



Humans and environmental sustainability: Lessons from the past ecosystems of Europe and Northern Africa

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Edited by
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UNDER THE PATRONAGE OF



CEA2018

This e-book includes the 61 long abstracts of oral presentations (41) and posters (20) presented at the three-day CEA2018, the 14th Conference of Environmental Archaeology. The LPP-Laboratory of Palynology and Palaeobotany of Department of Life Science, interdisciplinary biological center of the University of Modena and Reggio Emilia, organized the meeting in Modena (26-28 February 2018), in the historical and recently restored San Geminiano building. The scientific contributions were presented in 8 talk sessions and one poster session. Multidisciplinary *ABG Archaeo-Bio-Geo* studies on environmental reconstructions and palaeoecological research involving analyses of archaeological survey, human and animal bones, sometimes integrated to isotopic or molecular data, remote sensing and GIS, are reported in this e-book. Botany is the prevalent biological field contributing to environmental reconstructions, with analyses on plant macroremains, non-pollen palynomorphs and pollen, and with studies on flora and vegetation changes. Study areas are mainly centered on European countries, Mediterranean and Northern Africa, including five abstracts on Sahara, while two contributions concern South America.

The 1st Conference, called “The Archaeobotanical work group”, was organized in 2005, and was a working group round-table meeting between experts on environmental studies and archaeologists of the Czech Republic. Then, the meeting became an annual conference with more and more attendants from other countries. In 2017, the 13th CEA took place in Nitra, Slovakia, and was for the first time outside the Czech Republic. In Italy, the CEA2018 has been especially rich of presentations and interdisciplinary approaches, with many countries represented as study areas and participants coming to Modena. Titles and list of co-authors show an unexpectedly rich number of contributions to the Environmental Archaeology by Italian specialists joining colleagues from the Czech Republic, Poland, Norway, Sweden, Greece, Spain, France, Switzerland, Austria, Germany, Serbia, Slovakia, Republic of Macedonia, United Kingdom, United States of America, and other countries.

The congress was under the patronage of the project SUCCESSO-TERRA (on sustainability and the Bronze age in the Po plain-N Italy) and of the network BRAIN-Botanical Records of Archaeobotany Italian Network (<https://brainplants.unimore.it/>). Basic sponsorships were given by the Botanical Society of Italy, the Italian Institute of Prehistory and Protohistory, the scientific association Society of Naturalists and Mathematicians of Modena, the Superintendence of Bologna, Modena, Reggio Emilia and Ferrara, Civic Museum of Archaeology and Ethnology of Modena, with municipality of Modena and the Emilia Romagna Region. Besides the SUCCESSO-TERRA project mentioned above, financial support was provided by Fondazione Anna Maria Catalano ONLUS and CEDAD-Centro di DATazione e Diagnostica. We acknowledge all the projects, institutions and associations, the international scientific committee, the local organization committee and the Centro Interateneo EDUNOVA - Centro E-learning di Ateneo who contributed to the success of the conference.

*Anna Maria Mercuri
February 2018*

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SESSION 1

Detecting human impact: the ABG (archeo-bio-geo) research

Settlements, crops, woods. Land use and natural resources in a changing environment at the time of the Terramare (XVI–XII century BC, N Italy)

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Keywords: land use, environment, multidisciplinary research, Bronze Age, Terramare

Introduction

The civilization of the Terramare developed between the Middle and the Recent Bronze Ages (XVI–XII century BC) in the Po Plain of Northern Italy, and was based upon cereal farming, herding, and metallurgy (Bernabò Brea et al. 1997). The Terramare people also promoted a wide network of commercial exchanges between Northern Europe and the Mediterranean region. This civilization lasted for c. 500 years, before suddenly collapsing at *ca.* 1150 BC (Cardarelli 2009; Fig. 1), in a period of great civilization upheaval throughout the whole Mediterranean region. This paper discusses the initial results of an on-going research carried out in the framework of the *SUCCESSO-TERRA Project (PRIN20158KBLNB)*, aimed at elucidate the reasons, dynamic and timing of the collapse of the Terramare civilization.

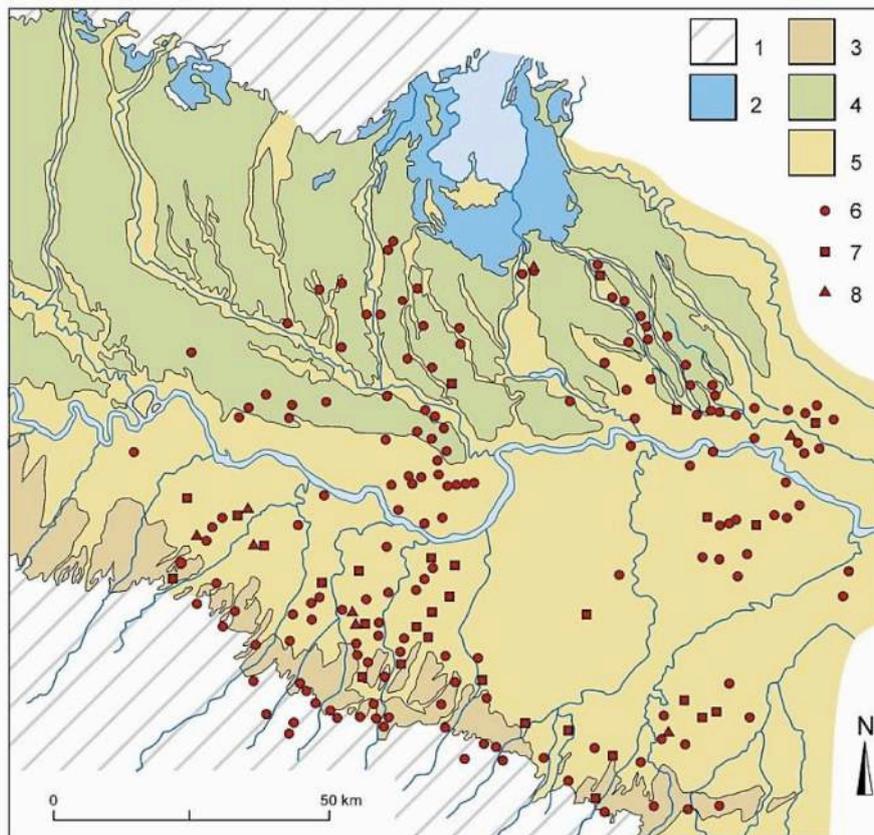


Figure 1 - Distribution of the Terramare and contemporary sites in the central Po Plain.

Materials and Methods

The research project includes the cooperation between geoarchaeologists, archaeologists, palaeoarchaeobotanists, and geochemists. It is based on the archaeological excavation in key sites (Terramara Santa Rosa di Poviglio - Bernabò Brea et al. 2004, Figs. 2,3; Terramara di Noceto - Bernabò Brea and Cremaschi 2009, and San Michele di Valestra sites - Cremaschi 1997), and a regional survey in the areas surrounding the archaeological sites. The results from archaeological, geoarchaeological (including micromorphology), archaeobotanical and archaeozoological studies are interpreted in a multidisciplinary perspective, and in a chronological framework based on many radiocarbon dates on different materials. Moreover, an independent palaeoclimatic reconstruction is investigated through the study of local speleothems.



Figure 2 - Terramara Santa Rosa di Poviglio, Villaggio Grande – plan of houses delimited by postholes

Results and Discussion

The subsistence strategies of the Terramare civilization were mainly based on cereal agriculture supported by the introduction of irrigated agriculture. Beside irrigated agriculture, it also introduced an innovative and sophisticated system of management of the natural hydrographic net. Artificial canals were excavated to draw water from the main watercourses, along which the settlements were located, to the moats of the villages and then redistributed to the fields throughout a dense network of irrigation ditches. The successful contribution of this irrigation method to agricultural practices triggered the Terramare civilization to its apogee and in consequence of it a growing demographic pressure developed from the Middle Bronze Age to the Recent Bronze Age.

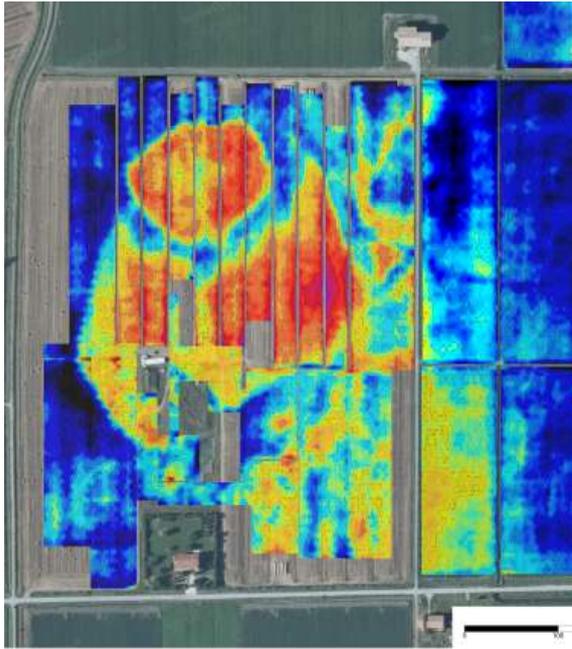


Figure 3 - The map of the Terramara of Santa Rosa di Poviglio as shown by the geophysical survey (Mele et al. 2015 in Cremaschi et al. 2015).

A further and important aspect of the land exploitation performed by the Terramare culture was deforestation, which was extended also to the lowlands that had never been cleared before. The need for extending clearance to larger areas was mandatory, as increased demographic pressure required large areas for cultivation and grazing. Moreover, a large quantity of timber was required to build villages. As a consequence, the pollen diagrams obtained from Terramare sites show a very high rate of deforestation; the latter is higher than in other Bronze Age settlements from the Alps and central Italy (Cremaschi et al. 2016). An estimation of the agricultural yield of cultivated fields of some Terramare sites in the basin of the Enza River (Emilia region, N Italy) indicates that the production of cereals was adequate to the demands of the Middle Bronze Age, but became critical during the period of demographic growth at the apogee of the Terramare culture in the Recent Bronze Age. From this period onwards, a progressively increasing environmental stress is also evident. Parts of the fields were probably left uncultivated and used for livestock grazing. Among domestic animal populations, the number of goats increased, less demanding than other animal species as pigs, which were better represented in previous periods.

The dramatically diminished availability of timber is confirmed by a change in building technique; the construction on deck and posts, which is a technique that demands large quantities of wood, was abandoned. Wooden palisades to improve the fortifications of villages were replaced by earthen ramparts; the necessity to protect villages suggests an increased societal instability due to a growing competition for natural resources (Cremaschi and Pizzi 2013).

An episode of drought at c. 1150 BC (3100 years cal BP), documented on both sides of the Alps and in the Apennines by several palaeohydrological archives, affected the Terramare area (Fig. 4). At the Terramara of Santa Rosa di Poviglio, the dry period caused a dramatic lowering of the water table, and consequently the turning off the hydraulic systems of the site (Cremaschi and Pizzi 2007). This forced the inhabitants to dig wells at the bottom of the moat surrounding the site to reach deeper water tables (Fig. 5). The site was abandoned in coincidence of this drought episode and at the same time the whole Terramare system collapsed. Likely the unexpected and intense drought, affecting a territory exploited beyond the limits of its sustainability, had dramatic effects (Cremaschi et al. 2006). It caused famine among livestock and humans, and pushed the social system to the collapse that led to the disappearance of the Terramare in the turn of a generation.

