoamerica with the locations of archaeological sites discussed.

Questions that remain unanswered are 1) did the environment of the frontier zone change through time? 2) How spatially homogenous were these changes? and 3) does the occurrence and the pace of environmental change correlate with cultural changes in the Classic period settlements?

BACKGROUND AND ENVIRONMENT

The southern boundary of the northwestern frontier zone follows the course of the Río Lerma-Santiago (Fig. 1). Annual precipitation averages 700-800 mm along the southern margin of the region, characterized by grassland and forested patches (Armillas, 1964: 63). As one moves northwest toward the Sierra Madre Occidental, rainfall decreases to 450 mm annually, and the landscape transitions to semi-arid steppe and desert.

DATA AND RESULTS

Samples were collected and analyzed from three Classic period monumental centers: Cerro Barajas, El Cóporo, and La Quemada.

Cerro Barajas is a volcanic massif characterized by more than 20 prehispanic settlements (Pereira *et al*., 2005). El Cóporo consists of several complexes of domestic and ceremonial architecture located both on the valley floor and in hilltop positions (Torreblanca Padilla, 2007). La Quemada is a 50 ha site located atop a small mountain and consists of more than 50 artificial terraces (Nelson, 1997). Radiocarbon dating at all three sites shows the peak of settlement at 600-900 AD. All were abandoned by 900 AD.

Sediment samples were collected systematically from every excavation level of three stratified midden deposits (La Quemada) or stratified trash deposits used as fill in monumental architecture (Cerro Barajas and El Cóporo). Samples at La Quemada and El Cóporo were floted using a combination of manual and machine assisted techniques. Samples at Cerro Barajas were floated manually.

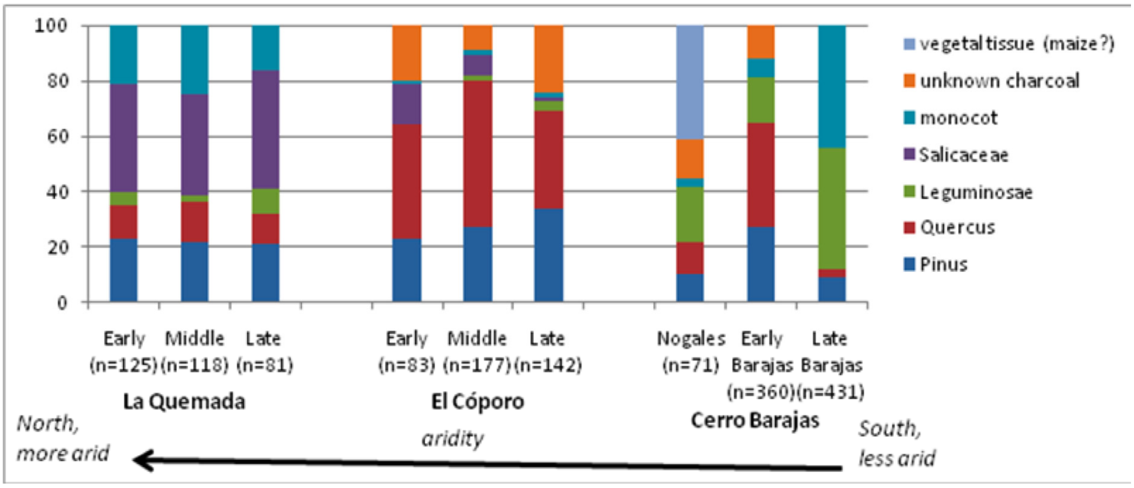

FIGURE 2. Results of charcoal analysis from the three Classic period monumental centers.

891 pieces of wood from 11 flotation samples were analyzed from the site of Los Nogales at Cerro Barajas. Fabaceae wood is present in all samples while pine and oak are both present in eight of the 11 samples. By counts, pine-oak and secondary forest zones are present in the assemblage almost equally (34% pine-oak, 30% Fabaceae). 520 pieces of wood from eight flotation samples were analyzed from the Gotas Complex at El Cóporo. Pine and oak are present in all samples, while legumes are present in only two (Fig. 2). Pine-oak forest also dominates the assemblage in counts (74%). 381 pieces of wood from 50 flotation samples were analyzed from three middens at La Quemada. The results indicate that the inhabitants of the site had access to pine-oak forest, a riparian zone, and open areas that appear to have included agricultural fields (Fig. 2).

CONCLUSIONS

The landscapes of all three archaeological zones have changed significantly since the Late Classic period, namely by the disappearance of pine-oak forest and the expansion of xeric plant communities. These changes are not uniform through time or space. While we see stability through time in La Quemada's assemblage, El Cóporo's hints at some depletion of pine-oak forest during the late phase, and deforestation is overwhelmingly clear for the Late phase at Cerro Barajas, the period of the most intense demographic growth. Further research is necessary to understand the negative correlation of deforestation with the degree of local aridity.

ACKNOWLEDGEMENTS

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Plants for life and death: evidence of use of plant resources in funerary activities of shellmound builders through the anthracological analysis of Jabuticabeira-II site (Santa Catarina, Brazil)

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Summary: *This work presents the anthracological analysis of a funerary area from a shellmound site dated from 2921-2357 to 1864-1534 cal years BP. This study is based on the premise that exploitation of land resources represented a significant role to the development of several quotidian activities; it aims to investigate the importance of plant resources in the sambaqui moundbuilders lifeway. Jabuticabeira-II site was situated in a restinga environment and the Atlantic Forest was also part of their resources catchment area. Evidence of selection of some elements related to the funerary ritual is presented. Seeds and palm fruits are especially related to features associated to funerary ritual, corroborating the hypotheses of mortuary offerings or feasts. A new hypothesis that is being investigated is here presented: that the sambaqui people might have themselves contributed to this landscape construction.*

Keywords: *shellmound, charcoal, formation processes, ritual, Brazil*

INTRODUCTION

Shellmound builders with a relatively complex sociocultural organization occupied the Brazilian coast during the Holocene. They are considered efficient and well succeeded fisher-gatherers, highly adapted to the coastal environment. The archaeological mounds usually have a complex stratigraphy, including alternating sequences of shell deposits and thin dark layers composed by burials, hearths and frequently postholes marking the occupation surfaces (Gaspar, 2000).

The study area is situated on the Jaguaruna region, Santa Catarina State, Brazil, at *ca*. 1 km from the southwestern margins of Garopaba do Sul Lagoon and at *ca*. 6 km from the sea (22J 699489/6835694 UTM). The climate is temperate sub-hot, with winter mean temperatures over 15 ºC and no dry season. Mean annual temperature is 20 ºC and mean precipitation is 1400 mm/yr. Although the natural vegetation is almost absent from this region nowadays, the site is situated in the phytosociological domain of the *restinga* ecosystem, typical of the Brazilian coast, and the Atlantic Forest is situated inland, in more elevated topographical areas.

Sambaqui Jabuticabeira-II attains 400 x 150 m, with up to 8 m in height. The site is formed by numerous alternated layers of funerary and filling deposits. The later are characterized by small mounds of shells and sand sediments virtually devoid of cultural archaeological remains, disposed above the funerary structures. Funerary layers are extremely rich in hearth features, charcoal remains, artifacts and faunal remains, especially fish bones (Fish *et al*., 2000).

MATERIAL AND METHODS

Charcoal samples were collected from a 4 m profile, the greater part of which is composed by filling layers that cover a funerary deposit about 60 cm-thick. The sediments of the filling deposits were collected by artificial levels 10 cm-thick; the funerary area was excavated according to the different archaeological features. Charcoal remains were recovered by flotation in the field. Charcoal pieces were manually broken exposing the fundamental wood anatomical sections and examined under a reflected light brightfield/darkfield microscope. Systematic determination was achieved using Atlas Brasil software, a reference collection, and the specialized literature. Data interpretation was based on the construction of charcoal diagrams and the application of multivariate analysis.

RESULTS AND DISCUSSION

All charcoal fragments over 4 mm were analyzed, attaining almost 4000 analyzed pieces. The number of *taxa* varies between 30 and 50 per sample, which represents a high floristic diversity, comparable to that of phytosociological studies (e.g. some recent phytosociological studies from different Brazilian vegetation types identified, in areas of 1-1.5 ha 592 to 924 specimens attributed to 31-54 taxa —Peixoto *et al*., 2005; Scherer *et al*., 2005).

The site was clearly situated in the *restinga* environment, corroborating previous studies, which indicated that these moundbuilders established themselves in this vegetation domain (Scheel-Ybert, 2000). However, the high proportion of Atlantic Forest taxa suggests that this dense ombrophilous forest of high biodiversity was also part of their resources catchment area. Palaeoenvironmental indicators are similar all along the charcoal diagram, suggesting that no significant environmental change took place during the occupation period. Initially, the relative vegetation stability during the late Holocene had been associated to the edaphic character of these vegetation types (Scheel-Ybert, 2000).

More recently, however, a new hypothesis is being investigated. The strong predominance of Myrtaceae obtained in most of the anthracological studies of shellmound sites (Scheel-Ybert, 2000; Scheel-Ybert and Dias, 2007) suggests that the *sambaqui* people might have contributed to this landscape configuration, especially handling Myrtaceae species (Bianchini, 2008).

Anthracological analysis disclosed a clear opposition between the “filling” and the “funerary” layers. The quantity of charcoal remains is significantly higher in funerary layers, as well as the taxonomic diversity, indicating the high intensity and the “long durée” of hearths in mortuary rituals. Indeed, the filling deposits presented *ca*. 700 charcoal pieces/m^3, while in the funerary area there were *ca*. 2700 pieces/m^3. Moreover, food remains are completely absent from the filling layers, while they are particularly abundant in the funerary samples (Fig. 1), attaining in some cases more than 30% of the analyzed remains. Arecaceae, Annonaceae, Myrtaceae, and Cucurbitaceae fruits or seeds were identified, all of them edible plants. Their abundance in the mortuary layers, associated to specific features like hearths, corroborates the hypothesis based on zooarchaeological studies, which suggests the practice of food offerings and/or ritualistic or feasting ceremonies (Klökler, 2008).

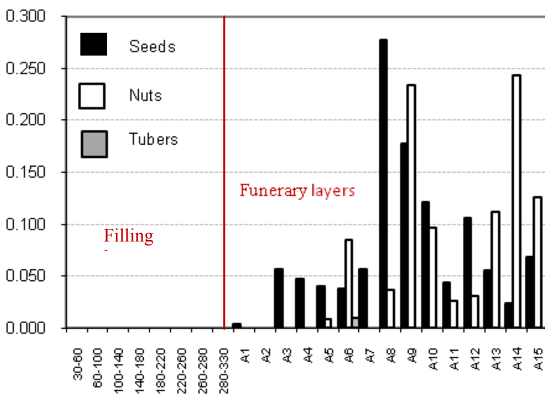

FIGURE 1. Ratios of seeds, palm nuts and tubers: charcoal in the different levels of the Jabuticabeira-II site.

CONCLUSION

Palaeoenvironmental and archaeobotanical results obtained so far indicate that Jabuticabeira-II moundbuilders inhabited the *restinga* environment for a very long time, exploiting their surroundings for domestic, utilitarian, and ritualistic wood and food.

The clear opposition between the “filling” and the “funerary” layers detected by anthracological analysis, contributed to reinforce the hypothesis that the formation processes of Jabuticabeira-II site are related to cultural activities of inhumation of the dead (DeBlasis *et al*., 2007).

Anthracological analysis of funerary layers revealed a varied set of seeds, many of them belonging to botanical groups that include several fruits thoroughly used in human diet. Their presence in mortuary layers suggests that they could be set as offerings, or consumed during the funerals in ritualistic or feasting ceremonies. This abundance indicates that they were important component of funerary rituals of the Jabuticabeira-II group.

Although presenting a relative stability, this landscape was probably deeply used and managed by these people. Virtually all of the daily and ritual activities, involved, in one way or another, practices of burning, selection, cutting, collecting, and/or transport of plants. Therefore, the Jabuticabeira-II mound builders, along a thousand years of continuous occupation, certainly left their marks in the vegetation.

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Wood charcoal production and forest dynamics in the Pedra Branca Massif, Rio de Janeiro, RJ, Brazil

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Summary: *Vestiges of dozens of historical charcoal kilns are found in the Caçambe River watershed (Southeastern Pedra Branca Massif, Rio de Janeiro, Brazil). They are remains of the charcoal production that took place in the region from late 19th to mid 20th century to supply Rio de Janeiro city. Taxonomic identification and diameter estimates, compared to present day phytosociological data, aimed to understand the Atlantic Forest dynamics under human influence. Almost a thousand fragments were analyzed from a kiln at the valley bottom and another at the top of the drainage basin.*

Key words: *charcoal kilns, anthracology, Atlantic forest, forest dynamics, Brazil.*

INTRODUCTION

Anthracological analysis of charcoal kilns has shown that wood charcoal production can have deep and long lasting effects in the landscape (e.g. Izard, 1992) or no significant change at all (e.g. Ludemann, 2002). No research of this kind has yet been carried out in tropical regions, although phytosociological studies in areas where historical land use is known, have shown that charcoal production may have long lasting effects (e.g. García-Montiel and Scatena, 1994).

The Pedra Branca Massif is located to the west of Rio de Janeiro city. At present, it is covered by Atlantic Forest, and up to now 156 charcoal kilns have been found among the woods. The charcoal production took place in this region at least from the late 19th to the mid 20th century, to supply the federal capital (Magalhães Correa, 1936).

This work aims to understand the forest dynamics under human influence, through the anthracological analysis of charcoal kilns located in the Southeast Massif, in the Caçambe River watershed, and its comparison with the forest that stands now in the same area.

MATERIAL AND METHODS

Two charcoal kilns were sampled: one at the valley bottom and another at the top of the drainage basin. Test pits of 0.04 m^2 located at the center, periphery and middle (between center and periphery) of the kilns were sampled. Non-stratified soil samples were obtained from 0.05 m layers. Soil was sieved and floted using 4 mm meshes. Charcoal fragments were broken by hand to expose transverse, longitudinal tangential and longitudinal radial sections, observed in a reflected light microscope with bright and dark fields. Taxonomical identification was based on wood anatomy literature and databases, and on a charcoal reference collection.

Minimum diameters were estimated using a diameter stencil. Sample validity was tested through saturation and Gini-Lorenz curves. Multivariate statistical analysis tested differences among samples (SIMPER and ANOSIM) and compared charcoal and phytosociological data (NMDS).

Phytosociologial data were obtained by Santos (2009), who surveyed trees around ten kilns in the studied area (four 100 m^2 parcels around each kiln). Volume and explored area were estimated based on kiln area and historic description (Magalhães Correa, 1936), to render phytosociological and archaeological data comparable.

RESULTS AND DISCUSSION

Taxonomic identification and diameter estimates were performed for 594 charcoal pieces from the valley bottom kiln (MPB IV) and 350 from the top of the drainage basin kiln (MPB IX).

Charcoal types were heterogeneously distributed through the archaeological sites, either horizontally or vertically, but were not statistically significant. Anatomical types or diameter classes could not be associated to charcoal kiln structure. These results, coupled to the absence of stratification in the sites, suggest that charcoal kilns were produced by single events.

In MPB IV 113 dicot types were identified (107 woody plants, six lianas), mostly pioneer and initial secondary *taxa* (e.g. *Cecropia* sp., *Guarea* sp., *Tibouchina* sp.). Diameter histograms revealed a coppice type vegetation (Nelle, 2002) (Fig. 1), confirming taxonomic results.

Although in a similar successional stage, present day valley bottom forest is dominated by the species *G.*

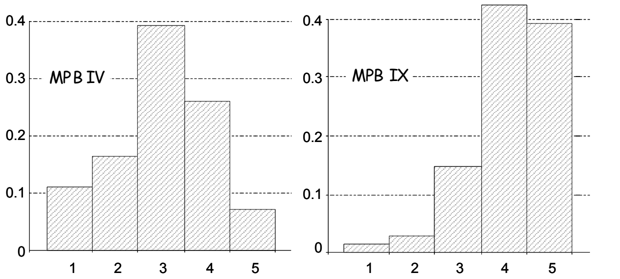

*FIGURE 1. Frequency histograms of charcoal fragments according to minimum diameter classes at sites MPB IV (n=594) and MPB IX (n=350) (***1:***0-2,9cm;* **2:***3-4,9cm;* **3:***5-9,9cm;* **4:***10-14,9cm;* **5:***>15cm).*

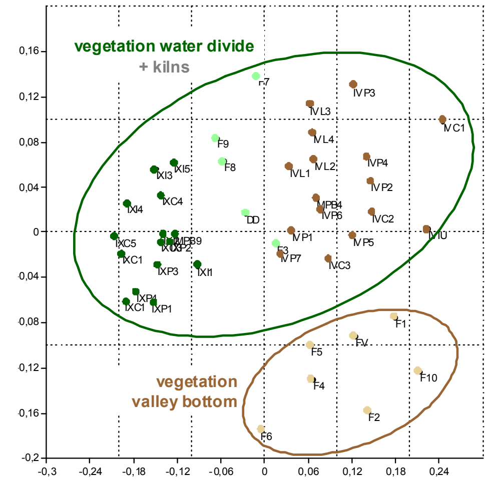

FIGURE 2. NMDS comparing charcoal assemblages to phyto-sociological data from valley bottom and top of the drainage basin (Santos, 2009).

guidonia (Santos, 2009) and has low species diversity, either by Atlantic forest standards or when compared to the charcoal assemblage.

In MPB IX 66 dicot types were identified (62 woody plants, four liana types), most of them characteristic of mid and late secondary succession (e.g. *Copaifera* sp., *Pouteria* sp., *Lamanonia* sp.). Diameter histograms revealed a profile that can be associated with large wood size type (Nelle, 2002) (Fig. 1), also corroborating taxonomic results, which suggest a forest in a more advanced successional stage.

Present day top of the drainage basin forest, also in a similar successional stage, has a similar diversity and structure pattern (Santos, 2009). The high diversity of both sites, coupled to the presence of many species much valued for other purposes, suggests that species selection was not practiced. Nowadays, species diversity is greater at the top of the drainage basin (Santos, 2009), while the charcoal assemblages suggest greater diversity in the valley bottom. NMDS showed that charcoal assemblages of both kilns and present day top of the drainage basin survey are more similar to each other than to present valley bottom (Fig. 2). SIMPER analysis identified the dominance of *G. guidonia* as the main cause of the separation of present day valley bottom.

G. guidonia is a common species in tropical forests, including the Atlantic Forest, but under few circumstances is the most frequent. It is possible that the historic management of the valley bottom somehow favored the spread of this species. Due to its allelopatic properties, it is possible that when in higher densities it prevents the establishment of other species. Consequently, it seems that an alternative successional pathway has been triggered, i.e. the successional pathway towards a dynamic equilibrium characterized by high basal area, biomass, and diversity expected in tropical forests (Schnitzer *et al*., 2000) does not seem to be happening.

CONCLUSION

The forest used to produce charcoal in the valley bottom had higher species diversity than nowadays. *G. guidonia*, the present time dominant species, was probably present in the past, but just as one more species. It is possible that the intense human use of the area triggered an alternative successional pathway in which the alellopatic *G. guidonia* became dominant and challenged the establishment of other species. The top of the drainage basin forest, in which human activities were less intense, does not seem to have had its dynamics significantly altered.

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Rethinking human impact on prehistoric vegetation in Southwest Asia: socioeconomics and long-term fuel/timber acquisition strategies at Neolithic Çatalhöyük

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Summary: Classic accounts of people-environment interactions in the archaeology and palaeoecology of Southwest Asia tend to conceptualize human impact on vegetation as an agent of significant, long-term negative change in the regional landscapes. In the case of archaeobotanical analysis, such approaches have been further influenced by ethnographic models of woodland exploitation positing sequential switches to "lower value" fuel species over time as "preferred species" are over-exploited. An additional influence form traditional accounts of vegetation ecology that describe climate and/or edaphic "climax" plant associations while attributing their decline or downright absence to long-term "destructive" human impacts. This paper summarizes recent results of macro-charcoal analysis from the long-term habitation (~7,400-6200 cal BC) of Neolithic Çatalhöyük in south-central Anatolia indicating switches in fuel/timber exploitation that bring into question the assumptions of these models. Drawing on these results, alternative frameworks are explored for conceptualizing prehistoric human impacts on woodland vegetation.

Key words: *Neolithic, Central Anatolia, Çatalhöyük, human impact, charcoal analysis*

BACKGROUND

The assumption that in Southwest Asia negative human impact on woodland and forest vegetation began as early as the Neolithic period is widespread. Archaeobotanical analyses of macro-charcoals have been used to argue that Neolithic communities exerted significant impacts on the landscape through clearance for cultivation, fuel collection for domestic and craft production, and livestock herding. However, such assumptions have found little or no support in off-site pollen and sedimentary records that (where available) have provided very little evidence of significant impacts on vegetation before the mid- to late Bronze Age. Particularly for fuel selection it has been argued, for example, that it is "selective" (cf. notions of "preferred fuel species") and thus that macro-charcoal sample composition is likely to reflect cultural filters. Assumed "preferred fuel species" (e.g., dense and slow burning taxa) are thought to be eventually substituted by species with lower density and heat value, spiny or difficult to collect taxa, and/or non-wood fuels (animal dung) in response to the over-exploitation and depletion of high-valued wood fuel species (e.g., Miller, 1985). More recent research (e.g., Asouti and Austin, 2005; Dufraisse *et al*., 2007; Théry-Parisot, 2002) has questioned the expectations of such models. A key criticism relates to their implicit assumption of the separation of fuel collection from the general sphere of economic activities, and its operation primarily as "resource extraction" resulting in linearly developing negative impacts on woodland vegetation. This paper addresses these questions in the context of macro-charcoal analysis from the Neolithic site of Çatalhöyük in central Anatolia. Recent analyses have extended the chronological range of the charcoal materials analysed from this site to its latest phases, thus providing the opportunity to examine a nearly complete macro-charcoal sequence covering its entire lifespan, in order reconstruct long-term trends of fuel/timber resource management.

PRELIMINARY RESULTS

Recent excavations at Çatalhöyük have focused on the exploration of the later levels of the site, in the South Area and the summit of the mound [TP Area] where the latest phases of Neolithic habitation dating to *ca*. 6200 cal BC have been unearthed, closing the chronological gap with the Chalcolithic West mound. Another recent development has been the reworking of Mellaart's phasing of the site coupled with a new programme of radiocarbon age determinations. This has resulted in a major revision of the site's phasing and thus a more realistic appreciation of temporal and spatial variation in sample composition compared to the Mellaart's level system previously used. Figures 1-2 present in summary form the charcoal data by phase. Although charcoal counts for midden samples from the TP and South Area is work in progress, preliminary results have indicated some interesting patterns that depart from previously reported patterns (Asouti, 2005). The first observation relates to the South Area samples, which suggest that the use of juniper increased with a parallel decrease of oak during the later phases of the settlement, while they also point towards a decrease in the use of riverine taxa (Fig. 1). However, a comparison of the latest levels of the site [TP] with the earliest (aceramic) ones [South G] (Fig. 2) reveals an interesting pattern: TP and South G assemblages appear very similar, except for the higher proportions of hackberry (*Celtis*) wood in South G and the higher proportions of juniper in TP samples. The similarity has to do with the high proportions of riverine taxa (Salicaceae, *Ulmus*) in both assemblages. An important difference between the South G and TP samples relates to the apparent higher diversity of the aceramic samples (with steppe shrubs, such as Chenopodiaceae, Maloideae and higher proportions of *Celtis*) which is not evident in the TP samples (Fig. 2).

There are several potential explanations for these seemingly contradictory patterns. If South G and TP samples were omitted from the analysis, percentage fragment counts would surely suggest the progressive expansion of oak in the early part of the sequence, followed by its replacement by juniper as the main source of timber and firewood, as well as the over-exploitation of the local riverine woodland. However, such a conclusion is contradicted by the high percentages of riverine taxa in the TP samples. Similarly, the low percentages of oak and juniper in the earliest and the latest phases of Çatalhöyük might be indicative of the limited use of these species as timber and fuel during these phases. Although it is possible that a small proportion of oak and juniper charcoal might have been introduced as a result of building destruction by burning, it should also be pointed out that there is no evidence of burnt buildings predating South Area phases P-S. I have argued elsewhere (Asouti, 2005) for the regular use of old defunct structural timber and timber preparation waste as a source of fuel. These patterns are subject to further investigation (microscopic analysis of samples from the later South Area and TP phases is currently in progress). However, preliminary as they are, they point to temporal changes in sample composition that cannot be explained as the result of either climate-induced changes or progressively negative anthropogenic impact on past vegetation.

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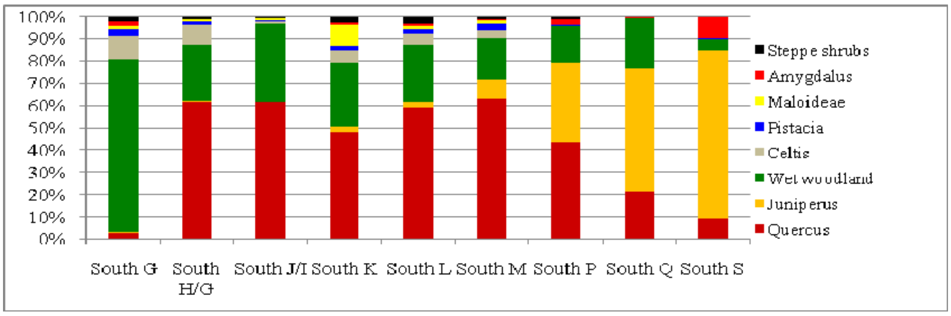

FIGURE 1. Percentage charcoal fragment counts for major taxa and groups of taxa present in Çatalhöyük external refuse deposits (middens) from South Area phases G (aceramic) to H-S (ceramic Neolithic).

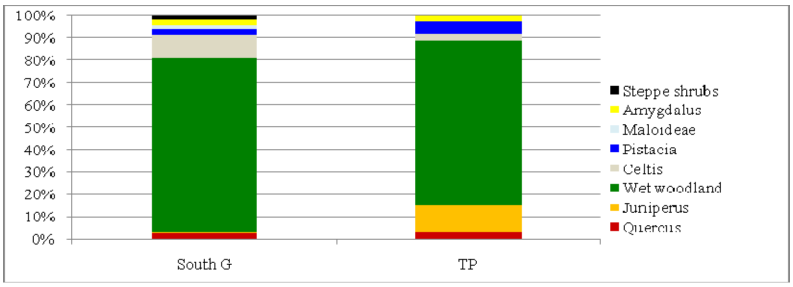

FIGURE 2. Percentage charcoal fragment counts for major taxa and groups of taxa present in Çatalhöyük external refuse deposits (middens) from South Area phase G (aceramic) and TP area (latest phase of Neolithic habitation on the east mound, ca. 6200 cal BC).

Anthracological analysis of an Early PPNB roof from Tell Qarassa North (southern Syria)

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Summary: *This work presents the results of the analysis of wood charcoal remains from a roof found in Tell Qarassa North (Early PPNB), southern Syria. The analysis was carried out in 50 burnt beams found* in situ*, as well as in 3 flotation samples from the same structure and in a flotation sample retrieved from a post hole. The taxa selected to build up the roof were* Pistacia terebinthus/palaestina*, Salicaceae and to a lesser extent* Amygdalus *sp. The structure was composed at least of a post of* Pistacia *wood which supported a structure made of branches and medium size trunks orthogonally disposed. The wood structure was covered with non-woody plant parts and adobe layers. Abundant xylophagous galleries and fungi remains identified in the charcoal remains point to a deterioration of the wooden structure previous to its burning.*

Key words: *charcoal, Near East, roof, building technology, PPNB.*

INTRODUCTION

During the Early PPNB significant changes in the building techniques were developed, among others the transformation from round to square shape houses or the stabilization of large-scale villages (e.g. Goring and Belfer, 2008, and references therein). In our study we will analyze an *in situ* burnt roof found in an Early PPNB context from the site of Tell Qarassa North and we will briefly characterize some of the building elements employed in its construction.

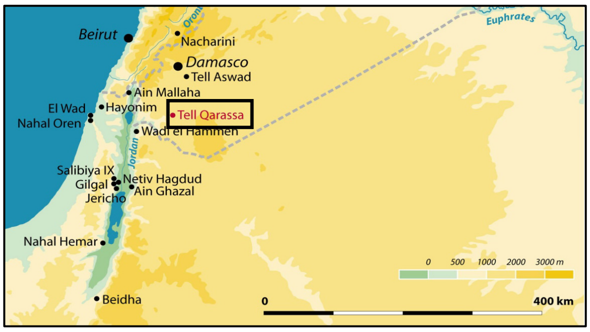

FIGURE 1. Location map of Tell Qarassa North.

Tell Qarassa North is located in the Leja basaltic plain, to the west of the Jebel el Arab mountain range, 20 km from the city of Sweida, southern Syria (Fig. 1), (Ibáñez *et al.*, 2009, Ibáñez *et al.*, 2010). Nowadays the climate in this region is arid to semi-arid, and the annual precipitation ranges from 250 mm in the north and southeast, to 530 mm in the central and upper parts. Tell Qarassa North is situated in a Mediterranean forest zone or Mediterranean island composed of a forest-like community of *Pistacia atlantica-Amygdalus korschinskii* and *Quercus calliprinos-Crataegus azarolus*. The site is formed by different spaces -up to 8- built up of basaltic stones, which can be considered as an aggregated habitat. So far, spaces 1 and 2 have been excavated. The roof here presented was found in space 1 (Fig. 2). The context has been dated to 8740-8470 cal BC, (Beta-290929, *T. monococcum* sp. charred seed).

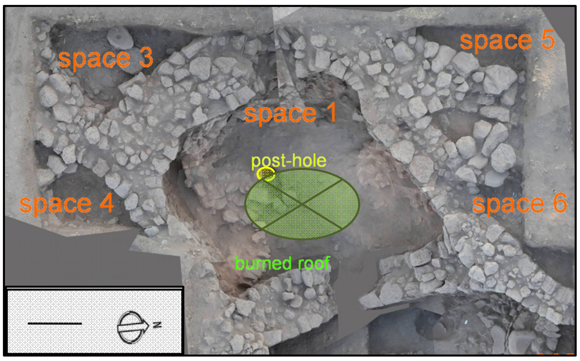

FIGURE 2. Excavation area of phase 2 of this zone, scale 1 m.

DATA AND RESULTS

The roof was sampled after identifying archaeologically each trunk or branch, taking the corresponding diameters and measuring their plunge and trend when possible. Apart from this, 3 flotation samples were taken from the burnt roof in order to assess whether other wood species had also been used. A post-hole was also sampled and processed through flotation. The wood was identified using an incident light microscope, several atlases (among others Fahn *et al.*, 1986; Schweingruber, 1990) and our own reference collection.

The identifications of the 50 beams indicate that the roof is mainly composed of *Pistacia* sp. (33 beams out of 50) which probably corresponds to *Pistacia terebinthus/palaestina* rather than *P. lentiscus* or *P.*

atlantica due to the pore distribution, growth rings and ray width and height. The second taxon best represented is Salicaceae which is present in 14 out of 50 samples. The wood probably corresponds to *Salix* sp. (willow) due to the presence of heterogeneous rays in many beams. Finally, the presence of *Amygdalus* sp. is also attested but only in 3 beams. The analyses of the 3 flotation samples retrieved from this roof suggest that no other taxa were used to build up the roof.

With respect to the size of the trunks used in the roof, different groups are clearly distinguishable: 1) small size branches (20-50 mm width), which are more than half of the elements, 27 in total; 2) medium size trunks (13 elements) which are 60-75 mm wide and; 3) few big beams of 100-140 mm width (7 in total). At least 4 branches preserve the outer bark. It is located immediately after the earlywood so spring cutting is suggested. Unfortunately this does not allow us to say when the roof was built because the wood could have been stored before it was employed in the construction of the structure. Apart from this it is interesting to point out that at least 33 beams present fungi and/or xylophagous galleries. Most of the trunks have markedly deformed and thinned cell patterns and mycelia filaments. However more work must be carried out to find out what type of alteration has been developed in each trunk and the probable reasons for it.

With regard to the post-hole sample, 100 charcoal fragments have been analyzed. 98 of them correspond to *Pistacia terebinthus/palaestina* and 2 to *Amygdalus* sp. so most probably the post was made of the former taxon. All the rings of the wood fragments present little curvature and very different ring width, but it has not been possible to assess whether they correspond to a single trunk or not in absence of more systematic ring measurements which are underway.

Concerning the adobe layer, it was found on the top of the roof structure. It includes phytoliths and abundant impressions of straw fragments which were probably intentionally cut for this purpose. It has not been possible yet to assess the cereal species to which this tempering material belonged. Apart from this, the adobe fragments also contain fungi carbonate filaments, micro faunal bones and small rounded rock fragments.

DISCUSSION

Considering the taxa identified in these analyses we suggest a selection of *Pistacia* sp. and Salicaceae to build up the roof. We find no straightforward relation between the taxa and the diameter sizes of the trunk and branches. In other words, it can be said that different size trunks were collected regardless the 3 species to which they belonged (Arranz, 2010 in press). The use of these taxa as building material is well documented ethnographically and archaeologically in different regions (Arranz, 2010 in press).

The presence of fungi and xylophagous galleries indicate an advanced state of deterioration which in fact could have led to an accidental burning of the house. However, the presence of some trunk fragments with an optimal preservation suggests that not all the structure was affected or that partial replacements might have taken place during use as it is common with thatching structures.

CONCLUSIONS

The analysis of the wood charcoal preserved in the burnt roof of the Early PPNB house Space 1 from Tell Qarassa North (Syria) gives us significant data on building techniques during this period and on the selection of plant raw materials for this purpose. In Tell Qarassa North the roof was supported at least by a post of *Pistacia terebinthus/palaestina* wood. The roof itself was composed of beams and small branches *of Pistacia terebinthus/palaestina*, Salicaceae and *Amygdalus* sp. disposed orthogonally and it was covered by straw and adobe layers. The high state of deterioration in most of the woody elements as well as in the adobe layers could have led to an intentional burning of the structure maybe within a practical cycle of renovation, rebuilding and structural repair of the dwelling.

ACKNOWLEDGEMENTS

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New samples of wood charcoal from Cabeço da Amoreira (Muge, Portugal)

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Summary: *We present data on the ongoing analysis of plant macroremains from the site of Cabeço da Amoreira, a Mesolithic settlement which integrates in the Muge shellmiddens in Portugal. Available data so far point to an extensive use of conifer wood.*

Key words: *anthracology, Muge,* Pinus*, Mesolithic, Cabeço da Amoreira.*

INTRODUCTION/BACKGROUND

Cabeço da Amoreira is a shellmidden, part of the Mesolithic complex of Muge, Santarém, in central Portugal dated to *ca*. 8000 and 7500 cal BP.

The settlement's size, its length of occupation, diversity of cultural material and presence of burials are factors that point Cabeço da Amoreira as a residential and semi-permanent site during its first phase of occupation (Bicho *et al.*, 2010, 2011). Its strategic localization, near the Tagus River, and the access to inland resources such as woods, permitted the exploitation of different and rich natural resources, as the estuary and surrounding forests.

Since the discovery of the Muge shellmiddens in 1883, Cabeço da Amoreira and other settlements were excavated by different teams. These previous studies from the 19th century till our days provided a diverse set of archeological data allowing extended studies in different areas of investigation (Ribeiro, 1884; Mendes Corrêa, 1933; Roche, 1972; Rolão *et al.*, 2006; Rocksandic, 2006; Wollstonecroft *et al.*, 2006).

With the intention of having a complete image of the settlement area of occupation, the present research team recovered various batches of sediment samples from different exposed earlier cuts in various parts of the site. From this sampling, the north profile has provided stratigraphic information, radiocarbon dates and plant/archeobotanical macroremains. The latter are presented in this study.

DATA AND RESULTS

The results presented here are from samples collected in the main area of excavation left by Jean Roche, in field work developed between 1952 and 1973. The samples were collected during the 2010 excavation season by Bicho's new team, within the project "The last hunter-gatherers in the Tagus valley - the Muge shellmiddens".