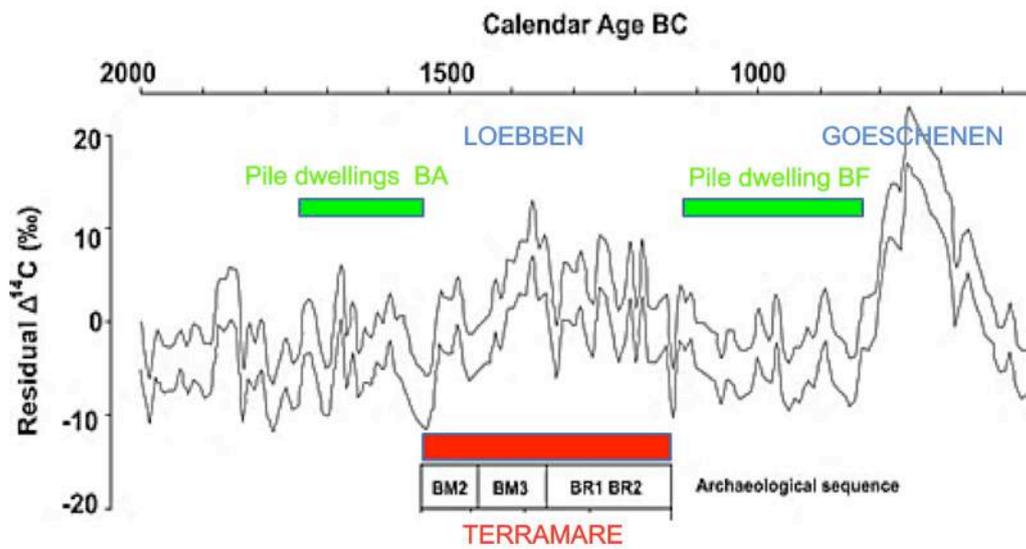


Figura 4 - The period of existence of the terramare (red bar) is compared to the oscillations of the residual ^{14}C , the main phases of advance of the Alpine glaciers (Loebben and Goeschenen) and the periods of presence of the pile dwellings in the Alpine area

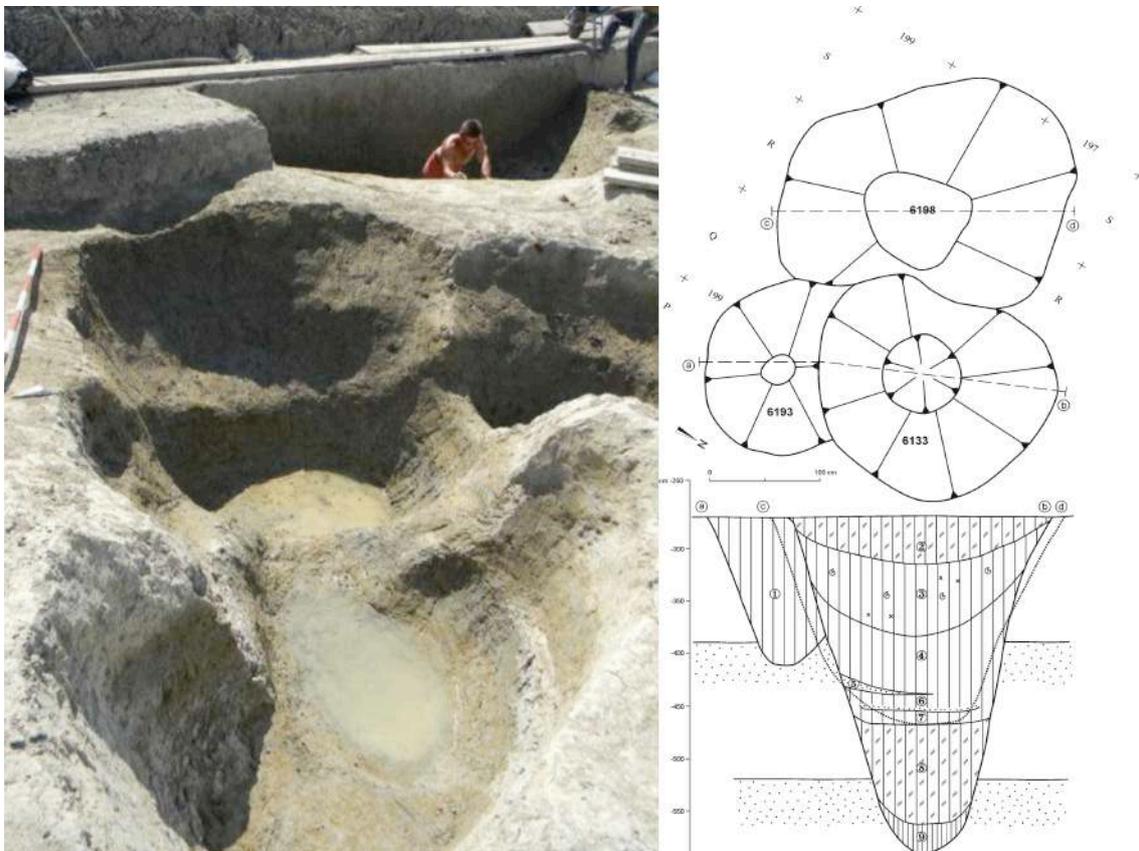


Figure 5 - Terramara Santa Rosa, Interconnected wells of the last phase

Conclusions

The working hypothesis so far followed indicates that the unfavorable concomitance between the exploitation of natural resources and climatic factors strengthened the crisis of the Terramare system. The results of the latest excavation seasons in the Terramara Santa Rosa di Poviglio (Cremaschi et al. 2016) suggest that the construction of fortifications at the end of the late Recent Bronze was suddenly interrupted, confirming the dramatic and instantaneous nature of the social and environmental crisis. The latter, on the basis of fresh radiocarbon dating seems to be placed at the end of III millennium BP. New data also indicate that frequentation of the site continued, albeit in a very limited way, even after the crisis and the consequent collapse of its defensive structures.

The Terramare crisis did not reach the Apennines: therein a recent excavations have established that the site of San Michele di Valestra does not show any interruption coinciding with the collapse of the Terramare, from which it is only 20 km away. The different environment and a different strategy in the exploitation of natural resources, a less impacting agriculture, and a greater role of pastoralism, have probably allowed these settlements to a greater resilience and to survive the climatic event that accompanied to the end of Terramare.

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EMPTYSCAPES

Towards Filling Gaps in Mediterranean Landscape Archaeology

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'On one matter there is universal agreement: the appearance of practically every square metre in the Mediterranean today, save a few remote fastnesses, has been altered, directly or indirectly, by the past activity of people' (Cyprian Broodbank 2013: 71)

'What at first appeared to be merely a period of technical re-equipment has produced profound practical, theoretical and philosophical problems to which the new archaeologies have responded with diverse new methods, new observations, new paradigms and new theory' (David Clarke 1973: 17)

Keywords: *Mediterranean, Italy, empty spaces, landscape, archaeological continuum, holistic*

The *Emptyscapes* project

The aim of the project is to use the 'traditional' methods of landscape survey in partnership with large-scale geophysical prospection, in due course airborne laser scanning, geo-archaeological and bio-archaeological. The research area is a stretch of a rural valley near the ancient city of Rusellae in southern Tuscany exploring completely new ground of a rural emptyscape.

The Etruscan and Roman city of Rusellae has been relatively well explored in the past, with a history running in fairly well-defined phases of foundation, elaboration and decline from the 8th or 9th century BC to the early 12th century AD, when primacy and the local bishopric were ceded to the growing town of Grosseto a few km to the south-west. At least some of the developments within the ancient city are known or suspected to have been matched by developments or transformations within the open landscape of the valley, including the foundation and decline of rural villas and (possibly) of centuriation during the Roman period.

Villages of one kind or another may also have been present during the Iron Age and Early Medieval periods, though their location and form remain unclear (Nicosia and Poggesi 2011). Today, the slopes either side of the valley are largely wooded. The relatively flat and topographically undistinctive landscape between present-day Grosseto and the site of Rusellae is now displays a rotating mixture of arable cultivation and pasture, dotted with small areas of woodland, vineyards and olive cultivation. A trapeze-shaped sample transect covering 2500 ha of the valley and hillslopes to the south-east of Rusellae was chosen as offering opportunities to explore a range of environmental and archaeological contexts, with lowland fields appropriate for magnetic survey flanked by wooded hillslopes which in due course will act as a test-bed for high-resolution laser scanning.

Previous field survey, aerial photography and the detection of archaeological evidence

From the late 1970s onwards the University of Siena has fostered a systematic programme of landscape and archaeological investigation within southern Tuscany, including the Rusellae area. As a result the area now has a substantial database and GIS, developed mainly through the examination and analysis of archaeological evidence and ancient literature, documentary and

epigraphic sources, place-name evidence, systematic field-walking survey and aerial photography, along with excavations of various scales. Despite this, many important archaeological questions still remain unresolved. Moreover, if we look at the 1:100,000 distribution map and switch instead to the 1:10,000 it is easy to appreciate how the ‘empty spaces’ predominate (Fig. 1).

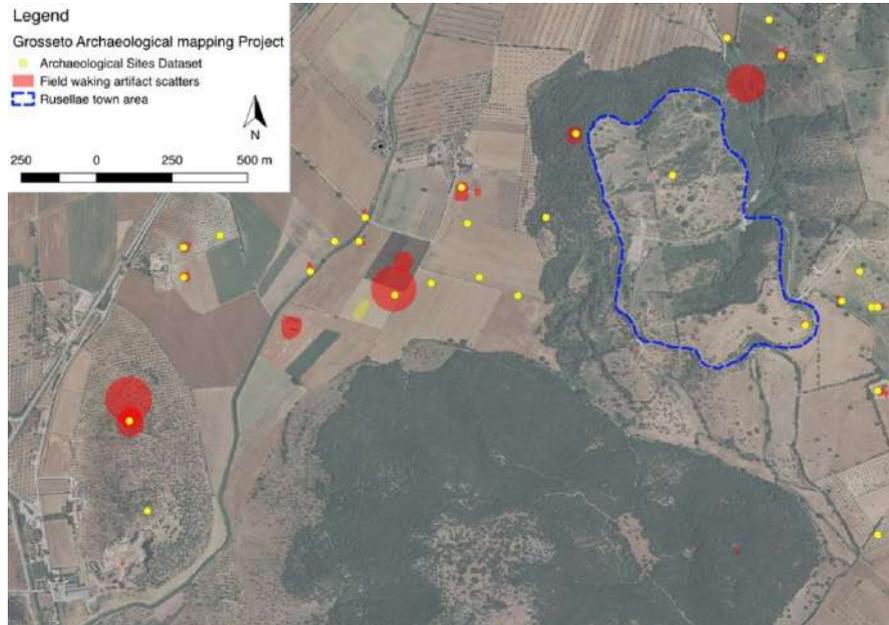


Figure 1 - Close up of the distribution map of sites detected by ‘traditional’ archaeological survey towards the north-eastern end of the sample transect, at a scale of 1:10,000.

This realisation raises a crucial question: what are we missing? The answer lies before our very eyes: the landscape and its transformations across time.

In an attempt to address the conundrum of the ‘empty phases’ and to fill what at present appear to be ‘empty spaces’, the Emptyscapes project has been making an intensive study of the sample transect at Rusellae so as to explore some key questions relating to the major cities of Rusellae, Grosseto and Vetulonium: for instance the urbanisation of the Etruscan cities and in particular their relationship with the surrounding countryside, the Romanization of the cities and the landscape, the process of Christianisation and finally the impact on settlement, society and economy of the end of the Antiquity and the beginning of the Middle Ages (new ruling classes, ‘incastellamento’, etc).

In the attempt to improve our understanding of the sample area we have so far collected around 450 ha of geophysical data (420 ha of magnetic and 30 ha of resistivity data); we have also undertaken exploratory aerial survey in the area and have recently commenced fieldwork with the purpose of collecting archaeological, geo-archaeological and bio-archaeological evidence within the chosen transect. However, after this amount of scientific effort, have we answered our research questions? Which new scenarios have been opened up? What new questions can we now ask? Has our understanding of archaeological and landscape transformations within the sample transect been substantially improved?

To answer these questions, or at least to provide a partial response, this article will present just one example (among many other available in this area) that will illustrate the impact of the work undertaken so far on our understanding of the area and of the overall potential of this approach within a carefully chosen tract of ancient landscape. Aerial survey but especially magnetic prospection has produced entirely unexpected results. In the north-east block, the magnetic data shows a cluster of anomalies that can be readily interpreted as anthropogenic functional

elements and natural features within the local landscape: cultivation patterns, road systems, buildings and geomorphological features. Within this complex there lies a double-ditched enclosure (marked in blue in Fig. 2), close alongside the present course of the river Salica. The enclosure was first identified in the magnetic data and then confirmed by intensive field-walking survey (Campana 2018).

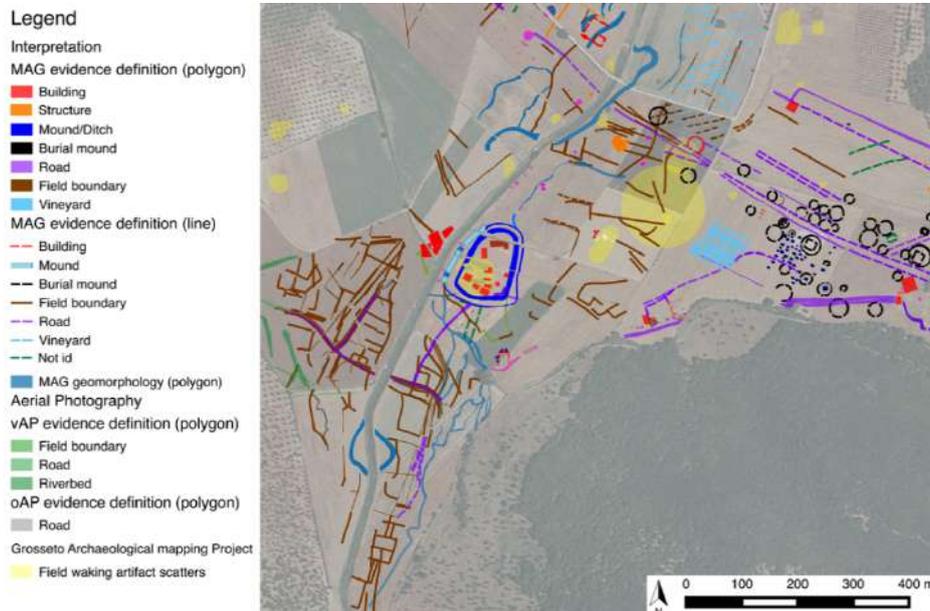


Figure 2 - Overlapping of the site distribution and archaeological mapping of magnetic measurements (Mag) as well as oblique (oAP) and vertical (vAP) aerial photography.

Within the 0.8 ha central area of the enclosure intense artefact scatters coincided with a number of clear magnetic anomalies, the size and shape of which suggested interpretation as buildings. In this case field observation and artefact collection were critical in identifying key features of the site: a significant variation in elevation (of as much as 1.5 m) matching the features visible on the magnetic map, and artefact scatters clearly indicating a medieval dating. What has been revealed here is a previously unsuspected artificial mound, or alternatively a settlement occupying a slight natural eminence within the local topography. Moreover, in the neighbourhood of the site, but mostly to the south and the west of the river Salica, magnetic anomalies reveal a pattern of field boundaries, roads and palaeo-riverbeds. The outstanding character of the magnetic data and local topography prompted a borehole survey and an intensive programme of artefact collection within a virtual grid of 10 m x 10 m ‘cells’, aimed at establishing the chronological range and function of the site and at providing a more detailed picture of the match between the magnetic measurements, micromorphology and artefacts distribution. Analysis of the collected artefacts showed a quite distinct pattern of intensive human activity deriving predominantly from the early 10th to the early or mid 12th century AD. On the basis of comparative studies of shape, size, morphology, artefact assemblage and chronological range this site can confidently be interpreted as a lowland medieval settlement that shares significant characteristics with three others identified during recent survey work in or close to the Grosseto lowland. It is possible, moreover, that the adjacent field system and road could be associated with the same cultural context and chronological range. Unfortunately, borehole survey program has been quite ineffective dating and generally improving our understanding of field boundaries and therefore proper test-excavation program is needed. However, in the meanwhile, we implemented comparative studies showing clear resemblances here to sites in Puglia revealed in the first instance through aerial photography (Guaitoli 2003), many of them sharing a general appearance to our field system in terms of size, shape and overall pattern, and in some cases also to the shape of the settlements themselves. However, the

settlement and in particular the field system (if genuinely associated with one another) illustrate an extraordinary vital stage of a society that had the capacity and/or need to reorganize settlement and landscape patterns, perhaps removing almost all vestiges of older patterns in the process. As a final remark in this context we should perhaps emphasize the complexity of the area under investigation. Past studies identified this as one of the most important areas within the Grosseto plain for agricultural production (Citter and Arnoldus 2007). Moreover, the present survey has produced clear evidence of a high level of hydrogeological instability in this locality. Therefore, the creation of this new settlement and perhaps field system, whether financed initially by the ruling classes or undertaken of their own volition by an existing rural community, would have required advanced know-how of the local area, along with social resources in terms of labour and productive capacity, to fulfil the project in the first place and to retain it as a viable social and productive concern over time.

Targeted small-scale excavation

To further improve understanding of the historical development and to provide feedback to the general research strategy a programme of targeted small-scale excavation was implemented during summer 2017. The excavation work was aimed at sampling the air-photo and geophysical anomalies interpreted as field boundaries and identifying dating evidence and bioarchaeological data to better explain the local pattern of land use and its transformation across time. The excavations were also targeted at the double-ditched enclosure in the hope of better defining the chronology and fundamental characteristics of the settlement and its possible connection to the adjacent field system. In the event the excavations revealed a substantial series of stratigraphical relationships and paleo-soils from which it was possible to collect samples for geomorphological, bioarchaeological and pollen analysis; these promise to provide a better understating of the past environment at various stages in the development of the local landscape pattern (Fig. 3). At the time of writing, towards the early 2018, analysis of the collected observations and samples is still in its initial stages but it can already be said that almost all of the features identified in the remote-sensing data were also readily traceable in the excavation trenches, along with paleo-soils and other relevant items not represented in the survey data.

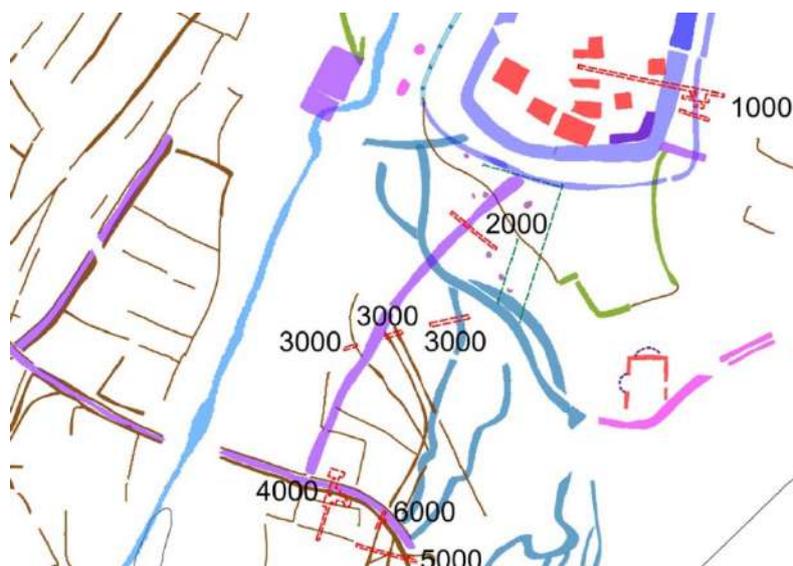


Figure 3 - Targeted small-scale excavations near Rusellae. Numbered and dashed red polygons show the outlines of the sample excavations carried out in the summer of 2017.

The excavations in trench 1000 confirmed that the fortification system of the settlement consisted of two ditches, each probably accompanied by an internal bank, a paleo-soil containing medieval pottery and in the case of the inner bank and ditch, by a wall too.

In five of the six test excavations clearly-defined anthropic paleo-soils were identified. Within the double-ditched enclosure the top of the paleo-soil (left undisturbed during the excavation) lay about 30 cm below the present surface, immediately beneath the recent ploughsoil. Outside the enclosure the thickness of the paleo-soil was seen to be about 30-40 cm, extending beneath the recent ploughsoil to a depth of about 60-70 cm from the present ground surface. Both inside and outside the enclosure the paleo-soil was relatively dark in colour and included plentiful organic elements and medieval pottery (Fig. 4). The only excavation trench that did not reveal this paleo-soil (trench 3000) was only excavated to a depth of 50 cm before being abandoned after of heavy rain made it impractical to continue the excavation work. There was no surviving evidence of deeper anthropic paleo-soils. Stratified deposits of Roman and Etruscan age were also entirely lacking, surprisingly so in a location situated only a short distance from a city that played a substantial role in the region throughout those periods. At the east end of trench 1000 and at both ends of trench 2000 the excavations were carried to a depth of up to 3.5 m below the present surface without revealing any sign of anthropic paleo-soils at these lower levels. In this connection, however, it is worth adding that both past and recent field-walking survey and artefact collection across this area produced only a very thin scatter of pre-medieval material, the overwhelming majority of the surface finds belonging to the 10th to 12th century AD, with only a very few finds from the early Middle Ages and Late Antiquity. Pottery and any other kinds of material from the Etruscan and mature Roman periods were exceptionally rare. The detailed examination and analysis of the sections in partnership with geomorphologists from the University of Siena, highlighted the presence of complex geomorphological activity and the widespread presence of clay layers produced by the settling of sediments in still water (Fig. 4). A reasonable interpretation would see this area as characterized by a small expanse of open water during Etruscan and Roman times, later reclaimed as dry land in Late Antiquity or perhaps during the very early part of the Middle Ages.