The wood charcoal comes from 22 shell and sediment layers retrieved from the stratigraphic profile. The sediment has been dry sieved with 1 mm mesh. Wood macro remains were present in most layers.

All charcoal > 2 mm (*ca*. 750 fragments) has been selected for anatomical identification at the University of the Basque Country (UPV/EHU). Present results point to a significant use of pine wood (Mediterranean pine: *Pinus* cf. *pinaster*, *Pinus* cf. *pinea*) as fuel by the inhabitants of the site. The presence of other taxa, such as *Quercus* sp. *ilex/coccifera*, *Quercus* sp. *Quercus*, is documented, but considering the total results, their percentage forms quite a minor part of the assemblage. Adjuvant results exist from earlier archeobotany studies for Cabeço da Amoreira (Wollstonecroft, 2006).

FIGURE 1. Plant of Cabeço da Amoreira showing previous and present work. The north profile is marked in the black circle (Bicho et al.*, 2010).*

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The exploitation of forest resources in mountain areas during the Neolithic in the northeast of the Iberian Peninsula

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Summary: *The aim of this work is to analyze the variability in the use of firewood in mountain areas in northeast Iberian Peninsula. The data obtained from the charcoal analyses in Cova del Sardo (4550-2500 cal. BC) is compared with other sites located in the south side of the Pyrenees and Prepyrenees. Differences in altitude and latitude explain the main differences in the consumptions of firewood: in middle and high altitudes* Pinus sylvestris-nigra *type is dominant; whereas,* Quercus *sp. deciduous and* Buxus sempevirens *are the most important taxa at low altitudes.*

Key words*: Neolithic, NE Iberian Peninsula, firewood, mountain areas.*

INTRODUCTION

The aim of this work is to analyze the variability in the use of firewood in mountain areas by the first farming communities in the context of NE Spain. Changes in the charcoal record may be a result of landscape modifications, both from climatic or antropogenic causes, or of a variation in the strategies of exploitation of the vegetal resources. Between 5500-2200 cal BC landscapes would have undergone profound transformations that affected unequally the whole country. The first farming communities developed strategies for use of resources that could have a significant impact locally. The more permanent settlements, on the one hand, and the introduction and subsequent consolidation of agro-forestry and livestock economy, on the other, have certainly had an impact on biodiversity and on the organization of the firewood collection strategies. The study of relations between these societies and their environment thus becomes a central goal to understand how resources were exploited.

The increasingly large amount of data on the harvesting of firewood in NE Iberian Peninsula shows the diversity of taxa consumed and allows analyzing trends in the use of resources. The longitudinal, latitudinal and altitudinal variables, determined the variety of wood resources in the environment. For that reason, and with similar way of life, it is expected to find recurrences in the use of taxa in similar environments. However this is not the only variable to consider, so the occupation or activity represented in the site (short or long term occupation, specialized activity, hunting or herding, domestic space, burial space) may also have an important weight in the organization of use of resources.

DATA AND RESULTS

The Cova del Sardo shelter (1800 m asl), in the Valley of Boi (Lleida), was occupied between 5500-2500 cal. BC and later in historical times (Gassiot et al., 2010). In this paper, we discuss data obtained from charcoal analysis of levels ranging between 4550 and 2500 cal. BC. The data are compared with other Neolithic sites, in cave and open air, on the south side of the Pyrenees and Prepyrenees. Data from the Bauma del Serrat del Pont, La Draga (Piqué, 2000, 2002), Balma Margineda (Leroyer and Heinz, 1992), Feixa del Moro, Cova de l'Avellana, Cova 120, Plansallosa (Ros, 1996) and La Prunera (Ferré and Piqué, 2000) permits us to discuss and contextualize the variability in the use of firewood and its causes. The data are analyzed using the criteria of recurrence (ubiquity), frequency (number of remains), and diversity (number of taxa). We analyze, also, their relationship with the longitudinal, latitudinal, altitudinal variables and the type of settlement. The results of the charcoal analysis from Cova del Sardo show differences between the three phases documented. During the earliest phase (4650-4450 cal BC), the taxa used was *Pinus sylvestris-nigra*, *Salix/Populus* and *Corylus avellana*. Between 3500-4000 cal. BC *Pinus sylvestris-nigra* remains the best represented taxon, but now followed in importance by *Juniperus* sp. This trend continues in the latest phase, dated between 2750-2500 cal BC. Moreover, some taxa are used repeatedly in all phases: *Salix/Populus*, *Prunus* and *Quercus* sp. deciduous, while occupying a discreet place in quantitative terms. Another remarkable aspect is the increase in the number of taxa from the earliest phase to the most modern. While in the earliest phase has been documented the use of a minimum of 5 taxa, between 3500-4000 this number increases to 11 and in the most recent phase (2750-2500) 8 taxa are documented.

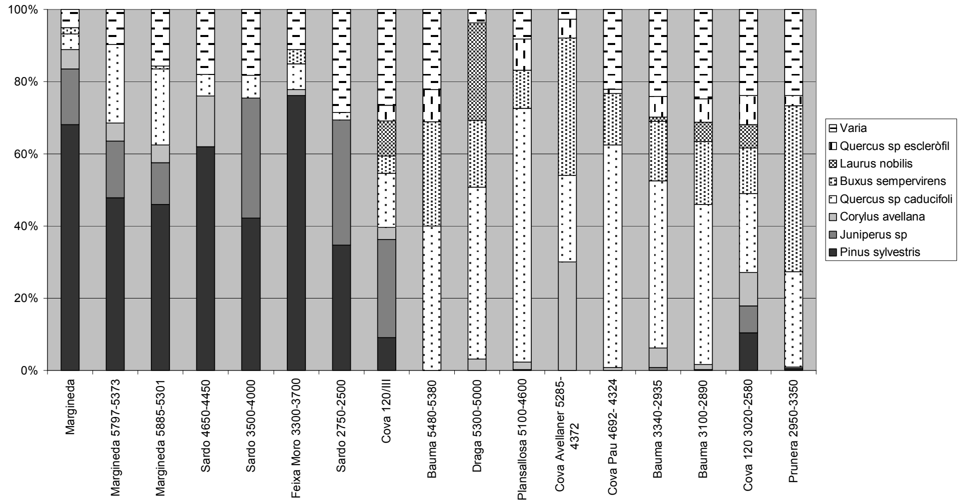

FIGURE 1. Results of charcoal analysis of Cova del Sardo in the context of sites in the South side of Pyrenees and Prepyrenees. Calibrated date BC is shown together the name of the site, from http://www.telearchaeology.com/c14/

DISCUSSION

Recurrence in the consumption of certain taxa may indicate certain continuity in regard to the catchment areas of the firewood and the species that grow there. In relation to other sites located between 970 and 1335 m asl some similarities can be documented concerning the consumption of certain species (Fig. 1). So, *Juniperus* and *Corylus* are also well represented in the early Neolithic occupations of Feixa del Moro and Balma Margineda, together with *Pinus sylvestris-nigra-uncinata typus*. The presence of *Quercus* sp. deciduous and *Abies* sp. is also documented. The results contrast, however, with those obtained for pre-Pyrenean deposits at low altitude. Thus, in La Bauma del Serrat del Pont, Cova 120, Plasallosa, La Prunera, Cova de l'Avellana, Cova d'en Pau and La Draga, all between 173 and 460 m asl, *Quercus* sp. deciduous and *Buxus sempervirens* are the best represented taxa in all phases (Fig. 1). It is also remarkable the recurring presence of *Quercus* sp. sclerophyllous, although always in small quantities. The altitude seems to be a crucial variable to explain the taxonomic distribution; without doubt reinforced by the easternmost location of these sites in relation to those of medium and high altitude, thus being more influenced by Mediterranean conditions. Altitudinal and latitudinal variables are therefore essential to understand the diversity of species represented in the sites. Conifers are most important in firewood collection strategies in middle and high altitudes, while deciduous and Mediterranean taxa are used mainly at low altitude sites.

ACKNOWLEDGEMENTS

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Neolithic landscape management at Cova de l'Or (Alicante, Spain)

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Summary: *Cova de l'Or is an important site for the Neolithic of the western Mediterranean. A complete cultural and environmental sequence for the Early and Middle Neolithic allows studying the management of forest resources since the arrival of the first farmers and until the intensification of herding activities that took place a few centuries later. Our research focuses on the analysis of wood charcoals recovered from the dung levels in trench K-34, which we compare with the available relevant data from trench J-4.*

Key words: *Neolithic, charcoal, Alicante, landscape, fodder.*

INTRODUCTION

Neolithic communities used the woodland that existed within their catchment in many different ways. Agricultural practices and herding activities required open space for fields and pastureland respectively. Moreover, since Neolithic times the relation between natural space and man-made landscapes became largely diversified due to differences in the management of forest resources that different farming practices demanded. Environmental archaeology and in part the "*5th International meeting of charcoal analysis. The charcoal as cultural and biological heritage*" aim at recording the history of those agricultural and/or pastoral landscapes that first appeared in the Neolithic.

In this paper we present new wood charcoal results from Cova de l'Or, namely from sector K where a sequence of the so-called "*niveaux bergerie*" (Beeching and Moulin, 1983) has been documented. Pollen and sedimentological analyses were carried out in trench K-34 (Martí *et al*., 1983; Fumanal, 1986; Dupré, 1988), while wood charcoal remains were analyzed from trench J-4 (Martí *et al*., 1980; Badal *et al*., 1994). We compare the two sequences aiming to evaluate the management of the woodland from the middle of the 6th to the 5th millennium BC, when intensification of pastoral activities took place and would correspond to the partially burnt dung levels presented in this paper.

THE SITE

Cova de l'Or is located on the eastern foothills of the Benicadell mountain range (38°50'40.71" N - 0°21'50.32" W) at 650 m asl (Fig. 1). Although a dissymmetry in temperature and precipitation is characteristic of the slopes of this mountain range, the southern being warmer and drier, the prevalent conditions overall are of the mesomediterranean type. The flora of the northern slopes is more humid (*Quercus faginea, Q. rotundifolia, Fraxinus ornus, Viburnum tinus,* etc.) while drought-resistant plants grow on the southern slopes (*Olea europaea* var. *sylvestris*, *Q. coccifera, Pinus halepensis, Rosmarinus officinalis, Erica multiflora,* etc.). The cave is oriented to the south and offers good conditions for habitation. Wood charcoal analysis of the archaeological deposits of trench J-4 was part of an earlier study while the materials here presented originate from trench K-34. Both trenches were located close to the cave entrance.

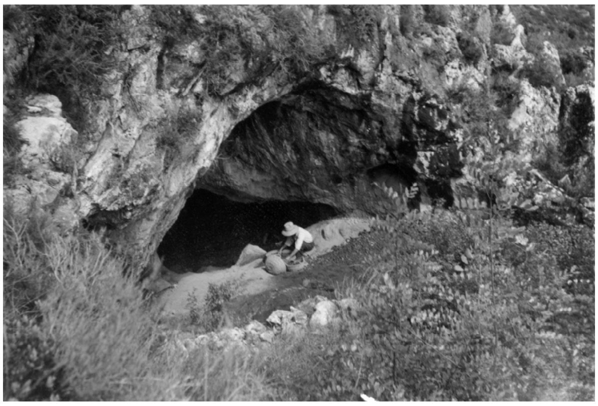

FIGURE 1. Cova de l'Or of Beniarrés (Alacant). Field work at 1955. Archive SIP

MATERIAL AND METHODS

The 2 m long sequence of trench K-34 includes 4 successive dung burnt levels within the upper 120 cm. Wood charcoal was scattered throughout the excavated deposits. We have analyzed material from layers between 260 and 320 cm depth, in which the fire levels were separated by habitation deposits. 900 wood charcoal fragments recovered from spits 15 to 10 (approximately 10 cm thick each) were processed for wood charcoal analysis. For the taxonomic identification of the specimens we used a Nikon Optiphot-100 dark/bright field incident light microscope with 50-500x magnifications, specialized plant anatomy bibliography and the reference collection of modern charred woods of the Laboratory of the Dept. of Prehistory and Archaeology, University of Valencia, Spain.

RESULTS

The wood charcoal assemblages of the 6 spits from trench K-34 comprise the same woody plants.

Differences concerning the presence of taxa are few and probably random. However, significant changes are observed in the frequency of occurrence of the taxa in consecutive layers, which may be attributed to environmental change or to human activities. In the two lowermost spits (levels 15 and 14) the percentages of evergreen and deciduous oak and riverside taxa account for more than 50% of the carbonized remains. Thermophilous flora is represented by *Olea europaea* (30%). *Pinus halepensis* and matorral plants are scarce (Fig. 2).

The archaeological finds and the radiocarbon dates place the beginning of these fire levels to the epicardial pottery phase, during the last centuries of the 6th millennium BC, and they provide evidence for a mixed economy (agriculture and herding). The results of wood charcoal analysis suggest the management and use of oaks. Mean annual temperatures of 13-17 ºC and a precipitation regime of the sub-humid type (mean annual 500-800 mm) would have prevailed.

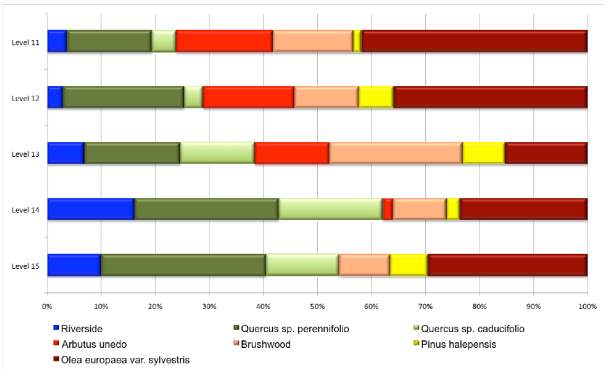

FIGURE 2. Synthetic charcoal analysis diagram of K-34 from Cova de l'Or.

From level 13 and up to level 10 *Arbutus unedo*, *Olea* and the *matorral* plants increase significantly while those taxa that require more humid conditions (riverside and *Quercus*) decrease. *Pinus halepensis* remains stable. The change observed in these assemblages is associated to the two lowermost dung levels in trench K-34 that date to the 5th millennium BC and may have been the result of a change in the management of the woodland oriented now towards stockbreeding.

High frequency of *Olea* wood charcoal is reported from other caves in the area where livestock levels have been identified (Badal 1999) and it has been interpreted as the result of the provisioning of leaf and branch fodder; in the sclerophyllous forest *Olea* is the most appropriate species for feeding livestock. In more humid regions relevant evidence from various sites documents the use of ash and other deciduous species for animal fodder (Carrión, 2002; Thiébault, 2005; Delhon *et al*., 2008).

In the southern part of the Valencian territory during the course of the Neolithic and in particular during the Middle and Final Neolithic, a tendency is observed towards the specialization of the productive activities. Certain areas become pastoral, especially the foothills of mountain ranges where most caves are located, while settlements established in low-land valleys are multi-purpose or clearly agricultural. Such evidence is available from the valleys of the Serpis and Albaida Rivers that delimit to the south and north the mountain range where Cova de l'Or is located. The important presence of trees managed for fodder, as it is the case of the oleaster, provides evidence for the pastoral practices in the caves of the Alicante region.

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Vegetation and firewood uses in the western Catalan plain from Neolithic to the Middle Age

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Summary: *In this study is presented the synthesis of the results of the anthracological analysis in the western Catalan plain from the Neolithic to the Middle Ages. The data is evaluated in order to provide a preliminary approximation on the development of vegetation and forest exploitation.*

Key words: *western Catalan plain, forest exploitation, vegetation, synthesis, human activity.*

INTRODUCTION

The western Catalan plain is located in NE Iberian Peninsula. This plain has been a densely populated territory since prehistoric times. The exploitation of forest resources in recent millennia has meant an important modification of vegetation and landscape. To characterize this exploitation since the beginning of agricultural production is of much importance to infer the relationship of the people who inhabited the plain with their environment.

The forest history is the result of environmental variables but also the interaction between people and their environment. The main objective in this study is to assess the evolution of the western plain's forests, in relation to human societies.

DATA AND RESULTS

Charcoal studies from the area, which have a long tradition, started in 1988. To date, materials from 18 archaeological sites (Fig. 1) of various periods and regions have been analyzed (Ros, 1994-1996, 1995a, 1995b; Piqué, 1998; Martín-Seijo and Piqué, 2008). However, such studies did not follow a predetermined order within the framework of a specific project.

The reason of this study is the lack of a synthesis that encompasses all these anthracological results and offers the evolution of the landscape in the plain from Neolithic until the Middle Ages. The data from all these previous studies were collected (Vila, 2010). This is a considerable volume of remains, with a total of 13,893 charcoal fragments from 455 samples. In order to make a regional synthesis from anthracological data and interpret the results in a palaeoenvironmental sense, there are several problems. One should keep in mind that the social activity that has generated the charcoals and the postdepositional processes have been specific to each site and may be the cause of the observed variability, especially in quantitative terms (Piqué, 1998: 7). On the other hand, the differences in the size of the analyzed samples for each site and the methods of recovery of the remains may have also influenced the results. If this aspect is kept in mind when developing their interpretation, it may offer some surprising results.

The data processing focuses, on the one hand, in the analysis of diversity (number of consumed taxa), the analysis of ubiquity (recurrence of use from the number of stratigraphic units in which the use of a taxon is documented) and the analysis of intensity of uses (from the number of remains, or frequencies per taxon). On the other hand, the continuity and the change in the most representative taxa are evaluated. We consider as representative taxa those which have provided more than one hundred pieces of charcoal. The objective is to determine the woods with economical value for each period and evaluate the causes of the differences observed throughout time. With the obtained results, we can see that the forest landscape of the Western Catalan plain from the Neolithic to the Middle Age presents a shifting panorama, always directly related to its social management.

With the adoption of agriculture, from the Neolithic/Chalcolithic periods, increasingly effective tools (stone axes, adzes, etc.) are made that allow more sophisticated logging activities. Due to the lack of data from previous periods we cannot affirm that those performances affected the vegetation cover. Still, we can document the most important taxa in the economic sphere. The best represented taxa and the ones that show a higher ubiquity are deciduous *Quercus* (oak) and evergreen *Quercus* (holm oak). Both are clear temperate climate indicators.

In the following period (Middle Bronze Age, 2700-1650 cal BC), with the emergence of large and scattered villages, we can see a different landscape use. The dominant species are now two kinds of trees, *Pinus halepensis* (white pine), evergreen *Quercus* (holm oak), and two shrubs, *Pistacia lentiscus* (mastic tree) and *Arbutus unedo* (strawberry tree). In this case, those tree and shrub species are the evidence of a dry climate. One should also keep in mind that the appearance of shrubs is an indicator of deforestation. However, the shrubs are important in the maquis formations, which occupy part of the Mediterranean coastal lowlands and the interior today.

These people from the Middle Bronze Age constitute the elementary substrate on which, in the middle of the second millennium BC, an emergence of new cultural, economic, and social attitudes takes place that will characterize the Segre-Cinca-Group (GSC) (1650-1250 to 1000-800/750 cal BC). In the three substrates that form GSC: GSC I (1650-1250 cal BC), GSC II (1250-1000 cal BC) and GSC III (1000-800/750 cal BC) (Alonso *et al*., 1999), a change in the use of resources can be observed. While in the GSC I the predominant taxa are resistant to dry climate (*Pinus halepensis, Pistacia lentiscus, Rosmarinus officinalis*), in the GSC II *Pinus halepensis* stands out above all the species. On the opposite, in the GSC III we can observe the predominance of a shrub, *Pistacia lentiscus*, followed by evergreen *Quercus*, *Pinus halepensis* and *Rosmarinus officinalis*. The population growth and its effect in relation to a possible deforestation could be the cause of these changes.

During the early Iron Age we can see an increase of the consumption of evergreen *Quercus* and deciduous *Quercus*. This change in the consumed taxa may relate to the existence of a more temperate climate. The increasing importance of other low shrubs of dry weather is also attested. This shift has been suggested by Gutiérrez and Peña (1992: 119), who state that at this time there is a trend towards a cooler and wetter climate, and assumes a progressive increase in the percentage of vegetation cover. Notwithstanding this, the data do not allow a clear verification of this change, mainly because of the scarcity of available data. We must not overlook other issues that could affect the final results, such as a possible change in the catchment areas due to fuel resources extinction in the areas that were closer to the settlements.

In the Iberian era the use of woods of higher quality such as evergreen oak and deciduous *Quercus* is attested again. But with the Romanization a radical change takes place, suddenly using a wide range of taxa. This is caused by the large deforestation that occurred everywhere during the Roman occupation, which probably meant a still greater enlargement of the catchment area of forest resources. The most notable event of the Middle Ages is the large increase in the number of taxa, possibly because of the lack of wood of the best quality in the surroundings of the settlements. Improved means of transport would allow a greater movement of wood.

The plant landscape evolution of the Western Catalan plain and its uses display the Mediterranean character of most of the preferentially used taxa throughout the history in this area. The increasingly intensive exploitation of the forest shows a clear deforestation, a fact that forced the societies of the time to look for wood in more distant areas, to collect increasingly larger numbers of tree and shrub species, and economize their use.

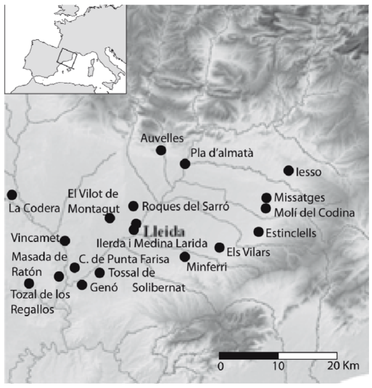

FIGURE 1. Map of the northeast of the Iberian Peninsula. Location of the 18 archaeological sites under study.

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Charcoals from a prehistoric fire-set pit in the Austrian Alps - dendro-dates, wood demand and forest utilization

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Summary: *Fire-setting was the most important technique in prehistoric times to exploit ore deposits. Remains of these workings found in a small pit in the mining area of Schwaz/Brixlegg (Tyrol, Austria) enable dendrological and dendrochronological investigations. With the results obtained even issues as wood demand and forest utilization can be addressed. This work will be continued to refine the knowledge on the history of mining in the Alpine Region, particularly for prehistoric times.*

Key words: *dendrochronology, copper-mining, wood utilization, Iron Age, Austria*

INTRODUCTION

The huge number of pits located in the mining area of Schwaz/Brixlegg indicates ore deposits, which already were exploited in prehistoric time (Goldenberg and Rieser, 2004). One of these small pits called MaukE (47°26'14'' N, 11°57'12'' E; 997 m asl) was explored in the 1990s for the first time by Gert Goldenberg and again more closely between 2007 and 2010 (Figs. 1 and 2). The pit is located at a steep slope and extends about 25 m into the dolomite rock. Copper ore was exploited in the pit MaukE in prehistory. Large quantities of charcoal were recovered from different positions within the pit. Radiocarbon results suggest ages at the transition from Late Bronze Age (LBA) to Early Iron Age (EIA).

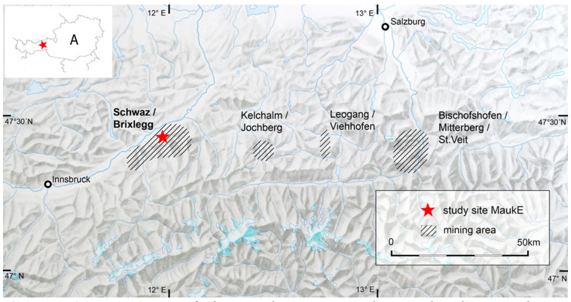

FIGURE 1. Location of the study site MaukE and other prehistoric mining areas within the mining region Schwaz/Brixlegg. (map basis: Alpen Reliefkarte - Tirol Atlas).

MATERIALS AND METHODS

Out of the assemblage of charcoals (completely charred) and - in rare cases - charred wood (partly charred) of different size tree-ring width (TRW) measurements were carried out on 240 samples so far. We determined the tree species, extrapolated the pith age for samples without preserved pith to give details on the size of the utilized timber and documented whether the samples originate from a log or branch. Based on several radii measured per artefact, average ring-width series of each object were established. Reference chronologies of the tree species fir (*Abies alba*), Norway spruce (*Picea abies*) or stone pine (*Pinus cembra*) samples were available for dendrochronological dating. AMS-Radiocarbon dating (at the Vienna Environmental Research Accelerator laboratory -VERA- Institute for Isotope Research and Nuclear Physics of the University of Vienna) was used for a first estimation of the time range of the MaukE charcoal samples.

FIGURE 2. The "great hall" of the pit MaukE. The dashed line marks the level of already removed deposits which belong to modern mining activities (photo: G. Goldenberg, 2008).

Within the interdisciplinary research project *HiMAT* (*The History of Mining Activities in the Tyrol and adjacent areas - Impact on Environment and Human Societies*) one partner (surveying and geoinformation) provides 3D data of the pit MaukE. Based on this information we can approximately estimate the volume of the mined ore. Moreover, numerous fire-setting experiments (e.g. Py, 2004) help us to estimate the amount of wood needed to exploit a certain amount of rocks by applying fire-setting as mining technique. The results of these experiments show that an ore/wood ratio 1:1 (simplified) can be assumed. Due to the rough estimate of timber used in the pit MaukE we assessed the impact of mining on the local forests.

RESULTS AND DISCUSSIONS

The results of the dendrochronologically analysed charcoal samples indicate that usually only softwood was used in the EIA fire-set pit MaukE: 88% of the samples were spruce, 10.4% were fir, 0.4% larch (*Larix decidua*), 0.8% were spruce or larch and 0.4% were alder (*Alnus* spp.). Other species have not been documented so far. The fact that pieces of hardwood were not observed cannot be attributed to a lack of such species in the vicinity of the pit: dendrochronological analyses on wooden remains from the prehistoric ore processing site Schwarzenberg Moos confirm a variety of species growing in the surrounding area of the fire-set pit MaukE (Nicolussi *et al*., 2009). Therefore, wood procurement can be assumed. Only two pieces were classifiable as part of twigs or branches. Even if we consider that small-sized branches were totally burned and therefore not preserved the results suggest that fuel wood was mainly processed from stem wood.

The tree-ring series established vary between 6 and 138 values. The median value (m=35.0) indicates that most of the examined charcoal samples show short tree-ring series. While comparing the established tree-ring series with each other we often detected high similarities regarding both growth level and year-to-year variability among each other. Based on these dendro-typological features we combined tree-ring series of 110 samples to 12 different groups - called *trees*. For these *trees* we estimated the diameters by applying the pith offset data established for the charcoals. The results suggest that the prehistoric miners processed timber between *ca*. 15 and 30 cm in diameter. All in all tree-ring series of 133 samples were cross-dated so far to a 149-year long local chronology. The last measured tree ring marks the year 707 BC. The best match (*overlap* = 105, *Gleichläufigkeit* 69%, t-values: t_{BP}, 8.4, t_H, 10.4) was obtained by comparison with the reference chronology from Villingen-Magdalenenberg, Southern Germany, which is based on fir samples (Billamboz and Neyses, 1999). The radiocarbon results prove the dendrochronological dating: because of the known distance between two ^{14}C-samples wiggle matching was possible: e.g. sample VERA 4870 (9 tree rings): single calibration (2σ): 760–410 BC; wiggle matching calibration (2σ): 765-685 BC; dendrochronological date of the ^{14}C-sample: 716-708 BC.

Due to the burning process the waney edges (the last-formed tree ring before felling, sampling, or death of the cambium) of the trees utilized as fuel wood were usually not preserved. However, we were able to identify a waney edge at one charcoal indicating a felling date in 708 BC. Interestingly the last measured tree ring of 16 series from different layers range between 707 and 712 BC. This implies that the fire-setting activities in the pit MaukE lasted only relatively few years and that the felling dates of the trees are close to 710 BC. Taking the stratigraphy of the dated samples at the different excavated positions into account we presume a single-phase exploitation of the pit MaukE. However, at the current state of the investigations it is not possible to decide if the pits in the surrounding of MaukE are from the same time period (late 8th century BC) or how long the copper-ore exploitations lasted all in all at that location.

The analyses of the charcoals also allow assessing the possible impact on the local forest. Considering some assumptions (e.g. seasonal workings in the pit MaukE over several years by few miners, specific gravity of the exploited ore, the ratio between rock exploited and fuel wood) it can be inferred that impact was limited. The prehistoric miners were able to cover the wood demand from the local forests which were utilized at a small scale (preliminary assumption). This assumption is supported by the observation that only few charcoals and with that *trees* show clearing effects. Moreover, the effects observed must not be related to the activities but could be a result of natural events (e.g. windbreaks). Additionally, the dominance of samples with relatively small tree rings indicate the utilization of naturally grown (closed) forests by the prehistoric miners.

CONCLUSIONS

All in all the dendrochronological results presented provide a deeper insight into a fire-set pit in the prehistoric mining area of Schwaz/Brixlegg. It can be stated: i) selective wood procurement (only softwood und mainly stem wood) was typical; ii) tree-ring data provide an accurate dating of the mining activities in the pit MaukE in the late 8th century BC (around 710 BC); iii) tree-ring width analyses imply a small scaled wood utilization of usually closed forests.

ACKNOWLEDGEMENTS

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The charcoal and wood remains and the settlement activity of the Zedmar culture population at Szczepanki site 8 (NE Poland)

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Summary: *The taxonomical identification of the charcoal and wood particles, discovered on site no. 8 at Szczepanki as well as pollen studies were conducted. The studied peat-bog archaeological site was occupied from the Late Palaeolithic until the Late Neolithic but most intensively in the time of the para-Neolithic Zedmar culture. The analysis proved the strong dependence of the number of charcoal and wood fragments on the settlement intensity, confirmed by the archaeological data. On site 12 different taxa of tree and shrub remains were registered. Among them alder was the most frequently identified* taxon. *In the time of the Zedmar culture, an essential growth of the taxonomic diversity of charcoal and wood particles was noted. Frequencies of oak and ash particularly increased that suggests the stronger exploitation of trees with a durable wood.*

Key words: *peat-bog archaeological site, charcoal and wood analysis, pollen analysis, Mesolithic, Zedmar culture, NE Poland*

INTRODUCTION

The site Szczepanki 8 in NE Poland is one of a few excavated archaeological sites of the para-Neolithic Zedmar culture in Europe. The Zedmar culture, chronologically simultaneous with the classic European Neolithic, with the economy based on foraging, was the first society producing pottery in the Great Mazurian Lake District area (Gumiński, 2003).

The site is located on the vast peat-bog covering a surface of *ca*. 25 km² and formed as an effect of terrestrialization of the former Lake Staświńskie. On one of the former islands the archaeological relicts were discovered (Fig. 1). Archaeological investigations showed that local occupation was initiated at the decline of the Palaeolithic and lasted till the end of the Neolithic period, whereas the most intensive was between *ca*. 5700 and 4000 ^{14}C BP, when the camp-site of the Zedmar culture existed.

Numerous archaeological artifacts as well as organic remains such as: wood and charcoal fragments, seeds and fruits, pollen grains, animal and human bones were found preserved in the undisturbed layers of the lake/peat-bog origin. This enabled to reconstruct changes of local vegetation in direct connection to settlement history.

DATA AND RESULTS

Samples for palaeobotanical analysis were collected during the archaeological excavations from the uncovered cultural layers. Parallel anthracological, xylological, palynological and carpological investigations were conducted. The deposition of the studied sediments (profile 31E10S-31EO) lasted from *ca*. 10200 ^{14}C BP (the Late Palaeolithic) until *ca*. 3000 ^{14}C BP (beginning of the Bronze Age).

The remains of 12 taxa of trees and shrubs were determined: *Acer* sp. (maple), *Alnus* sp. (alder), *Betula* sp. (birch), *Corylus avellana* L. (hazel), *Fraxinus excelsior* L. (ash), *Picea/Larix* (spruce/larch), *Pinus sylvestris* L. (common pine), *Populus* sp. (poplar), *Quercus* sp. (oak), *Salix* sp. (willow), *Tilia* sp. (lime), *Ulmus* sp. (elm) (Fig. 2).

Both charred and uncharred material revealed the similar taxonomical composition and similar number of fragments of individual taxa. The most numerous were alder, oak, and hazel remains. In the fraction of burnt pieces also ash, pine and elm were registered in higher numbers. The total number of lime, birch and maple fragments ranged from 1 to 3%, while the other taxa were represented by values below 1%. Among the uncharred wood fragments a considerable number of small twigs of deciduous trees, bark as well as thin scraps of wood were found.

DISCUSSION

The oldest part of the profile was deposited in the Palaeolithic time, when the island was seldom visited by humans. From that period no traces of burnt material were found. Among the uncharred wood remains only single alder and birch fragments were identified. Early presence of *Alnus* wood is a very interesting phenomenon in the context of palynological data suggesting its local occurrence from the Boreal period (*ca*. 8700 ^{14}C BP). In the Mesolithic period, when the settlement became more intensive though still periodical, the content of charcoal and wood particles gradually increased. Apart from alder (still predominant in the number of fragments) also hazel, pine, and elm appeared. From the beginning of the Neolithic, simultaneously with the initiation of the permanent settlement on the island by the Zedmar society, sharp increase of the burnt remains was noted. In the studied

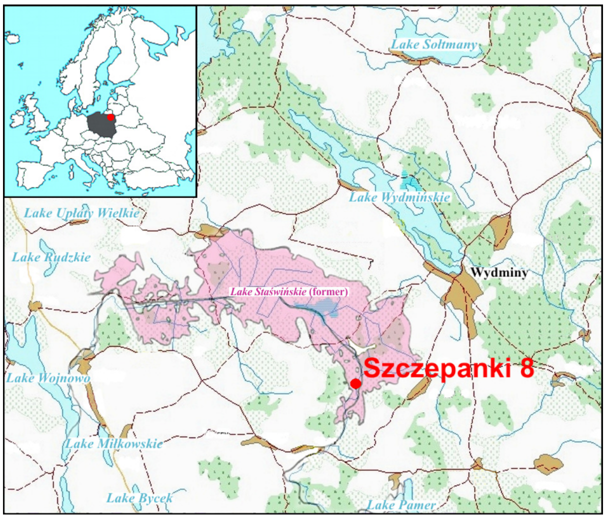

FIGURE 1. Location of Szczepanki 8 site, north-eastern Poland.

samples oak, ash, lime, willow, poplar and maple appeared more frequently and numerously.

The mentioned taxa could grow on the island, but more abundantly they occurred on the nearby lakeshore, from where wood could be easily transported to the island. In that time strong increase of oak charcoals occurred. New trees, particularly oak and ash, could have been important for humans in the context of a yearlong exploitation of the island. Features of their wood could become more esteemed with respect to its use as building material. In the Neolithic the greatest concentrations of uncharred small twigs of deciduous trees (mainly of alder and hazel) and bark pieces were found. This can suggest a whittling or barking of hazel and alder branches. Both taxa provide a light and resilient wood which was probably used for production of spears for fishing and hunting.

The transformation of the lake into marshes (*ca*. 3500-3000 ^{14}C BP) made access to the open water (important source of food) difficult and caused the decrease of settlement intensity on the island. In the Late Neolithic deposits charcoals almost disappeared and the number of wood fragments decreased.

CONCLUSIONS

The increased intensity of the island occupation in the time of the Zedmar culture corresponds to the enlarged accumulation of charcoal and wood fragments in the sediments. Before as well as after this period the representation of charcoal and wood remains was visibly smaller. Palaeobotanical data are in agreement with the information provided by archaeological studies concerning human impact on local environment.