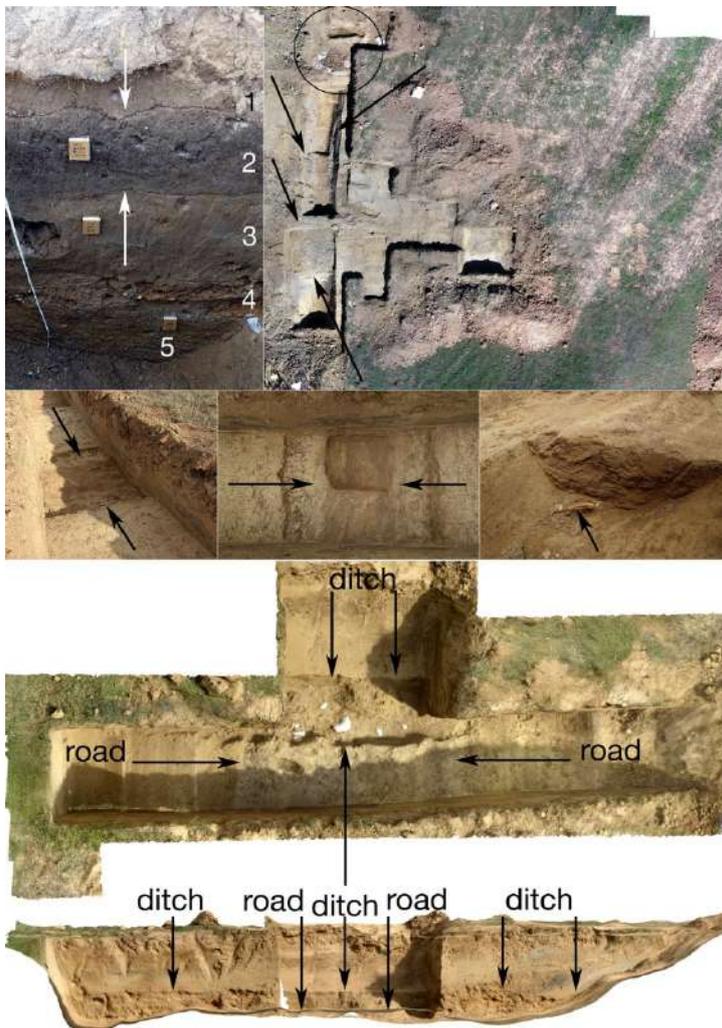


Figure 4 - Targeted small-scale excavations near Rusellae. Top left: section of trench 2000 showing the clearly defined topsoil (1), black paleo-soil (2), and natural clay deposit mixed with other natural sediments (3, 4, 5). Top right: drone-derived orthophoto of trench 4000 showing the the road (indicated by black arrows) and the close proximity of the two Lombard burials (black circle). Central row: trench 5000 showing a ditch filled (from left to right) by sand deposits at the top and gravels and ceramic material at the bottom. Bottom: plan and section of trench 6000; the plan view at the top is a drone-based orthophoto showing the road (running top to bottom) where it is clearly overlain and cut (from left to right) by the small ditch originally identified in trench 5000; the lowest part of the illustration is derived from a 3D simulation showing the section of the trench, with light-coloured ploughsoil at the top and arrows to mark the upper surface of the darker-coloured ditch-fill where it clearly overlies the arrowed surface of the road at the very bottom

Sample trench 4000 was located so as to intersect a magnetic feature that had been interpreted as part of a road system, at this point running approximately east to west. The excavation confirmed the presence of a substantial hardstanding appropriate as the foundation levels of a road. A short distance to the north and at the same depth as the road there were discovered two inhumation burials. One was in a simple *fossa terranea*, devoid of grave goods, while the other had a stone cover-slab and contained a brooch, a necklace and a pair of earrings typical of the early Lombard period in this part of Italy. In the survey datasets there was no trace of any settlement within 150 m of the burials – the double-ditched enclosure lies 200 m to the north-east and on current interpretations belongs to a considerably later date. It therefore seems reasonable to suggest a connection between the road system and the burials, and to infer that the road may still have been in use when the graves were dug.

In trench 5000 one of the small ditches that appeared from the geophysical data to serve as field boundaries was shown to have a filling of sand above a thin layer of gravel at the very bottom, with organic remains and plentiful fragments of charcoal along with sherds of pottery that appeared to be entirely consistent with medieval material of the 10th to 12th century AD. The fillings were systematically sampled for environmental analysis and radiocarbon dating. If current impressions are confirmed, it seems highly likely that this part of the field system identified through non-destructive survey will be confirmed as fitting within the same chronological bracket as the double-ditched settlement (Fig. 4).

Trench 6000 was directed at the relationship between the road uncovered in trench 4000 and the ditch identified as a field boundary in trench 5000. The field boundary clearly overlay and partially cut the road, the surface of which lay approximately 40 cm below the level from which the ditch was cut. The road therefore seems to have been out of use by the time the field boundary began to collect pottery and other material provisionally dated to the 10th to 12th century, like that associated with the double-ditched settlement located about 200 m to the north (Fig. 4). Within the current state of data processing the evidence collected so far provides an entirely new and now broadly phased picture of the area under investigation. Studies of local geomorphological dynamics have revealed the presence of still water within a probable pool or wet area which on present evidence seems to be present throughout the Etruscan and Roman periods and perhaps onward into Late Antiquity. After this, pottery began to appear, as does evidence of a new feature in the form of a road or road-system, attesting to a new phase of activity probably associated with reclamation of the wet area or to climate change (or perhaps to a combination of the two). During or soon after Late Antiquity it appears that the wetland area had already been reclaimed and a high-quality road built across it, an enterprise that would have demanded significant economic resources and technical expertise. At the beginning of the 7th century two Lombard burials were placed alongside the road, roughly in the centre of the area examined so far (Fig. 5). A little later a small amount of 8th and 9th century pottery found its way onto the area which then saw the major development of the double-ditched enclosure and its apparently associated field system during the 10th to 12th century. By this time there was a wide-spreading medieval paleo-soil within an apparently well-structured agrarian landscape characterized by a regular system of small ditches defining fields or property boundaries and no doubt providing local drainage.



Figure 5 - The north-eastern part of the Rusellae study area: the yellow area represents the hypothetical wetland or small lake bounded to the north by a workshop or productive centre dated by surface finds to the Roman period (inset on the right) while in the other directions there are obvious boundaries in the higher land of Moscona and Mosconcino. The southern limit is very narrow and available maps show that is marked by a sort of dam, either natural or anthropic, which may become the focus future small-scale excavation. The inset on the left shows an orthophoto of the two burials discovered near the centre of the area alongside the road. The inset on the right shows the Roman-period complex at the northern end of the wetland area.

Conclusions

The survey and interpretation described above have borne out the potential effectiveness of this approach to rural landscapes in Italy, and by implication in much of the Mediterranean area, showing clearly that the concept of the archaeological *continuum* is a reality that lies almost within our grasp, even in the specific environmental and archaeological conditions of the Mediterranean world. Previous research strategies in Italy have been largely reactive, with a focus on the known or partly known through the use of methodologies, which reveal only a limited part of the potentially recoverable evidence. Archaeological distribution maps, particularly for the Rusellae area, consisted until very recently of a collection of dots within a sea of ‘emptiness’. Indeed, in most cases the empty spaces seemed to be in the majority. If we can overcome this limitation, as has been demonstrated here, we will be able to open up completely new opportunities to explore a wide range of as yet unanswered archaeological and historical questions. In the writer’s view this capacity to uncover and document previously inaccessible evidence is important for two key reasons, the first being essentially archaeological while the second methodological. The identification, for instance, of a previously unsuspected funerary landscape, field systems, enclosures or of structured medieval settlements on the lowland around Rusellae, and so forth, cannot be dismissed as the simple addition of dots or detail to the mapped record of the area. The newly discovered enclosures represent a form of settlement previously unknown in lowland Tuscany (Settia et al. 2013). Archaeological concepts developed in recent decades, of a largely ‘uninhabited’ Tuscan countryside in the formative centuries of the medieval period, have thus been thrown open to further discussion. The results achieved so far are also important for a methodological reason. Given that exactly the same pattern of advance in data capture and archaeological understanding has ensued wherever these new holistic approach to landscape studies have been applied in the UK (Powlesland 2009) and in the continental Europe (Neubauer 2013) it is a reasonable to argue on the basis of the results achieved so far that the same partnership of traditional and innovative

methodologies ought to continue producing the same improvement in Italy too, helping us to examine and possibly revise present perceptions about the content and progressive transformations of the Italian countryside.

Acknowledgements

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Recent surveys of ancient human impact on soil chemistry in Messara Plain, Crete

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Keywords: *human impact, topsoil, settlement pattern, pXRF, geochemistry*

Introduction

Human settlement activities produce accumulations of certain chemical elements (many of them we call nutrients) in anthropogenic soils (Fleisher and Sulas 2015; Oonk et al. 2009; Smejda et al. 2017). A large-scale mapping of elemental composition of topsoil can be used for detection of chemical anomalies that may indicate locations of past settlements, cemeteries or other activity areas (agricultural or metallurgical production etc.). However, other sources of soil enrichment with nutrients are also possible, e.g. by modern application of agricultural fertilizers, keeping of domestic animals, modern waste deposition, or by specific composition of the local geological bedrock affecting pedogenic processes (Stockmann et al. 2016). The aim of the geochemical survey reported in this presentation was to study potential relationship between ancient settlement pattern and chemical composition of contemporary topsoil.

Materials and Methods

Elemental composition of topsoil in two landscape transects (Porti and Miamou) were surveyed and mapped in 2015 and 2016. These survey areas were known for the presence of Bronze Age and later archaeological structures (consisting mainly, but not exclusively, of settlements and tombs). Measurements were conducted directly in the field as well as in the laboratory conditions, using a portable X-ray fluorescence spectrometer (pXRF). This instrument provides information on chemical composition of tested materials in real time, the results being shown on the display and stored in the memory of the device for later analysis. The spectrometer used recognizes the range of elements of the periodic table from Magnesium up to Uranium. The data were subsequently used for statistical and spatial analysis. The geochemical sampling was conducted in the field in an irregular grid of points that overlapped spatially with the grid of squares used for surface collection of finds and architectural survey. Locations of samples were recorded by a handheld GPS unit, allowing for comparison of geochemical data with a number of environmental and archaeological variables.

Results and Discussion

There is a statistically significant correlation of certain chemical elements, which were introduced into soil as a result of historic or even pre-historic human activities. These correlated elements include especially phosphorus (P), potassium (K), sulphur (S), zinc (Zn) and copper (Cu). These elements are (among others) normal constituents of any living organism. We can expect that the decomposition of organic waste and deposition of biomass ashes on or near archaeological sites causes the elevated concentrations of these elements in soils (Smejda et al. 2017). Detected areas of increased levels of these elements in topsoil are compared with the number of pottery fragments on the surface (Fig. 1). The squares rich in ceramics are usually located in or near the areas with higher concentration of phosphorus. This element has been traditionally recognized as a good indicator of past human activities and the most useful chemical indicator for archaeological prospection. Other elements show different spatial

patterns, which can be shaped either by local geology or human activities that can be interpreted only hypothetically.

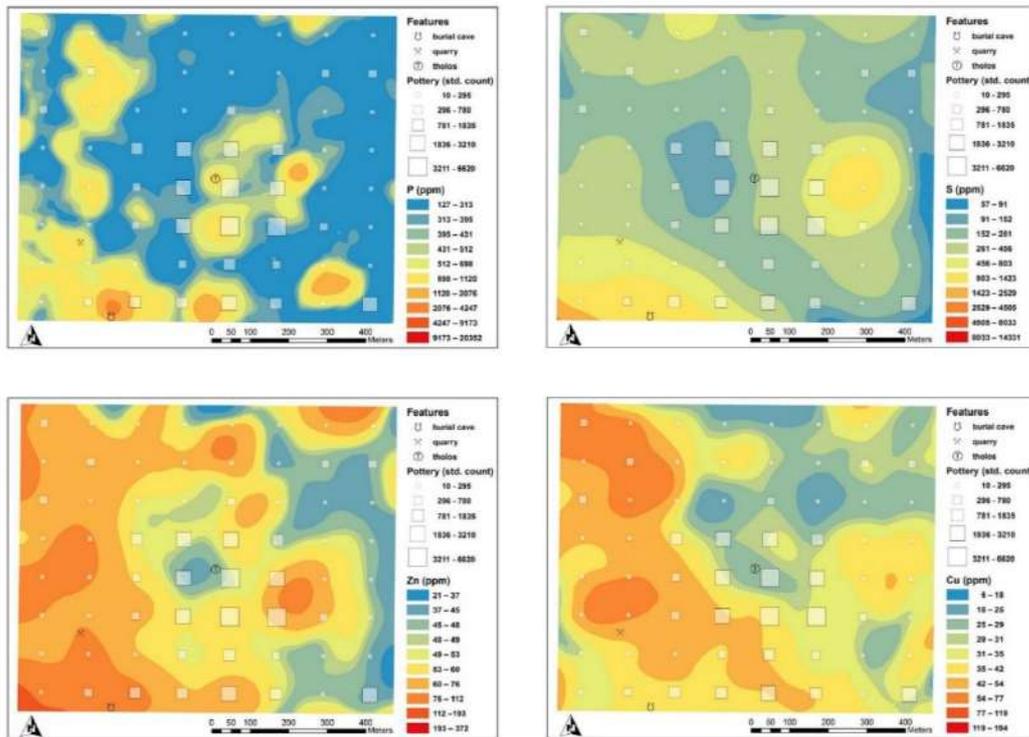


Figure 1 - Soil concentrations of P, S, Zn and Cu in the Porti survey area are shown in the colour scale (see the legends). White squares indicate standardized total counts of pottery fragments found in individual survey units.

Conclusions

It is the part of general archaeological knowledge that ancient settlement activities in many cases could have substantially increased concentrations of some chemical elements, especially those typical of organic matter or metallurgical production, in contemporary topsoil (Oonk et al. 2009, Vyncke et al. 2011). This type of research is however underdeveloped in the Mediterranean-type semiarid environments. The changes of soil chemistry detected in our surveys might be caused by the deposition of biomass ashes and waste from domestic contexts as well as from workshops. Another potential source of increased concentrations of nutrients in our survey areas is represented by human burials. These chemical traces of ancient activities can persist in the soil even several thousands of years after abandonment of settlements or other areas of accumulated traces of human presence in the landscape. Better knowledge of long-term human impact on soils can improve our understanding of environmental sustainability.

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Towards an Environmental Resources Archaeology, escaping from site (and ‘off-site’)

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Introduction

Over the last few years, we can find an unsolved contrast between the use of basic concepts like “off-site” and “on-site” in studies concerning the archaeology of landscape. Such definitions are still employed by different approaches and disciplines concerning landscape studies such as - referring to Italy - environmental archaeology, archaeobotany researches (Quiros Castillo 2014; Mercuri et al. 2015) and archaeological surveys (Corsi 2016). However, these terms have never been accurately defined: a more careful analysis reveals that they are misleading archaeologist’s “constructions”, which merely repeat the mechanical template of the Man/Nature dichotomy (often referred to as Site/Environment), detrimental to a real understanding of the relationships that have historically occurred in the landscape.

This contribution presents a brief review of how such a contrast arose and has been structured in archaeological practice and theory, persisting until today (David and Thomas 2016). Thus, through some case studies, we propose a shift of attention from the (false) problem of the disciplinary definition (environmental archaeology, archeobotany, landscape archaeology etc.), focusing on a new specific archaeological object: the ecology of environmental resources.

Materials and Methods

We will discuss two case studies from mountain areas of northeastern Liguria, carried on by researchers of LASA (Laboratory of Environmental Archaeology and History, Univ. of Genoa). Over the last 25 years, thanks to the dialogue between archaeologists, natural scientists and social historians, LASA developed a peculiar research method, largely referred to the development of the British Historical Ecology (Moreno 1990). This contamination between historical and geographical studies has been defined as ‘geographical-historical microanalytical approach’ (Cevasco 2007) and is based on three main issues: cross-use of multiple sources (ground sources and documentary sources), historical regressive method and topographic approach (to the local context). Case studies presented here are very different and are placed in different geographical context: 1) the wetland site of *Mogge di Ertola*, in a small plateau located on the watershed between two Apennine valleys (Guido et al. 2013) and 2) remains of charcoal burning sites found in woodlands across the Ligurian Apennine (Stagno et al. 2016).

In both cases, the set of sources varies from sedimentary to observational ones. A large number of techniques was used: traditional archaeological surveys; charcoal and pollen sampling; floristic surveys; documentary, iconographic and cartographic analysis.

Results and Discussion

If we apply current concepts of on-site/off-site for these researches, the investigated objects appear to be curiously anomalous. The small wetland of *Mogge di Ertola*, for example, usually considered as an off-site (and properly protected as a “biological archive”), has been investigated as an “archaeological site” giving an amount of information on practices employed since the Bronze Age to medieval period in managing the pastoral resources.

On the contrary, remains of charcoal burning sites, recently emerging as legitimate archaeological features, inform on woodland species composition as well as on localized economic and social system of woodland management practices and the past ecology of the environmental resources. In each of these cases, the same objects are approached by different disciplinary points of view: a multiscale approach that does not suffer from the changing of scale, from the ‘punctual’ feature of charcoals to the whole mountain slope.

Conclusions

Since the 1980s, in response to the dichotomy between site and off-site, a “siteless” archaeology was suggested (Dunnell 1992). We propose an approach similar to this one. Actually, by overcoming the traditional “site” concept, attention can be focused on individual objects: interdisciplinary research can be conducted without the hindrances of disciplinary fences, but rather applying different techniques (surveys, sampling, floristic surveys, etc.) to the same object and processes. Only by abandoning a collector-categorical setting guided by the ‘cultural’ and ‘natural’ dichotomy, it will be possible to reconstruct a ‘from feature to process’ history. The archaeological traces of the ecology of past environmental resources involved in management, production and consumption can be related to spatially defined social practices, historically changing over time and defined by access rights and rules. The archaeological survey cannot be addressed to general reconstructions but must operate at the detail scale with a diachronic key, through a regressive method that allows investigating both the (historical) formation processes of present vegetation and the system of environmental knowledge and management practices employed over time by different social groups.

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1st millennium BC forest ecosystem transformation in Bohemian sandstone areas: Were humans involved?

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Keywords: *forest history, grazing, retrogressive succession*

Introduction

Czech sandstone areas represent the ideal model territory in Central Europe to study the history of interactions between humans and lowland forest ecosystems. For their complicated, rugged terrain they have never been intensely farmed in history and prehistory. Still today, they represent wooded, relatively large islands surrounded by agriculturally exploited lands (Fig. 1). The composition of their forest vegetation is considered to be close to nature and therefore their nuclei are declared protected areas. The investigation to their long-term (Late Glacial and Holocene) history is facilitated by the presence of a large number of outstanding paleoecological archives.



Figure 1 - Aerial view to one particular sandstone area in NE Bohemia (local name: *Teplické skály*) – a forested island of rugged rocky terrain surrounded by “average” agricultural landscapes. Photo: P. Pokorný.

Materials and Methods

The paper summarizes a multi-proxy, environmental-archaeological study conducted by us in various sedimentary archives, that are especially abundant in the study area: minerogenic and organic lake sediments, peat, sandy accumulations under rock-shelters, colluviums and soil

profiles. Methods involved include the following types of analyses: pollen, micro-charcoal, fresh and charred (including wood charcoal) plant macroremains, geochemical, palaeomalacological, vertebrate remains (bones) and, last but not least, archaeological excavations and analyses. For testing hypotheses we use basic explorative statistics and simple numerical modeling.

Results and Discussion

Using pollen and plant macrofossil (incl. charcoal) analyses carried out in various sedimentary records in the sandstone areas of Bohemia, we have succeeded in demonstrating that there has been radical ecosystem rebuilding in these special, rugged landscapes in the course of the 1st millennium BC. At that time, the climax communities of wet, nutrient-rich broadleaf deciduous and spruce forests, which formed at the end of the Early Holocene, and which survived relatively steadily over the Middle Holocene, came to the sudden decline. “Modern” types of beech, fir and pine forests, which are found still today in these near-natural areas, have replaced them. Our data further show that this ecosystem rebuilding particularly dramatically affected highly sensitive invertebrate animal populations bound to the forest interior. Mollusc communities, to which we have especially good insight, have experienced a radical reduction in biodiversity associated with episodes of local extinction.

The null hypothesis, which we have succeeded in supporting rich documents, points to a natural change in connection with the progressive depletion of the ecosystem through decline in biologically active mineral compounds. It seems to be a particularly dramatic development that is characteristic of the temperate ecosystems of our planet not only in the course of the Holocene but also during all previous interglacials (Birks and Birks 2004). Nutrients, especially biologically active forms of phosphorus, have arrived in sandstone areas (otherwise characterized by extremely nutrient-poor, acidic Cretaceous sandstone bedrock) in the form of a wind-transported dust during the loess accumulation phase of the Last Ice Age (Muhs 2013). The humid and warm Holocene climate, which has been acting for many millennia to soil substrates enriched with this wind-transported dust, has resulted in soil degradation due to the successive loss of nutritive cations; surface acidification thus resulted in a retrogressive soil and biological successions (see e.g. Wardle et al. 2008 for a general background derived from studies of long chronosequences).

Against the backdrop of controlling climatic and related geochemical processes, numerous biotic and other influences can be observed; the effects of repeating forest fires, for example. They could act both synergistically and antagonistically with the main trend. An important aspect of attention is, among other influences, the history of various human activities. Were people at any critical time ever present? If so, how did they utilise these demonstrably forested and agriculturally marginal areas? Was their influence so strong that it could have influenced the process of ecosystem degradation under the conditions of predominantly naturally driven acidification and nutrient loss?

To answer these questions, we have been conducting comprehensive environmental and archaeological research in four of the sandstone areas of the Czech Republic for many years. Contrary to the original expectation (see the Introduction), we are now able to show that during most of the agricultural prehistory, these rugged areas have been inhabited and extensively exploited by human populations. One of the peaks of prehistoric use falls into the younger phase of the Bronze Age, i.e. directly into the critical period of observed ecosystem transformation (roughly around 1000 BC). This simple temporal correlation suggests that people really could participate in the changes. But in what concrete way this occurred? Our data do not yet make clear conclusions, but we are gradually gaining support for the working hypothesis that people in these wooded areas have acted as nomadic shepherds. The grazing pressure was, however, so weak that it did not cause deforestation. However, it has worked synergistically with dominant natural trends, so it has probably accelerated changes in ecosystem geochemistry, soil

degradation, forest vegetation change and subsequent collapse of vegetation-related biological communities (as we have found namely for molluscs).

Conclusions

Our case study demonstrates that prehistoric grazing activities in near-natural, lowland, but agriculturally marginal areas of Central Europe were probably a significant factor in the formation of novel Late Holocene forest ecosystems. Such forests, which have so far been considered almost entirely natural, dependent mainly on natural processes such as migration, competition and naturally-driven succession of soil characteristics.

Acknowledgements

The presented topic is related to a broader long-term interest of our group for the research of Bohemian sandstone areas. Contributions to this broader research are due to a wide range of collaborators. Namely: Vojtěch Abraham, Jiří A. Svoboda, Sandra Sázelová, Martin Novák, Helena Svitavská, Arnošt L. Šizling, Ivan Horáček, Jan Hošek, Kristýna Hošková, Jitka Horáčková, Martin Pták, Petr Meduna, Jan Wild, Vojen Ložek, Jindřich Prach, Jiří Sádlo. To all of them belongs our most sincere thanks. The contribution is supported by a grant no. 17-07851S of the Czech Science Foundation (GAČR).