ACKNOWLEDGMENTS

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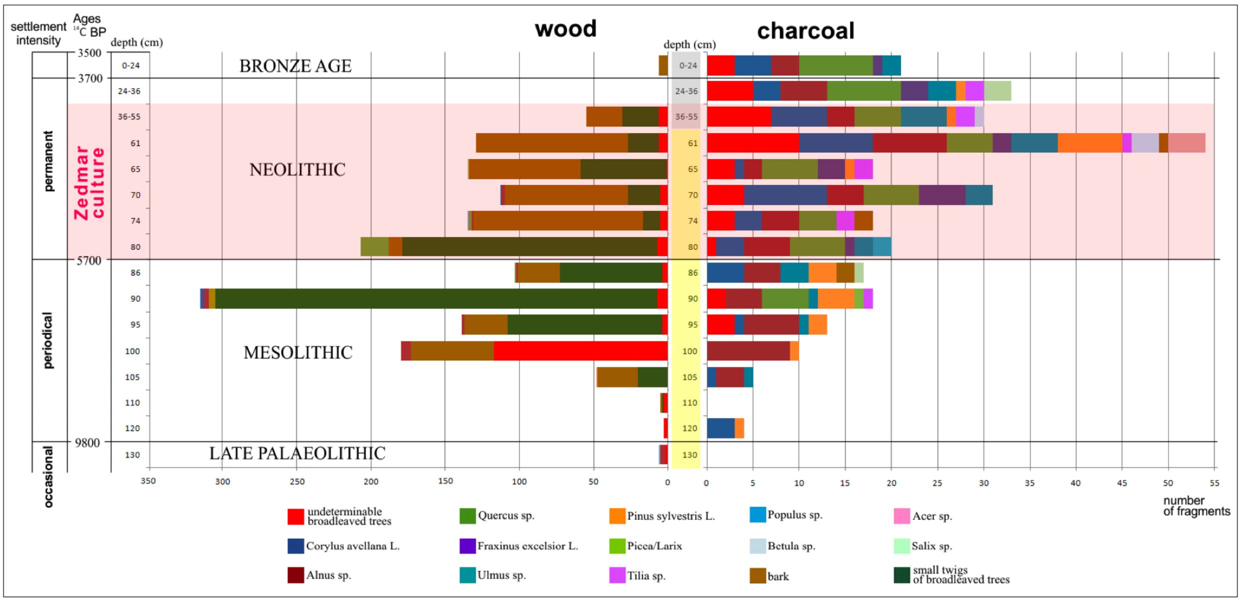

FIGURE 2. Szczepanki 8. Taxonomical composition of charcoal and wood fragments in the profile 31E10S-31EO.

Long term vegetation changes in the Bilina River region, Czech Republic

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Summary: *The Bilina River region has been continuously inhabited since the Palaeolithic. The present study reconstructs the effects of a long term settlement on vegetation in the Bilina River region by means of pollen and anthracological analyses with respect to archaeological data. The anthracological analysis has provided a better potential for recording human induced shifts in contrast to pollen analysis which reflects rather better general trends in plant succession in the region.*

Key words: *anthracology, pollen analysis, Bilina River region, vegetation changes, human impact*

INTRODUCTION/BACKGROUND

The history of human induced changes in the environment is as old as the history of mankind. The Bilina River region including the large (max. extent *ca*. 25 km^2) Komořanské Lake has been continuously inhabited since the Palaeolithic. The study here presented focuses on the environmental changes during the Neolithic to the Medieval period (resp. Atlantic-Subatlantic interval, *ca*. 7000 – 600 BP).

The principal aim is to reconstruct the effects of long term settlement on the vegetation in the study region by the means of pollen and anthracological analyses with respect to archaeological data.

DATA AND RESULTS

The number of archaeological sites was derived using information from the Czech Archaeological Database (Kuna and Křivánková, 2009).

Pollen analyses

In the Atlantic period *Quercus* sp., *Ulmus* sp., *Tilia* sp. and *Fraxinus excelsior* dominated in the vicinity of the lake. *Fagus sylvatica* became one of the steady forest components in the region in the end of the period. The fast entry of *Abies alba* into the region was typical for the Subboreal period (SB). The originally widespread mixed oak forest was gradually replaced by *Picea abies*, *Abies alba* and *Fagus sylvatica*. However, an expansion of *Picea abies* was limited by the better adapted to the local conditions *Picea abies* and *Abies alba*. *Carpinus betulus* appeared in insignificant amounts in this period. A continuous human activity since the SB is evidenced by uninterrupted pollen curves of cereals and other synanthropic plants.

During the Early Subatlantic, vegetation cover was deeply affected by anthropogenic activity. A sudden decrease was noted for *Abies alba*, *Fagus sylvatica*, *Picea abies*, *Quercus* sp. and other woody forest species. Increase of cereals and other synanthropic pollen was recorded.

Fir, spruce and beech were abundant in surrounding forests in the Late Subatlantic along with very common *Carpinus betulus* appearing in the piedmont zones and alder colonizing the swampy periphery of Komořanské Lake.

Anthracological analysis

Anthracological analysis was focused on eight archaeological localities in the study region located at 180-270 m asl. Samples were dated to the Neolithic, Bronze Age, La Tene, Roman and Medieval periods.

Neolithic localities are typical with the presence of *Quercus* sp., *Acer* sp., *Tilia* sp., *Ulmus* and *Fraxinus* excelsior (*Quercetum mixtum*). Samples dated to the Bronze Age are distinctive by the strong dominance of *Quercus* sp. with *Pinus sylvestris*, *Fagus sylvatica*, *Carpinus betulus* and *Corylus avellana* also commonly preserved. La Tene samples are similar to the Bronze Age ones, although *Abies alba*, *Acer* sp., *Ulmus* sp., *Alnus* sp., *Salix/Populus* sp., *Tilia* sp., *Betula* sp. and *Picea abies* reach higher percentages. *Prunus* sp., Rosaceae, Pomoideae and *Cornus* sp. are rarely found.

Oak remains are dominant during the Roman period; however, *Fagus sylvatica*, *Pinus sylvestris*, *Carpinus betulus*, *Abies alba*, *Populus/Salix* and *Corylus avellana* are widespread too. *Fraxinus excelsior*, *Acer* sp., *Alnus* sp., Pomoideae, *Ulmus* sp., *Tilia* sp., *Betula* sp., *Picea abies*, *Juniperus* sp. decline in the corresponding samples. Early Medieval forest can be characterized as a bright oak-hornbeam forest with lower amounts of *Tilia* sp., *Ulmus* sp., *Cornus* sp., *Prunus* sp. and *Frangula alnus*. Higher abundance of *Abies alba*, *Carpinus betulus*, *Fagus sylvatica*, *Betula* sp. distinguish the samples from earlier periods.

Oak and beech prevailed in the High Medieval samples. A large amount of fir, birch, spruce, alder, and poplar/willow was also found.

DISCUSSION

Our study documents evident differences between results of pollen and anthracological analyses. Palynological results are heavily influenced by the origin of a sediment profile gathered from the large lake. Such samples necessarily combine pollen from the extensive and fuzzy spatial scale. In contrast, anthracological analysis shows only the vegetation changes in the vicinity of archaeological sites, deeply influenced by human activities.

Neolithic charcoal assemblages significantly differ from other samples. The species composition occurring in the Bronze Age remains more or less similar until the High Medieval Ages. Oak remains the dominant species with slight fluctuations in abundance over time affecting the abundances of light-demanding trees. Early Medieval samples have similar character as prehistoric samples, but fir, hornbeam, birch and beech reach higher abundances. A significant change was detected in the High Medieval samples, which were influenced by importing timber from the forests at higher altitude. On the contrary, pollen analysis reflects abrupt species succession without any remarkable record of an anthropogenic impact.

CONCLUSION

Analysis of large assemblages of charcoals provides valuable data for the reconstruction of vegetation changes. It provided better potential for recording human induced shifts in contrast to pollen analysis, which reflects rather better general trends in plant succession in the region. This implies the necessity of combining various methods to document an authentic picture of vegetation cover in the past since each single approach tends to overestimate or down weight some studied aspect.

First anthracological results from Rhine's plain and comparison with other palaeo-environmental data

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Summary: *Rescue excavations on the high-speed railway of the "LGV-est" between Baudrecourt and Strasbourg have initiated palaeo-environmental studies in Kochesberg region (Bas-Rhin, Alsace). The results of charcoal analyses from three sites are presented here: Ingenheim* Hungerberg*, dating to the recent Neolithic (4000-3600 BC), Mittelhausen* Langmatt*, dating to the Hallstatt D (6th century BC) and Mittelhausen* Vorderen Berg*, dating to the late Iron Age (5th century BC). All sites are located in a perimeter of ten kilometres around the* Vierbruchgraben *valley bottom. These analyses allow for the first time, a proposal of woodland evolution in this micro-region. During the Neolithic period, the forest environment was rather closed while it was much more open during the Iron Age. These results are consistent with the pollen and plant macro-fossils analyses from an "off-site" core taken close to the investigated sites. They indicate a moderate influence of Man during the Neolithic period and an increasing deforestation starting with the Iron Age. Anthropogenic indicators show a strong agricultural influence with wet meadow vegetation on the valley bottom, probably influenced by livestock grazing.*

Key words: *eastern France, charcoal analysis, plant-macro-fossil analysis, pollen analysis, Rhine valley.*

INTRODUCTION/BACKGROUND

In the context of this conference, we present here the preliminary anthracological results for the Rhine valley. Archaeobotanical studies are very scarce in this region. Rescue excavations preceding the construction of a high-speed railway line, which link together Baudrecourt (Lorraine) and Strasbourg (Alsace), have allowed the analysis of charcoal and plant macro-fossils. Archaeobotanical data from three archaeological sites provided the opportunity to discuss preliminary results of charcoal analysis and to compare it to other palaeo-ecological data. The following sites were investigated: Ingenheim *Hungerberg*, attributed to the Michelsberg culture (4000-3600 BC), Mittelhausen *Langmatt*, dating to the Hallstatt D period (6th century BC) and Mittelhausen *Vorderen Berg*, dating to the beginning of the late Iron Age (La Tène A2/B1, 5th century BC). They are all located in a perimeter of ten kilometres around the valley bottom of the *Vierbruchgraben* in the Kochersberg region.

The interest of these studies is assembling results from different sites located close to each other and establishing the environmental evolution of woodland from the Neolithic period to the Iron Age. These data will be compared to palynological and carpological studies from an "off-site" core located close to the investigated sites.

GEOGRAPHIC SITUATION

The Kochersberg region is located west of Strasbourg between the foothills of the Vosges and Rhine valley (Department of Bas-Rhin). The fertile, loamy and not completely decarbonised soils on loess attracted early human settlements. Deforestation was intense and at present, there are only a few scattered woodlands of oak-hornbeam forest type and some woody riverside vegetation.

DATA AND RESULTS

The following data was obtained from similar contexts: mainly from pits used for domestic waste disposals. Only dispersed charcoals particularly rich in taxa (Chabal, 1997) deriving from the fill of pits have been used in this study. The similarity between the proportions of recorded taxa with present forest formations allow for a reconstruction of the past forest environments exploited around the sites.

The excavation of Ingenheim was directed by Christophe Croutsch, PAIR (Pôle d'Archéologie Interdépartemental rhénan) in 2009. Seven pits were studied from the recent Neolithic (4000-3600 BC). By determining 1437 charcoal fragments, 14 taxa were identified. The proportions of oak reach and sometimes exceed 80% while heliophilous species located at the edge of the valley are much less visible. The charcoal spectra present an image of a closed forest environment.

The excavation of Mittelhausen *Langmatt* was directed by Yohann Thomas, Inrap (Institut national de recherches archéologiques préventives) in 2010. One investigated pit was dated to the Hallstatt D period. A dozen taxa have been identified represented by 213 charcoal fragments. Heliophilous taxa dominate with over 50%. Forest taxa total 44%, while the riverine taxa do not exceed 2%. The predominant presence of heliophilous species in the charcoal spectra suggests an image of an open environment. The site is situated in the valley bottom but the riparian forest taxa are not well reflected in the charcoal spectra.

The excavation of Mittelhausen *Vorderen Berg* was directed by Yohann Thomas in 2009. Five pits of the early La Tène period (La Tène A2/B1) were studied. At least 14 taxa have been identified from 579 charcoal fragments. The forest species are well represented while the heliophilous species are present not more than 5% of the sample. The represented taxa could indicate a rather closed environment. The changing proportions of taxa between different pits probably reflect the diversity of forest types. The presence of riverine taxa could indicate the site proximity to a wetland where firewood could be collected.

The results of these three sites were grouped in the diagram (Fig. 1).

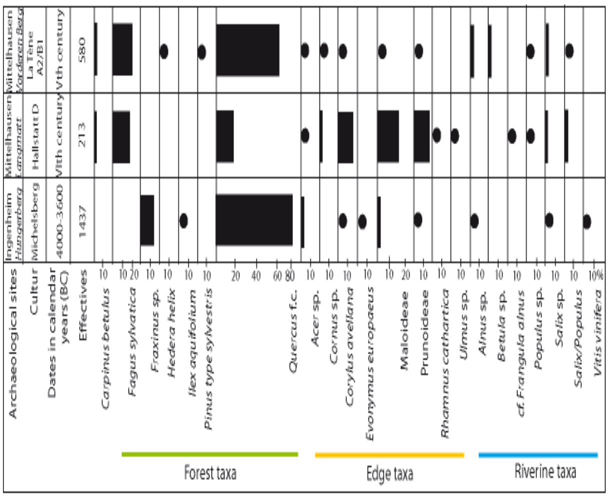

FIGURE 1. Anthracological diagram of the LGV-est sites

DISCUSSIONS AND COMPARISONS WITH PALEO-ENVIRONMENTAL DATA

The results from pollen and plant macro-fossil analyses from a core collected "off-site" in the valley bottom of the *Vierbruchgraben* (Table 1) (Ertlen and Schneider, 2010) allow for a comparison with the charcoal analysis. These indicate only a partially opened environment during the Neolithic period when human impact was less intense. From the Iron Age onwards, we can observe a strong agricultural influence reflecting increasing deforestation and land-use. Plant macro-fossils are indicating that the valley bottom was occupied by meadows, probably used for pasture (Wiethold, 2010). Such presence of a semi-open environment could explain the poverty of riparian taxa at Mittelhausen *Langmatt*.

The anthracological results from Mittelhausen *Vorderen Berg* show a significant increase in forest taxa. The hypothesis of a forest return is not supported by palynology and sedimentology results. In the context of an open environment, the increase of oak could be explained by the exploitation of stump shoots, coppicing. The spectra of the La Tène A2/B1 site could then reflect changes in the methods of supplying firewood.

	Floodplain vegetation	Regional Végétation	Erosion	Archaeological remains	14C age
S6	No data	No data	severe erosion	High density of villages	
					688 / 728 cal. AD
S5	Wet and open environment, pasture	Open landscape in Kochersberg with cereals and pasture	Little sloap erosion	High Middle Age: Settlements in Kochersberg and close to the watershed	
					530 / 650 cal. AD
S4	Peat bog with alder Open wetland with birch and maple	Totaly closed landscape	No erosion		
					246 / 335 cal. AD
S3	Open wetland and medow anthropized	Reconquest of the forest (S3a) Indices of human impact, cereals, ruderal and microfossils associated with livestock (S3b)	Sloap erosion	Antiquité : Settlements in Kochersberg Tène : Settlements in Kochersberg, and close to the watershed Hallstatt : High density of settlements in Kochersberg and inside the watershed	
					810 / 740 cal. BC
S2	Wet environment occasionaly flooded, partly open	Weak data, little human impact	No erosion	Bronze Age: very little evidence in Kochersberg	
					3960 / 3770 cal. BC
S1	Weak data	Poor data	Little sloap erosion	Michelsberg : Settlements in Kochersberg and inside the watershed	

TABLE 1: Sedimentology, pollen and macro-fossils analyses

CONCLUSION

Intense human impact is only noted from the beginning of the early Iron Age (800 BC) onwards. A change in the exploitation of the environnement could have taken place in the younger Iron Age (La Tène A2/B1). Further studies in the Kochersberg region will be necessary to verify and to refine the proposed hypotheses. The work performed in the Kochersberg region does underline that the comparison of charcoal, pollen and micro-fossil data is an essential approach to study the human impact on the forest environment during prehistoric times.

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Environment and forest edges exploitation in northern France and Belgium during the Neolithic

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Summary: *This synthesis of charcoal studies brings together 24 neolithic occupations in northern France and Belgium. The woody environment is quite similar all along the period. However, the variation of the percentage of Rosaceae species will be discussed even though in Hesbaye, their sudden arrival during the second part of the LBK has been interpreted as a consequence of human activities and forest edges management.*

Key words: *Neolithic, northern France, Belgium, forest edge, Rosaceae*

INTRODUCTION

This work proposes a synthesis of charcoal analyses carried out in northern France and Belgium (Fig. 1), in order to study the woody environment during the Neolithic period (5500-2500 BC), as well as the development and the composition of forest edge.

Twenty four occupations, mostly habitat settlements, are taken into account (Table 1, Fig. 1). Charcoal fragments result mainly from domestic firewood. The unbalance between chronological periods and studied geographical areas reflects the lack of research on neolithic sites in northern France and Belgium (Table 1).

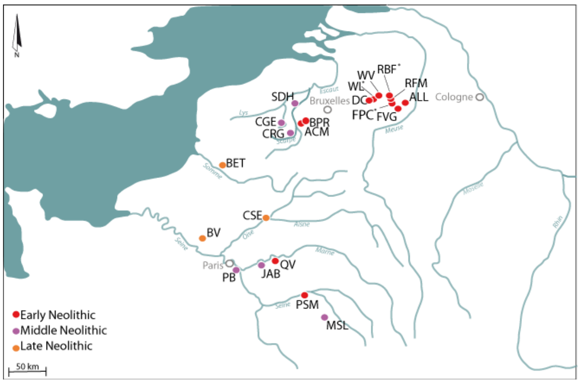

FIGURE 1. Location of the neolithic sites studied. See table 1 for abbreviations.

RESULTS AND PRELIMINARY DISCUSSION

The observation of the charcoal diagram (Fig. 2) shows the dominance of *Quercus* whereas the *Fraxinus* percentage is variable probably depending on the regional edaphic conditions. Hazelnut is present in all sites. *Ulmus* and *Tilia* appear more frequently during the Early Neolithic. This could be related to the decline of both species in the pollen diagram of the Hesbaye region, which has been correlated with the activities of the Bandkeramik people (Bakels, 1992: 16).

Fagus appears at the end of the Final Neolithic, which is a little bit earlier than the first mention in the synthetic pollen diagram of the Paris basin where the presence of *Fagus* is recorded since the second part of the Subboreal, around 3270±80 BP (Leroyer, 2006: fig. 4; see Leroyer *et al.*, in this volume).

		Abbr.	Settlement	Charcoal fgts	Bibliography
EARLY NEOLITHIC	Pioneers (Hesbaye)	FPC	Fexhe-le-Haut-Clocher-Podrî l'Cortri	804	Salavert, 2010
		RBF	Remicourt-En Bia Flo II	546	
		WL	Waremme-Longchamps	308	
		WV	Waremme-Vinâve	316	
		AL	Alleur	2030	Salavert 2010
		ACM	Aubechies-Coron Maton	315	
		BPR	Blicquy-La Petite Rosière	465	
		DC	Darion-Colia	3502	Buydens, 1999
		FPC	Fexhe-le-Haut-Clocher-Podrî l'Cortri	1998	Salavert, 2010
		FVG	Fexhe-le-Haut-Clocher-Voroux Goreux	811	
		PSM	Pont-sur-Seine-Marnay	129	Salavert, unpublished
		RBF	Remicourt-En Bia Flo II	3142	Salavert, 2010
		RFM	Remicourt-Fond de Momalle	1425	
		WL	Waremme-Longchamps	3271	
	Bl./VSG	DC	Darion-Colia	1051	Buydens, 1999
		QV	Quincy-Voisin	1051	Salavert, unpublished
MIDDLE NEOLITHIC	MK	CGE	Carvin-Gare d'Eau	886	Salavert, unpublished
		CRG	Corbehem-Rue du Gouy	670	Dufraisse, unpublished
		SDH	Spiere-De Hel	1464	Buydens and Damblon *in* Vanmonfort et al., 2001
	Chasséen	BV	Boury-en-Vexin 1	259	Thiébault, 1991
			Boury-en-Vexin 2	150	
		PB	Paris-Bercy 1	4489	Pernaud, 1997
			Paris-Bercy 2	162	
	NMII	JHC	Jablines-Le Haut du Château	2300	Solari in Bostyn et al., 1992
		MSL	Mesnil-Saint-Loup-Les Vieilles Vignes	261	Salavert, unpublished
LATE NEO	SOM	BV	Boury-en-Vexin		Thiébault, 1991
		CSE	La Croix-Saint-Ouen-La Station d'Epuration	1658	Pernaud, 1997
FINAL NEO		CSE	La Croix-Saint-Ouen-La Station d'Epuration	1891	Pernaud, 1997
		BET	Bettencourt-Saint-Ouen		

TABLE 1. List of sites and cultures studied, number of charcoal fragments identified and main bibliographical references consulted for each of them.

The Rosaceae taxa (Maloideae, Prunoideae) appear at the second LBK period. The developing of such heliophilous species could be related to the opening of fields or pasture lands by the first farmers of Central Belgium and thus to human activities (Pernaud, 1997; Salavert, 2010). However, their absence in the pioneer charcoal assemblages and their brutal appearance may correspond to a particular exploitation and maybe the management of the edge forest for firewood, fruit gathering and fodder (Kreuz, 1992; Salavert, 2010). The percentage of Rosaceae varies and could indicate a difference in the degree of anthropization of the environment from site to site, and thus, the economic status of neolithic settlements (conclusions have to be taken cautiously considering the preliminary nature of this work).

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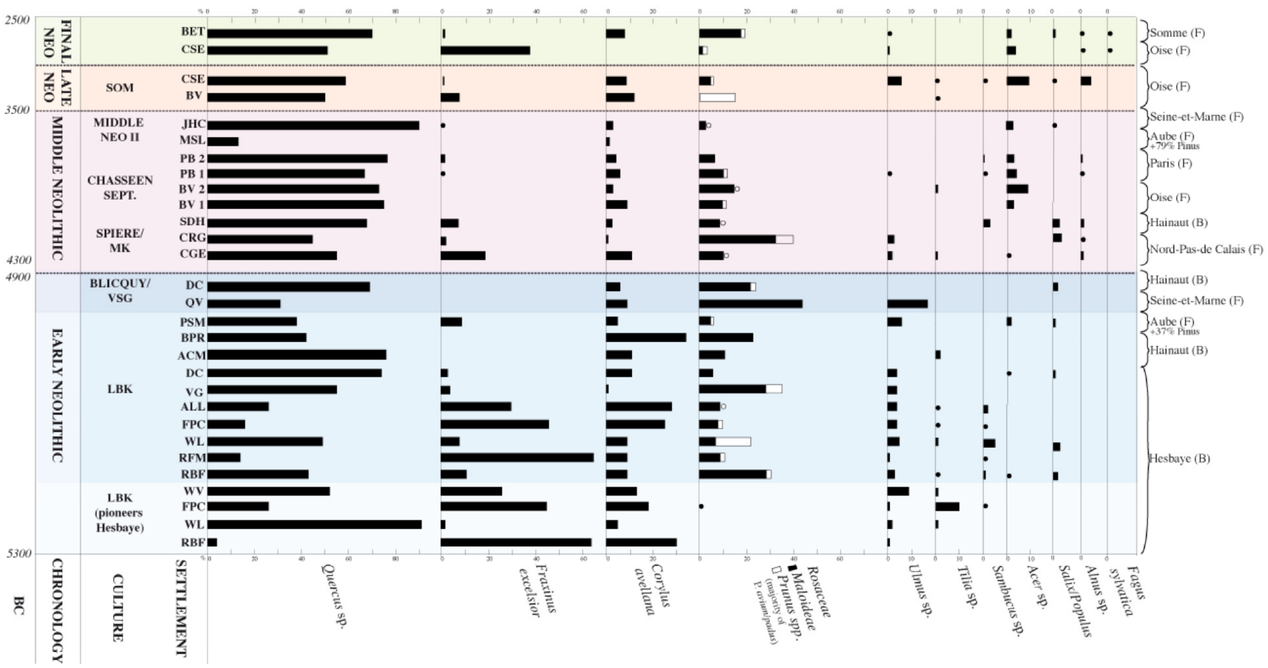

FIGURE 2. Simplified charcoal diagram of 24 neolithic occupations in northern France and Belgium (dots: <1%). Only main species identified are mentioned. Each colored stripe corresponds to a different chronological period. Inside the colored stripes, sites are potentially contemporaneous.

Charcoal analysis from Porto das Carretas: the gathering of wood and the palaeoenvironmental context of SE Portugal during the 3rd millennium

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Summary: *Charcoal analysis from the Chalcolithic and Bell Beaker period/early Bronze Age settlement of Porto das Carretas (southeast Portugal) suggests the presence of three distinct ecological and physiographic units used by human communities as source areas for wood gathering: the alluvial Guadiana margins, where* Fraxinus angustifolia *was present, probably as a component of the riparian forests; the valley slopes, dominated by sclerophyll species such as* Quercus - *evergreen and* Olea europaea*; and the interfluves where* Pinus pinea *might have been present. The anhtracological spectra identified at Porto das Carretas suggest a palaeovegetation mosaic compatible with a Mediterranean type of climate. Previous archaeobotanical investigation in the area suggests the existence of significant environmental changes since the 3rd millennium onwards. Data from Porto das Carretas in general fits well into these local models.*

Key words: *Porto das Carretas, charcoal analysis, third millennium BC, wood gathering, palaeoecology.*

INTRODUCTION

Porto das Carretas (Mourão, southern Portugal) is a settlement in the left margin of Guadiana River. The archaeological excavation took place between 1997 and 2000 under the supervision of part of the authors (Tavares da Silva and Soares, 2002). Two major phases were identified and their chronology was confirmed by a series of ^{14}C dates. During the Chalcolithic (Phase I - *ca*. 2900-2500 cal. BC) the site was fortified and during the Bell Beaker period/early Bronze Age (Phase II - *ca*. 2500-2200 cal. BC) a monumental architectural ensemble was built (Soares *et al*., 2007; Soares and Tavares da Silva, 2010).

Charcoal analysis was done in order to get information on the plant resources used by the human communities, mainly wood gathering strategies, and also to assemble relevant information on the palaeovegetation regional mosaic and related palaeoenvironmental conditions.

MATERIALS AND METHODS

All Phase I charcoal assemblages were recovered in non-structured fireplaces. Phase II anthracological assemblages were gathered inside structured fireplaces as well as scattered in the surrounding of those structures.

All laboratory work was done in the Laboratory of Paleoecology and Archaeobotany (exIPA). Charcoal fragments were hand sectioned in order to obtain the three diagnostic sections. They were observed and identified under the microscope; identification was assisted by wood and charcoal reference material and atlases (e.g. Schweingruber, 1990).

The tentative discrimination of *Quercus* species was done using new criteria. Being conservative, these criteria allowed us to define different morphological types. Their correspondence with the eponymous species is discussed.

RESULTS

A total of 403 charcoal fragments were studied. The assemblage is significant although not very rich. Results are summed in Table 1 and Figures 2 and 3.

According to the morphological criteria used, different *Quercus* morphological types are included in the samples: *Quercus faginea*, *Quercus ilex* subsp. *ballota*, *Quercus coccifera* and/or *Quercus suber*. The significant presence of *Quercus* sp. is a result of abundant small sized fragments.

Phase	I	II	
Charcoal	Conc.	Sca.	Conc.
Fraxinus angustifolia		*8*	
Olea europaea	*36*	*22*	14
Pinus pinea	*37*	*26*	31
Pinus pinea / pinaster			1
Rosaceae cf. *Pyrus* sp.	5	3	2
Quercus - evergreen	*27*	*61*	6
Quercus - deciduous		*1*	1
Quercus sp.	*54*	*35*	16
Undetermined	5	2	10
Total	164	158	81
Fruits and seeds			
Vicia faba var. *minuta* (frag.)	41		
Pinus pinea (cone scales)		2	2

TABLE 1. Results from the charcoal analysis (Sca.- Scattered; F. – fireplace)

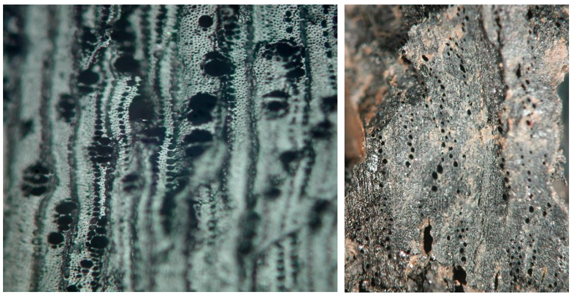

FIGURE 1. Olea europaea *(left) and* Quercus evergreen *(right)*

DISCUSSION AND CONCLUSIONS

The results from both occupation phases are very similar —the only significant difference being the exclusive presence of *Fraxinus angustifolia* and *Quercus faginea* in Phase II.

Three main ecological and physiographic units on the regional territory zonation were probably used by the human communities, during the Chalcolithic, as source areas for wood gathering: the Guadiana River alluvial planes, the valley slopes and the interfluves. This is suggested by the anthracological spectra, assuming for the past the same ecological preferences of the plant species as shown in the present-day.

Riparian forests, probably bordering the low alluvial terraces, are represented in the samples by sparse charcoal fragments of *Fraxinus angustifolia* (ash). The Guadiana valley slopes were covered by sclerophyllous vegetation types, probably represented by the presence of *Quercus ilex* subsp. *ballota* (holly-oak), *Q. faginea* (portuguese-oak), *Q. coccifera* (kermes-oak) and *Q. suber* (cork-oak), *Olea europaea* (most probably wild olive-tree) and one Rosaceae (cf. *Pyrus*.). Probably on the interfluves, with poorer acid soils, stone-pine formations were present, as testified by the frequent presence of *Pinus pinea* wood and cone scales.

The occurrence of *Vicia faba* var. *minuta* seeds suggests its cultivation. On the other hand, the wood types more abundant in the anthracological spectra correspond to tree species with edible fruits: stone-pine, holly-oak and olive-tree. Although these trees were probably part of the natural vegetation at that time, they could also have had a prominent role in the human diet, perhaps also being selectively maintained.

The anthracological spectra identified at Porto das Carretas suggest a palaeovegetation mosaic compatible with a Mediterranean type of climate, probably not much different from the present-day theoretical schematic biogeographic zonation proposed for the region. Although palaeoecological and archaeobotanical studies in the region are not abundant, nearby palynological and anthracological studies suggest the existence of environmental change since the 3rd millennium cal BC (4360±50 BP). The local anthracological signal of such changes is the increasing relevance of *Q. ilex*, *Olea europaea* and *Pistacia lentiscus*, while *Q. faginea* and *Q. suber* became more sporadic (Espino, 2004). This change is considered both anthropogenic and natural, as humidity seems to have decreased while temperatures rose. In the Portuguese southwest coast, on the other hand, palynological investigations suggest a drier climatic phase for the Late Chalcolithic, although a temperature signal is not clearly revealed from the data (Mateus and Queiroz, 2000).

The charcoal data from Proto das Carretas is not different from data obtain in other sites, but one must argue its suitability to validate palaeoenvironmental hypotheses. The sclerophylly of the vegetation testifies to a response to humidity-stress and does not correlate directly to temperature. Besides, the data refer just to the occurrence of species and does not give information about vegetational trends which could be correlated to climatic shifts. To achieve palaeoecological and palaeoenvironmental reconstructions we must have sustainable data from time-series with a suitable significant quantitative approach to address the issue of the relative spatial shifts of the main Mediterranean vegetation domains in the region.

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Charcoal analysis in the district of Loma (Jaén, Spain)

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Summary: *A study has been made of the charcoal from two archaeological sites located in the district of Loma (Jaén, Spain) and dating from the second half of the 4th to the first quarter of the 2nd millennium BC. The results indicate the presence of a thermophilous oak forest with elements that indicate a wet environment during the 4th and 3rd millennium and an aridification of the climate together with a loss of tree cover from the beginning of the 2nd millennium onwards.*

Key words: *charcoal analysis, Late Neolithic, end of the Copper Age, Bronze Age, Andalusia.*

SETTING AND BIOGEOGRAPHY

The sites studied are situated in the district of La Loma, in the province of Jaén (Spain), within the Guadalquivir River Depression, which occupies a large part of Andalusia. This district has slightly elevated relief over the Guadalquivir Valley, equidistant between the mountain systems of the Sierra Morena to the north, Sierra Mágina to the south and the Sierras of Cazorla-Segura to the east, with the west remaining open to oceanic influence. The zone is situated in the lower mesomediterranean bioclimatic level, and biogeographically it belongs to the Hispalense sector, of the Betic province. The dominant vegetation series is that of *Quercus rotundifolia* (Rivas Martínez, 1987; Valle, 2004). Currently, the area is occupied by olive cultivation, with natural vegetation identifiable only at isolated points inaccessible to grazing and ploughing. The supramediterranean and oromediterranean levels are found in the mountain massifs of Sierra Mágina and Sierras of Cazorla-Segura (Fig. 1).

METHODOLOGY AND SITES

The charcoal from two sites was studied: Las Eras del Alcázar of Úbeda and El Cerro del Alcázar of Baeza. The charcoal comes both from collection at different points as well as from the manual flotation of sediments.

For the diagram constructed and the conclusions drawn, the charcoal was grouped according to the chronological-cultural sequence defined for each site. In the Eras del Alcázar of Úbeda, three time periods were defined: the first was *ca*. 3500-2500 BC, between the Late Neolithic to the Middle Copper Age, defined urbanistically by circular dwellings excavated in the soil with rammed-earth walls of adobe and plant material; the second was *ca*. 2200-2000 BC, defined as the Late Copper Age, with beaker pottery and free-standing dwellings on the ground; finally, the third period was *ca*. 2000-1700 BC and belongs to the Bronze Age, the urban pattern changing to rectangular dwellings (Lizcano *et al*., 2009).

In the Cerro del Alcázar of Baeza, the charcoal was analysed from a Bronze Age settlement, where a succession of 4 major phases of occupation were determined from *ca*. 1900 to 1500 BC (Pérez and Lizcano, 2003), coinciding in part with the last phase of the previous settlement. All four phases present similar characteristics in terms of the construction system of the rooms, with rectangular dwellings and the materials used for the floors occupied.

RESULTS AND DISCUSSION

The results of the charcoal analysis indicate the predominance of *Quercus ilex-coccifera* vegetation, with percentages of 40 to 80%. It bears noting that at the levels where *Quercus ilex-coccifera* diminishes, *Pinus halepensis* increases, although the percentages are far lower (Fig. 2). This somewhat erratic trend of the percentages reflects the opening of the vegetation in the Copper Age for the creation of open fields of cultivation, favouring the presence of *Pinus halepensis*; meanwhile, in the Bronze Age, different species are used in definite construction phases of the dwellings.

Therefore, we made an overall evaluation of the two anthracological phases defined, corresponding to the two major chronological periods: Neolithic Final-Copper Age (*ca*. 3500-2000 BC) and the Bronze Age (*ca*. 2000-1500 BC).

Qualitatively, it should be highlighted that in the beginning, there was a greater number of taxa identified (18) than in the Bronze Age (diminishing to 13), indicating the beginning of a loss of floristic diversity. Notable among the taxa that disappeared are deciduous *Quercus* and *Quercus faginea*, which indicate lower moisture, while the disappearance of *Phillyrea* and the decline of *Pistacia lentiscus* would indicate a slightly colder environment. In counterpoint during the Bronze Age, appeared *Retama* while *Rosmarinus officinalis* slightly increased. All this implies a trend towards aridification during the Bronze Age that would correspond to the general pattern defined for the western Mediterranean from the Middle Holocene onwards (Carrión *et al.,* 2010).