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SESSION 2

Detecting human impact: the ABG (archeo-bio-geo) research

Cultural landscape and local economy in central Sicily: *Philosophiana* between the Roman and Middle Byzantine periods

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Keywords: *integrated approach, longue durée, economic change, farming practices*

Introduction

Begun in 2009, the *Philosophiana* Project focuses on the urban-style settlement and *mansio* of Sofiana and on its environs in central Sicily, at only six aerial kilometers from the Villa del Casale at Piazza Armerina, one of the richest and most famous late Roman villa of the western Mediterranean (Vaccaro and La Torre 2015). The project, currently directed by the Universities of Messina and Trento, uses the case study of Sofiana to investigate settlement and economy of the interior of Sicily, which in Late Antiquity became of strategic importance for the grain supply of Rome. The crucial role of inland Sicily as the main wheat supplier of Rome continued in the early medieval period, when the Church owned large land estates in this region. Through the application of an interdisciplinary approach the project tackles the reconstruction of settlement and economic patterns in the long period between the early imperial and the Middle Byzantine period (1st century BC-9th century AD) and aims to investigate the impact of local economic strategies on the cultural landscape (Bowes et al. 2011; Vaccaro 2013, 2017).

Materials and Methods

Initially the project used archaeological field walking and geophysical surveys, integrated with GIS analysis, to define the size of the buried site of *Philosophiana* and reconstruct its phases of expansion and shrinkage in the *longue durée* (Fig. 1). At the same time, field survey was extended to the hinterland of the large site with the aim of investigating the settlement network around it and possible economic relationships between central place and smaller rural sites in the diachrony. Subsequently, in 2012, excavation was begun at *Philosophiana* and focused on the northern district of the site, where continuing occupation between the late 1st century BC and the early 13th century was detected.

Research focused particularly on the architectural, topographic and functional transformations occurred at the excavated area over its long-term use and material culture, with particular emphasis on pottery, was analysed in great detail to reconstruct the site's connections with the local, regional and Mediterranean markets. Ceramic study took also advantage of the application of minero-petrographic and residue analysis to determine the source and content of some of the most challenging amphorae. Indeed, the study of Mediterranean amphorae has been of fundamental importance to understand the extent to which imported foodstuff integrated the local diet.

In 2013, excavation was extended to the immediate environs of Sofiana, in an area east of the site, where part of a Middle-Byzantine (early 8th-mid 9th century AD) large craft-working district specialised in the production of good quality tableware, storageware and small amphorae. Since the beginning of excavation, great importance has been given to the application of the bioarchaeological approaches for the study of local agrarian practices, animal husbandry and, overall, the ways in which the large site of Sofiana impacted on the cultural landscape. Therefore much effort has been done to collect and analyse both archaeobotanical and faunal materials. Archaeobotany has so far focused on pollen analysis from the

uninterrupted sequence of occupation of the site between the Augustan and Swebian periods (see Methods in Mercuri et al. in press). The zooarchaeological datasets cover the same period.



Figure 1 - Aerial view of previous and ongoing excavations at the “monumental” area of *Philosophiana*

Results and Discussion

Despite the site originated as a small town in the Augustan period, it experienced its largest expansion between the 4th and 5th centuries AD, when it reached 21 ha in size. However, compared to the early and mid Roman periods when the main occupation concentrated in the northern district, the site developed particularly towards south, east and west. At the time of the construction of a large bath-complex in the age of Constantine, part of the northernmost area of the site had already been abandoned. The period between the 4th and 5th centuries also coincided with an increase of small rural sites in the environs of the central place. Their surface features suggest that they are interpreted as outbuildings and small houses rather than actual farms. These may have been seasonal sites used in periods of more intensive farming activities. In the 8th and 9th century AD, when the site shrank to almost half of its former size, it probably lost its

centripetal force as most of the rural settlements in the environs clustered more distantly from it and occupied a new ecological niche, particularly rich in water, and more suitable for intensive agrarian practices.

The palynological evidence shows a landscape characterised by significantly low forest cover in all periods, suggesting a wider availability of cultivable fields than nowadays. The importance of cereal production seems to have been a long-lasting pattern as one would expect for this area of Sicily. However, the impact of crop production progressively decreased from the later 7th century AD onwards; this phenomenon is even more marked in the 10th and 11th century AD. *Olea* is documented in all periods, although its importance seems to have increased from the Middle-Byzantine period onwards. Interestingly, *Vitis vinifera* is first documented in the early/mid Roman period, and again with very low values both in the later 3rd-early 4th AD and between the late 6th and mid 7th century AD. It has not been so far documented in early medieval contexts but reappears in one dated from the 10th-11th AD. The landscape around *Philosophiana*, according to the pollen evidence, was constantly characterised by pastureland with a possible increase after the 7th century.

The study of faunal remains suggests the importance of local mixed animal husbandry and regular access to meat consumption by people living at the site. This emphasis on animal husbandry parallels the impact of pastureland around the site. Pig production reached its apogee in the early/mid Roman period and decreased in Late Antiquity to peak up again from the 10th/11th century AD. Sheep/goat (with an emphasis on sheep), although well documented in the early and mid Roman contexts, increased in Late Antiquity, whereas cattle (mostly used as draft animals) slightly dropped after the Roman period, possibly as a consequence of the fact that agricultural lands were increasingly given over to pasturage into Late Antiquity and the medieval age. The study of butchery age of the three main domesticated taxa shows a higher incidence of young animals being part of the local diet in the early and mid Roman periods then in later times, suggesting more sophisticated eating practices between the 1st and 3rd century AD. The study of material culture allows us to move from the local scale and understand the long-distance economic connections of the site. According to ceramics, Mediterranean connections increased from the 2nd/3rd century AD onwards and during Late Antiquity the site came to play a crucial role as a commercial hub for the redistribution of Mediterranean commodities (particularly from Tunisia) to the island's interior.

Conclusions

The integration of a wide-range of archaeological and bioarchaeological approaches to the study of *Philosophiana* and its hinterland is allowing us to move away from a traditional site-centered analysis towards a more in-depth understanding of the interrelations between local communities and the cultural landscape.

A territory of central Sicily that, on the basis of textual sources, has been traditionally associated to large-scale grain production for Rome is revealing a wider diversification of production activities in which mixed animal husbandry played a major role. At the same time the consistent presence of *Olea* pollen suggests the importance of this cultivation in the hinterland of the site. Moreover, the local economy also took advantage of the integration of *Philosophiana* in the Mediterranean systems of trade and made the site particularly important for the redistribution of maritime imports. When the economic links with Tunisia were interrupted at the end of the 7th century AD, the persisting economic vibrancy of the site is demonstrated by the fact that it developed its own production of good quality ceramics and particularly of small transport amphorae possibly used to trade local surplus of agricultural produce such as olive oil and/or wine.

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Palynological approach to pastoral activities reconstruction in S Italy: a palaeoecological contribution to support biodiversity awareness

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Keywords: *palynology, pasture indicators, archaeological sites, Southern Italy*

Introduction

In circum-Mediterranean countries, human impact had a great influence and generated impressive patterns of landscape complexity (Butzer 2005; Mercuri 2014). The study of paleoenvironmental records has fundamental importance for understanding the present-day biodiversity and to define a new approach to the planning for sustainable human-environment interactions in the central Mediterranean area. The combined evidence of pollen and non-pollen palynomorphs-NPPs from archaeological records has been especially useful in reconstructing the complexity of landscape transformations that occurred in these lands, continuously exploited for cultivations and pastures. This research deals with palynological approach to reconstruct farming activities in Southern Italy, focusing on pasture indicators allowing the identification of pasture farming and its role in the landscape transformation of this Mediterranean region.

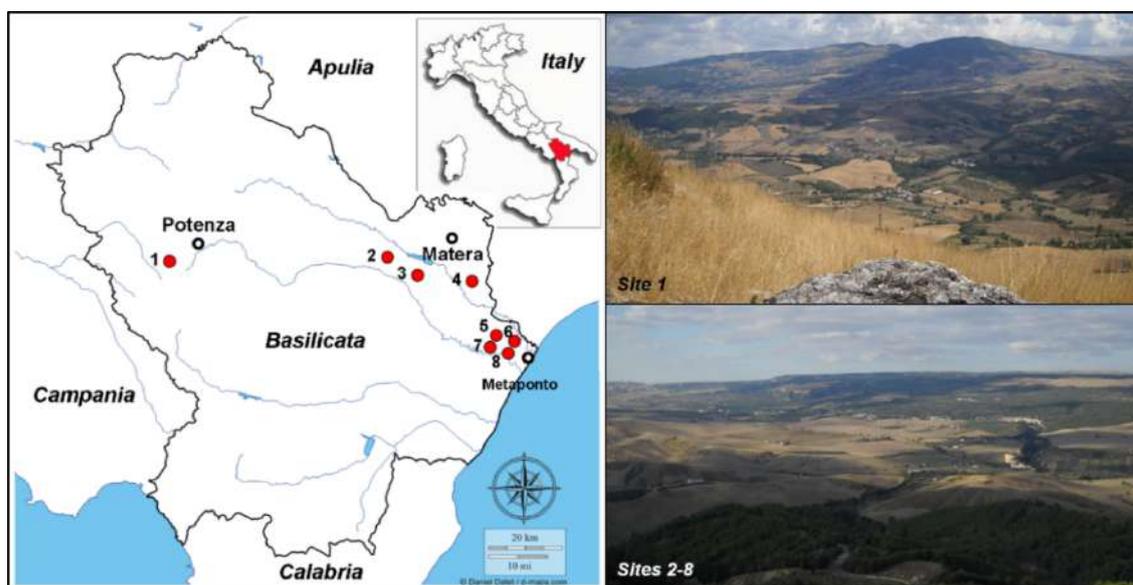


Figure 1 - Location map of the 8 archaeological sites studied for pollen and NPPs in Basilicata, Southern Italy (A), and the current landscapes of the study area (B). The sites have been studied in collaboration with the University of Basilicata (1-4) and the University of Austin Texas (5-8).

Materials and Methods

This research has been carried out on samples from the main archaeological sites of Basilicata region located in a transect from the Apennines (1 site) to the coast along the Bradano river (7 sites; Fig. 1). A set of 121 pollen samples were taken from archaeological layers – small trenches, rooms or floors of houses, and spot samples, dated from 6th cent. BC to 15th cent. AD (Florenzano 2013). Pollen samples were treated for pollen extraction (laboratory treatments

included heavy liquid separation; Florenzano et al. 2012). Pollen and NPPs were counted in the same samples. A mean of about 400 pollen grains and 200 NPPs were counted per sample. The sums of local pastoral pollen indicators-LPPI (Mazier et al. 2009; Brun 2011), strictly correlated to local pastoral activities, were calculated in all samples.

Results and Discussion

The archaeological samples contained good concentrations both of pollen and NPPs. The pollen preservation was generally good, although many deteriorated grains were found as usual in archaeological layers. All the sites showed low forest cover (always < 20%) and prevalence of herbs, while plants of wet environments were present in traces. The pollen spectra were marked by anthropogenic pollen, including crop cultivations (mainly *Olea* and cereals) and grazing plants (both palatable herbs, e.g. Fabaceae, Poaceae, Brassicaceae, and not palatable/toxic herbs, e.g. Cichorieae and Chenopodiaceae; Florenzano et al. 2015). The general composition of spectra is indicative of dry pastures. Moreover, coprophilous fungi (*Sordaria*, *Podospora*, *Sporormiella*, *Cercophora* and *Delitschia*) confirmed presence of herbivores that dropped faecal remains. Significant values of LPPI (37% on average), together with coprophilous fungal spores, strongly suggest that pastoral/breeding activities were widely and continuously practiced in the area. The microfossil record outlines that the long-term livestock activity has led to the current plant biodiversity of the region.

Conclusions

This research points to the impressive role that pastoralism has had as agent of shaping the Mediterranean landscape in the last 3 thousand years. The palynological data improve knowledge and awareness about biodiversity and the long-term human impact in modern landscapes of Southern Italy.

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Agriculture, forestry resources and Late Neolithic daily life at the pile-dwelling site of Palù di Livenza (NE Italy)

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Keywords: *Neolithic agriculture, Neolithic environment, Palù di Livenza, Northeast Italy, peat bog*

Introduction

Palù di Livenza is a wetland zone at the foot of the Cansiglio Cretaceous plateau in the Pordenone area.

Its geomorphology, the karst springs of the Livenza river and the plenty of natural resources made the area particularly attractive to prehistoric groups since the Late-glacial period. Archaeological research, carried out by the Soprintendenza between 1981 and 1994 in Sectors 1 and 2, highlighted materials and wooden features of a Late Neolithic pile-dwelling settlement (Corti et al. 1998; Vitri and Visentini 2002). The site preserves important archaeological and palaeoenvironment deposits.

In 2011, Palù di Livenza was inscribed on the World Heritage List of UNESCO in the transnational serial property *Prehistoric pile-dwellings around the Alps*. In recent years, new excavations have been started by Soprintendenza at the Sector 3 (Micheli et al. in press) to gain a better insight into everyday life in the Late Neolithic site, its chronology, and the settlement dynamics. Since the good state of preservation of organic materials, a specific attention is given to the systematic sampling of plant macro-remains (woods, fruits, seeds and charcoal).

Site and Materials

In Sectors 1 and 2, about one thousand of wooden architectural elements were found among which there were wooden piles and planks; around 700 of these wooden elements were systematically sampled. The archaeological excavations revealed wooden structures on aerial platforms and land reclamation works. On the basis of the archaeological evidence, at least three types of architectural features were recognized proving different phases of site occupation between the middle of the 5th millennium and the middle of the 4th millennium BC (Corti et al. 2002). In Sector 3, a well preserved and very rich Late Neolithic archaeological context of cultural remains and organic materials dated preliminarily between 3950 and 3650 BC discloses around 200 wooden piles and 40 horizontal elements (Micheli et al. in press). Both wooden architectural features and archaeological artefacts are being studied.

The wooded landscape

The study of old and new data regarding wooden architectural elements and some wooden artefacts, like information obtained by anthracological analysis and limited pollen data, shows that during the Late Neolithic phase the wooded landscape around the pile-dwelling settlement was covered by a mixed oak forest in which the tree species diversity and incidence vary according to soil moisture conditions and microclimatic and pedological characteristics. The plant association is however different compared to the current wooded landscape dominated by the oak and also to the presumed original mixed oak forest now spread both in the plains around

Palù di Livenza basin and in the surrounding hilly areas. White hornbeam and black hornbeam were apparently lacking or, maybe, not employed in architectural features by Late Neolithic people. Beech was instead well attested although it is now a more mountainous species. The most frequent tree taxa are hazel and deciduous oaks, even though the occurrence of beech, maple and alder is significant (Corti et al. 1998). The tree species characteristics of wet environments are not very common, despite the damp conditions of the basin and the technological properties that these woods offer in the manufacturing of wooden implements (Micheli and Rottoli in press). Although white hornbeam evidence appears in the only one core pollen diagram available so far for Palù di Livenza (Pini 2004), its occurrence as plant macro-remain is documented by a single seed found during sieving of the soil excavated in Sector 3. Besides, some lumps of organic material with tooth-marks identified by archaeometrical analysis as birch bark tar confirms the use of this tree species for its peculiar properties, although it grows in higher and cooler zones along the slope rising towards the Cansiglio plateau.

Seeds and Fruits

The recovery of abundant plant macro-remains of cereals indicates well developed agricultural practices and that the likely staple was barley. Einkorn wheat, emmer wheat and a naked wheat are also harvested; however, the real incidence of each varieties of wheat is still uncertain, due to the limited number of remains found and the inability to carefully determine some waterlogged chaff. The cultivation of naked grain seems more important at Palù di Livenza during the Late Neolithic phase than it was during the Early Neolithic of the Friuli plain (Rottoli and Castiglioni 2009). The cultivation of millet is doubtful. Data regarding legumes are very limited and uncompleted. In addition, there is evidence of seeds and capsule fragments of flax confirming plant processing at the site for its nutritious seeds or fibres use. Palù di Livenza is the oldest site in Friuli Venezia Giulia with remains of opium poppy (Castelletti et al. 1992; Corti et al. 1998).

The role of wild fruits collecting from woodland or scrub is abundant and varied as important supplementary food sources. These macro-remains constitute about a third of the archaeobotanical evidence with a very high incidence of blackberry followed by acorns, hazelnuts, raspberries, strawberries, European dewberry, elderberry and few grape seeds. The collection counts also apples, pears, cornelian cherry, figs, alkekengi, cherries and plums.

Conclusion

The variety of trees species employed, cultivated crops and fruits collected indicates a multispectrum subsistence economy. It proves in fact the exploitation of different plant resources and various natural environments that extended progressively from the pile-dwelling settlement in the basin and beyond in the surrounding plain and along the slopes of the Cansiglio plateau. The archaeobotanical evidence outlines a complex picture of the forest vegetation around the site and of the agricultural productions that help to disclose the human-environment interactions occurred at Palù di Livenza during the Late Neolithic phase.

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Chewing tar at the Late Neolithic pile-dwelling site of Palù di Livenza (NE Italy)

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Keywords: birch bark tar, x-ray microCT, FTIR analysis, waterlogged settlement, Late Neolithic

Introduction

Palù di Livenza is a Late Neolithic pile-dwelling site located in a wetland zone at the foot of the Cansiglio plateau in the Pordenone area. The first investigations, carried out in the early 80s at a drainage channel in the middle of the basin, highlighted archaeological materials and wooden features of a Late Neolithic settlement; nevertheless, several archaeological issues are still debated and unclear. Luckily enough the site is mostly protected and still unexplored, thus preserving important archaeological and palaeoenvironmental deposits (Corti et al. 1998; Corti et al. 2002; Vitri and Visentini 2002). For this reason, in 2011 Palù di Livenza was inscribed on the World Heritage List of UNESCO in the transnational serial property *Prehistoric pile-dwellings around the Alps*.

In recent years a new phase of research has started by Soprintendenza to identify a reliable stratigraphy and related settlement phases, to collect new samples for ¹⁴C dates and dendrochronology as well as to gather new data regarding cultural and material development. Since organic materials showed a good state of preservation, we focused on systematic sampling of plant macro-remains (wood, fruits, seeds and charcoal). The excavation has been limited to a small trench (Sector 3) where we have been investigating a rich and well-preserved Late Neolithic deposit dated between 3950 and 3650 BC (Micheli et al. in press).

Materials and Methods

Among the huge amount of organic materials resulted from an accurate wet soil sieving of the archaeological layers, we found three small hardened lumps displaying tooth-marks (Fig. 1) and a larger amorphous piece (Fig. 2). In order to define their micro-structure and composition we have analysed them using X-ray computed micro-tomography (microCT) at the Multidisciplinary Laboratory of the “Abdus Salam” International Centre for Theoretical Physics (ICTP) of Trieste (Tuniz et al. 2013) and Fourier-transform infrared spectroscopy (FTIR) at the Chemical and Life Sciences Branch of the Synchrotron Infrared Source for Spectroscopy and Imaging (SISSI) Beamline at Elettra-Sincrotrone Trieste.

Results and Discussion

Three small lumps with tooth-marks are made from a very homogeneous and low-density material (Fig. 3), while the larger sample has revealed a rolled-up structure made from layers

showing slightly different densities (Fig. 4). Very small samples (about 1 mm large) have been taken to identify their chemical composition and processed for FTIR measurements at the SISSI Beamline. The spectra obtained from all four samples match those of birch bark tar.



Figure 1 - Small lumps of organic material with tooth-marks (samples G1-G3) (photo: archivio Soprintendenza ABAP FVG).



Figure 2 - Amorphous piece (sample CORT) (photo: archivio Soprintendenza ABAP FVG).

According to these data, the three lumps (samples G1-G3) are likely the results of dry distillation of birch bark, while the larger amorphous piece with a scroll-up structure (sample CORT) can be interpreted as a rare evidence of tar distillation residue corresponding to a bark roll heated to extract the tar. The term tar is used here to indicate the result of the destructive heating of wood, bark or resin. Archaeological and ethnographic evidence indicate that birch bark could also be mixed with other resinous plant to produce a substance also referred to as wood tar. According to the obtained results, the small lumps of Palù di Livenza are almost entirely composed of birch bark tar, detected on the surface of the larger amorphous piece too. This substance, due to its various functional and natural properties, was largely used during prehistory since the Palaeolithic time (Aveling and Heron 1999).

Birch (*Betula* sp.) is a pioneer species widespread in temperate zones and occurring in open landscapes or in young forests following a disturbance. On the basis of the only so far available core pollen diagram for Palù di Livenza (Pini 2004), birch appears sporadically in the basin or in the surrounding territories only before the pile-dwelling village was settled. At the present, it grows in higher and cooler zones than Palù di Livenza along the slopes rising to the Cansiglio plateau.

As confirmed by the analysis of the amorphous piece, our samples are direct evidence of an intentional distillation of birch bark tar in the settlement to be used for its several properties. Birch bark contains a high percentage of betulin (birch camphor) and betulinic acid that have respectively anti-inflammatory and antibacterial properties and can be therefore used for