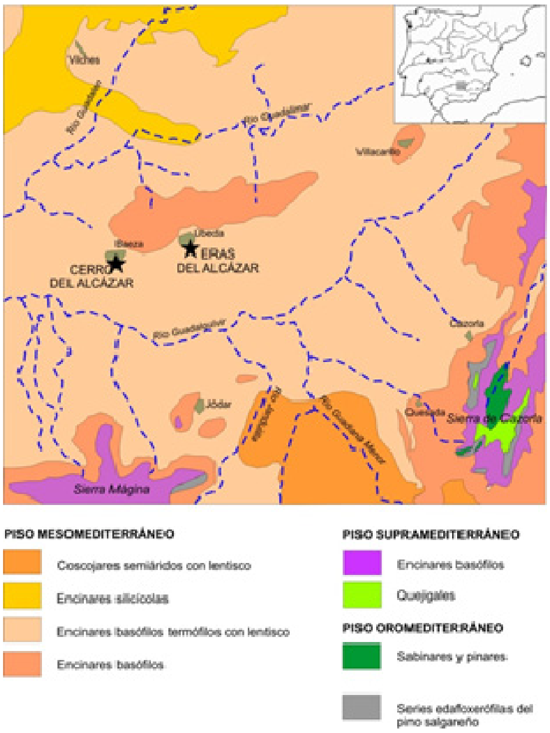

FIGURE 1. Map showing the sites and vegetation of the zone.

Though the general pattern of floristic evolution coincides with the palynological analysis made at these sites (Fuentes *et al.,* 2007), there is no coincidence concerning the main taxon determined. For palynology the main taxon is *Pinus* sp. while for charcoal dating it is *Quercus ilex-coccifera*. This discrepancy can be reconciled by the fact that palynology reflects mainly the vegetation of the nearby sierras, such as Segura-Cazorla to the east and Sierra Mágina to the south, as Loma de Úbeda, being situated in the zone immediately below, is open to the winds that deposit the pollen in the surrounding sierras. Meanwhile, charcoal analysis reflects the vegetation of the surroundings closest to the settlements, introduced by the inhabitants.

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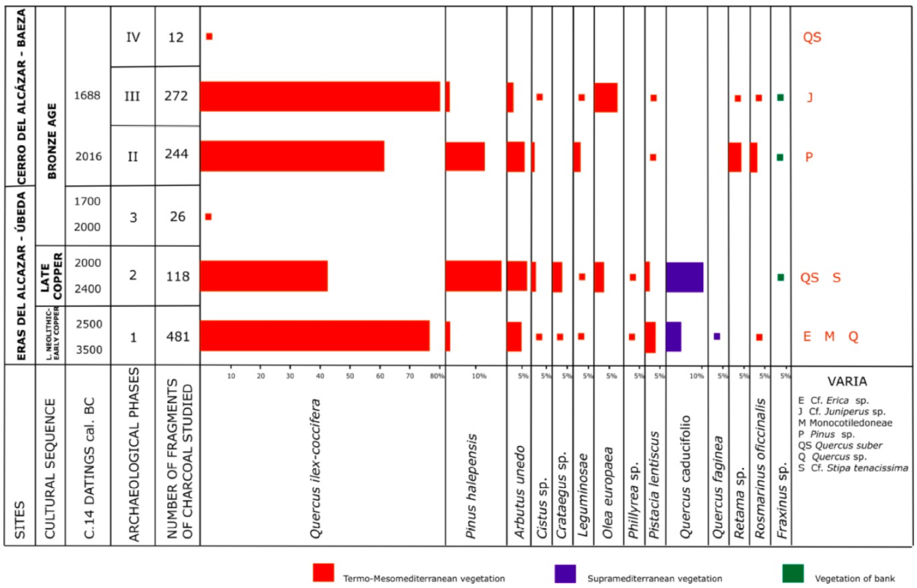

FIGURE 2. Anthracological diagram of district of Loma (Jaén, Spain).

Anthracology from the Far East: a case study from the upper Ying valley (Henan province, China)

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Summary: *The aim of this work is to present a short history of charcoal studies in China and the results from the anthracological study of different samples from the upper Ying valley including sites from different chronologies and deposits. The materials under study come from sites dating from the Yangshao to the Erlitou phase. The study shows that the most important and present in all samples is* Quercus *ssp. deciduous. The rest of the taxa are only present in some samples showing the variability of the assemblage:* Ziziphus/Paliurus*, cf.* Phyllostachys*,* Cotinus/Rhus*,* Melia*,* Morus*,* Pinus*,* Prunus*. In the record there are elements from the oak forest composed by different oak species and other shrubs or trees that were exploited for firewood.*

Key words: *Chinese anthracology, landscape, firewood management, oaks*

INTRODUCTION

The background of Chinese anthracology is still very limited considering methodology and general results. In China, the first evidence of charcoal analysis dates from 1954. Gu (1957) identified the anatomical structure of a natural charcoal fragment in the Changbai Mountain. However, charcoal analysis in archaeological sites began at the end of the 20th century. In 2002, Cui (Cui *et al*., 2002), on the basis of the analyses of charcoal fragments from Dadianzi and Halihaitu sites (Bronze Age) proposed vegetation reconstruction. Furthermore, Wang *et al.* (2002) studied the wood exploitation of ancient populations using charcoal analysis and analyzed quantitatively the climate and the environment. In addition, Wang *et al*. (2004) introduced anthracology applied to archaeological sites. From that point onwards, charcoal from archaeological sites has been analyzed in order to study former ecosystems, assess changes in vegetation communities over time, recognize the effect of human activities on plants and extract information on wood exploitation (see Wang *et al*., 2004, 2005, 2011; Wang and Wang, 2007).

In this work we present the anthracological study of different samples from the upper Ying valley including sites from different chronologies and deposits. The upper Ying valley is an alluvial basin in the Henan province, bordered by the Luoyang basin to the northwest, within China's central plain. The Ying River flows west to east, surrounded by the Songshan Mountains to the north and the Jishan Mountains to the south (Zhang *et al*., 2010). The local chronology in this region is based on both ceramic typology and radiocarbon dating which, in combination, suggest three broad archaeological divisions: a late Neolithic 'Yangshao' phase (*ca*. 4000–2500 BC), a transitional 'Longshan' phase (*ca*. 2500–1800 BC) and an early Bronze Age 'Erlitou' phase (*ca*. 1800–1600 BC) (Zhang *et al*., 2010).

RESULTS

The materials under study come from the bucket flotation of 15 samples from 8 sites (GSH, SHD, WAD, WWW, XFD, XIW, YFT and YUQ). Identification of the charcoal fragments was done on the basis of different wood anatomy atlases. In general the samples were poor and some of them only provided few charcoal fragments. The study of 310 charcoal fragments has yielded 10 different taxa distributed among the different samples (Table 1). The most important taxon and present in all samples is *Quercus* sp. deciduous. The rest of the taxa are only present in some samples being *Ziziphus/Paliurus* the most important among them. Other taxa are cf. *Phyllostachys*, *Cotinus/Rhus*, *Melia*, *Morus*, *Pinus*, *Prunus*.

The different periods show similar patterns being *Quercus* the most important taxon. Moreover, the largest sample shows the largest variability corresponding to the Late Longshan period. Therefore we consider that it would be necessary to study a larger amount of charcoals to view the relative differences among samples.

DISCUSSION

The obtained dataset from the Ying valley suggests the presence of species from broad-leaved forests dominated by oaks. In the record there are elements from the oak forest composed by different oak species and other shrubs or trees. Environmental studies of different types of sequences show that during the first phases of the Holocene there was an important forest cover (Cui *et al*., 2002; Guanglan *et al*., 2005; Ren, 2007; Itzstein-Davey *et al*., 2007). According to these authors, the main forests grew under favourable climatic conditions. Their evolution and transformation seem to be in relation with the intensification of human activities. Moreover some changes in the general environment involve oscillations in humidity rates. The formation processes of the assemblages from the Ying valley are the result of rubbish accumulations in pit structures. Therefore the origin of this charcoal could be wastes of fuel wood and/or wastes of other activities (agriculture, wood construction, objects). The importance of oaks in these assemblages permits to suggest the exploitation of these taxa in an organized society. Fruit producers such as jujube, plums, mulberries, china berries, are also present in the charcoal assemblage. In this sense we remark the absence of acorns and on the contrary the abundance of oaks in the charcoal assemblage. Furthermore, the difference in percentages between the most important taxa in the assemblage and the rest of the taxa is significant. The distribution of taxa suggests a managed and organized exploitation of certain species or forests.

	Periods			
Taxa	Yanshao	Early Longshan	Late Longshan	Erlitou
Cotinus/Rhus			3	
Fagaceae	3		1	1
Lauraceae			1	
Melia azedarach			3	
Morus	1		5	1
Morus/Melia			2	
Pinus	3			
Prunus			1	
Quercus	8	4	18	6
Quercus sp. deciduous	54	7	122	4
Quercus/Castanopsis	1	1	2	
Ziziphus/Paliurus	2	3	9	
cf. *Phyllostachys*			9	
cf. Anacardiaceae			2	
cf. Melia				2
cf. Quercus			1	
cf. Rhus			1	
cf. Vitex			1	
cf. Ziziphus		2		
Angiosperm	2	7	15	1
Total	**74**	**24**	**196**	**15**

TABLE 1. Results from the charcoal analyses from the Ying valley by periods.

CONCLUSION

On the basis of the anthracological analyses from these sites we can conclude that: 1) the landscape was dominated by oak forests and firewood management was directed to the use of oaks as the main species; 2) a larger sample should be studied in order to asses the degree of transformation of the forest during these periods as well as to determine forest management patterns; 3) Chinese anthracology is starting to spread since the end of the last century onwards and the study of more sequences from other areas and periods will permit in the future to understand the complexity of environmental and cultural changes in this vast region.

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Use of wood in the ancient cult of fire temple at Mele Hairam (south-western Turkmenistan), based on preliminary charcoal analysis

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Summary: *The analysis of charcoals from an ancient temple dedicated to the cult of fire, discovered in the south-western Turkmenistan (the Mele Hairam site), was conducted. The following taxa of trees and shrubs were identified:* Fagus orientalis*,* Populus *sp.,* Tamarix *sp.,* Ulmus *sp., Chenopodiaceae type I and type II, Pomoideae cf.* Crataegus/Cydonia *type, as well as cf.* Pistacia *sp., cf.* Punica granatum*, cf.* Tamarix *sp. and undeterminate anatomical type III.* Tamarix *sp. was the most numerous and frequent taxon at the site, followed by taxa from the Chenopodiaceae family and* Populus *sp. These are common trees and shrubs growing also nowadays in Turkmenistan. The wood used in the fireplaces at the Male Hairam site was probably not imported, but originated from the nearest surroundings of the temple.*

Key words: *charcoal analysis, wood anatomy, Zoroastrian temple, archaeological Mele Hairam site, south-western Turkmenistan*

INTRODUCTION

The archeological Mele Hairam site is situated in the area of the Serakhs Oasis, in south-western Turkmenistan. At this site the Zoroastrian temple dedicated to the cult of fire was discovered. The temple was occupied during the Sasanian times, *ca*. 2rd – 7th century AD. (Kaim, 2002; Website: The Polish Archaeological Mission in Iran and Central Asia, online: 2011). The Mele Hairam site is located on the Turanian Lowland, on borderland of two kinds of deserts: sandy and clayey ones. Near the Mele Hairam site there are two permanent rivers, Tadzen and Murghab. On the Turanian Lowland occur saline soils, swamps and halophytes connected with them. Also saline ground-waters are found there. Steppe and desert plants cover the Turanian Lowland with the predominance of grasses and some shrubs.

The taxonomic identification of charcoals from the Mele Hairam site aimed at answering the question about what kinds of woods were used to keep up a fire in the temple as well as from where they originated (from the nearest surrounding area, or imported especially for this purpose).

DATA AND RESULTS

Sixteen soil samples coming from different chambers of the temple and from the altar were analyzed. Charred wood material was found in twelve samples only.

Among the charcoal fragments the following taxa were distinguished, *Fagus orientalis*, *Populus* sp., *Tamarix* sp., *Ulmus* sp., Chenopodiaceae type I and type II, Pomoideae cf. *Crataegus/Cydonia* type. Approximately determined were cf. *Pistacia* sp., cf. *Punica granatum*, cf. Tamarix as well as indeterminate anatomical type III. In the sample originating from the altar four taxa were determined, *Tamarix* sp., *Chenopodiaceae* type II, *Pomoideae* cf. *Crataegus/Cydonia* type and *Ulmus* sp.

At the site, *Tamarix* sp. shows the greatest abundance of fragments (36.8% of the total sum of fragments) (Fig. 1). The less numerous taxa are: *Populus* sp. (23.6%), anatomical type III (14.8%), Chenopodiaceae type I (8.3%), cf. *Tamarix* sp. (4.8%), Pomoideae cf. *Crataegus/Cydonia* type (2.6%), and cf. *Punica granatum* (0.9%). The other taxa constitute together 1.5% of all fragments. 6.7% of the total sum of charcoal fragments remained undetermined because of excessive charring (undeterminable). *Tamarix* sp. is also the most frequent taxon at the site. In comparison with the other taxa also *Populus* sp., *Chenopodiaceae* type I and *Pomoideae* cf. *Crataegus/Cydonia* type appear quite often.

DISCUSSION

In the present-day Turkmenistan the most common plants are those growing in extreme types of habitats, such as xerophytes and halophytes. The most popular are species of *Calligonum* from the Polygonaceae, *Haloxylon ammodendron*, *H. persicum* and different species of *Salsola, Aellenia, Anabasis, Arthrocnemum*, *Halogeton* from the Chenopodiaceae family, *Artemisia* from the Asteraceae family as well as *Tamarix* from Tamaricaceae (Ovezliev *et al.,* 1997).

Plants from the Chenopodiaceae family are particularly common on the Turanian Lowland (Ovezliev *et al.,* 1997). Wood of different species of Chenopodiaceae is quite similar in broad outline. The determination was limited therefore only to family level and two anatomical types. The distinguished categories of Chenopodiaceae type I and type II wood might represent two different genera.

The determination of *Fagus orientalis* is an interesting phenomenon. Beech is not a characteristic genus for the oasis vegetation, and presently is unknown from Turkmenistan. *Fagus orientalis* is the only beech species occurring nowadays in that part of Asia, but is known from Asia Minor, Caucasus, Northern Iran (Krüssmann, 1977; Russell *et al.*, 2004) and Pakistan (Safdari *et al.*, 2008).

The determination cf. *Punica granatum* was based on the similarity to pomegranate wood. However in the analyzed material the absence of crystals typical for that taxon was noted. The charcoal fragments determined as cf. *Pistacia* sp. show wood structure similar to this genus. In the determined material only homogenous rays were observed, which is not a typical feature of *Pistacia* wood (Fahn *et al.*, 1986).

The group of charcoals with wood anatomy similar to *Tamarix* sp. was determined as cf. *Tamarix* sp. This taxon has homogenous rays as well as numerous tyloses in vessels, which are not described in tamarisk wood (Fahn *et al.*, op. cit.; Neumann *et al.*, 2001).

Among the investigated charcoals a group of undetermined fragments with similar anatomical features was recognized. They could not be determined on the basis of the available reference materials and were described as anatomical type III.

CONCLUSIONS

The majority of the taxa recognized at the archaeological Mele Hairam site are characteristic for the present-day vegetation of the Turanian Lowland. The most numerous and frequent taxa were *Tamarix* sp., *Populus* sp. as well as taxa from the Chenopodiaceae family. These plants belong to the common trees and shrubs nowadays found in the area of Turkmenistan. To keep up fire in fireplaces in the temple, during the Sasanian times, trees and shrubs potentially easily accessible, originating from the nearest surrounding area of the site, were used.

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I would like to sincerely thank Professor Katharina Neumann for her kind help in the determination of charcoals from the Mele Hairam site and for offering me the chance of seeing the slides from the reference wood collection of the Johann Wolfgang Goethe University in Frankfurt am Main. I cordially thank Professor Barbara Kaim (Institute of Archaeology, Warsaw University) for lending me the material for investigations.

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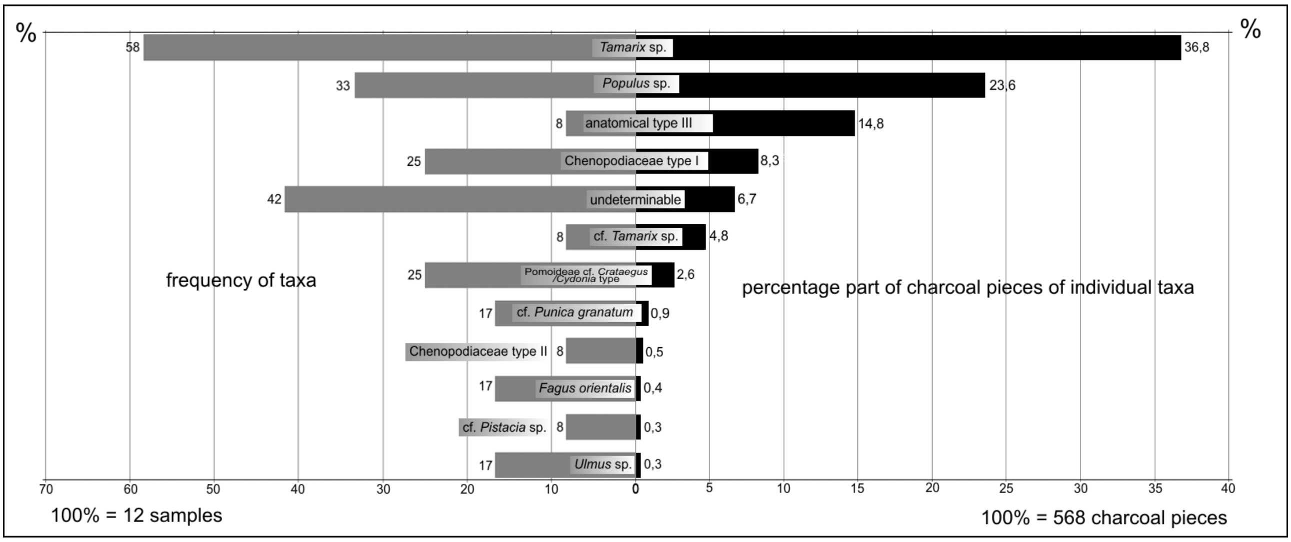

FIGURE 1. Frequency and percentage part of charcoal fragments of individual taxa from Mele Hairam.

The environment of the Nok sites, Central Nigeria – first insights

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Summary: *Charcoal analysis points to savanna woodlands as the prevalent vegetation in the Nok region. Fabaceae s.l. and Phyllanthaceae dominate the assemblages. Within these groups identification to genus or species level is difficult, but unambiguous savanna taxa (e.g.* Faidherbia albida*) point to woodland vegetation. Further investigations are needed in order to clarify if this woodland was of anthropogenic origin or natural and if its composition was influenced and changed by human impacts.*

Key words: *archaeological charcoal, vegetation reconstruction, savanna, Nigeria*

INTRODUCTION

The Nok-culture in Central-Nigeria is famous for its impressive terracottas, but until recently only few things were known about Nok: the sites date between 500 BC and 200 AD and besides the terracottas, slag and furnaces were found, putting the Nok-people among the earliest societies that mastered iron-production in West Africa. However, their socio-economic background remained obscure. At the Goethe-University, Frankfurt, research on the Nok-culture started in 2005, aiming at unveiling the society behind the art (Rupp *et al.*, 2008).

The sites excavated so far are located in the hilly foreland of the Jos Plateau, northeast of the Nigerian capital of Abuja. Relief is undulating with granite outcrops and elevations between 300 and 900 meters. The region receives annual rainfall of 1300-1400 mm (Adefolalu, 2003) and belongs to the Southern Guinea vegetation zone (Keay, 1953).

The vegetation consists of a mosaic of secondary savannas, semi-evergreen rain forest and *Isoberlinia* woodland. At the border of rivers denser gallery forests are present, often with *Terminalia* sp. Where cultivation is possible, the natural vegetation has been profoundly modified to farmed woodland, with fields including useful trees and bush fallows in various stages of regeneration (Keay, 1953).

In the vicinities of the sites pearl millet (*Pennisetum glaucum*) and fonio (*Digitaria exilis, D. iburua*) are widely grown. The cultivation of yams seems to be confined to profound soils. Manioc, rice and sugar cane are mainly found in depressions and at river banks. Maize and sorghum are acknowledged to be cultivated but were not observed during the archaeobotanical field seasons. The spectrum of crop plants is diversified by various other legumes. Land use includes animal husbandry and the gathering of wild plants like wild yams and tree fruits.

From archaeobotanical studies at various sites a plant exploitation system based on mixed cropping of pearl millet and cowpea (*Vigna unguiculata*) can tentatively be reconstructed. This system is also known from the Nigerian Chad Basin in the same period. Fruits of tree species in the archaeobotanical assemblages stress the importance of wild resources. The combination of cropping systems based on cereals and pulses with oleaginous fruit exploitation is characteristic for the prehistoric economy of the Sahel and Sudan zones. It was probably present all over the West African savannas at the beginning of the Iron Age.

DATA AND RESULTS

Two families are present in all sites: Fabaceae s.l., which constitute the largest number of fragments, and Phyllanthaceae. In one sample from Janjala, *Parinari* type is dominating over Phyllantaceae and Fabaceae wood types. The other sample from this site consists almost entirely of fragments of *Terminalia* type.

The wood of many taxa of the Fabaceae lacks discrete, non-overlapping characters and thus renders it difficult to define wood types down to species or even genus level. In many cases we can only establish wood types that comprise several genera, like Detarieae 1, a type that is present in all sites. Apart from typical family characteristics (small vessel groups, vestured pits and crystals in chambered parenchyma cells) the fragments of this type have mostly uniseriate rays and aliform parenchyma. The woods of *Isoberlinia* and *Berlinia* species belong to this group as well as, among others, *Anthonota, Monopetalanthus* and *Gilbertiodendron*. The type Detarieae 2 is quite similar but has broader rays, it includes the wood of *Afzelia* and *Guibourtia* species. Among the Phyllanthaceae *Uapaca* type is present in four sites and Phyllantaceae 1 type in three sites. Wood of the Phyllantaceae 1 type has scarce paratracheal parenchyma, broad rays, simple perforations, enlarged vessel-ray pits, septate fibres and crystals in rays. It includes at least *Antidesma* species, *Spondianthus preussii* and *Margaritaria discoidea* (syn. *Phyllanthus discoideus*). The latter has occasional scalariform perforations, but should still be taken into consideration when recognizing Phyllantaceae 1 type, because they are often not visible in smaller fragments. *Uapaca* type also has broad rays and enlarged vessel-ray pits, but it lacks septate fibres and has silica in rays instead of crystals. Other Phyllanthaceae are present only in Iddah with single or few fragments. Other wood types identified are: *Allophylos africanus, Anogeissus leiocarpa, Faidherbia albida, Khaya, Ochna,* Rubiaceae I and *Terminalia*.

DISCUSSION

We interpret the results of the charcoal analysis as indicating woodlands in the surroundings of the Nok sites. Taxa with Detarieae wood types are also present in the rainforest, but since the assemblages comprise wood types that point to unambiguous savanna taxa like *Anogeissus leicarpus* and *Faidherbia albida*, it is concluded that the species comprised in the Detarieae wood types of the Nok sites rather belong to woodland taxa. The wood types found in the charcoal assemblage fit very well the taxa mentioned by Kershaw (1968) in his vegetation descriptions for the Zaria province, his southern sample areas being comparable to where the Nok sites are situated. Especially *Isoberlinia doka* and *Parinari curatellifolia* are constituents of two associations he has described. Both associations grow adjacent to inselbergs and profit from the gradual release of water from the hills, which maintains the woodland during the dry season. *Afrormosia laxiflora* (syn. *Pericopsis laxiflora*) is constantly present in these associations as well.

Anogeissus leiocarpa, as well as *Khaya* wood type, which were present in Ungwar Kura, Iddah and Janruwa, and *Terminalia* of Janjala and Akura could point to the exploitation of gallery forests.

From the archaeobotanical remains, we have to assume the presence of fields and fallows in the vicinity of the sites. However, evidence of unambiguous woody fallow species is missing from the charcoal assemblage so far. This is not surprising however, since in fallows within *Isoberlinia* woodland the major woody taxon is *Isoberlinia* itself (Keay, 1953).

CONCLUSION

The presence of savanna woodland in the vicinity of the Nok sites seems probable. Assemblages with wood from Fabaceae and Phyllantaceae together with typical Sudanian species like *Faidherbia albida* and *Anogeissus leiocarpa* lead us to presume that wood was collected from *Isoberlinia* woodland.

At the moment it is not possible to differentiate between wooded farmland, woodland of anthropogenic origin, or natural, less influenced woodlands. It was not possible to identify unambiguous fallow species so far.

Gallery forests were exploited as well, but possibly not on a regular basis or only for special purposes. Further analysis might clarify the significance of wood types from these taxa in the assemblages.

Semi-evergreen forest might have been present, but cannot be proven by the charcoal assemblages. Climatic data corroborate that forests could have been present: from the middle of the first millennium BC higher precipitations are indicated for the wider region - by a high water level of Lake Bosumtwi (Ghana) around 200 BC (Shanahan *et al.*, 2006) and the expansion of forest in the Dahomey gap of southern Benin (Salzmann and Hoelzmann, 2005). The Nok area might have received higher rainfall than today during the second half of the first millennium BC as well. Depending on the duration of the dry season and the atmospheric humidity throughout the year, 1300 to 1600 mm annual rainfall would have been sufficient for the development of at least a drier semi-evergreen rain forest, which is present at the borders of the Guineo-Congolian region today (see White, 1983).

Further analysis of charcoal from accurately defined contexts, with secure dating will help to gain a better picture of the woody vegetation of the area and of the dimension of human impact.

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The dry stone wall of "Paretone dei Greci": an anthracological approach

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Summary: *Dry stone constructions are a common occurrence in many Mediterranean landscapes. One of these structures known as "Paretone dei Greci" (Taranto, Southern Italy) was subject to an archaeological investigation. Soil and sediment material within this wall, as well as those above and below it, were sampled and processed for archaeobotanical studies. In this manner it was possible to understand its building technique as well as giving it a chronological context. Through an anthracological analysis it was possible to insert the "Paretone" within the surrounding agricultural landscape, thus better highlighting its function in relation to the history of the territory.*

Key words: *dry stone wall, archaeobotany, Middle Ages, southern Italy.*

INTRODUCTION

Dry stone and rubble structures are immediately characterized by problems in understanding of their function, chronology and classification (Hodges, 1991). These are a result of the technology employed in their construction, which remained similar throughout time, area of diffusion and patterns of use (Lewuillon, 1991). Generally, archaeologists limit themselves to descriptive investigative techniques when dealing with these kinds of artifacts. It is very rare for example that such structures are subject to a proper investigation of their stratigraphic contexts.

The present study aimed to evaluate the information potential of an archaeobotanical investigation applied to dry stone constructions. The context under investigation is an imposing dry stone wall structure (Fig.1), situated in the countryside of Taranto (southern Italy). The building is locally known as "Paretone dei Greci" (the great wall of the Greeks) and, prior to this research, it was dated to the Byzantine period or even earlier (Stranieri *et al.*, 2009).

FIGURE 1. A section of the "Paretone dei Greci" (Taranto, Italy).

METHODOLOGY

In its current condition, the structure looks like a wall about 2 km long, consisting of two outer faces and a rubble filling in between, about 4 m wide and between 1 and 3 m high on average.

The excavated area was a trench of 3×8 m perpendicular to the wall, in which it was possible to remove all the components forming the wall itself and the earth strata that abutted it and those which were covered by it. In addition, three other trenches of 1×2 m were opened in the earth layers upstream and downstream of the structure. The stratigraphy of the wall was found and documented in the section, and then removed. Archaeobotanical sampling was done in each excavated stratigraphic unit (Fig. 2).

DATA AND RESULTS

The wall, which now appears as a single intervention, turned out to be, in the course of excavation, the result of at least two different building phases, separated by a period of use and/or degradation (Fig. 3).

The substrate on which the two external sides and the fill between them were set up (UUSS 17, 27, 29) is characterized by an overwhelming presence of *Erica* sp. (Fig. 3 Cfr. "Substrate"). The first structural phase (U.S. 20) gave charcoals related exclusively to *Erica* sp. Another phase, still belonging to this first structural phase can perhaps be found in the U.S. 8, which is primarily characterized by the presence of *Quercus ilex* L. (Fig. 3 Cfr. "I structural phase").

The phase immediately preceding this implementation (UUSS 34 - 35) has been dated on archaeological basis to the 7th-8th centuries and is characterized by the constant presence of *Erica* sp. (and, unlike the stratigraphic units constituting the substrate, *Ostrya carpinifolia* Scop. and *Quercus ilex* L.). The immediately following period (U.S. 15) as opposed to UUSS 34-35, was radiocarbon dated to between 670-880 cal. AD (CeDaD- Università del Salento). In this case anthracological analysis confirmed the same species found in the preceding phase to which is added to the conspicuous presence of *Olea europaea* L. (Fig. 3 Cfr. "ante I structural phase"). The second structural phase (UUSS 3-4-10-11) dates definitely later than the 8th-9th centuries and perhaps dates to the early 16th century.

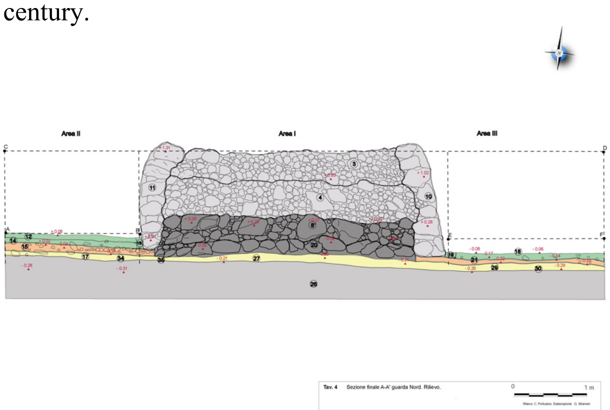

FIGURE 2. Final section of the "Paretone dei Greci".

The soil from its foundation cuts and fills (U.S. 13-19) returned antracological remains related to *Olea europaea* L., *Erica* sp., *Myrtus communis* L., *Cistus* sp., *Ostrya carpinifolia* Scop., *Sambucus* sp., *Prunoideae* and *Pomoideae* (Fig. 3 Cfr. "ante II structural phase").

In the absence of diagnostic dating elements and given the very small number of antracological remains found within them, the remaining stratigraphic units (not cited) pertaining to the accumulation at the East side of the *Paretone* (UUSS 18-21-28-32) do not allow for any hypothesis to be made.

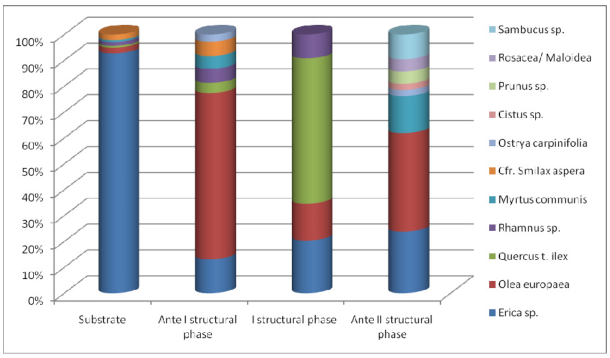

FIGURE 3. Results of the anthracological analysis (Total fragments: 460).

DISCUSSION AND CONCLUSIONS

The proposed approach necessitates a reflection on the peculiar dynamics of the taphonomy of the basin of deposition which contained the investigated plant macroremains (Leonardi, 1992). First, due to its inherent design features, this type of structure becomes from time period immediately following the implementation of structural elements, a basin of deposition that could be called "partially open". The spaces and interstices between a stone and the other allow the passage of sediment and of macro and micro remains of anthropic, animal or plant origin up to the floor deposition. This at the same time limits the processes of post-depositional removal. From a diachronic perspective, it can also be defined as "temporarily open". The process of input and removal of "material" ends when the basin is full and/or when the construction of new structures seals the preceding ones.

The absence of any thermally altered elements near the structure indicates that the charcoal remains were transported into the context and then organized as a result of depositional and post-depositional actions by physical and biological agents. The potential basin of origin still would not have been be very far from the place of discovery, because the charcoals do not present, after a comprehensive visual examination, a high index of rounding erosion. Consequently, since the charcoals are of a "dispersed" type, they indirectly provide information on the evolution of the paleovegetation of the area.

The phase preceding the building of the structure and the first structural phase are characterized by a landscape of low degraded scrub vegetation. The second structural intervention is placed in a vegetational stage moving towards a mature forest. Finally, the foundation fills of the third stage show, by the presence of plums and apples that the landscape had changed again as a result of increased human exploitation.

In conclusion, it can be said that the integration of the information given by the archaeobotanical investigation of a dry-stone structure has allowed it to be viewed within its original vegetation. This has provided a subject for further dialogue towards the understanding of the history and function of the artifact within the landscape.

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Charcoal analysis at the San Chuis hill fort (Allande, Asturias, Spain)

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Summary: *The archaeological site of the San Chuis hill fort (Allande, Asturias, Spain) is located in the central part of the western Cantabrian Range. The site was occupied between 920 - 480 cal BC (2870 - 2430 cal BP) and 100 cal BC - 540 cal. AD (2050 - 1410 cal BP). Repeated and long-lasting occupation resulted in the overlapping of architectural structures from the first and second Iron Ages and the Roman Period. The study of the wood charcoal remains recovered from these structures has allowed us to distinguish two groups of timber: one used in the construction of the buildings and another used as firewood.*

Key words: *hill fort, Iron Age, Roman period, firewood, timber, woodland exploitation.*

INTRODUCTION AND ARCHAEOLOGICAL BACKGROUND

The San Chuis hill fort (Allande, Asturias, Spain) is located in the western part of the Cantabrian Mountain Range, at 780-800 m asl and at a distance of 35 km from the coast. The site is situated between the Eucolino and Submontano bioclimatic levels and the vegetation series of *Quercus robur* and *Quercus pyrenaica*.

The hill fort was discovered in 1952 and was excavated by Professor Francisco Jordá Cerdá during the 1960's and 1980's, while over the last ten years excavations were continued by one of the authors (Jordá Pardo, 2009). The sequence covers a long period of time from 920 to 480 cal BC (2870 - 2430 cal. BP) and from 100 cal BC to 540 cal AD (2050 - 1410 cal BP); the minimum span of this occupation is 1160 years. The chronology of the settlement is finely defined by nine radiocarbon dates (Jordá Pardo *et al*., 2002; Marín *et al*., 2008). On the basis of the radiocarbon dates, the stratigraphy, the overlapping structures and the recovered materials, we have distinguished three clear phases of occupation, the two earliest related to indigenous populations and the latest to the roman reoccupation.

The oldest occupation is a settlement located at the high quarter of the hill fort. There, we have uncovered the remains of a timber structure that was built over the rocky substrate which contained burnt seeds and pottery of the first Iron Age with an age between 890 and 530 cal. BC. The following occupation dated between 710 and 130 cal BC, is characterized by the construction of circular stone structures at both the high and low quarters of the hill fort. Associated to these are pottery from the Second Iron Age and remains of metallurgic activities. The third occupation dates to the Roman period, between 110 cal BC and 530 cal AD; it is characterized by the development of rectangular stone structures, densely built at the high quarter, either over the previous circular ones or as new foundations. From this settlement, pre-roman pottery, *Terra Sigillata Hispanica*, *tegulae*, roman common pottery and iron slags have been recovered.

The recovery and analysis of wood charcoal samples from San Chuis, is significant for the archaeological research at the Asturian hill forts. There are not many palaeoenvironmental results from the area - among others La Campa Torres (Buxó and Echave, 2001), Camoca, Moriyón and Olivar (Camino Mayor, 1999) - and the new data from San Chuis will enrich our knowledge of the past vegetation and the use of timber.

DATA AND RESULTS

We have analyzed eleven (11) wood charcoal samples recovered from excavated levels of the indigenous settlement, of the roman reoccupation and of the tumble of roman structures destroyed after a fire (roofing material and wall structure) (Table I).

The following taxa have been identified: *Pinus nigra-P. sylvestris* (black-Scotts pine), *Corylus avellana* (hazel tree), *Erica* sp. (heather), *Ficus carica* (fig tree), *Fraxinus* cf. *excelsior* (ash), Leguminosae (legume undershrubs), *Quercus* sp. deciduous type (oak), Rosaceae (the rose family) and *Salix* sp. (willow).

Wood charcoal samples from the indigenous settlement include mainly fuel remains scattered on the floors of the circular structures. These reflect the natural vegetation that would have been exploited for firewood; in the surroundings of the hill fort *Quercus* sp. deciduous type woodland would have grown in which mountain pines, heather and legume undershrubs would have been present as well as some riverine plants (ash, willow).

During the Roman occupation some of the indigenous structures were reused (with the addition of rectangular walls) and new ones were built. From the habitation floors of these there are only two wood charcoal fragments documenting the presence of *Erica* sp. and *Quercus* sp. deciduous type.

Level	SC 1, N VI (indigenous)		SC 3, N IV-III (Roman)	
Taxa/Context	Occupation	Landfill	Occupation	Construction
Corylus avellana		*		*
Erica sp.			*	*
cf. *Erica* sp.				*
Ficus carica				*
Fraxinus sp.	*			
Leguminosae	*			*
Pinus nigra-sylvestris	*			
Quercus sp. deciduous	*	*	*	*
Rosaceae	*			
Salix sp.	*			
Non-identifiable	*			
Total number	**43**	**3**	**2**	**252**

TABLE 1. Plant taxa identified in San Chuis scattered wood-charcoal samples.

Nevertheless, the wood charcoal sample from the tumble level of the Roman tower provides significant evidence for the plant species used for the construction of the walls and roof (dated to 2050±50 BP -UBAR-216). For the roof, twigs of 10-15 mm diameter of *Erica* sp, Leguminosae and *Quercus* sp. deciduous type would have been used. Within the rest of the tumble material *Corylus avellana, Erica* sp., *Ficus carica* and *Quercus* sp. deciduous type were identified (Fig. 1).

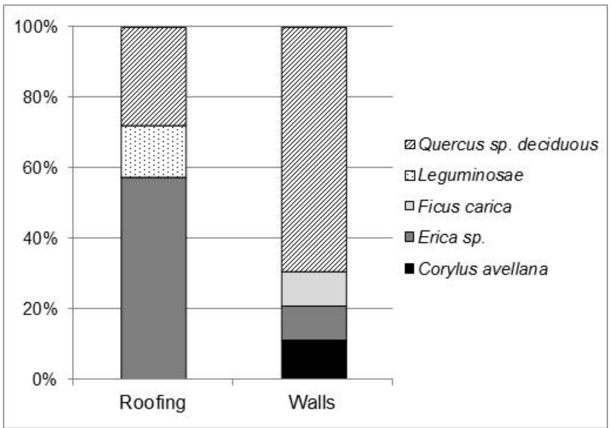

FIGURE 1. Plant taxa identified in the construction layers of San Chuis.

DISCUSSION AND CONCLUSIONS

On the basis of the analysis of wood charcoal from San Chuis we have reached the following conclusions:

- The analysis of wood charcoal material recovered from the indigenous settlement indicates that a variety of species were used for firewood in domestic hearths except for *Erica*. Deciduous oak woodland around the cave would have included mountain pines, heather, legume undershrub and some riverine taxa (ash and willow).

- For the construction of the Roman tower, heather was mainly used as roofing material and deciduous oak timber for the vertical structure; *Corylus avellana*, Leguminosae and *Ficus carica* are also included in the tumble of the structures.

-The construction timber shows morphological characteristics of two clearly defined types: gross oak beams and twigs or small diameter branches of various taxa, oak included.

- Bark preservation in some twigs shows that the timber used for the construction was mainly cut in the early autumn that is the most favorable season for obtaining the best mechanical qualities. However, a small percentage of wood collected during the non favorable season, may indicate that either construction activities were quite long-lasting or that the collected wood was stored for some time; alternatively these characteristics may reflect periodic restoration of roofs and walls.

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Identification of archaeological wood remains from the roman mine of Arditurri 3 (Oiartzun, Basque Country)

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Summary: *The study of the wood assemblage from the Roman mine of Arditurri 3, mining district of Oiasso, has focused on different types of materials in terms of sizes, use and mode of preservation. Bigger pieces of worked wood mostly preserved through waterlogging include* Quercus*,* Fagus*,* Corylus*,* Acer *and* Fraxinus*. Smaller fragments of charcoal probably related to the roasting involved in ore extraction include a bigger spectrum of* taxa *which may respond to a less selected and more opportunistic use of woodland resources.*

Keywords: *wood, charcoal, Roman, mining.*

INTRODUCTION

The mining exploitation of Arditurri in Oiartzun (Gipuzkoa, Basque Country) belongs to the Roman mining district based in Oiasso. Oiasso was mentioned in Greek-Latin sources as the polis of the furthest Vascones from the coast (Strabo, III, 4.10). It represents the border between Iberia and Aquitaine and was located at the end of the Via coming from Tarraco (Strabo, III, 4.10; Ravenna Cosmography 308.17 and 318.2). The archaeological identification of Oiasso is quite recent. J. Rodríguez Salís found in Irun the remains of the site (Rodríguez Salís and Tobie, 1971). Since then, the number of roman finds has increased and today we have the picture of a quite important urban site (ca. 10-12 ha) which included significant harbour installations and a mining district in the vicinity dedicated to the exploitation of silver, copper and iron (Urteaga, 2008a).

Arditurri, located in the metamorphic ring of the mountain massif of Aiako Harria, represents the mining outcrop which is farthest from Oiasso (6.5 km distance). The finding of the mining area happened due to the works carried out by J.A. Sein in Arditurri through royal concessions (Thalacker, 1804) when several galleries were exposed after a controlled explosion. However, archaeological works did not start until 1983 when the controversy related to the roman chronology of the galleries could be assessed (Urteaga and Ugalde, 1986).

This study focuses on the study of the wood macroremains recovered from the mine Arditurri 3 which is located in Otsamantegi valley, next to the open air quarry of Santa Bárbara (Fig. 1). Mining work here has been dated in the 1st and 2nd centuries AD (Urteaga, 2008b). It has been classified as an example of surveying gallery with passage gallery.

The wood assemblage studied here may respond to at least two main uses: 1) artifact and framework making and 2) fuel for roasting the rocks in order to facilitate the extraction of the hardest veins.

FIGURE 1. Arditurri 3, entrance of the tilted gallery.

MATERIALS AND METHOD

Two types of wood pieces have been analyzed: 1) 224 fragments that present cuts, marks or evidence of woodworking, and 2) 382 fragments of smaller pieces of wood recovered from 14 different contexts which have been defined at the mine. The state of preservation of the wood is diverse. In general it has preserved in a waterlogged environment although some of it is charred. Charring is more frequent in the smaller fragments than in the bigger pieces that present evidence of having been manipulated. During archaeological work and after fieldwork all wood fragments have been preserved in humid conditions. Charcoal was identified following the standard procedures by hand fragmentation and anatomical observation on an incident light microscope. Non charred wood was left to dry during a few hours and small fragments were thin sectioned with a razor blade so anatomical features could be observed.

RESULTS

The results of the analysis of the pieces with woodworking evidences are summarized in Figure 2.

Five taxa have been identified: *Acer*, *Corylus*, *Fagus*, *Fraxinus* and *Quercus* subg. *Quercus*. Almost half of the pieces identified belong to the group of deciduous oaks (*Quercus* subg. *Quercus*), whereas the other half is represented by maple (*Acer* sp.), hazel (*Corylus avellana*) and beech (*Fagus sylvatica*, Fig. 3) with percentages that range between 14% and 23%. Ash wood (*Fraxinus* sp.) is less abundant (4%).

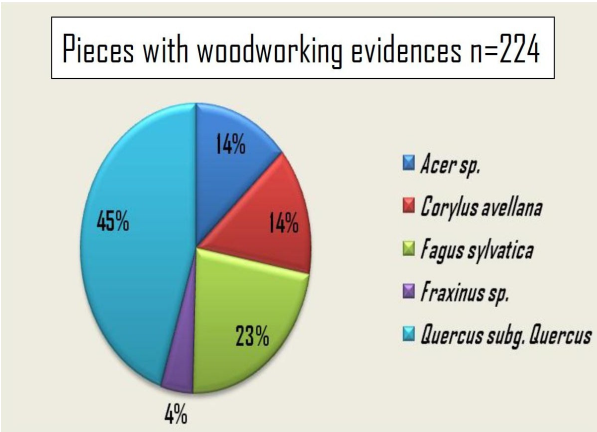

FIGURE 2. Identification of pieces of wood with cuts or evidence of craftwork.

*FIGURE 3. Shovel made of beech wood (*Fagus sylvatica*).*

As we can see in Figure 4, the smaller fragments which are mostly preserved through charring show a higher diversity of taxa: *Acer*, *Corylus avellana*, *Fagus sylvatica*, *Fraxinus*, *Ilex aquifolium*, *Quercus* subg. *Quercus*, *Quercus ilex/Q.coccifera*, *Salix*, *Ulmus*, Rosaceae and Fabaceae. The best represented wood is beech (*Fagus sylvatica*) and the group of the deciduous oaks (*Quercus* subg. *Quercus*) although it is significant the important presence of holly (*Ilex aquifolium*), maple (*Acer* sp.) and hazel (*Corylus avellana*). In smaller percentages ash (*Fraxinus* sp.), willow (*Salix* sp.), elm (*Ulmus* sp.) and the group of the woody legumes are also present.

CONCLUSIONS

The study of the Arditurri 3 Roman wood assemblage gives us information on the use of woods for crafts and for fuel in a mining exploitation. In the first case, woods with woodworking evidence and used for artifacts show a higher selection of taxa, whereas woods used as fuel, probably in the context of ore extraction, are more diverse and might respond to a more opportunistic exploitation of woodland resources in the vicinity.

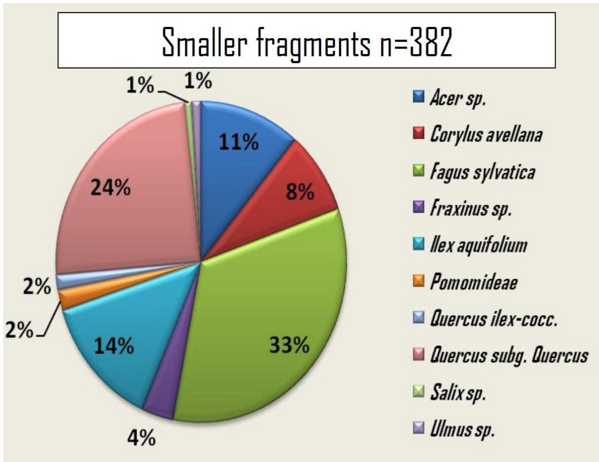

FIGURE 4. Identification of smaller wood fragments.

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Fuel wood use in a lime kiln at *Egnathia* (South-eastern Italy) during Late Antiquity

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Summary: *During the last archaeological investigation at* Egnathia *(South-eastern Italy) a lime kiln was found. The anthracological study, jointed to taphonomical and size analyses of the charcoals, allow us to define the use of wood as fuel and to recognize specific utilization of timber (carpentry wood) derived from dismissed structures.*

Key words: *lime kiln, charcoal analyses, Late Antiquity, wood management, south-eastern Italy.*

INTRODUCTION

Since 2009, the collaboration between the Laboratory of Archaeobotany and Palaeoecology of the University of Salento and the Department of Antiquity of the University of Bari has allowed to apply tailored archaeobotanical analysis at *Egnathia*. The aim of this work is to study human-environmental interaction, in particular: i) the exploitation of plant resources, ii) the identification of the catchment area.

The site is settled on the Adriatic coast of Apulia region, on the border between Messapia and Peucezia ancient regions (Fig. 1). Its location favored a long anthropic history, from the Bronze Age (16th-15th century BC) till the medieval period (10th-15th century AD). In particular, *Egnathia* has played a central role in the trade between the Mediterranean Basin and the Apulian hinterland during the Roman period and the Late Antiquity.

FIGURE 1. Location of Egnathia.

Archaeological investigations show a series of Late Antiquity structures built after the earthquake of 365 AD. In this period, in fact, *Egnathia* underwent an urban reorganization: some public buildings, such as the Baths, were re-functionalized as productive structures (e.g. lime kilns).

Actually, few studies were conducted on ancient lime kilns especially focusing on structures and on the reconstruction of the different phases of lime production (Jackson, 1973; Gelichi and Novara, 1990; Baragli, 1998; Petrella, 2007). Many ethnoarchaeological studies give information about lime kiln fuel used in Italy (De Guio, 1995; Bandini *et al*, 1999; De Guio and Bressan 2000; Balenzano and Moresi, 2004) and in other countries in the last century (Adam, 1994).

DATA AND RESULT

The lime kiln of *Egnathia* is located to the south of the Episcopal basilica (Fig. 2). The furnace was recovered filled with its original charge: calcareous stones and fuel. The furnace has a truncated cone shape and a diameter of about 3 meters.

FIGURE 2. Lime kiln found in the area to the south of the basilica.

The samples were collected from all layers of the furnace. The charcoals belong to two main dimensional categories: small (< 1 cm) and bigger charcoals (> 7 cm). The latter are slightly vitrified and characterized by radial cracking; they constitute the main part of the assemblage. The quantitative difference between the two size categories could be due to combustion activity who has acted more destructively towards the smaller branches (Fig. 3).

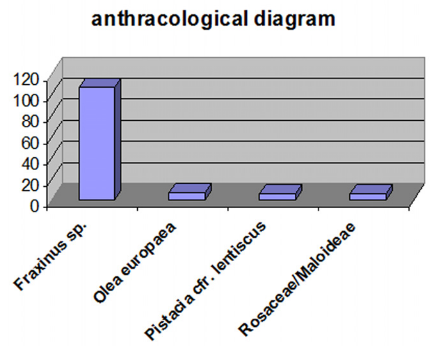

FIGURE 3. Anthracological diagram .

Anthracological analyses identified four taxa: *Fraxinus* sp., *Olea europaea*, *Pistacia lentiscus* and *Pyrus/Sorbus* type (Rosaceae/Maloideae). *Pyrus/Sorbus* has been recognized also as fuel in the hypocaust of the *tepidarium.* The larger charcoals belong exclusively to *Fraxinus* sp., while smaller fragments are related to the other species.

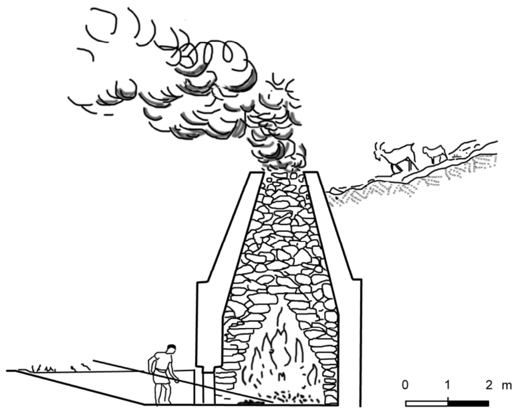

FIGURE 4. Example of a lime kiln (by Adam 1994, modified)

DISCUSSION

The ethnological examples describe the use of olive stones, almond shells and small branches as lime kiln fuel, probably due to their ability to guarantee a rich flame (Adam, 1994; Balenzano and Moresi, 2004); only in few cases wood was used (Bandini *et al.*, 1999).

In our study the fuel wood selected seems to respond to a particular demand: ash wood, defined by high calorific value, represents a probable re-utilization of carpentry material. The other taxa were used as branches to develop a flame able to reach the upper calcareous stones (Fig. 4).

CONCLUSION

The anthracological analysis of the lime kiln of *Egnathia* shows the use of fuel derived from carpentry wood and available wood taxa growing near the site: in this way the best result in terms of calorific value and duration is obtained.

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Archaeobotanical analysis in sedimentation deposits of Roman and Medieval pits in caves of NW Iberia. Cova do Xato and Cova Eirós (Lugo, Galicia, Spain)

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Summary: *The charcoal analysis results of the firewood consumption, as well as the carpological ones of seeds and fruits, in two caves with roman and medieval levels located in the eastern part of the Lugo province (Galicia), NW Iberia, are analyzed. The results arise from the anthropic exploitation of occasional or permanent sites situated in not very populated areas.*

Key words: *caves, NW Iberia, charcoal, seeds.*

INTRODUCTION

Since 2007 and under the supervision of the Grupo de Estudo para a Prehistoria do NW Ibérico of the Universidade de Santiago de Compostela[1], several archaeological sites have been dug in search for Palaeolithic settlements in the Lugo province (Fábregas *et al*., 2008, 2009). The substratum of this area, where the only few karst spaces of Galicia can be found, has allowed the formation of caves occupied since prehistoric times. In two of them, Cova do Xato (1080 m, Folgoso do Caurel, Lugo) and Cova Eirós (780 m, Triacastela, Lugo), evidence from the Pleistocene period, as well as of Roman and Medieval settlements has been registered. Both sites are situated in a mid-mountain area, in the so-called Eurosiberian climatic region. This paper summarizes the results from the charcoal and carpological analysis of the charred remains found during the excavations.

DATA AND RESULTS

The analyzed samples were found in sedimentation deposits: in a hearth in Cova do Xato and in a burnt level inside a store-pit in Cova Eirós. The flotation of sediment in meshes of 2, 1 and 0.5mm of light and specific samplings were combined. Also two pollen analyses were carried out, although the ones from Cova Eirós did not bring back positive results due to conservation problems.

During the Cova do Xato excavation, pollen samples from different strata were collected (Expósito *et al.,* 2008). The obtained data helped explaining the paleoenvironmental context in two levels of the Roman period (4th-5th century AD). In both, the arboreal pollen prevails over the NAP (between 60-80%) and *Corylus avellana* stands out -when only taking into account the AP it accounts for 80% of the total- and in less proportion *Quercus* sp. deciduous, *Betula*, *Quercus ilex/coccifera*, cf. *Juniperus* sp., *Pinus* sp. and *Alnus* sp. Cistaceae (Expósito *et al*., 2008) was the only shrub identified.

Charcoals come from the flotation of 39.5 litres of sediment (2 samples) and the manual collection of a further 46. Comparing natural vegetation with harvested firewood, important differences can be seen. The charcoal analysis has showed that *Quercus* sp. deciduous is the most common species (67.1%), even though, the most common one in the area is the hazelnut tree, which percentagewise is the third represented inside the cave. Besides oaks, other taxa from the deciduous forest and woodland undergrowth such as *Corylus avellana* (7.5%), Rosaceae/Maloideae (1.4%) and *Prunus* sp. (0.6%), as well as water bound species such as: *Fraxinus* sp. (9.5%), *Salix/Populus* (1.4%) and *Ulmus* sp. (0.6%) are predominant. Also bushes of Fabaceae (10.2%) and thermophilic bushes such as *Arbutus unedo* (0.6%) are common. The use of firewood indicates a temporary harvest of green or still humid branches, observing radial cracks in 20.6% of the charcoals, as well as vitrification in 8.2% and the reduced action of the entomofauna, only detected on *Quercus* sp. deciduous.

Regarding the carpological remains only four seeds and a fragment of wheat (*Triticum aestivum/durum*) very distorted, have been found.

For Cova Eirós 10 litres of sediment have been floated and 5 charcoals manually gathered in medieval levels. In them, they burnt firewood including species from the riparian forest or associated to humid areas such as *Salix/Populus* (27.6%), *Betula* sp. (20.9%), *Ulmus* sp. (6.6%) and *Fraxinus* sp. (5.7%). There is also an important representation of species from mixed deciduous forests: *Quercus* sp. deciduous (14.2%) and Rosaceae/Maloideae (14.2%), in less proportion *Castanea sativa* (2.8%), *Corylus avellana* (1.9%) and

[1] *Ocupaciones humanas durante el Pleistoceno en la cuenca media del Miño* (HUM/2007-63662), and *Poblamiento durante el Pleistoceno Medio/Holoceno en las comarcas orientales de Galicia* (HAR2010-21786). Ministerio de Ciencia e Innovación.

Prunus domestica/spinosa (0.9%). Taxa associated to bush formations such as Fabaceae (3.8%) and thermophilic bushes such as *Arbutus unedo* (0.9%) also appear.

In firewood consumption, we observe a temporary harvest of green or humid branches of *Quercus sp.* deciduous, Rosaceae/Maloideae and *Ulmus* sp. (5.7% with radial cracks and 1.9% with vitrification) and deadwood of *Quercus* sp. deciduous and Rosaceae/Maloideae (2.9% with entofauna action). A fragment of a *Betula* sp. wood container used as firewood in a hearth was also found.

In one of the two storage pits carbonized seeds and fruits have been found; however, these do not relate to the original use of the pit but rather to a later combustion process associated with the last phase of sedimentation when the pits were filled. The identified remains correspond both to cultivated and wild species: caryopsis of wheat cereals (*Triticum aestivum/durum* and *Triticum dicoccum/spelta*) barley (*Hordeum vulgare*), fragmented hazelnut achenes (*Corylus avellana*) and seeds from some type of flax (cf. *Linum* sp.).

FIGURE 1. Excavation process of storage pits from Cova Eirós.

DISCUSSION

Both sites studied are located in areas not very common for human settlement. Even though, we cannot specify the duration and the significance of the settlements due to the small area excavated, the presence of two pits –possibly used for storage – in Cova Eirós allow us to reject the temporary occupation of this settlement. In Cova do Xato we cannot precisely determine the occupation of the cave: whether it was opportunistic, seasonal or permanent; however, it is not only situated at a higher altitude (more than 1000 metres) but it is also in a less humanized habitat.

The charcoal analysis of Cova do Xato, in a wooded habitat, shows a majority of *Quercus* sp. deciduous as opposed to the hazelnut tree more common in the area; this is possibly related to the use as firewood. The exploitation strategy of using both trunks and small and medium size branches is regarded as being opportunistic.

In Cova Eirós, the timber consumption appears to be linked to riparian forests; maybe related to the woodland retreat during the Middle Ages, due to a strong anthropic pressure on the land –reclamation of forest land, fuel production, wood supply, etc.- (Guitián, 2001). The importance of fruit trees appears to be linked to other charcoal analysis in medieval contexts, a period where silviculture is rapidly gaining importance. References to chestnut, apple, pear, cherry or fig trees are constant in the written sources of this age (López, 2009). Even though the carpology sample is reduced, in a vegetable-rich diet, a strategy based on the growing of cereal as well as in the use of wild fruits exists.

In the vicinity of both sites, nowadays we find fields which indicate that a farming area could have existed.

CONCLUSIONS

The obtained results allow us to gain a deeper knowledge of the environmental exploitation in cave settlements in recent historical contexts. These show, not only the use of farming products, but also of seasonal or opportunistic vegetable resources in which food and wood are included. One of the possible interpretations is that we have evidence of an occasional settlement or a shepherd’s shelter in Cova de Xato and maybe a more permanent one in Cova Eirós.

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Fuel from late-antiquity smithing earths: a comparison between Lecce and Faragola sites (Puglia-Italy)

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Summary: *The results of anthracological investigations of Late-Roman/Early-Medieval smithing earths from two different archaeological contexts are here presented. The sites are located in two diverse environmental settings of Apulia region (SE Italy): P.tta Epulione, in the southern part and Faragola village in the north. Despite the great number of species available in both contexts, oak and mastic tree wood were preferred to because of their intrinsic values as fuel; nonetheless, selection cannot prescind from exploiting local resources.*

Key words: *smithy, fuel, charcoal, Late-Roman/Early Medieval, southern Italy.*

INTRODUCTION

Anthracological analyses of fuel residue from ancient forges are still very rare, even if the discovery of smithies in archaeological contexts provide an unique opportunity to understand: i) the way in which man chose fuel for mineral working and ii) the impact of such specialized activities had on the local environment. Unlike other fire-activities, such as domestic hearths, which can use straw or dung as fuel, metallurgy requires exclusively timber (or charcoal) because of the high thermal value needed.

Qualities of timber are defined by three main factors: inflammability, persistence and height of the flame and, even more, calorific value. This last one mostly qualified a timber as good fuel.

Combining archaeological observations and anthracological analysis, it is possible to: identify wood species employed as fuel in smithing; point up some pattern in the selection of timber; define the catchment basin of ancient metallurgy.

Within this work, we intend to show the results of archaeological-anthracological analyses carried out in two Late-Roman/Early-Medieval sites, located in two different environmental settings of Apulia region (SE Italy): P.tta Epulione, in the southern part and Faragola village in the north (Fig. 1).

P.tta Epulione archaeological evidence dates back to the 3rd century AD and clearly refers to a blacksmith's workshop placed in ancient Lecce, very close to a roman road. The anthracological records of those forges have been compared with the palaeoenvironmental data collected in the coeval site of P.tta Castromediano, in order to define the catchment basin and, eventually, to recognize a selection of the fuel.

Evidence at Faragola was found in the Early-Medieval levels (6th-7th century AD), which obliterated the Late-Roman monumental ruins. They provide unique information on metallurgic activities for this period in the area. Besides, being part of a wider anthracological 'campaign' carried out at the site, comparison can be made with other contexts and intentional selective patterns can be inferred.

FIGURE 1: *Localization of the archaeological sites above mentioned.*

DATA AND RESULTS

The excavation of a blacksmith's workshop at P.tta Epulione has revealed a sequence of three plans of burnt clay, layers of ash and remains of hearths, overlapped between them and characterized by abundant iron slags. Those layers could be interpreted as working plains for metallurgical activity. The three forging hearths represent different phases of use, over a brief time period (phase I: US 253; phase II: 283 and 282; phase III: 289 and 291). The working plain of phase I (US 254) was flanked by two pits, in which a pair of anvil bases were probably inserted, and a particular concentration of charcoals and ashes.

The examination of charcoal remains collected in P.tta Epulione's forges, has led to the following results:

Phase I

Forge: *Quercus ilex* type 40%; *Olea europaea* 60%;
Working plain: *Pistacia lentiscus* 60%, *Q. ilex* type 30%, *Olea europaea* 5%, *Erica* cf. *arborea* 2%, *Rhamnus*/*Phillyrea* 2%.

Phase II

Forge: *Olea europaea* 49%, *Quercus ilex* type 34%, *Erica* cf. *arborea 2%*, seeds remains 15%.

Phase III

Forge: *Olea europaea* 47%, *Quercus ilex* type 17%, *Erica* cf. *arborea 17%*, *Rhamnus/Phillyrea* 4%, seeds remains 15%.

The anthracological spectrum of smithies identified at Faragola site reveals that *Quercus* cf. *pubescens* wood accounts for 85% of the total fuel employed, while *Pistacia lentiscus* and *Rhamnus/Phillyrea,* for 6 and 9% respectively.

DISCUSSION

Anthracological analysis of P.tta Epulione clearly shows:

a) the large incidence of olive tree and evergreen oak as main fuels in smithing activity, along the whole sequence of forges;

b) the utilization of pruned branches of olive trees as fuel, because of the contemporary presence of olive charred fruits in archaeobotanical records.

c) the charcoal mound, found next to the forge of phase I (US254), represents the results of cleaning actions and refers to the second last charge of the forge, in which mastic-tree wood was mainly used.

d) all the taxa attested as fuels belong to the landscape described in the P.tta Castromediano anthracological record. *Quercus ilex* and *Pistacia lentiscus* trees refer to the maquis xerophytic vegetation, as attested in ancient maps and documents, while *Olea europaea* reminds of the particular countryside landscape (Primavera *et al.,* in press).

Fuel identification in Faragola reveals:

a) Oak was the main employed taxon, while mastic tree and buckthorn were probably used as lightning elements.

b) Comparison with hearth and kiln fuel, as well as carpentry, reveal that the elements found in the forges were part of the local natural environment. This included, on the hill-top, coppice dominated by *Quercus* cf. *pubescens*, *Ulmus* cf. *minor*, *Acer* sp., *Fraxinus* cf. *excelsior*, and, in the sunny river valleys, termophilus wood made by *Rhamnus/Phillyrea*, *Pistacia lentiscus*, *Juniperus* sp. (Caracuta and Fiorentino, 2009).

CONCLUSION

The anthracological analyses carried out in the Late-Roman site of P.tta Epulione and the Early Medieval settlement of Faragola, reveal a programmatic selection of wood.

Despite the great number of species available in both contexts, oak and mastic tree wood were preferred because of their intrinsic values as fuel. Nonetheless, the selection cannot prescind from exploiting local resources. Evergreen oak together with olive were preferred in the south, where xerophilous wood is much more attested, while deciduous oak and buckthorn were more abundant in the north, where coppice is widespread.

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Wood for fuel in Roman hypocaust baths: new data from the Late-Roman *villa* of Faragola (SE Italy)

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Summary: *Archaeological excavations in the villa of Faragola brought back to light a complex system of hypocaust baths dated to the Late-Roman period. This finding, which represents one of the most important thermal complexes in southern Italy, offered the possibility to correlate the traditional study on the architectural characteristics with the analysis on charcoal remains. Results of radiocarbon dating define the chronological pattern of use, while anthracological analysis reveals an intentional pattern of wood exploitation*

Keywords: *Fuel, charcoal, hypocaust baths, Late-Roman, villa, South-Italy*

INTRODUCTION

Traces of hypocaust are widespread all across the Roman Empire, but whereas the structure of these systems has been widely documented and several analyses were carried out to identify the way of functioning, very little is known about the wood used as fuel (McParland *et al*., 2009).

Archaeological excavations in the *villa* of Faragola brought back to light a complex system of hypocaust baths dated to the Late-Roman period. This finding, which represents one of the most important thermal complexes in southern Italy, offered the possibility to correlate the traditional study on the architectural characteristics with the analysis on charcoal remains.

Investigations reveal that the plan extends over a vast area of more than 1000 square metres: a long corridor led to a room with a geometric mosaic which guaranteed access to a locker room and a huge room paved with a polychrome mosaic decoration for entertainment and gymnastic exercises (*apodyterium*). The route included a stop in the cold bathroom (*frigidarium*), with pools filled with cold water called *natatio*. From the *frigidarium* it was possible to move progressively towards the heated area, crossing the two *tepidaria*, the huge *caldarium*, and two *sudationes*, heated rooms used for massages and rest.

The hypocaust, which in Greek means 'fire underneath', provides the heat for the warm and hot rooms. The principle of such a system is that a furnace, or furnaces, are needed either to provide direct heat from burning (exhaust gases), or to heat water and generate steam. Furnaces were placed near *calidaria*, which had the floor popped up by cylindrical supports made of brick and limestone, called *pilae.* By covering the ground along the hypocaust system, flue gas arose from charcoal and/or wood burned in a furnace (*praefurnium*), which also provided heating of the bath. The water was heated in copper or bronze tanks above the furnace combustion chamber. Hot flue gas would also heat up the water in the pool through *chimneys* placed at the corners of the room, which provided flue gas flow. Together with the heating through the ground, many baths were also heated through the walls by structural elements referred to as *tubuli*, which were usually made of brick (Basaran and Ilken, 1998)

Despite the great importance of fuel in such structures, little is known about the types of fuel used to fire Roman hypocaust furnaces. It is often stated that the fuel to feed the hypocaust would have been wood (Yegül, 1992), a hard wood (Blyth, 1999). However, it is also suggested that charcoal might have been used as it would have been easier to generate more heat (Rook, 1978, 1992, 1993).

The anthracological analyses of Faragola give information on the wood selection and the impact that the thermal system had on the local environment.

DATA AND RESULTS

Three different *praefurnia* (Amb. 36, 52, 48) were sampled and tree-branches were radiocarbon dated to get the correct chronological pattern of use. The section of the *praefurnium* of Amb. 36 was sampled and a young branch of *Quercus* deciduous was dated to 70-260 cal. AD (LTL4383A). Elements of the mosaic decoration limited the use of this first nucleus to the 2nd-3rd cent. AD. Microstratigraphical excavation was carried out on burned remains of the furnace of Amb.52 and several layers were identified. Residues of charcoals and ashes, resulting from cleaning, are buried under clay floors following a cyclical pattern. Two samples of oak (LTL 4382A and LTL 4381) limited the use of Amb.52 to the 4th-5th cent. AD.

The last radiocarbon measurement, obtained from a young branch of mastic tree from the furnace (Amb.48), dated the last thermal complex to the 5th-6th cent. AD (Fig.1).

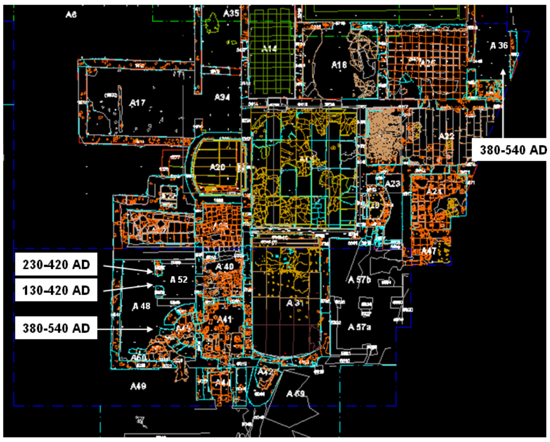

FIGURE 1: Map of the Faragola baths with spots on radiocarbon dates

The anthracological analysis was carried out on 1859 charred wood fragments collected in the three furnaces. Three taxa, *Quercus* deciduous, *Pistacia lentiscus* and *Rhamnus/Phillyrea* are ubiquitous, followed by *Sorbus* sp. and *Ulmus* sp. Few remains of *Quercus* type *ilex*, *Punica granatum*, *Populus/Salix*, *Acer* cf. *campestre*, *Olea europaea*, *Juniperus* sp., are also attested (see especially Amb. 52).

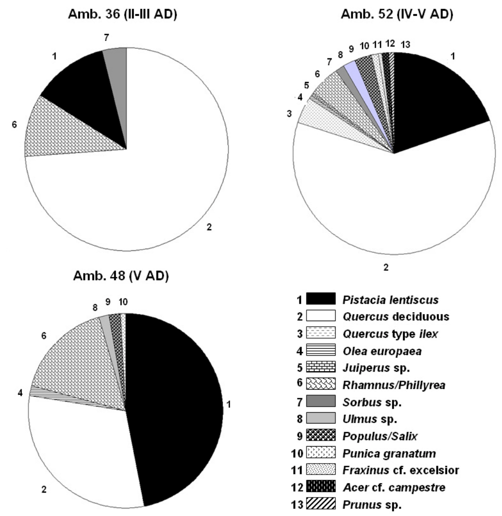

FIGURE 2: Percentages of wood species found in the praefurnia.

DISCUSSION

The study carried out on the fuel of the thermal complex represents only a small part of the larger anthracological investigation which took place in the Faragola site. The information provided by the archaeobotanical analysis regard both the Late-Roman villa and the Early Medieval settlement which spread over its ruins.

A complex system of exploitation of natural resources was pointed out and changes in the vegetal cover were hypothesised from the 2nd to the 7th cent. AD. At least three different catchment basins were identified: the coppice on the hill-top, the thermophilous wood in the sunny valleys, and the riparian vegetation along the local streams. Fuel used in the hypocaust baths seems to come especially from the first area, where *Quercus* deciduous would have grown. Partially exploited was also the thermophilous wood where *Pistacia lentiscus* and *Rhamnus/Phillyrea* were collected. The impact that the human community had on the environment during the Late-Roman phase led to changes in wood supply during the following period. The employment of *Quercus* deciduous as fuel was limited to specialized activities, while minor essences were preferred for common use (Caracuta and Fiorentino, 2009).

CONCLUSION

The analysis of charred remains collected in three different *praefurnia* of the thermal complex of Faragola opens new perspectives in the study of hypocaust baths. Despite the long use of the system, from the 2nd to the 5th cent. AD, a strong continuity in wood selected for fuel can be seen. Different catchments were over-exploited until socio-political conjunctures signed the abandonment of the villa.

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An attempt to reconstruct forest communities on the basis of plant material from Roman Iron Age in Poland

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Summary: *The change in forests from the Late Pre-Roman to Late Roman Iron Ages is discussed. The reconstruction is based on the remains (charcoal, seed and fruit) of trees and bushes found at the selected archaeological sites located in different regions in Poland. The numerous remains suggest that the most common or the most often exploited forest communities were mixed forests with a domination of Scots pine (*Pinus sylvestris*) and oak (*Quercus *sp.).*

Key words: *charcoal, forest, Roman Period, Poland.*

INTRODUCTION

Charcoals occurred most numerously and most abundantly among the identified plant remains from archaeological sites in Poland. In this paper, results of macroscopic analyses of plant remains were completed from different archaeological sites and features (burial, hearths, pits and other) dated to the Late Pre-Roman, Early Roman and Late Roman periods (2nd century BC to ca. the middle of the 5th century AD) (Lityńska-Zając, 1997, 2001). Archaeobotanical sites represent the following cultures: Puchov, Przeworsk, Wielbark Cultures, Tyniec and Dębczyno Groups and West Batlic circle.

RESULTS

Remains of trees and shrubs from the Late Pre-Roman and Roman Iron Ages are on the most part charcoals, charred and uncharred seeds and fruit and imprints of leaves and seeds. Altogether, based on those data, 53 taxa were identified, including 35 species, 11 identifications to the genus and 1 to the family levels. The species or genera found have been grouped according to their occurrence in present-day forest communities based on the studies of W. Matuszkiewicz (2001) and K. Zarzycki *et al*. (2004).

Charcoals have been found from the Late Pre-Roman Iron Age at 4 sites, belonging to the Przeworsk culture. Oak (*Quercus* sp.), Scots pine (*Pinus sylvestris*) and ash (*Fraxinus excelsior*) were the most common species, present at 2 sites. The most common remains are those of the oak and then poplar or willow (*Populus* sp./*Salix* sp.) and elm (*Ulmus* sp.). Material from the Late Pre-Roman period is very poor and represents only the region of Little Poland.

11 taxa from 8 sites have been described on the basis of charcoal from the Early Roman Period. Furthermore, hazelnut (*Corylus avellana*) occurred at 3 sites, birch (*Betula* sp.) at one site and elm also at one site. The most common were the remains of oak, present at 6 sites and Scots pine found also at 6 sites. Charcoal fragments of these two species occurred in greater numbers than others whereby pine fragments were more common than oak fragments. The charcoals were found at sites belonging to various cultures, namely Przeworsk, Puchov, Wielbark and the West Balt circle.

On the basis of a small number of sites and preserved specimens found there, it is difficult to indicate what causes differences in the occurrence of particular taxa apart from the fact that the research material was scanty.

Remains of trees and shrubs from the Late Roman Period were identified at the largest number of sites, 31, and were strongly differentiated. The ones that most often survived were Scots pine (21 sites), oak (14 sites) and coniferous trees impossible to identified even to the genus level (14 sites). As far as the number of fragments is conserved, the most numerous are from oak and then Scots pine, spruce and/or larch *Picea abies/Larix* sp. and hornbeam *Carpinus betulus*.

In the sets of trees and shrubs described herein, we can notice a large diversity of taxa preserved with a clear dominance of several species, especially Scots pine and oak.

DISCUSSION AND CONCLUSIONS

An analysis of trees at archaeological sites on the basis of palynological (Dybova-Jachowicz and Sadowska, 2003) and isopollen maps (Ralska-Jasiewiczowa, 2004) indicated that charcoal remains of species with borders of their ranges on Polish soil were found at sites located inside these ranges. This was confirmed for the most part by the similarity of palynological and anthracological data. This also enabled us to indicate certain differences in the development of the vegetation from the Roman period in several geobotanical regions.

A reconstruction of forest communities indicates which communities could have developed in the vicinity of settlements. Numerous finds of pine and oak in nearly all geobotanical regions and chronological units suggest that coniferous mixed forest occupied large areas. In the Suwalsko-Augustów region (north-east Poland) numerous pine remains confirm the occurrence of humid coniferous mixed forest similar to that found today in northern Poland. Out of the genera of trees and shrubs found, the following were capable of growing in forest habitats located on airy ground: maple (*Acer* sp.), beech (*Betula* sp.), ash, linden (*Tilia* sp.), hornbeam, hazel and spindle tree (*Euonymus europaeus*) bushes. Wood was also found coming from marshy swamps in which poplar, elm, ash and willow are capable of growing. These last taxa occur more often at Late Roman sites. This fact may indicate a greater exploitation of wood from the forest in this complex. Some of these trees are present in macroscopic fragments only in certain regions, for example spruce on the Little Poland plateau or fir (*Abies alba*) in the Carpathians. This indicates regional differentiations in forest complexes.

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Woody plant resources in the medieval site of l'Esquerda (Roda de Ter, Barcelona, Spain)

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Summary: *L'Esquerda is located at the NE of the Iberian Peninsula. The site has provided charcoal samples from the Iberian period to the Middle Ages. We present here new results from the Early Middle Age and principally the Late Middle Age. The catchment area of forest resources is reduced at the vicinity of the site. No outside contributions are observed. An important aspect is the relationship between* Buxus sempervirens *and* Quercus *type deciduous in domestic contexts. Riparian forest is present in the anthracological record too. Discussion is also made on wood selection and the rest of the economic activities in relation to forest exploitation.*

Key words: *anthracology, L'Esquerda, Middle Ages.*

INTRODUCTION

The Iberian and Mediaeval site of l'Esquerda is situated in a meander of the Ter River, between 450 and 480 m asl (Fig. 1). Since the eighties, we have analyzed macro remains (Cubero *et al*., 2008) of different cultural phases of the village, the Iberian period (Cubero, 1999), the Early Middle Age and also the Late Middle Age (Cubero and Ollich, 2008).

DATA AND RESULTS

The Early Middle Age charcoal samples originate from a few pits; instead Late Middle Age samples come from domestic contexts, like habitat levels, beams, and fire or handle tools. Wood has been gathered with the sediment or isolated. In the second case remains are single and visible to the naked eye. In some circumstances, it has been able to have a special idea of the wood distribution inside the houses.

Three main groups could be assumed, (1) riparian and deciduous riverside forests were developed, (2) *Quercus* deciduous was dominant with shrub and bush communities (3) and also signs of agricultural activities are recorded (Table 1). Attention should be paid to the relationship between *Quercus* deciduous and *Buxus sempervirens.* This relation is apparent already in the Iberian period, but during the Middle Ages it seems slightly modified: *Buxus sempervirens* is less important now.

DISCUSSION

The obtained results are a first approximation of the medieval landscape, especially of the Early Middle Age. This extraction context is not comparable with other contexts from the Late Middle Age. The samples should be increased because the number of remains is not meaningful. The anthracological record shows a dominant and exploited oak forest with elements from evergreen forest, some fruit trees, cultivation of nut trees, and a riparian forest little used. Oak was used in building for beams, therefore its great ubiquity.

CONCLUSIONS

Little anthacological research is carried out in the context of the medieval period. This king of information allows us to gather a basic knowledge of l'Esquerda (*Roda civitas*) environment and its surroundings. So, it is necessary to continue this type of analyses to understand the ways in which the forest was exploited associated at agriculture and handcraft.

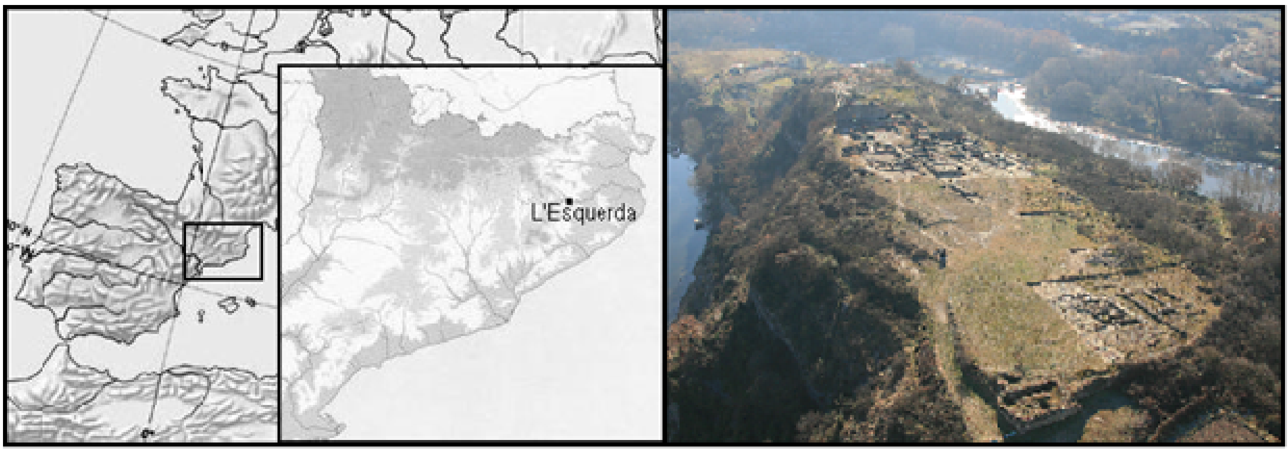

FIGURE 1. Situation and aerial view of L'Esquerda (Masies de Roda-Roda de Ter).

Taxa	E M A (500 AD)	L M A (1200-1300 AD)
Alnus sp.	2	7
Populus /Alnus sp.		1
Populus sp.	6	5
Salix sp.		14
Ulmus sp.	3	53
Buxus sempervirens	6	156
cf. *Viburnum tinus*		8
Pomoideae (*Sorbus*)		1
Prunus avium / *cerasus*	4	2
Prunus cf. *spinosa*	5	
Prunus sp.	6	5
Corylus avellana		2
Quercus type caducifolia	50	332
Quercus type sempervirens		1
Quercus sp.	9	1
cf. *Catanea sativa*		1
Fagus sylvatica	3	18
Juglans regia		16
Total	100	623

TABLE 1. Taxa identified at the Middle Age site of L'Esquerda (NR).

ACKNOWLEDGEMENTS

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Woodland use in Gasteiz during the Middle Ages (700-1200 AD)

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Summary:
Wood charcoal retrieved from archaeological contexts dated ca. *700-1200 AD in Vitoria-Gasteiz (Northern Iberia) suggests that* Quercus *subg.* Quercus*,* Fagus sylvatica *and Rosaceae where the main fuels used in domestic activities. The use of* Fagus *increases through time and* Prunus *and Pomoideae are very important in contexts related to metallurgy.*

Key words: *woodland, Middle Age,* Quercus*,* Fagus*, metallurgy.*

INTRODUCTION

The Project of restoration and excavation of the Santa María Cathedral of Vitoria-Gasteiz (Basque Country, Spain) has included as one of its main areas of research the analysis of different types of bioarchaeological material in order to shed light on past landscape and on the economy and subsistence in Gasteiz during the Middle Age (Azkarate and Solaun, 2009). The excavated contexts have been sampled for plant macro-remains, faunal remains and pollen.

The village of Gasteiz (named Vitoria in 1181 through the Fuero given by the King of Navarre Sancho VI the Wise) has a strategic location in the centre of the “Llanada alavesa” plateau, a crossroads between the Meseta, Ebro Basin, Western Pyrenees and Atlantic Valleys. From the end of the 7th century or early 8th century AD a permanent settlement can be documented.

Here we present the result of the wood charcoal analyses which have focused on the period from the 8th to the 12th century AD, a moment when written records are particularly few for this area. The aim of this work has been: 1) to identify the charred wood preserved in the different types of contexts, 2) to offer new information that helps us understand past vegetal landscape around the site, 3) to know the selection and exploitation of woodland resources by the inhabitants of the village, and 4) to assess the existence of woodland management practices during this period.

MATERIAL AND METHODS

During the excavation of the immediate area around the Santa María Cathedral a systematic sampling strategy has been carried out. For wood charcoal 44 samples have been analyzed with an average of 40 l of sediment per sample being processed through flotation. They come from stratigraphic units with different origins and functions. The number of fragments analysed is higher for the earlier centuries (8th-10th) due to context availability which is smaller in the later periods. Here we present: 1) scattered wood charcoal from general contexts which most probably derives from domestic fuel, and 2) wood charcoal from stratigraphic units where primary iron metallurgy is attested (8th and 9th centuries AD only). Both types of contexts show different results. Fragments bigger than 4 mm have been identified and the samples include both, the flot and the charcoal collected from the residue.

RESULTS

Scattered charcoal (700-1200 AD)

The results of the analysis of scattered charcoal are summarized in Figure 1. There is a higher diversity of taxa during the earlier centuries, including the samples from metallurgical activities (*Pinus, Acer, Cornus, Corylus, Fagus, Fraxinus*, Rosacae, *Quercus* subg. *Quercus*, *Quercus ilex/Q.coccifera, Salix, Ulmus, Rhamnus* and most probably *Juglans*). During the first centuries, according to our results, the most important fuel in the village is deciduous *Quercus* wood followed by Rosaceae (which here includes *Prunus*, Pomoideae and Rosaceae) and some *Fagus sylvatica*. Beech wood increases its importance through time and eventually becomes the most important fuel during the second half of the 11th century and during the 12th century (Fig. 1). Although we must bear in mind that the number of fragments analysed for these last periods is lower, it probably reflects a major trend. The rest of the fuels have a minor representation with the exception of *Fraxinus* during the first half of the 11th century and *Corylus avellana* during the 12th (both close to 10%).

Contexts linked with iron metallurgy (8th and 9th centuries AD)

Contexts associated with the primary reduction of iron ore have been detected in the earliest occupations (8th and 9th centuries AD). Rosaceae wood (*Prunus* and Pomoideae) are the most important fuels here (almost 70% of the total) followed by deciduous oaks (18%)

and *Fagus sylvatica* (8%). Other woods such as *Acer*, *Cornus*, *Corylus*, *Fraxinus*, *Salix* and *Ulmus* are present in percentages lower than 2% (Fig. 2).

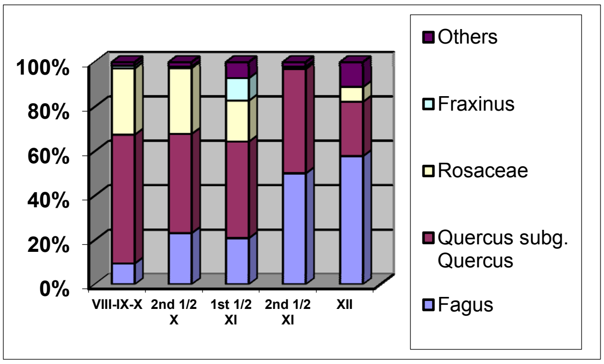

FIGURE 1. Summary of the scattered wood charcoal not linked to metallurgy identified along the sequence from the Cathedral of Vitoria-Gasteiz (n=1493).

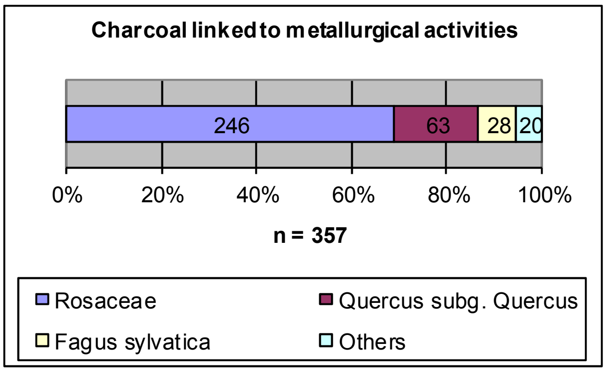

FIGURE 2. Summary of charcoal results from wood coming from contexts where primary reduction of iron ore has been attested.

DISCUSSION

As a major trend in the charcoal samples not linked with metallurgy, we can see the general importance of *Quercus* wood and progressively of *Fagus* which eventually becomes the main fuel during the 11th and 12th centuries. Different explanations might be suggested taking into account that *Quercus* formations would be the potential ones in the immediate vicinity of the village (Aseginolaza *et al*., 1992): 1) a growing impact in *Quercus* woodlands which might result in overexploitation, 2) an extension of *Fagus* in the plateau where the site locates, 3) cultural preferences and changes in fuel and raw material use, and/or 4) changes in wood catchment areas.

The selection of Rosaceae wood (at least *Prunus* and Pomoideae) for iron reduction seems clear maybe due to their firing properties when used (density, size).

CONCLUSIONS

According to the contexts analysed, the main wood used during the Middle Ages in Gasteiz are *Quercus* subg. *Quercus, Fagus sylvatica* and Rosaceae. The importance of *Fagus* increases through time and *Prunus* and Pomoideae are particularly important in contexts related to the reduction of iron ore. There are a higher number of taxa during the earliest medieval centuries. Until the second half of the 11th century we suggest a diversified, maybe opportunistic exploitation of woodlands next to the site. From that moment the importance of *Fagus sylvatica* seems to increase significantly, something that might be related to an organized exploitation of the beech woodlands located in the mountains away from the plateau where the village is located. We suggest this might reflect a change in the main wood catchment areas of the site. As cautionary notes we must say that the number of fragments and samples analysed is bigger in the older periods and, thus, we find here a higher reliability and also a higher probability of minor taxa to appear. Also, the Fuero of Vitoria (1181) suggests the existence of different supply areas of wood for building and for fuel, both with free and restricted access: "Y donde quiera que halláreis madera para hacer casas, y leña para quemar, tomadlas sin ninguna contradicción, excepto las cosas conocidas y defendidas en las cuales no está permitido su uso".

ACKNOWLEDGEMENTS

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Anthracology in the Caves of Fuentes de León (Badajoz, Extremadura, Spain): notes for the characterization of the plant environment of the neolithic communities and Roman period of the SW of the Iberian Peninsula

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Summary: *We present a preliminary study of archaeological wood charcoal macro-remains of some caves of the Natural Monument of Fuentes de León (Cueva de Los Postes and Sima de Caballos). The results are summarized in a particular anthracologic sequence that makes it possible provide new data on the palaeoecological and palaeoenvironmental evolution inside the SW of the Iberian Peninsula between 7500 and 2000 BP.*

Key words: *Anthracology, plant environment, Holocene, Neolithic, Copper Age, anthropic intervention.*

INTRODUCTION

We report here preliminary anthracological results from two of the cavities that form the Fuentes de León Natural Caverns Monument (Badajoz, Extremadura, Spain) to add to anthracological and archaeobotanical record which, since the 1990s, has been systematically developed in our region and the surrounding areas. Although excavation work is still in progress, including the recovery of plant macro-remains, we present anthracological data obtained up to the 2007 campaign which encompass the funerary deposits from Cueva de Los Postes from between approximately 7500 and 4500 BP, and the Roman occupation of the Sima de Caballos in the first centuries of our Era.

The recovery of anthracological samples from these sites consisted of a mixed strategy of direct collection, both dry and wet sifting of the charcoal, and floating the sediment by stratigraphic unit and excavation grid. This protocol allowed us to recover a high number of scattered remnants of charcoal on which we have made an initial anatomical analysis of 3,117 fragments, of which the distribution by context and stratigraphic unit are summarized in the anthracological diagram of Figure 1.

DATA AND RESULTS

3117 charcoal fragments have offered a taxonomic listing of 24 determinations in addition to the "non-identifiable" group. The set of taxa are divided in two gymnosperms (*Pinus nigra-sylvestris* and *Juniperus* sp.), twenty-one dicotyledonous angiosperms (*Alnus glutinosa*, *Arbutus unedo*, Cistaceae, *Erica* sp./Cistaceae, *Erica* sp., *Fraxinus* sp., Labiatae, Leguminosae, *Olea europaea*, *Phillyrea*/*Rhamnus alaternus*, *Pistacia lentiscus*, *Pistacia terebinthus*, *Populus*/*Salix*, *Quercus ilex-coccifera*, *Quercus* sp., *Quercus* sp. t. evergreen, *Quercus* sp. t. deciduous, *Quercus suber*, Rosacea t. Maloidea, *Rubus fruticosus* and *Viburnum tinus*) and one monocot angiosperm (cf. Monocotyledon).

The measurements allow us to suggest the existence in the environment of the caves of a panorama of complex vegetation composed of conifers (which in the case of the pines had always been considered introduced in our region), a greater diversity of oaks, as well as riparian elements, in contrast to the types of vegetation found today in this environment such as mesophylls cork and oak (Devesa, 1995).

If we look at the results sequentially, anthracological data from Fuentes de León provide a glimpse into an evolving vegetation in which environmental and anthropogenic factors intervene in its historical development (Fig. 1).

Thus, the base units of the diagram (SU's 12 and 11), with an absolute dating of 7360 ± 50 BP, although dominated by sclerophyllous-evergreen vegetation highlighting the relative values of *Olea* and to a lesser extent, *Quercus ilex -coccifera*, are the only ones that show the presence of mountain pine character accompanied by *Juniperus* sp.

The absence of *Pinus nigra-sylvestris* and *Quercus* sp. t. deciduous and character point of *Juniperus* sp., together with the maintenance of the thermophilic vegetation in the EU's 10 to 8 are the arguments that allow the establishment of a new phase in the anthracological sequence between 7000 and 5445±40 BP.

It would be from this time coinciding with the EU's 7 to 5, culturally linked to the Copper Age, when the vegetation shows signs of a drastic transformation related to human intervention on the environment. In this sense, the dramatic decline in *Olea* curve and less of other oaks such as *Quercus suber*, with the notable increase of bushes and shrubs such as *Arbutus*, *Pistacia*, Cistaceae and Leguminosae, among others, are symptomatic evidence of the significant transformation of the environment that occurred at that moment, perhaps as part of a consolidation period of the producing societies as we seem to detect during the

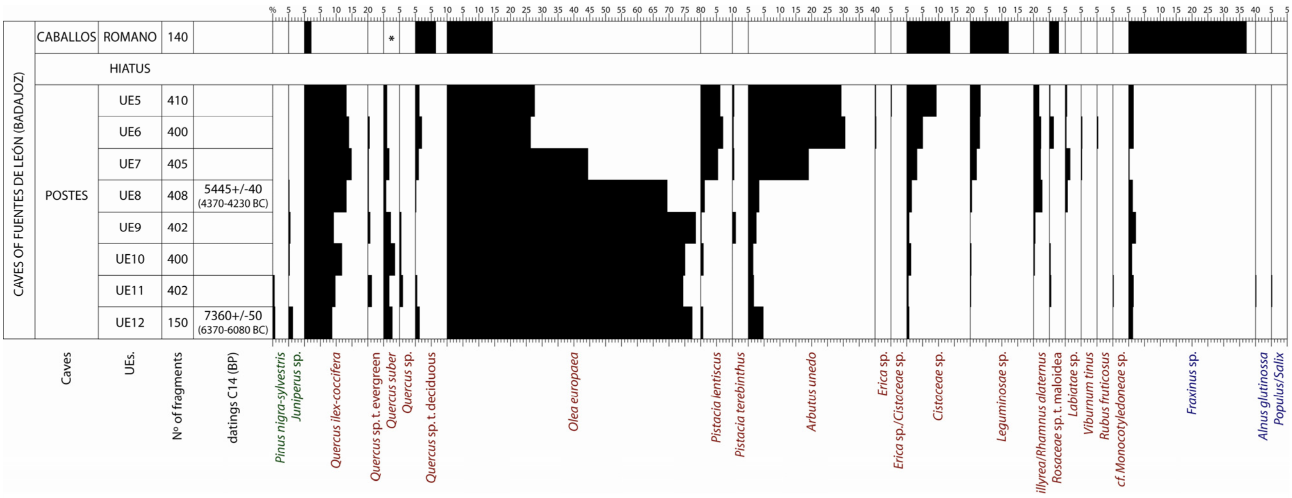

FIGURE 1. Anthracological diagram of Fuentes de León's caves (Badajoz, Extremadura, Spain).

Chalcolithic of the Guadiana Basin (Enríquez, 1990). This degree of human intervention could be extended to the Roman phase of Fuentes de León, although the recovery context of the anthracological samples and the low volume of the same force us to be cautious at the moment.

DISCUSSION

The sequence of vegetation offered by the anthracologic study of Fuentes de León allows, for the moment, to expand the documented view which in this area we have so little information in SW Spain. The establishment of sclerophyllous-evergreen vegetation of thermophile character does not appear to be unique thereof, insofar as some anthracological records in the Portuguese Tagus (Figueiral, 1998) and pollen from the peneplain of Caceres show a similar profile to chronologies of Old and Middle Neolithic (López, 2006). However, the picture of the vegetation of the SW does not appear to be uniform. In these same periods, the vegetation spectra varied according to the biogeographic context which we analyzed from the interior (Duque, 2004; Carrión, 2005) or Portuguese coastal and sublittoral (Mateus and Queiroz, 1993).

Within this scenario, the presence of mountain pine (*Pinus nigra-sylvestris*) in Fuentes de Leon, although always timely documented, seem to repeat anthracological sequences like those of the river Sever (Duque, 2004) and palynological of the River Tajo (López, 2006) with chronologies between 8000 and 6000 BP.

In one sense, the most obvious signs of transformation of natural vegetation in the peninsular SW appear to begin around the periods documented at the caves of Fuentes de Leon with the process of reduction of forest elements and the extension of a diverse series of bushes and shrubs, to which the strongest signal begins to be detected during the Copper Age of SW Spain.

ACKNOWLEDGEMENTS

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Protohistoric Anthracology in the middle valley of the rivers Guadiana and Tajo (Extremadura, Spain)*

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Summary: *We report here anthracological data obtained from proto-historic archaeological sites in the middle valleys of the Guadiana and Tajo over the past two decades, articulated in two laboratory areas: Vegas Altas-La Serena in the Guadiana and Penillanura Cacereña in the Tajo.*

Key words: *Anthracology, palaeoecology, palaeoenvironment, timber, Final Bronze, Early Iron Age, Second Iron Age, Romanization.*

INTRODUCTION

One of the shortcomings and differences accused of archaeological research in the area SW of the Iberian Peninsula has to do with the scarcity of archaeobotanical studies, including anthracological studies.

Since the 90's of last century, thanks to a lever of the move by our university by Dr. Gil-Mascarell, began to integrate the archaeological research projects of the Department of Prehistory at the University of Extremadura this type of issues (Rodríguez, 1998 and 2004), first establishing a framework for collaboration with researchers from the University of Valencia (Grau *et al*., 1998) and later with the training of researchers for doctoral theses (Hernández, 1999; Duque, 2004a).

The result of all this, we bounded geographical frameworks within this vast territory with anthracological sequences spanning the I millennium BC. One of them is in the regions of Vegas Altas-La Serena in the south of Extremadura, in the middle valley of the Guadiana with anthracologial studies of sites such as Magacela (Badajoz) - VIII century BC, II-I centuries BC and I century AD-, Manzanillo (Villar de Rena, Badajoz) - VII-VI centuries BC-, La Mata (Campanario, Badajoz) -VI-V centuries BC- and Entrerríos (Villanueva de la Serena, Badajoz)- IV-III centuries BC- (Duque, 2004a and in press; Duque and Pérez, 2009). In the northern region of Extremadura, associated with the valley of the Tagus, the Penillanura Cacereña, we are implementing an action plan that, in the immediate future, we will obtain an anthracological sequence comparable to that of the Guadiana from the results already obtained in the Sierra del Aljibe (Aliseda, Cáceres) (Grau *et al*., 1998; Grau, 1999; Duque, 2004) -VIII-V centuries BC and II-I BC-, the ongoing work of La Ayuela (Aldea del Cano, Cáceres) -VII-V centuries BC-, and the possible archaeological interventions in the pre-Roman settlement of Sansueña (Aliseda, Cáceres) -IV-III centuries BC-.

DATA AND RESULTS

The anthracological study all of these sites have been based on microscopic analysis of light reflected from 24,482 pieces of coal which have obtained a taxonomic list of 37 determinations sites scattered as shown in Figures 1 and 2.

DISCUSSION

The anthracological data obtained so far for the moment let us point out in summary form a range of issues such as greater diversity and complexity that shows the structure of the vegetation when compared with the series of current vegetation of these areas: oak acidophilic and basophilic in the Vegas Altas-La Serena and holm oak and cork for the Penillanura Cacereña. On the contrary, these are recurrent in all the analytical elements are present that show trees and shrubs or a greater diversity of vegetation series in the past or greater complexity of these (Figures 1 and 2).

On the other hand, the presence of conifer Mediterranean type is evident in most of the analytical although residual values. Matter that makes us once again propose the presence of the same naturally in the vegetation of these areas. A circumstance which also can be seen clearly in the use of these species is to build at different times of the early history (Duque, 2004b and in press).

Another interesting comment is about the dynamic that show anthracological diagrams which in general is a greater impact on the environment as we approach the final centuries of the I millennium BC. Circumstance that we can correlate with the agricultural economy of these spaces in addition to the livestock and the cultivation of cereals and pulses, we observe the development of arboriculture at least from the V century BC.

* National Project, Ministry of Science and Innovation: HAR2010-14917 (2011-2013).
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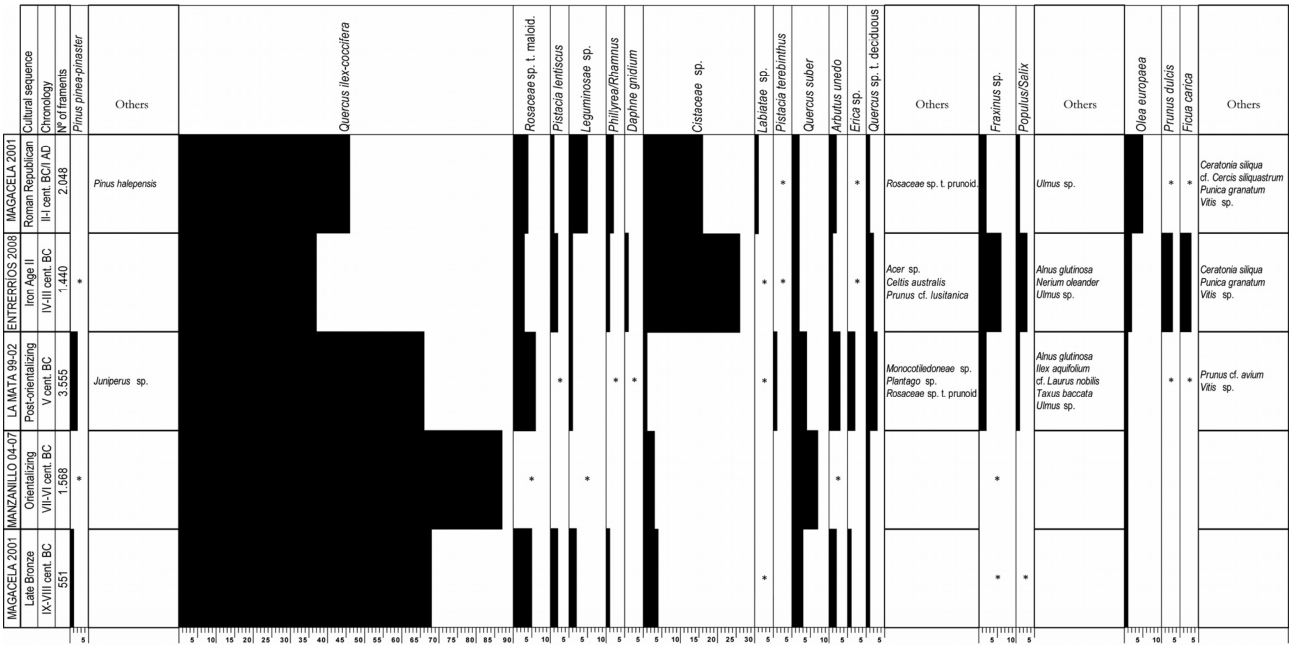

FIGURE 1. Anthracological diagram of Vegas Altas-La Serena.

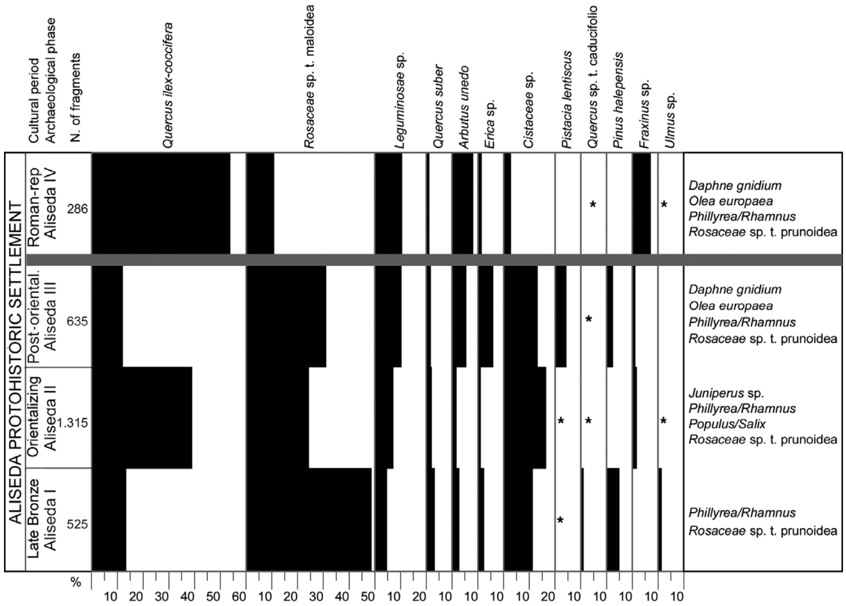

FIGURE 2. Anthracological diagram of the settlement of the Sierra del Aljibe (Aliseda, Cáceres).

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Interpretation of firewood management as a socio-ecological indicator

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Summary: *We present and discuss the contribution of conceptual and ethnobotanical approaches for understanding firewood management in pre-industrial societies based on biotic ecology (hunting-fishing-gathering, pastoralism, agriculture). The elaboration of a "chaine opératoire" whose final product is fire and that is based on a common knowledge allows us to highlight complex ecological and cultural processes linked to firewood management. However, ethnobotanical methodology and models are rarely directly applicable to charcoal analysis. It is suggested that dendrometical tools and ethnoarchaeological data must be developed to improve our understanding of firewood management as a socio-ecological indicator.*

Key words: *charcoal analysis, fuel, firewood, dendrometry, ethnoarcheobotany*

INTRODUCTION

Humans belong to a complex adaptive system, whereby societies integrate with their environment through systems of production, exchanges, and transformations. These interactions and adaptations can be at least partially understood through the study of plant resources, which form the basis of subsistence and combustion fuel for human economies. The transition from a system of hunter-gatherers to one of pastoral-farmer-producers 8000 years ago in Western Europe accelerated these processes of "reciprocal influences". Archaeobotany therefore, is a discipline situated at the heart of these questions, and which allows us to understand the forms of co-evolution between humans and the management of plant resources over the *longue durée* (Thiébault, 2010).

The production of fire for heating, defense, light, cooking, and the production of goods is a technological act and constitutes in itself a socio-economic activity, dependant on the social context (Dufraisse *et al*., 2007). It is important to consider whether anthracology represents an adequate approach to comprehend this technological act with its socio-economic dimensions, and how the study of carbonized wood remains can document the forms of co-evolution between humans and the botanical environment.

SOCIO-ECONOMIC ASPECTS OF FIREWOOD SELECTION

To respond to these questions we have adopted the analytic approach of technologists in order to deconstruct a "total fact" (here, the production of fire) and to propose an adapted analytic grid. This permits the systematic collection of data that can be used to inform the anthracologist. Thus, Figure 1 is constructed using a common knowledge base that relies on historical, ethnographic, universal principles and archaeological data.

However, this *chaine opératoire* brings to light a number of intrinsic and extrinsic characteristics for which the mechanisms of adaptation and feedback are still poorly understood. The development of (i) dendrometric tools to highlight the intrinsic characteristics of the wood resources collected and the forested plant communities that were exploited and (ii) ethnoarchaeobotanical references to understand their socio-economic functions, appear crucial for the analysis of firewood management as a socio-ecological indicator.

The *chaine opératoire* proposed here shows that while the environmental constraints may be numerous, technological and economic choices significantly influence the patterns of firewood selection at many stages. For example, we cite wood diameter. Recent years have seen the development of techniques to measure the radius of curvature and of models to reconstruct the diameters of the wood exploited using wood charcoal remains. Their application to the Neolithic sites around Chalain Lake (dated between 3200 and 2700 BC) has demonstrated that the wood selected, less than 10 cm in diameter, reflects very specific technological demands, related to accommodating a hearth in a wooden construction. As a result, when the human communities occupying the shores of the lake were forced to harvest the largest trees, as a result of the exploitation of new territory, we note an increase in the frequency of splitting mauls in the archaeological strata.

However, not all of the stages of the *chaine opératoire* necessarily lead back to the same social, technological, and economic processes. A number of concepts or theories such as time allocation, optimal foraging, or carrying capacity return specifically to the socio-economic organization of these communities and permit the anthracologist to propose better developed socio-ecological interpretations. We mention the comparative example of sites in Central Belgium and French Jura, where at different points during the

Neolithic, agricultural practices (intensive cultivation of small areas in Belgium vs. extensive cultivation of larger areas in Jura) seem to have determined the management strategies of firewood, and therefore also the paleoecological representativeness of the anthracological assemblages (Salavert and Dufraisse, in preparation). Here, again, the development of dendrometric tools focused on the width of growth rings, should permit us to more precisely narrow down our estimates of the distances traveled, a parameter that seems essential.

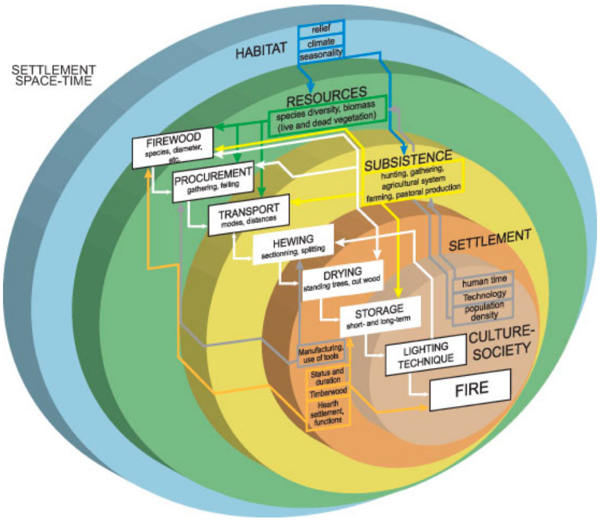

FIGURE 1. Intrinsic and extrinsic characteristics of the chaine opératoire related to the production of fire.

THE CONTRIBUTION OF ETHNOBOTANY

Ethnobotanical methods offer considerable promise for improving our understanding of the different forms of selection and use of wood. Supported by concepts of species diversity and the calculation of indices (Gentry and Philipps, 1993), these methods provide a deeper understanding of the use of different wood fuels and their availability in the local environment. Transposed to anthracology, it was possible to demonstrate that during the Middle Neolithic of Clairvaux Lake (4000-3600 BC) the wood species that occurred most abundantly in the environment were not necessarily those used for fuel (Dufraisse *et al.,* in press).

The models that result from ethnobotany often bring up ideas that we have not yet mastered and that cannot be directly applied to anthracology. We cite the model of the law of least effort proposed by Shackleton and Prins (1992), whose fundamental principles depend on the abundance of wood in the past (which the anthracologist cannot know) and on the population density (which is a debated parameter in archaeology).

On the other hand, ethnoarchaeology's objective is to seek out interpretative keys that are applicable beyond the narrow framework of a single period, region, or culture (Gallay, 1986). The development of this goal, applied to the management of plant resources, what can be termed *ethnoarchaeobotany*, begins to enrich our frames of reference (for example Piqué, 1999; Picornell, 2009) and should permit us to understand and interpret the functions and mechanisms that underlie the *chaine opératoire.*

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The very beginning of anthracological investigation

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Summary**:** *Modern anthracological research with lots of technical equipment and physical and chemical measurements seems to be a fairly young subject in science. However, the technical literature of the Renaissance and the Baroque is full of hints concerning anthracological investigation, long before microscopes and computers where in use. The most amazing comments were written by Vannoccio Biringuccio in 1540. He wrote about charcoal which was found in ruins more than 400 years old. One page before this he describes that there is a visible difference between the sizes and qualities of wood and several techniques of carbonisation. Of course these observations were not used for answering questions like ours today. The main interest in research about charcoal concerned the search for the best charcoal for different technical processes. On the whole the old literature contains a broad knowledge about the possibilities of using charcoal. This knowledge could be interesting and useful today for interpreting anthracological samples from pre-industrial working-places.*

Key words: *renaissance and baroque literature, technical charcoal use, history of anthracology*

INTRODUCTION

Before fossil coal was used as main fuel for industrial sites, the energy support was based on charcoal. For this reason the technical literature of the renaissance and baroque period, but also the technical and scientific literature of the 19th century contains a lot of information about the possibilities of using charcoal and wood as fuel in general, but also much detailed information about the usage of different wood species for charcoal production. The quality of charcoal is often a main topic, and it seems that not every kind of charcoal fits for every technical process. The need of identifying different charcoals and checking the quality before buying it was based on an early form of anthracology, developed over centuries and combining physical, chemical and economical research.

SOURCES AND CONTENTS

The oldest mention of different kinds and qualities of charcoal is from the Roman period. Plinius distinguishes between charcoals from soft and hard wood and knows that iron-smelters try to choose charcoal from *Quercus*, *Fagus* and *Carpinus* (Plinius nat. hist. lib. 16, 27).

In the renaissance period the old Greek and Roman way of scientific thinking again was the foundation of modern natural science. The oldest hint about anthracological research in order to find out something about the properties of different charcoals in this period seems to be the Venetian book “de la pirotechnia” from Vannoccio Biringuccio, 1540. Biringuccio found out, that the quality of charcoal depends on the technique of charcoal-burning, the age and diameter of the tree and the dryness of the wood. In his opinion it is important for every metal-worker to be able to distinguish between these different kinds of charcoal for a good producing process. While he confirms the knowledge of Plinius concerning the use of charcoal from hard woods for iron-smelting, he describes the use of charcoal from *Populus*, *Salix*, *Abies* and *Acer* as waste because of the higher consumption. Charcoals from soft woods (at Biringuccio every kind of wood except *Quercus*, *Fagus* and *Carpinus*) can be used for any unspecific work while only charcoal from *Betula* can not be used by gold- and silversmiths (Biringuccio, 1540, 61 v).

One paragraph, where he describes a typical archaeological-anthracological research demands special mention: Biringuccio reminds of the discovery of charcoals below an at least 400 year old ruin, and he concludes that the charcoal must be older. In this context the durability of charcoal is mentioned first. (Biringuccio, 1540, 62 v).

Due to the forth growing use of artillery and the need for good gunpowder several kinds of charcoal where tested in the 17th century. The artillery lieutenant J. C. Plümicke (1821, 146-147) investigated old orders about the quality of gunpowder and quoted a French law from 1669, where all woods of *Frangula* where signed over to the powder mills.

Further, extensive investigations about wood and charcoal where published by Hannß Carl von Carlowitz in 1713. He was responsible for a sustainable forest-management in order to produce charcoal for ironworks in the mountains of Saxony (Germany). Besides the invention of the still valid rules of sustainable forest-management, he investigated different kinds of carbonisation techniques in order to find the most effective one. In general, the charcoal from kilns gives the best charcoal; stumps and twigs, charred in a pit (as it was usual until the 19th century) only gives small charcoal-pieces, which are useless for industrial usage (Carlowitz, 1713, 391). The deputy-forester Speck (1821) also gives a hint for unpopular stump and oak-charcoal in context with the copper mill near Flensburg (Schleswig-Holstein, Germany). In the opinion of Carlowitz (1713, 391) and Speck (1821, 17-23) the best charcoal for iron or copper works, as already known, is charcoal from hard wood; the biggest size of charcoal pieces can be reached by charring one year dried coppices (Carlowitz, 1713, 391). Big charcoal pieces are important for the draught inside the furnaces. These results were also confirmed by charcoal-investigators from France (DuHamel du Montceau, 1762, 14) and Sweden (AF Uhr, 1820). In this context DuHamel describes the problem of too fast and ineffective burning kilns due to the use of dried wood. He also mentions the problem of sparking oak-charcoal, which is not very pleasant for the workers. The authors also agree on the lowest amount of charcoal by the use of big logs respectively wet or fresh wood because of the risk of incomplete carbonisation (Carlowitz, 1713, 391; DuHamel du Montceau, 1762, 13).

The investigation of DuHamel du Montceau shows a wide knowledge about the physical and chemical properties of different kinds of charcoal. In general, he distinguishes between “braise” (charcoal made by extinguishing a fire with water) and kiln-charcoal. He has a clear idea about the fact that the amount of air during carbonisation leads to clearly visible differences: braise is soft and consists of small pieces with a crumbed and matt surface, kiln-charcoal is hard, contains bigger pieces and has a bright surface. Kiln charcoal is burning much hotter than braise. During carbonisation the wood looses different gases and fluids. DuHamel identified a small amount of sulphur, tar or wood-oil, a kind of alcohol (methylene), burning gases (acetylene) and a kind of acid (vinegar). By burning kiln-charcoal a suffocating gas (carbon monoxyde) arises (DuHamel du Montceau, 1762, 5-8). In comparison to fossil coal, charcoal has better reducing properties (DuHamel du Montceau, 1762, 11).

While the technical literature about charcoal looses its importance during the industrial revolution in the 19th century, the knowledge of the properties of charcoal was used in the archaeological context again. D. F. Unger investigated some Roman graves and determined diameters and species of the burned woods inside the graves (as Biringuccio did more than 300 years before). He compared his samples with samples from J. D. Büsching and E. v. Berg (1830) and assumed a spread of coniferous wood in northern Germany during the last centuries.

DISCUSSION

For many sciences as history, physics, (al)chemistry or music there will be the question raising, whether the research of the renaissance and the baroque period is “real science” or just some kind of upper class excitement. We have to accept that most of the older interpretations are differing from ours today, as ours will differ from future ones. But still some of the old scientists are quoted widely today (just think about Plinius, Newton or Linné).

This short overview of research on charcoal before the 20th century shows the quality of the old knowledge about the subject. In contrast to current research, the old scientists and foresters could not use microscopes, diagnostic machines or computers. Instead of the microanatomic differences, they distinguished the different kinds of charcoal just by view, like a carpenter distinguishes different woods, but lots of their observations can be confirmed or specified with our methods today. Unlike today, the main questions about charcoal before the 19th century were predominately economic ones, even if the idea of archaeological-anthracological research is first mentioned in the 16th century. In the meantime, the paleoclimatic and ecologic research seems to be quite modern.

CONCLUSION

As in every science time is going on and methods, questions and observation-methods are changing, but the main point is still the same: we get information from charcoal. The old observations, even if the old interpretation differs from ours today, can give important hints to be able to discuss the economic situation of archaeological working sites. The old knowledge about the different types of charcoal also helps us distinguishing kilns from extinguished fireplaces. The old anthracological research also enables us to reconstruct old charcoal-burning processes, which can be helpful for building up and running experimental kilns. In a humorous sense, at least we can be proud to follow one of the oldest sciences in the world (besides theology, of course).

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Polynesian earth ovens and their fuels: interpretation of wood charcoal remains from Anaho Valley, Nuku Hiva, Marquesas Islands

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Summary: *Earth ovens are, and were, a key component of many traditional Polynesian societies. As repositories of wood charcoal, they potentially offer an opportunity to date prehistoric activities, study cultural practices, and reconstruct the flora of past landscapes. In this study, over 800 fragments of wood charcoal from Anaho Valley, Nuku Hiva Island in the Marquesas Islands were analysed for information on fuel sources, cultural usage patterns, and the prehistoric lowland vegetation. The materials come from seven ovens distributed across the valley and date to two broad time periods: 1450-1650 AD and post-1640. Methodological issues relevant to wood charcoal analysis are discussed and considered in relation to these assemblages prior to interpretation of the results. Examination of a single functional class of fire features (ovens) allows formation processes to be held relatively constant across the set of samples. Varied quantitative issues are explored, including measures of abundance and variability in sample size.* Thespesia populnea *(Pacific rosewood, mi'o) and* Sapindus saponaria *(soapberry, koku'u), two native hardwoods, are identified as dominants in this assemblage. This is perhaps not unexpected given that oven stones are heated to high temperatures, and good quality fuel is desirable for this purpose. As a corollary, charcoal derived from oven features is likely to offer an incomplete view of past vegetation, although it may reflect the dominant local vegetation. Finally, joint consideration of ethnohistoric and archaeological evidence suggests the possibility that anthropogenic impacts led to declines in an important economic species,* Thespesia populnea.

Key words: *wood charcoal, earth ovens, fuel wood, anthracology, Polynesia.*

INTRODUCTION

The study of archaeological wood charcoal is of particular value in reconstructing ancient vegetation patterns on Pacific Islands where the native flora has been substantially modified by centuries of human settlement and, more recently, by introduced European herbivores. Charcoal from archaeological contexts also aids understanding of past cultural activities, including patterns of fuel use, cooking practices, timber choices and ritual activities. In this study, we look at fuel remains from the traditional Polynesian earth oven (Fig. 1). Using a case study from the Marquesas Islands, East Polynesia, we consider why particular woods may have been used as oven fuels and the degree to which archaeological oven samples provide useful profiles of local vegetation. Several methodological issues are also explored, including how to best quantify and compare wood charcoal assemblages, and the potential impact of sample size on certain measures of interest.

DATA AND RESULTS

The present analysis was a pilot study aimed at exploring the potential of wood charcoal from Polynesian archaeological contexts to inform on past cultural practices and environmental conditions. It was also designed to evaluate two alternative models of fuel use: one that fuel selection is largely opportunistic; the other that purposeful fuel selection may occur in some situations. The present analysis tests these alternatives using a single class of fire feature, the closed earth oven. It is argued that this specific type of fire feature potentially had demanding fuel requirements to thoroughly heat the associated cooking stones.

FIGURE 1. Anaho Valley residents arranging food in a contemporary Marquesan earth oven.

This study draws on samples from Anaho, a broad valley on the northeast coast of Nuku Hiva. Microclimate conditions within Anaho are varied, ranging from xeric on the northern slopes to mesic in the south. As a result, the valley flora is of mixed composition. Samples come from features associated with two temporal contexts: a relatively early subsurface occupation layer on the northern coastal flat dating to 1450-1650 AD, where stone architecture is lacking, and deposits associated with late prehistoric (post-1640 AD) raised stone structures which are widely distributed throughout the valley.

Nine woody species, as well as coconut and other monocotyledon tissues, were identified in this assemblage of over 800 fragments from seven features (Fig. 2). Taxa identified include *Celtis pacifica*, *Cocos nucifera* (coconut), *Cordia subcordata*, *Sapindus saponaria* (soapberry) and *Thespesia populnea* (Pacific rosewood); several others were designated as unknown. Overall, in most samples, a narrow range of woody species was found. This is notable given that even within this single functional category (i.e., ovens), some variability might be anticipated based on occupant status, site location and the types of food being cooked.

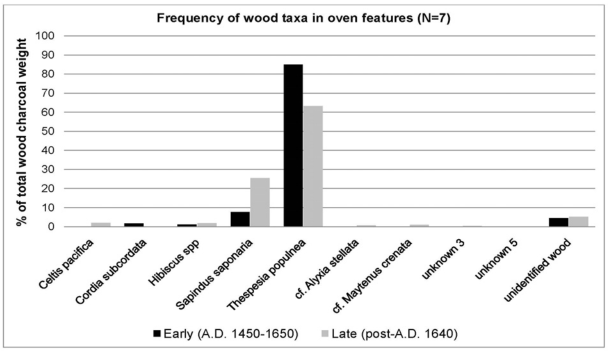

FIGURE 2. Frequency of wood charcoal taxa by weight.

Although all of the recovered species are found today within walking distance of the archaeological sites, two vegetation habitats are represented: typical human-modified lowland vegetation and arid vegetation of the northern valley slopes and ridgelines. To consider the possibility of temporal change in fuel use, features from the two time periods outlined above were compared. There are three dimensions of variability that are of interest: variation in species composition changes in the proportional contribution of different wood taxa over time, and changes in species richness. In most of the Anaho ovens only one to three taxa were identified (Fig. 3); when other species were observed, they generally were represented by extremely small amounts of material. Overall, there is little change in species composition across the seven ovens examined. Similarly, there is little variation in species richness. There are two changes of consequence: first, there is a modest decline in the abundance of *Thespesia* and a modest increase in *Sapindus* as measured by both frequency and, more conservatively, ubiquity values. Second, it is notable that monocot tissues are present in only one early oven but occur in all late ovens.

DICUSSION AND CONCLUSIONS

A relatively large charcoal assemblage, by tropical Pacific standards, was identified from seven oven features dispersed throughout Anaho Valley. This assemblage includes samples from both coastal and inland locations over a time span of roughly 200 to 350 years. During this period, residences shifted from a concentration on the coast to a wider dispersal throughout the valley. However, there was only modest variation in the types of wood used as fuels with two locally available species, *Thespesia populnea* and

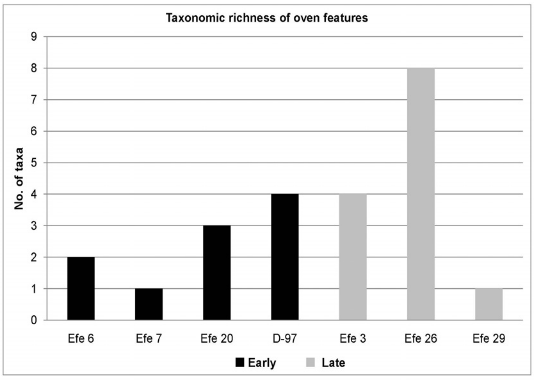

FIGURE 3.Taxonomic richness by oven feature.

Sapindus saponaria, dominating. The prevalence of these two species, which are high quality fuels, is consistent with the idea that fuels used in the Anaho ovens were the result of selective rather than opportunistic behaviour. While additional samples from both ovens and other contexts are needed to fully evaluate this hypothesis, it cannot be discounted on present evidence. Moreover, these findings are broadly consistent with studies elsewhere in the Pacific (Allen, 2005; Di Piazza, 1998). An important corollary of these findings is that earth oven samples in isolation provide a poor basis on which to reconstruct ancient vegetation patterns; charcoal samples from a broader range of fire features and depositional contexts are critical to such an exercise.

The combined archaeological and ethnohistoric evidence also intimate that an important fuel species, *Thespesia populnea*, was reduced over time either through purposeful harvesting or more generally as a result of changes in the local vegetation. As a result, Anaho Valley residents may have travelled further and over more steeply sloping ground to secure another high quality fuel wood, *Sapindus saponaria*, or used alternative sources. Human impact on local plant resources is not unexpected given the now well-documented anthropogenic effects on faunal resources and island landscapes (e.g., Kirch and Hunt, 1997). This study, however, may be the first archaeological analysis to suggest anthropogenic impact(s) on an important Pacific timber species, which was once widely, used for fuel, utilitarian, ornamental and religious purposes.

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People, trees and charcoal: some reflections about the use of ethnoarchaeology in archaeological charcoal analysis.

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Summary: *The aim of this presentation is to put together the different ethnoarchaeological approaches that charcoal specialists have proposed for firewood management. Analyzing these works within the framework of the theoretical development of both the charcoal analysis discipline and ethnoarchaeological studies, we expect to start reaching a consensus in relation to the possibilities and the limits of ethnoarchaeological studies, and to the issue of interpretation in archaeological charcoal analysis. We propose the orientation of theses studies towards the socio-ecological analysis of firewood management considering the no suitability of ethnoarchaeology to discuss the palaeoecological representativeness of archaeological charcoal analysis (explored in detail from statistics, taphonomy or experimental archaeology) through the universalization of current social behaviour.*

Key words: *firewood, ethnoarchaeology, charcoal analysis, ethnobotany, human-environment relations.*

INTRODUCTION

In the last 20 years ethnoarchaeological studies carried out by charcoal specialists have occasionally turned up in bibliography, specially focusing their attention on domestic firewood. Robert F. Heizer already pointed out in 1963 that domestic fuel had been a neglected research topic in social sciences (Heizer, 1963). From an archaeological point of view, he looked for interpretative models of fuel management in non-Western households in ethnographic literature, observing that this had been an unattended aspect of human social life (Heizer, 1963). At the end of this paper, R. Heizer pointed at ethnography as a source of inspiration for archaeologist to address the question of fuel in its social depth (Heizer, 1963: 192).

This suggestion has been taken into account since the 1990s, when, after a period of intense introspection and debate on the analytical potential and limitations of archaeological charcoal analysis, the aims and scope of the discipline have been expanded at length (Asouti and Austin, 2005). These new perspectives have boosted the search for new fields of study and the formulation of new theoretical and methodological corpus. Ethnoarchaeology and experimental archaeology have been pointed out as relevant venues of inquiry (Asouti and Austin, 2005).

Since then, ethnoarchaeology has been tempted in different scenarios by various researchers with diverse objectives. Ethnoarchaeology itself has not been defined or systematized as an academic discipline and ethnoarchaeological fieldwork is developed in a multiplicity of situations, which makes the standardization of methods and even aims difficult (David and Kramer, 2006). Ethnoarchaeological studies made by charcoal specialist focusing on firewood are not an exception in this sense.

THE ETHNOARCHAEOLOGY OF FIREWOOD

During the 1990s some of the ethnoarchaeological studies addressing firewood were used to test the methodology of charcoal analysis in relation to landscape reconstruction (Ntinou *et al.,* 1999). Another kind of studies that has received attention from charcoal specialists is the one known as "firewood paleoeconomy" in hunter-gatherers societies. This kind of study uses ethnographical observation to "test" the paleoeconomical models theoretically constructed by charcoal specialists in relation to fuel management. Researchers address this question both through ethnoarchaeological fieldwork in contemporary societies (Henry *et al*., 2009) and by comparing recent archaeological sites with ethnographic accounts made by 19th and 20th century travellers or ethnographers (Piqué, 1999).

Beyond this paleoecologic–paleoeconomic dichotomy, some ethnoarchaeological studies of firewood have been oriented towards the improvement of the interpretative background of archaeological charcoal analyses. In some cases, a specific ethnographic scenario is analyzed and compared to an archaeological case in order to "test" the theoretical assumptions (Zapata *et al*., 2003; Dufraisse *et al*., 2007). In other cases, the methodological and theoretical background of charcoal analysis is discussed through an ethnographical analysis of current cases without a specific archaeological problem (Picornell *et al*., in press). Furthermore, the ethnoarchaeological study of forest management and cultural perceptions of the environment are directed towards the study of the cultural constraint of firewood management (Guiot, 2002)

DISCUSSION AND CONCLUSIONS

Given this diversity of aims and theoretical assumptions, our presentation is going to explore this variety of situations with the aim to start reaching a consensus in relation to the possibilities and the limits of the ethnoarchaeological studies of firewood management in human societies of the past, and even of the present, considering this specific human activity within the framework of human-environment relations and everyday landscape practices.

In relation to this aim, we will suggest some discussion points as: the orientation towards the anthropological analysis of firewood management from a socio-ecological point of view as a way to connect charcoal analysis with archaeological and anthropological theoretical agendas; the no suitability of ethnoarchaeology to discuss the palaeoecological representativeness of archaeological charcoal assemblages by universalizing current social behaviour, or the methodological concern in relation to the critical application of ethnoarchaeological and ethnobotanical qualitative and quantitative methods.

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Bronze Age firewood exploitation in south eastern Iberia: a study focusing on wood diameter estimation

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Summary: *This study evaluates the management of different sizes of firewood utilised in the Argaric settlement of Barranco de le Viuda (Lorca, Murcia). A dendrometric analysis was performed to estimate the radius of the curvature of growth rings in charcoal remains identified as* Pinus halepensis*. An analysis of two archaeological levels and two structures revealed that branches of a small calibre, mostly between two and five cm in diameter, were used. Fragments between five and fourteen cm were less abundant, and pieces larger than fourteen cm in diameter were found in only one of the structures. Treatment of the data by a mathematical model will allow the results to be corrected following certain parameters, such as the shrinkage caused by carbonisation or the error percentage associated with the measurement tool.*

Key words: *radius of curvature, dendrometry,* Pinus halepensis*, Prehistory, Iberian Peninsula*

INTRODUCTION

The interaction of Argaric Bronze Age groups with the wood resources available in their environment was probably conditioned by degraded forest areas (Pantaleón-Cano *et al*., 2003). The combination of their socio-economic patterns, based on the overexploitation of resources (Carrión *et al*., 2007) and the progressive climatic aridification of the Holocene (Jalut *et al*., 2009) is most likely the origin of that regional deforestation.

Studying firewood exploitation patterns is essential in characterising the economy of these societies. In addition to the taxonomic diversity of woodfuel, another key criterion in the analysis of the selection process is the caliber of the wood, which can be estimated using different dendrometric techniques (Ludemann and Nelle, 2002; Dufraisse, 2002; 2006; Marguerie and Hunot, 2007).

This study evaluates firewood management patterns in the Argaric village of Barranco de la Viuda (Lorca, Murcia). Its anthracological spectrum is dominated by *Pinus halepensis*, together with sclerophyllous *taxa* (*Olea europaea* var. *sylvestris*, *Pistacia lentiscus*), xerophytes (*Ephedra*, Chenopodiaceae), Ibero-African plants (*Periploca angustifolia*, *Tetraclinis articulata*) and dry riverbed vegetation (*Tamarix*) (García Martínez 2009). Specifically, this study presents the results of the dendrometric analysis carried out on *P. halepensis* charcoal fragments from Level I (1920-1680 cal BC 2σ) and Level II (1840-1640 cal BC 2σ), and from two structures (Vessel-Ashtray and Combustion Structure 6H15), associated with Level II.

METHODS

This study is based on an estimation of the radius curvature of *P. halepensis* growth rings by evaluating the distance between the pith and the rings of the measured charcoal fragment. A reference study was performed prior to application to the archaeological remains in order to assess the validity of two dendrometric methods on conifer anatomy. The methods were applied to two fresh and charred *P. halepensis* sections. Measurements were made with a binocular (magnification x10) and with the help of an image analysis program (NIS Elements 3.1).

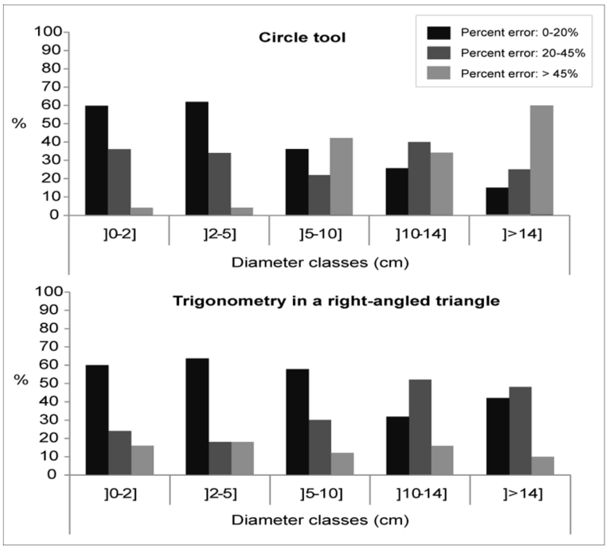

FIGURE 1. Error percentages associated with the use of the circle tool and the trigonometry on a carbonised P. halepensis section.

The first technique tested, known as a "circle tool," is based on the morphology of a growth ring. This tool extrapolates a perfect circle from certain reference points marked on the edge of the ring. The second method, based on the trigonometry of a right-angled triangle (hypotenuse = opposite side / sinus α) takes into account the angle formed by two wood radii and the distance between them.

The results of this reference frame (Fig. 1) clearly show that the circle tool is only acceptable for measuring diameters of less than 5 cm. The average error percentage is around 40-50%. However, the trigonometric tool is very reliable until at least 10 cm in diameter, and moderately reliable beyond 10 cm. The results with an error percentage greater than 45% are not significant. Its average error percentage, regardless of diameter class, is around 25%. As a result, the archaeological charcoals were all measured using the trigonometric tool.

DATA AND RESULTS

The first stage of the study was to estimate the diameter of the charcoal fragments from Barranco de la Viuda. The raw measurement data (Fig. 2) for Level I and II showed a similar trend of firewood composed mainly of small branches measuring up to 5 cm in diameter. A moderate number of fragments between 5 and 10 cm were documented. Branches longer than 10 cm were less common, and there were no branches that exceeded 14 cm. In the structures analysis, the Vessel-Ashtray also showed a preponderance of fragments up to 5 cm in diameter. The Combustion Structure 6H15 displayed slight differences, though: the majority of measurements were of the 2-5 cm diameter class. While there was little presence of small-caliber wood (0-2 cm), fragments exceeding 10 cm appeared more often. Diameters larger than 14 cm were documented only in this structure.

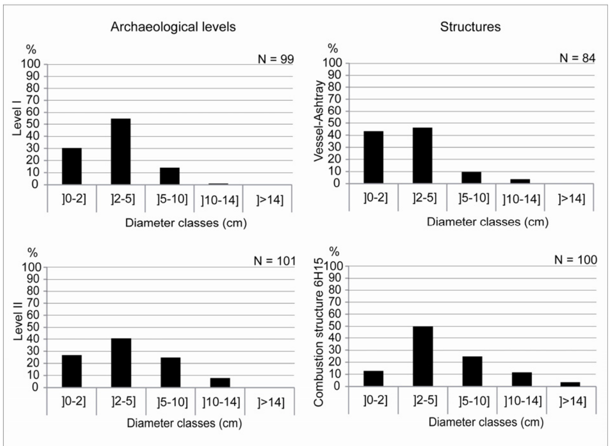

FIGURE 2. Raw results of the measurements of P. halepensis *charcoal fragments from Barranco de la Viuda.*

A second, exploratory phase will treat the raw results through mathematical modeling. This model (Dufraisse, 2002; 2006), whose goal is to restore the diameters of the originally burned wood, is currently under review within the ANR research project DENDRAC (dir. A. Dufraisse). Its use reveals a very useful tool for implementing certain corrective parameters (Dufraisse and García Martínez, submit.). In the present study, the correction factors will take into account the deformation of wood associated with combustion, and in particular to the shrinkage. An additional correction factor will be the error percentage associated with the trigonometric measurement tool. The average error percentage obtained (25%), as well as the overestimation (% of positive error) predominant in small diameters and underestimation (% negative error) which occurs more often in the largest calibers (> 10 cm) will all be taken into consideration.

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Wood-charcoal in a ritual context at La Bastida de les Alcusses (Moixent, Valencia, Spain)

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Summary: *Fieldwork carried out in 2010 at the Iberian* oppidum *of La Bastida de les Alcusses has revealed the existence, under the floor of the main gate, of a layer with abundant wood-charcoal and metal objects. Both the typology of the objects and their stratigraphic-spatial layout suggest that this is a ritual deposition related to the foundation of the site. Among the timber remains two species have been identified (Aleppo pine and holm oak) and they might be interpreted as lumber pieces or wooden objects that were consciously burnt before being deposited, although we do not rule out the possibility that it was wood harvested specifically for this purpose.*

Key words: *Iron Age, Iberian* oppidum*, timber, gate, ritual/foundational context.*

INTRODUCTION

La Bastida de les Alcusses is an Iberian *oppidum* built on a hilltop dominating the surrounding plains. The settlement has a 4-metre thick wall delimiting an area of about 4 hectares and an unfinished second wall to the west delimiting an area of 1.5 hectares. The *oppidum* has four gates (three to the west and one to the east) and three towers (two between the west and south gate and another larger one, by the east gate). The urban layout of the settlement is structured with a main road, a perimeter circuit and a net of smaller streets and *plazas*. Blocks of houses of different size are built within this network of roads and *plazas*. The settlement was occupied during the 4th century BC and was abandoned due to a violent conflict with other Iberian groups of the area.

During the excavation carried out in 2010 an outstanding deposition of objects was recorded beneath the floor of the west gate, on a paved area belonging to an earlier building. The typology of the materials -iron weapons, wooden structures, seeds and fruits, and ceramic vessels, its treatment -most of them were burnt- and its layout lead us to consider that this was a ritual deposit.

A preliminary inventory of the objects recovered lists iron objects, pottery and other finds. Among the iron objects, there are nails and pieces for assembling wooden objects and a set of 4th century BC southeast Iberian weapons, including falcata swords, shields, spears and *soliferrea* –a type of javelin made out of iron. Pottery vessels –among them a red-figure krater- and other organic materials such as seeds -cereals and olives- and animal bones were also recovered. It is important to note that these objects were part of a ritual performance and for this reason the weapons should not be considered as remnants of a conflict but ritualized objects instead: in fact they are bent, following the treatment of weapons deposited as grave goods in Iberian cemeteries, although the present contexts are not tombs (Bonet and Vives-Ferrándiz, 2011). In this abstract, we present the results of the analysis of the wood remains and of the associated iron pieces.

MATERIAL AND METHOD

In the above described layer, 33 pieces of wood of varied morphology and size have been recovered and analyzed. The wood was in a fragile state of conservation as it was very fragmented and, in some cases, only partially burned, which had resulted in the complete degradation of the non-charred parts. During fieldwork, drawing and measurement of every single piece was undertaken, as was their disposition on the floor. Before their removal, obtaining a complete section of each wooden piece was attempted, not without difficulty because of the above mentioned poor conservation.

The analysis included the following observations: botanical identification; reconstructing the pieces in order to assess their original morphology; trying to get a whole section and identify any traces of woodworking; estimating the minimum diameter of the timber (the fragments were large enough to work it out with a circle grid); assessing the cutting season from the presence of bark; and analysis of wood decay caused by xylophages.

RESULTS OF THE WOOD ANALYSIS

All the timber belongs to two species: almost all are of Aleppo pine (*Pinus halepensis*) while only two are of holm oak (*Quercus* sp. evergreen). Some of them are square-worked, but other branches maintain their natural morphology including the bark: we are not able to assess if they ever formed part of a wooden structure (e.g. lattice of the roof or beams) or if they would have been used specifically as fuel for burning during the ritual performance. In this sense, the identification of the cutting season (on the basis of the presence of bark), shows a rather uniform pattern, as all the wood was cut during an unfavorable season for plant growth, i.e. from beginning of the summer to winter. This homogeneity might indicate that the set of branches represents a specific, one-time occurrence.

It has also been possible to measure the exact diameter of branches that conserve their bark. They are quite varied, ranging between 11.6 and 2.3 cm, but most were 5 cm or less. Regarding the pieces which do not preserve their whole radius, the minimum diameter has been estimated between 11 and 15 cm.

The wood had a significant microorganism attack pattern (fungal hyphae and ducts of xylophages); this alteration is more visible on larger timbers, whereas the branches are apparently less altered. This could be related to the use of two kinds of wood in this context: on the one hand, reused wooden structures and/or objects contaminated during their lifetime, and on the other, wood cut and provided as fuel, although this hypothesis will be confirmed in a later stage of the study.

DISCUSSION AND CONCLUSIONS

Wood and fire played a central role in the formation of this record. Almost all the timber recovered belongs to Aleppo pine. This is precisely the most frequent species in other contexts of the settlement (Table I) and it is also present in the abandonment levels of other gates and houses, therefore confirming in its use for different purposes as a species widely available in the environment.

Taxa/Context	Soils	Dumps	Construction	Objects
Erica sp.	*	*	*	
Fraxinus sp.		*	*	*
Juniperus sp.		*		
Leguminosae	*	*		
Olea europaea	*	*		
Pinus halepensis	*	*	*	*
Pinus pinaster	*	*		
Pistacia terebinthus				*
Prunus sp.	*	*	*	
Quercus sp. deciduous	*	*		
Quercus sp. evergreen	*	*	*	*
Rosmarinus officinalis	*	*	*	
Salix-Populus		*	*	*

TABLE 1. Taxa identified in the different contexts of La Bastida

In this sense, no specific plant species was selected for this ritual performance. The presence of "natural" wood represents either the collection of firewood for this purpose, or that they might have formed part of uncarved structures. In fact, construction elements and other objects were probably reused –and burnt– because they were of exceptional significance.

So far, no wood sample has been clearly identified as weaponry parts (e.g. handles), despite the sampling strategy, which separately selected the charcoal laying near the pieces from other wood structures. In other contexts of La Bastida as well as in other Iberian sites the use of high-quality woods for making handles and wooden tools has been documented (Carrión and Rosser, 2010; Pérez *et al*., 2011), but in this case, no other species apart from pine and holm oak have been identified. The available evidence suggests that the wooden objects were manipulated after their burning and before being deposited. In fact, nails and other iron pieces for assembling wooden structures were removed from the objects before being deposited.

A preliminary interpretation for this finding is that it is a ritual deposit. Although we need to be aware of the fact that the material is still under study, we suggest that it could be a heroic, collective ritual performed by the elites that inhabited the settlement. It might have been a foundational ritual that was performed in what was going to be a highly significant public space, the main gate of the village. Another avenue of interpretation under consideration is that this is a memorial of a singular act, or featured events, like cenotaphs (graves without burials) or warrior memorials.

In any case, the similarity of this practice with funeral ritual is remarkable: not only were the weapons bended following the treatment of those deposited in Iberian tombs (Quesada, 1997), but also fire played an essential role, as wooden objects and structures were intentionally burned before being deposited. The study of the rest of the materials will help to better understand the characteristics of this outstanding context.

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The cremation structures of the Roman Empire: anthracological data *versus* historical sources

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***Summary**: During the excavation of the Roman necropolis site Richeaume (Bouches-du-Rhone, Provence, France), cremation primary structures have been identified. A specific protocol consisting in collecting the entire sediment for sampling charred funeral remains on a grid of 20 to 40 cm, was systematically experimented and put into practice. The first anthracological results offer a reading of both qualitative and quantitative spatial residues of the cremation (including the discovery of the ignition lock, and technical aspects revealing a specific choice adapted to the practice of cremation). This reading led to interpret anthracological results in a technical and social prospect. These results led also to a systematic re-reading of written Roman sources, collecting exhaustive historical documents and comparing them to previous and new data. The terms used by ancient writers to describe the structures studied by anthracologists, far from being general, relate to facts and precise gestures.*

Key words: *anthracology, cremation, Roman Empire, iconography, written sources.*

INTRODUCTION

The research focuses on the gestures and burial practices associated with ancient cremation structures in Provence and intends to approximate and compare archaeological and historical data to charcoal analyses results. Furthermore, this new approach led to new perspectives. The Richeaume site (Puyloubier, Bouches-du-Rhone) falls within the Massif de la Sainte-Victoire, in the upper valley of the Arc, about thirty miles from Aix-en-Provence. The immediate environment of the necropolis has some biological richness, as it is bordered to the south by a vast agricultural plain and the edge of forest and scrubland. The site is logically placed in the meso-Mediterranean bioclimatic vegetation where series of Aleppo pine and green oak characterize the actual vegetation.

DATA AND RESULTS

The development of an appropriate sampling methodology (Cenzon-Salvayre, Durand, Mocci submitted) for this type of structures during the archaeological excavations, according to the methodology of anthropological collection (Bel, 1996) analyzes of the charcoal remains guided us toward a specific supply of certain species on morphological and ecological criteria. An image of the setting up of the funeral pyre and of the course of cremation has been proposed based on the first results obtained. It allowed speculating a strict conduct of fire (identification of the wick ignition, data on the morphology). Thus, the construction of the funeral pyre appears as a specific *know-how* concluding the hypothesis about the presence of a crematist: the *ustor* mentioned in the Roman texts, i.e. Lucain, (La Pharsale, VIII, 736), Martial (Epigrammes, III, 93, 23), Catulle (49, 4), Cicéron (Pro Milone, 90, 7).

These results led to a systematic re-reading of written sources, collecting exhaustive historical documents and comparing them to previous and new data. This new reading angle can also be applied to the iconography. All forms of Roman historical data are essential to recognizing the steps of the cremation orchestrated by a society of living people, taking into account the social and religious aspects around the deceased. The terms used by Roman writers to describe the structures studied by anthracologists, far from being general, relate to facts and precise gestures.

Our archaeological and anthracological studies demonstrate a real construction of funerary structures and a real fire management. Knowledge of fire behavior have guided most of the people responsible for this task: the intersection of the logs forming thermal conduits (empty space between the logs) is used for supplying air to the fire which rises; cremations lead to technical moves that respond to specific burial structures to allow the removal of flesh, as shown by various ethnoarchaeological studies conducted by Gilles Grevin in India (Grévin, 2009).

All funeral pits analyzed reveal the predominant presence of *Pinus halepensis*, (a total of 1631 fragments was analysed) (Table 1). The Aleppo pine is preferentially used as body burning fuel. The criterion of the chemical properties of wood itself seems insufficient to explain this predominant presence of Aleppo pine in the primary cremation structures. However, the morphology of the fuel must answer both to the requirements of a construction and to funeral stable pyrolysis adapted to the cremation of a body which is variable although more prevalent. The determination of the majority of Aleppo pine responds perfectly. Thus, the analysis of charcoal burial shows that human beings interact with their environment and adapt to it according to needs related to use and precise construction. In the environment of Richeaume, the Aleppo pine is one of the available species of tree layer that meet morphologically and is necessitated by the construction of a funeral structure and controls the fire of the pyre.

Chronology: I- mid II AD	Inc6 N.	%	Inc7 N.	%	Inc8 N.	%
Arundo donax-Phragmites communis	2	0,4				
Fagus sp.	11	2,5				
Pinus halepensis	183	40	366	55,2	444	86
Cf. *Pinus*	118	26	209	31,5		
Pinus sp.	41	9			24	4.7
Quercus ilex-Q. coccifera	32	7,4	35	5,5		
Vitis sp.	20	4,4				
Monocotyledon					39	7,7
Indeterminate	38	8,3	32	4,8	6	1,2
Non-identifiable	9	2	20	3	2	0,4
Total	454	100	662	100	515	100

TABLE 1. Results of the analysis in the three pits.

Some texts are very precise about the kind of construction and use specific terms to describe them. Lucain uses the word “compositum” *(...) iam quod compositum uiolat bustum manus hospital, da ueniam: quid if sensus post fata relictum* (...). The translator of the Belles Lettres considers *compositum* as regular logs, which means a high pyre and built to accommodate the body (p. 122 note 3.). Furthermore, anthracological results show that small caliber wood elements could have been used for burning the pyre by multiplying the points of ignition at the bottom of the pit, under the logs forming the structure of the funeral pyre. Insights recorded of this action are found again, especially in the text of Lucain where conventional ignition of this type of structure is described: "(...) *nobile corpus robori premunt nulla, nulla membrane stru recumbunt: admotus Magnum, not subditus, Accipe ignis* (...)" the fire is lit next to Magnus and not below it (Lucain, *De Bello civili, VIII, 763*), as it should be done in normal circumstances.

Iconography shows details which indicate a precise choice on small and large wood material. It can be observed in one painting attributed to Myson (Attic Red-Figure Amphora *ca*. 500-490 BC. – Musée du Louvre). The painter has represented a historical fact related by the authors of Antiquity: Croesus, King of Lydia, who was defeated in 547 BC by Cyrus, mounts his pyre, but a miraculous rain sent by Apollo saves him from the flames.

CONCLUSION

Therefore we wish to emphasize these first results obtained by cross-reading of anthracological, historical and iconographical data. These multidisciplinary analyses demonstrate that re-reading Roman texts and iconography is possible. They illustrate a lighting of charcoal and archaeological data reveals a chain operating cremation and a real technical and social organisation around the act of cremation.

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Firewood selection in Roman cremation rituals in Northern Gaul: ritual, functional or opportunistic?

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Summary: *Charcoal assemblages from 101 Roman cremation graves from 12 different sites from northern Belgium have been identified. These have been compared with charcoal assemblages from refuse deposits, reflecting the domestic use of firewood. As no apparent differences could be found, it is concluded that firewood selection for Roman cremation rituals was based on functional and opportunistic reasons rather than ritual.*

Key words: *firewood, charcoal, Roman, cremation, Belgium*

INTRODUCTION

Cremation was the most common funeral practice in northern Roman Gaul during the first three centuries AD (Bechert, 1980). Although Roman age cremation graves are frequently found during archaeological excavations, charcoal from these graves has been studied only very occasionally.

This presentation gives the results of a systematic study of wood use in the Roman cremation ritual in Northern Gaul. Next to the identification of woody taxa that have been used for the construction of funeral pyres, it is assessed whether there are any differences in wood use for the cremation ritual and domestic use. Therefore the charcoal assemblages from the cremation graves are compared with those from refuse pits from the same or nearby Roman sites to detect possible differences in wood selection strategies.

RESULTS AND DISCUSSION

A total of 101 Roman age cremation graves have been analyzed, originating from 12 different sites from northern Belgium. The analyzed graves were located in graveyards associated with small, rural settlements or large cemeteries associated with urban Roman settlements. Next to these cremation graves, the charcoal assemblages from 7 refuse pits from the same or nearby Roman sites have been analyzed for comparison with the assemblages from the cremation graves.

The charcoal assemblages of most graves are clearly dominated (>50%) by one single taxon, which is in most of the graves *Quercus* sp. In 23% of the graves, only *Quercus* sp. charcoal has been found. In some of the other graves *Alnus* sp. or *Fagus sylvatica* is the dominant taxon. All other taxa appear in small quantities only.

Except for *Abies alba*, all identified taxa from the cremation graves belong to the natural vegetation of northern Belgium and can have grown in the proximity of the sites. However, the charcoal assemblages of the individual cremation graves are not a good reflection of the composition of the vegetation surrounding the site as most graves contain very few taxa, and therefore are clearly biased by human selection. On the other hand, there are no indications that certain tree taxa have been avoided because of a taboo on their use for cremation rituals as, except for some rare trees, all available taxa have been found in one or more cremation graves.

Abies alba which does not belong to the natural vegetation of Belgium, has been found in several graves from northern Belgium. *Abies alba* charcoal has also been found in several Roman cremation graves from sites in Germany like Frimmersdorf (Rheinland) (Tegtmeier, 1997), Zülpich (Rheinland) (Becker *et al.*, 1999), Wölversheim (Hessen) (Kreuz, 2000), while these sites are also situated outside the natural range of this tree.

The charcoal assemblages of most of the individual cremation graves are much stronger dominated by one single taxon, respectively *Quercus* sp., *Alnus* sp. or *Fagus sylvatica* than is the case for the refuse deposits. When the total charcoal assemblage of several graveyards is pooled and compared with those from the refuse deposits, however, these differences become less pronounced (Fig. 1).

The complete cremation of a human body demands a large volume of good quality wood fuel in a single event of time (Herrmann, 1990). The charcoal residue from the refuse deposits on the other hand results from the repeated collection of fuelwood for uses which do not necessarily require large amounts of large diameter wood. Also the burning characteristics of the collected taxa might not be as important for domestic use, like heating or cooking, as for cremations. The differences observed between the two types of deposits are therefore believed to be the consequence of functional and opportunistic reasons rather than ritual or symbolic motivations.

CONCLUSIONS

Charcoal fragments from 101 Roman cremation graves from northern Belgium have been analyzed. Although most of the graves are clearly dominated by one single taxon, mostly *Quercus* sp., this does not seem to be the consequence of wood selection for symbolic reasons or ritual as the cremation graves do not differ significantly from the charcoal assemblages from contemporary domestic refuse deposits.

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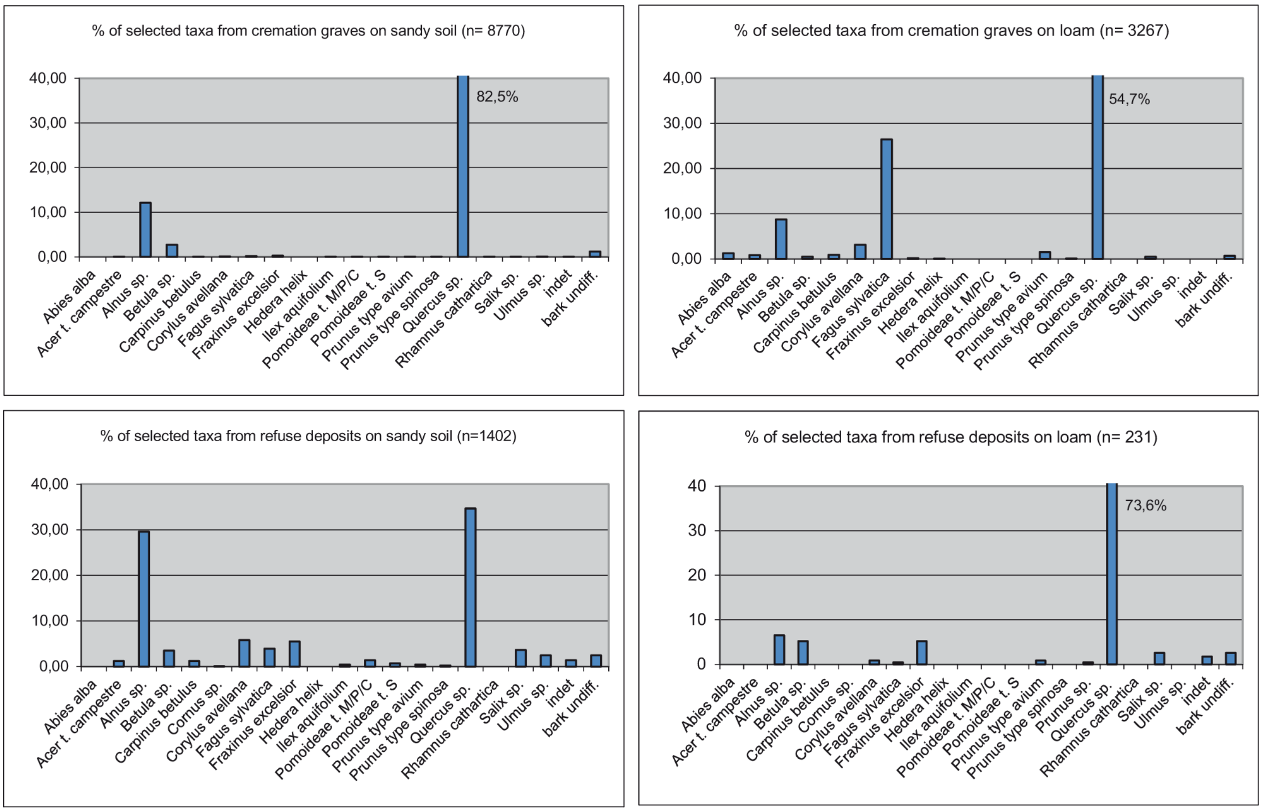

FIGURE 1. Percentages of selected taxa from Roman cremation graves and refuse deposits from sites on sandy and loamy soil types.

Well lining in ancient hydrological system of Fratte settlement (Salerno, Italy): cypress wood use in the Archaic period (6th-5th century BC)

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Summary: *Recent archaeological investigations in the archaic settlement (6th-5th century BC) of Fratte (Salerno – Italy) reveal a complex system of the underground water exploitation by use of wells. Thanks to peculiar environmental conditions it was possible to retrieve many cypress wood fragments. Some of these were found on the internal well surfaces. Integration between ethnographical study and wood technology has shown that the xylotomic finds have been used as lining of the sandy/clayish layers, intercepted from the ground perforation in the 6th-5th century BC.*

Key words: *wood remains,* Cupressus*, well lining, 6th-5th centuries BC, Italy.*

INTRODUCTION

The Etruscan-Samnite settlement of Fratte lies on the Scigliato hill (71 m asl) in the Salerno north-eastern zone (Campania, Italy), in a favourable topographical position above the course of the Irno river (Fig. 1). The geomorphological and hydrogeological history of the Irno valley has conditioned the use of the whole territory, favouring human settling since the ancient times (Pontrandolfo and Santoriello, 2009).

FIGURE 1. Fratte settlement localization and picture of the archaeological area.

The archaeological investigations have allowed recognizing the presence of a complex system of underground water exploitation, dated to the 6th-5th century BC. This hydrological system, scattered on the whole hill, is composed of ten wells and at least five shallow-holes connected to underground burrows, used for the transport of solid and fluid materials (Orrico, 2008; Scelza, 2009) (Fig. 2).

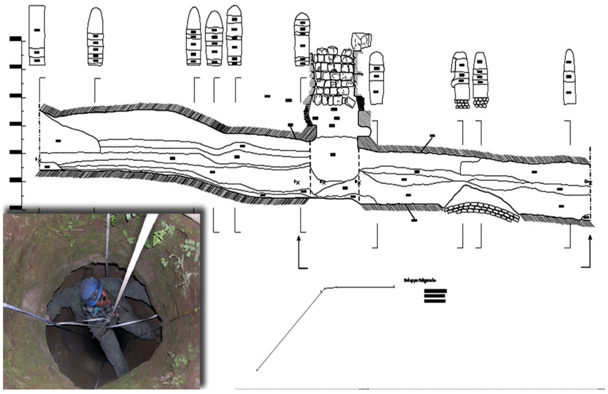


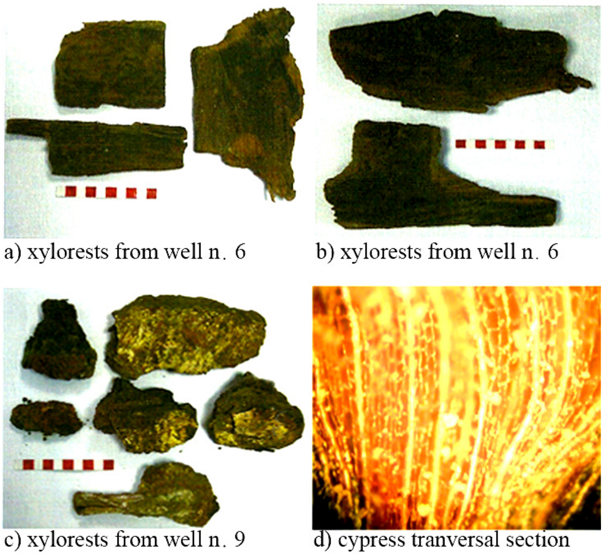
FIGURE 2. The hydrological system relief and picture of one of the wells during the excavation.

DATA AND RESULTS

Hand sampling strategies inside the wells n. 6 and 9 have allowed recovering many wood fragments, characterized by reddish color and yellowish concretions.

Safety reasons and dangerous conditions during the excavation have not allowed a more accurate sampling. 14 wood fragments from well n. 6 and 12 from well n. 9 were retrieved in correlation with the lining of the structure. The xylotomic analysis performed at the Laboratory of Archaeobotany and Palaeoecology of the University of Salento, assign these fragments to cypress wood (*Cupressus*).

The fragments have mainly rectangular shape with an average size of 20 cm length, 10 cm width and 1.5 cm thickness (Fig. 3).



a) xylorests from well n. 6 b) xylorests from well n. 6

c) xylorests from well n. 9 d) cypress tranversal section

FIGURE 3. Fragments recovered and their xylotomic analysis.

DISCUSSION

According to the shape of the finds, the wells would have contained cypress planks, recovered to the depth of 16 m. This depth corresponds to a sandy/clayish layer, rather friable.

The manufacture of wood and the geological composition of the sediment show that the wells had wood lining walls to sustain the crumbly layer (Hazeltine and Bull, 2003). This interpretation is confirmed by ethnographical comparisons, this well digging technique is still widespread in many villages of Niger and Zambia (Sutton, 2002; Danert, 2006) (Fig. 4).

FIGURE 4. Wood employment in a hand drilled well in Zambia (Sutton, 2002).

The cypress wood choice does not seem to be casual but reflects the ancient knowledge of the elevated resistance of the wood of this plant to damp environments (Giordano, 1980, 1999; Tampone, 1996). The cypress results to be the ideal solution, therefore, to cover the walls of the wells.

A supplementary observation concerns the yellowish coloration of wood fragments from well n. 9. A more careful chemical analysis of this one has revealed that it is sulphur. The sulphur exhalations, connected to the depletion of the groundwater, would be the cause of the abandonment of well n. 9.

CONCLUSIONS

The xylotomical analysis of the fragments retrieved inside the wells has shown the exclusive presence of cypress wood to build the lining. These techniques were used as an alternative to stone cladding.

The choice of cypress wood as lining solution for the wells depends on its chemical/physical characteristics. In fact, the presence of this only *taxon* in the wells does not reflect the taxonomical richness of this area during the 6th-5th centuries BC (Colaianni, in press).

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Metallurgy and forest landscapes from the Gallo-Roman to the Modern Period in Périgord-Limousin (France)

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Summary: *The results of charcoal analysis from a Roman bloomery and 14 modern charcoal kilns are presented in this article. Charcoal samples were collected in the area known as* Châtaigneraie Limousine*, in Périgord-Limousin (France). These results show that the chestnut was already used for metallurgical activities during the Roman period. Nevertheless, its use would have been more important as coppicing species during the Modern period for the production of charcoal. Some forests situated at the flat areas of the hills would have been transformed to mono-specific chestnut woodlands during this period. This intensive exploitation of the woodlands however would not have changed all the landscapes. On the valley slopes, the presence of the oak would have been very important together with the chestnut. At hilltops, the ancient vegetation would have been conserved with the presence of the beech. Although the use of the forest was intensive and constant, preservation of these formations has been observed from the 15th century until nowadays.*

Key words: *chestnut,* Châtaigneraie Limousine*, charcoal kiln, roman bloodery, forest landscape*

INTRODUCTION

The study area, called *Châtaigneraie Limousine* (Limousin Chestnut grove), is situated at the limits of Haute Vienne, La Dordogne and La Charente departments in France. The etymological origin of this place is linked to the important role that chestnut played, first as a fruit tree and starting in the 18th century, as a coppicing species related to the proto-industrial activities such as the production of charcoal for metallurgical purposes due to its low cost and ease of growth in comparison to the oak (Magne, 2004).

We present the results of charcoal analysis from a Roman bloomery (Atelier Commune de Soudat) and 14 modern (15th-20th centuries) charcoal kilns. The main objectives of this study are: 1) to know the evolution of the indigenous vegetation of the studied area, where oak tree and beach tree were the principal species, 2) to know when the foreign chestnut was introduced at the study area and which is the role it plays across time and 3) to know which was the landscape exploited during the most intensive period of forest exploitation, the modern period.

METHODOLOGY

At the Roman bloomery, 2 liters of sediment were recovered from a charcoal accumulation. For the charcoal kilns, 30 x 30 cm surveys were performed and every 5 cm a sediment sample was recovered. Furthermore, this sediment was sieved with a 4 and 2 mm sieves column and only charcoals larger than 4 mm were analyzed with a reflected light optic microscope.

At the Roman bloomery, we analyzed 250 charcoal fragments. At the charcoal kilns 125 charcoal fragments were analyzed for each inferior and superior level, of every charcoal kiln.

RESULTS AND DISCUSSION

We identified *Fagus sylvatica* as the principal species. Decidous *Quercus* represented 10% of the total and *Castanea sativa* was present (Fig. 1). The chestnut, a foreign species, was probably introduced during this period in France (Belligaud and Fredon, 1985) and is related to metallurgical activities. These results are similar to other roman sites of Périgord-Limousin (Fredon, 1984, 1995; Poirier, 1999; Peyrony, 2001).

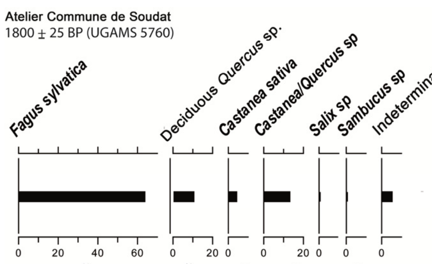

FIGURE 1. Results of the charcoal analysis of the Roman bloomery from Soudat.

For the rest of the structures, all of them modern charcoal kilns, we can classify the results in three different categories:

1) We observe a mono-specific forest, formed by *Castanea sativa*, representing more than 70% of the analyzed charcoal fragments. The other species (deciduous *Quercus*, *Betula* sp. or *Alnus* sp.) were rare. This type of vegetation was only identified at the

charcoal kilns situated at flat areas of the hills. It is a monotone and artificial landscape, as a result of chestnut monoculture.

2) A more varied woodland containing deciduous *Quercus* and *Castanea sativa* was observed, where *Quercus* dominated in most of the cases and *Castanea* encompassed 10-35% of the total, except in T.D.C. were it represented 90%. This type of forest was identified in the charcoal kilns situated at the valleys slopes, where chestnut and oak would have principally grown and we could find other species like the beech, elm, hornbeam or hawthorn. At the clearances, we could find the birch or hazel and near the water sources, the alder, willow or elder. This landscape is less artificial than the vegetation of the flat areas of the hills. Probably, the harder slopes of this landscape played an important role in the less intensive exploitation of these landscapes.

3) The third type of vegetation is composed by *Fagus sylvatica* representing over 10% of the total together with the deciduous *Quercus* and *Castanea sativa.* Charcoal kilns that show us this vegetation were situated at the slopes of the highest mountains. We could classify it as ancient woodland conserved over time. This landscape is the least artificial of the three types of identified forests (Fig. 2).

We do not observe any change in the vegetation neither between the superior and inferior levels of each charcoal kiln nor between the charcoal kilns of different chronologies. We can say that the intensive exploitation of the woodland does not cause deforestation of the exploited forests because of controlled exploitation due to the availability of the wood for charcoal production.

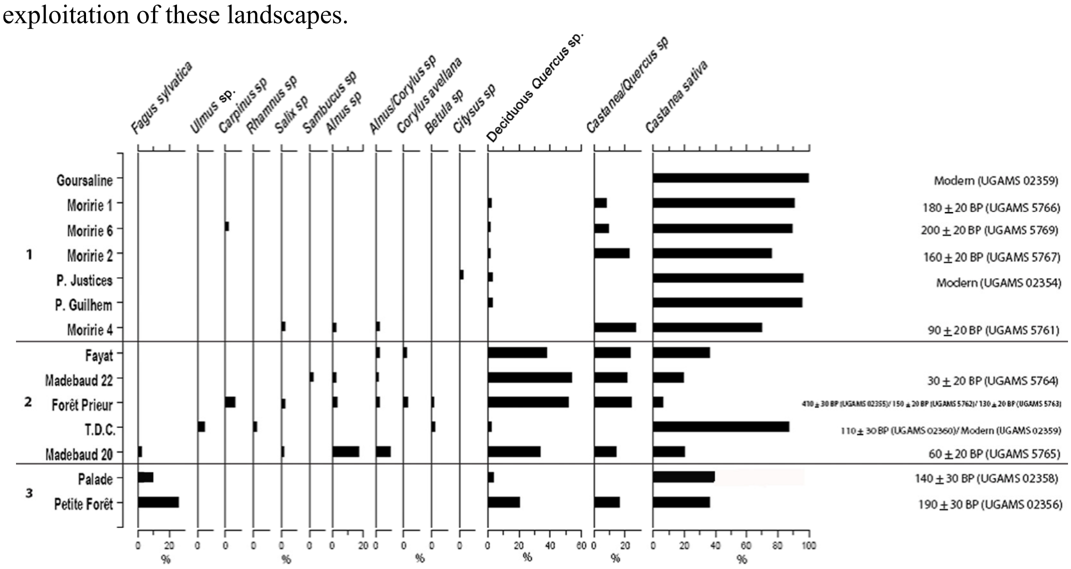

FIGURE 2. Results of the charcoal analysis of 14 modern charcoal kilns.

CONCLUSION

The results show us a landscape formed mainly by oak and beech and a punctual presence of chestnut during the Roman period. Progressively, beech decreases and the population of oak and chestnut become more important until the present time (Euba and Allée, 2009). From the modern period, beech, a relictual species corresponding to ancient vegetation, is conserved at the highest hills, coppicing woodland of oak and chestnut is present on the slopes and a mono-specific chestnut forest at the flat areas of the hills.

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Anthracological analysis of three chariots in South Bulgaria

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Abstract: *The presence of wood in the archaeological site is usually connected with its usage in different activities: construction, instruments of production, etc. Well preserved wooden parts of chariots were found for the first time in the territory of Bulgaria. Three chariots from South Bulgaria are studied. The analysis made it possible to identify the following taxa:* Quercus *sp.,* Fagus *sp.,* Carpinus *sp., Acer sp.,* Picea *sp. and* Abies *sp. The results indicate the presence of several tree species. The most commonly used is the oak. The data show that* Pinus nigra *was then still existing and later as result of cutting it disappeared. The third species is ash. It is known that this wood is very good for making various carpentry tools.*

Key words*: chariot, Roman time, wood, Bulgaria*

MATERIAL

Two chariots dated to the 3rd century BC were discovered during excavations of Dalgata mogila Tumulus near the village of Karanovo, Nova Zagora. This is one of the very few cases where we can trace the entire pattern of ritual practices accompanying burials of prominent Thracians who believed in a better after–life. That is why the deceased were to be laid with all the objects they needed during their lifetime.

The carts – one four-wheeled and one two-wheeled chariot – were placed near the tumulus. The two-wheeled chariot is characterized by its extremely interesting design and exquisite decoration. The saddle – horses were laid near the carts. The funeral feasts, offering and libations marked the beginning of piling the burial mound. The chariot from Karanovo is closest to the Roman *cisium* – a two-wheeled cart famous for its high speed and luxurious design.

The second cart is a 1900 years old well-preserved chariot found in an ancient Thracian tomb in southeastern Bulgaria. The cart is a four-wheeled chariot. At the funerary mound, were also discovered table pottery, glass vessels and other gifts for the funeral of a wealthy Thracian aristocrat.

Another chariot was discovered near Nova Zagora in the location Triagalnika. The chariot there is a two-wheeled one and it is dated to the second half of the 1st century to 3rd century.

The objects of study are the wooden parts of this chariot – plates, rims, nails, hubs, wooden objects from the basket of the chariot, wooden chairs, etc.

RESULTS

The analysis made possible to identify the following taxa: *Quercus sp., Fagus sp., Carpinus sp., Acer sp., Picea sp.* and *Abies sp.*

The results indicate the presence of several tree species. The most commonly used is the oak. It is the *taxon* most often found and its wood is very appreciated for construction.

Furthermore, there were found fragments of ash, hornbeam and beech. With less participation some conifers as pine, fir and spruce are also present. The data show that *Pinus nigra* was then still existing, and it disappeared later as result of cutting. Its habitat is the mixed deciduous forests dominated by oak that nowadays are not present. The third species is ash. It is known that its wood is very good for making various carpentry tools.

Charcoal analysis of the Iron Age archaeological site in Los Morrones I, Cortes de Arenoso, Castellón, Spain

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Summary: *During the excavations of the year 2007 at the Iron Age settlement in Los Morrones I (Cortes de Arenoso), three habitation areas affected by fire were documented, providing plenty of charred wood remains. Since these woods might have been part of building structures, they may supply data about their use in construction during that period.*

Key Words: *Iron Age, settlement, building structures, charcoal analysis.*

INTRODUCTION

The farm Los Morrones, located in the city limits of Cortes de Arenoso, is a broad archaeological area where four settlements have been found, proving the long occupation of this space situated in the high plateau of Alto Mijares. Among all settlements, the one, which seemed to be the best preserved called Los Morrones I, was dating back to the Old Iron Age. Therefore, we decided to initiate a series of interventions with highly satisfactory results (Barrachina, 2004-2005). The results in the first three archaeological works showed a group of rooms which might have been part of the same house. All the structures are concentrated on the top of the hill, apparently without extending towards the steep slopes.

DATA AND RESULTS

During the 2009 works, an entire room was excavated (Room 2) and so were part of the other two (Rooms 1 and 3). It was possible to document elements that showed the effect of fire on structures not made in stone. All of them provided abundant remains of charred wood, although in Room 1 they were smaller and scattered. Since those remains were part of building elements, they can put forward data related to their use as building material during that period.

The 104 samples obtained are remnants of timber from the room structures; they were retrieved manually and each item was marked individually (VV.AA. 2003). Afterwards, using a reflection optical microscope, an anatomical analysis was carried out on one or more than one charcoal fragments from each sample. Through that examination, it was possible to identify three taxa: *Pinus nigra-Pinus sylvestris,* deciduous *Quercus* and evergreen *Quercus.*

Following the anatomical analysis, the study of data in connection with the stratigraphic units (S.U) was carried out (Table 1).

After gathering all the data, the next step was to examine the distribution of the identified taxa in relation to each room (Fig. 1). Three facts can be observed:

1. The significant presence of deciduous *Quercus* and *Pinus nigra-Pinus sylvestris* charcoal, shows that the construction timber was used, among other things, as building material for elements such as poles, beams, roof, floorboards, doors, stairs, furniture, etc., which might have been part of the rooms.

2. Findings in Room 1 differ from the other rooms, since the only taxon represented is *Pinus nigra-Pinus sylvestris*.

3. The presence of evergreen *Quercus* is scarse; it was identified only in Room 2.

S.U	Number of samples	TAXA		
		Deciduous Quercus	*Evergreen Quercus*	*Pinus nigra-Pinus sylvestris*
1017	4			100
1025	64	64,4	1.5	34,1
1026	1	100		
1027	2	50		50
1028	12	75		25
1029	3			100
1032	18	66,6		33,4

TABLE 1. Los Morrones I. Percentage of taxa identified in relation to stratigraphics units.

DISCUSSION

The settlement of Los Morrones I is situated on top of a hill at about 1146 m asl, in the municipality of Cortes de Arenoso, in the natural region of Alto Mijares. The site is framed in the *maestracense* chorological sector, under the influence of the following bioclimatic levels (Roselló 1994, Peris *et al.,* 1996): a) Superior Mesomediterranean. It is located south of Cortes de Arenoso. Evergreen oaks are predominant, although the valley bottoms are covered by deciduous oaks, b) Supramediterranean. It is located to the north of Cortes de Arenoso, where extensive *Pinus nigra* forests grow. At the lower levels, they mingle with evergreen oaks, c) Oromediterranean. It is located at the top of Las Cruces peak (1710 m asl). *Pinus sylvestris* here clearly dominates. This vegetation was already exploited by the inhabitants of Los Morrones I in the Iron Age, as we can infer from the three identified taxa in this study, since the retrieved samples were taken precisely from those forests. However, the extension of these formations cannot be determined through this analysis due to the origin of the samples; these were concentrated samples associated with building structures that provide ethnological data, but not environmental data at a quantitative level (Grau, 1991; Chabal, 1991). What seems to be evident is that deciduous oak, pine and evergreen oak woods were selected for a specific purpose. This particular use is unknown so far, although we could be talking about poles, beams, roof buttresses, lintels, stairs, etc., which fell down to the room level during the fire.

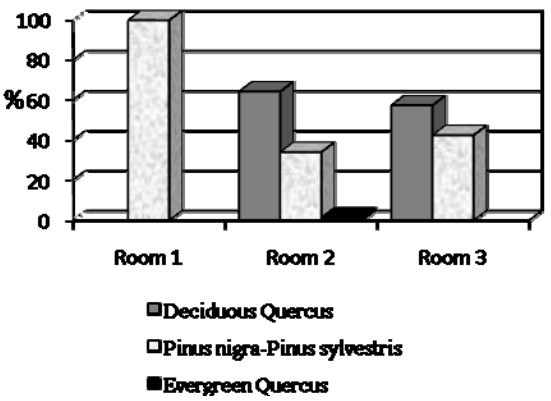

FIGURE 1. Los Morrones I. Taxa identified in relation to each room.

Other archaeological sites dated to that period, such as Castellet de Bernabé (Llíria, Valencia) and Puntal dels Llops (Olocau, Valencia) (Grau, 1991), have revealed remains from the building structure (Grau, 1991). This has also been documented in Los Villares (Caudete de las Fuentes, Valencia) (De Haro, 2002).

CONCLUSIONS

At the archaeological site of Los Morrones I, three rooms affected by fire have been documented, providing charcoal remains of deciduous *Quercus*, *Pinus nigra-Pinus sylvestris,* and evergreen *Quercus*, which were part of building structures. Deciduous *Quercus* and *Pinus nigra-Pinus sylvestris* were mainly used as timber and evergreen *Quercus*, to a lesser extent. The woods were extracted from areas near the site: *Pinus nigra-Pinus sylvestris* from the north of Cortes de Arenoso and deciduous *Quercus* and evergreen *Quercus* from the hillsides and the valley bottoms to the south.

The extension of the excavated areas, including Room 3, it is likely to offer new data that complement those presented here. We should not forget that what we present here in detail is only a first approximation from the study of the carbonized remains.

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