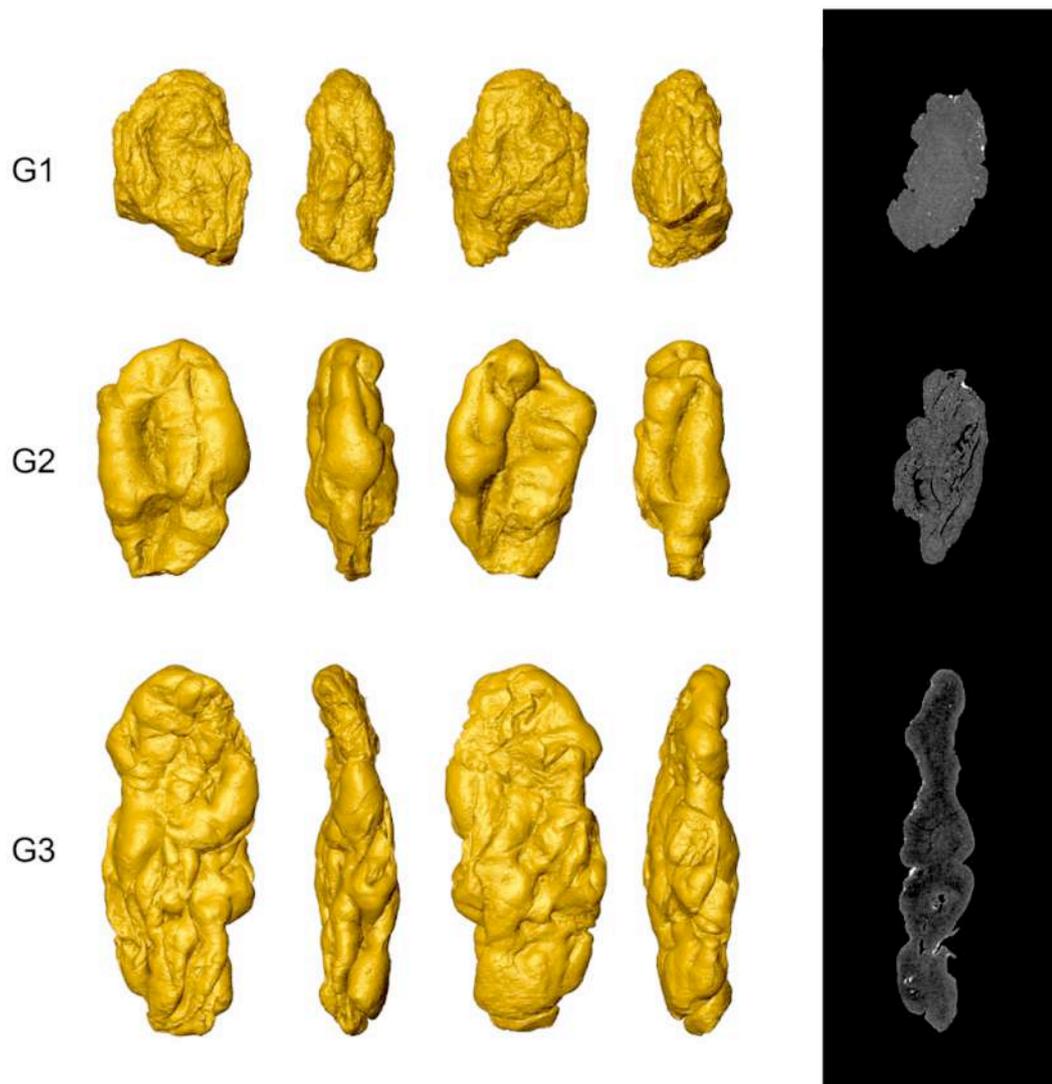


Figure 3 - MicroCT virtual rendering and sections of the samples G1-G3
(photo: Archivio ICTP TS).

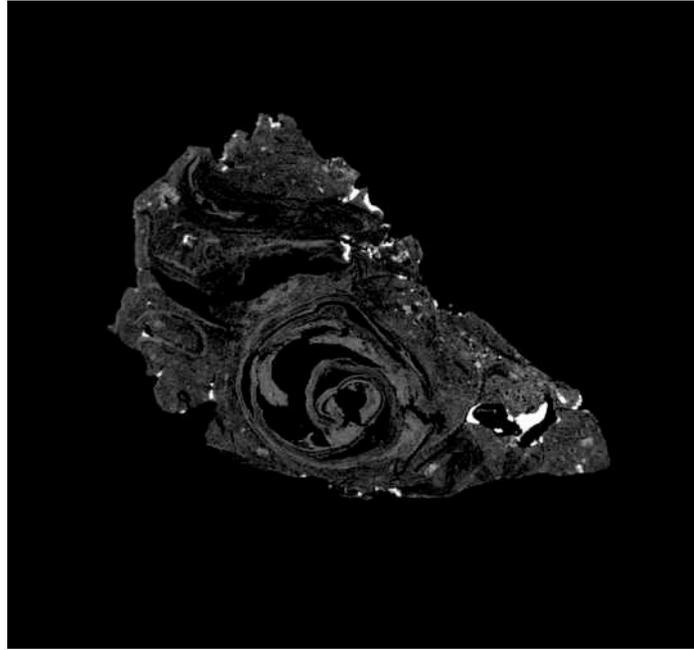


Figure 4 - MicroCT virtual section of the sample CORT showing a scroll-up structure (photo: Archivio ICTP TS).

pharmacological purposes (Polland and Heron 2008). However, birch bark tar was likely used in prehistoric times mainly as adhesive to attach handles to stone tools or to repair broken artefacts (Aveling and Heron 1999; Binder et al. 1990; Regert et al. 1998; Sauter et al. 2000). Nevertheless, at ambient temperature the birch bark tar becomes solid and must be partially reheated to be employed. This process can be easily accomplished by chewing the tar lumps. The tooth-marks present on the three analysed lumps are a probable evidence of a chewing process aimed at softening the tar for practical use. At the same time, we cannot exclude that it was chewed also for therapeutic-palliative purposes since the tar antiseptic properties alleviate toothache and sore throats and help to keep teeth and gums clean.

Conclusion

The materials here presented date back to the 1st half of the 4th millennium BC. Therefore, they represent the oldest evidence confirmed by archaeometrical analysis of distillation and use of birch bark tar in a Late Neolithic waterlogged Italian site.

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Structure and useful plant dynamics on Prague Castle: archaeobotanical and ethnohistorical perspective

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Keywords: Prague Castle, Central Europe, new plants, archaeobotany, databases, useful plants

Introduction

The Prague castle is the most important archaeological site for Medieval period in Czech Republic. Its continuity since the 9th century to the present times with many economic, social, politic and structural changes is broadly reflected in archaeological structure of many sites, buildings and rich archaeological layers (Frolík and Smetánka 1997). The archaeological investigation of Prague castle and its vicinity since the first half of the 20th century offers knowledge about the historical development stretching from the early medieval hillfort of Czech dukes throughout medieval Royal residence to the early modern ages, when Prague castle was undoubtedly the prominent European city. In 1583 the Emperor Rudolf II Habsburg relocated his court from Vienna to Prague (Beneš et al. 2012). Existence of his court can be connected with vast amount of imported and luxury goods, visible in rich archaeobotanical evidence.

This paper compares archaeobotanical assemblages from 11 archaeological investigations in Prague castle. Five samples were taken from Arcades of Royal palace, the imperial horse stables, Ludvík wing building, sediments under the octagonal chapel and foundry yard. Whole samples are dated to the period 9th-15th century and reflect the intensive human impact since the 9th century (Čulíková 2001). Next samples came from waste arcade in front of the Archbishop's Palace in Hradčany Square dated to the 16th/17th century, where was made the first archaeobotanical evidence of poke weed (*Phytolacca americana*) in the Central Europe (Čulíková 2007). Next samples were taken from cesspits of the hospital St. Antonín dated to the 16th/17th century. The most important findings are the first evidence of tobacco (*Nicotiana rustica*) in the Central Europe and the first evidence of common box (*Buxus sempervirens*) in Bohemia (Čulíková 2008). The early medieval sediments from the III courtyard of Prague castle and samples from Jiřské square dated to the 8th-12th century represents typical sortiment of usefull plants (Čulíková 1992, 1998). Samples from the Middle wing of Prague castle dated to the 9th-12th century also reflect the unusal sortiment useful plants (Komárková 2002). The last archaeological excavation is waste vault infill in Vladislav hall dated to the 16th/17th century where the numerous imported species were determinated as e.g. olive (*Olea europaea*), sweet almond (*Prunus dulcis*), sweet chestnut (*Castanea sativa*), peanut (*Arachis hypogaea*), pistachio nut (*Pistacia vera*) and coffee (*Coffea arabica*). All of these plant products are unique in the archaeobotanical context in central Europe (Kosňovská 2011, 2013). This paper is aim to gain the benefits which offer the Czech archaeobotanical database with combination of such an archaeological site. We offer possibility how read archaeobotanical knowledge in context of time dynamics and plant assortment.

Materials and Methods

Data presented here cover archaeological excavations with archaeobotanical investigation since 1985-2009. Whole data set was collected in archaeobotanical database ArboDat (Pokorná et al. 2011) enabling countless options of data processing. For purpose of this paper only the cultural

useful plants were filtered and assorted to categories such as cereals, pulses, fruit (native/imported), vegetable, nuts, spice/ drug, oil plant and decorative. Archaeobotanical assemblages came from different type of deposits such as waste layers, cesspits, ditch and waste vault infill. Assemblages were strongly biased by different behavioural and taphonomical conditions; however, it is possible to trace some differences in changing assortment of plants during historical periods.

Results and Discussion

The first results on useful plant assemblage's analysis from Prague Castle show some dynamic structural changes from common species in the early Medieval times to luxury species in the early Modern period. In correlation with historical periods the assortment of cereals (*Triticum aestivum*, *Secale cereale*, *Panicum miliaceum*, *Hordeum vulgare*, *Avena sativa*) and local fruits (*Fragaria vesca*, *Prunus insititia*, *Malus domestica*, *Rubus idaeus*, *Rubus fruticosus* aggr.) and drugs (*Anethum graveolens*, *Humulus lupulus*) remain almost the same. The change is visible in the early Modern period when the luxury and imported plants emerged and increase according to brisk trade. It is related to plants as pepper, almond, olive tree, coffee, peanuts, common box and so on. This period is interesting and essential for ethno-historical perspective.

Conclusions

Archaeobotanical evidence, recorded from Prague Castle in the early Modern period indicate, in comparison with the early Medieval layers, that the plant composition of the assemblages shifted towards unusual and exotic species. It reflects the high social status of this key political area of Bohemia and its central economic and trade position. From an ethno-historical point of view, we can conclude that Prague Castle belongs to the most diverse sites of the Central Europe.

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SESSION 3

Long-term environmental reconstruction for landscape management

Holocene vegetation dynamics and land-cover estimates in Auvergne: key tools to landscape management

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Keywords: *human impact, cultural landscape, Auvergne, palynology, REVEALS*

Introduction

The nomination of the “Chaîne des Puys” at the UNESCO world heritage list makes crucial the development of effective and sustainable management strategies of current landscapes of the Auvergne mountains. This is important since a human-induced loss in biodiversity is observed in the vegetation communities of these medium mountain areas. Recent advances in palynology provide fresh insights in the environmental-decision making (e.g. Gaillard et al. 2010; Mariani et al. 2017). The results of their application in Auvergne are discussed in this paper. Firstly, multi-proxy palaeological investigations were undertaken at high spatio-temporal resolution and allowed to scrutinize the long-term trajectories of landscape evolution arising from the complex interplay between human impact and adaptability, climate oscillations and environmental evolution. Secondly, mechanistic models for regional vegetation reconstruction provide the first attempts to quantitative reconstruction of land cover in Auvergne.

Materials and Methods

Two nearby sites are both located at the south of the Chaîne des Puys (Fig. 1). Lake Aydat (N 45°39.809'; E 2°59.106'; 837 m a.s.l.) originated from the damming of the Veyre River by a basaltic flow at c. 8551 ± 400 cal. BP. Espinasse fen (N 45°38'; E 2°53'; 1160 m a.s.l.) is a circular depression surrounded to the north by a volcanic structure. The fen occupies a basaltic maar, formed around 12,400 cal. B.P. Lake Pavin (N 45°39.809'; E 2°59.106'; 1197 m a.s.l.) is a maar lake located in the Mont-Dore area. It originates from a phreato-magmatic explosion occurring c. 7000 years ago. For these 3 sites, the age-depth models and other details and references are presented respectively in Lavrieux et al. (2013), Miras et al. (2004) and Chassiot et al. (2016).

Samples for pollen and non-pollen palynomorphs analyses were prepared using standard procedures. We undertook quantitative vegetation reconstructions using pollen dispersal models (Sugita 2007) to convert pollen percentages into past regional vegetation cover data. The REVEALS (Regional Estimates of Vegetation Abundance from Large Sites) model employing the Gaussian plume model for pollen dispersal was applied.

Results and Discussion

The integrated palaeoecological approach allows an improved understanding of past vegetation dynamics and provides land-cover data to make a quantitative contribution to landscape management and past cultural dynamics. In this sense, this study:

(1) provides a better knowledge of the base-line conditions of the Holocene vegetation and a better definition of its natural variability especially to climate oscillations. For example, the rapid substitution of the mixed oak woodlands by the beech and fir forests between c. 5500 and

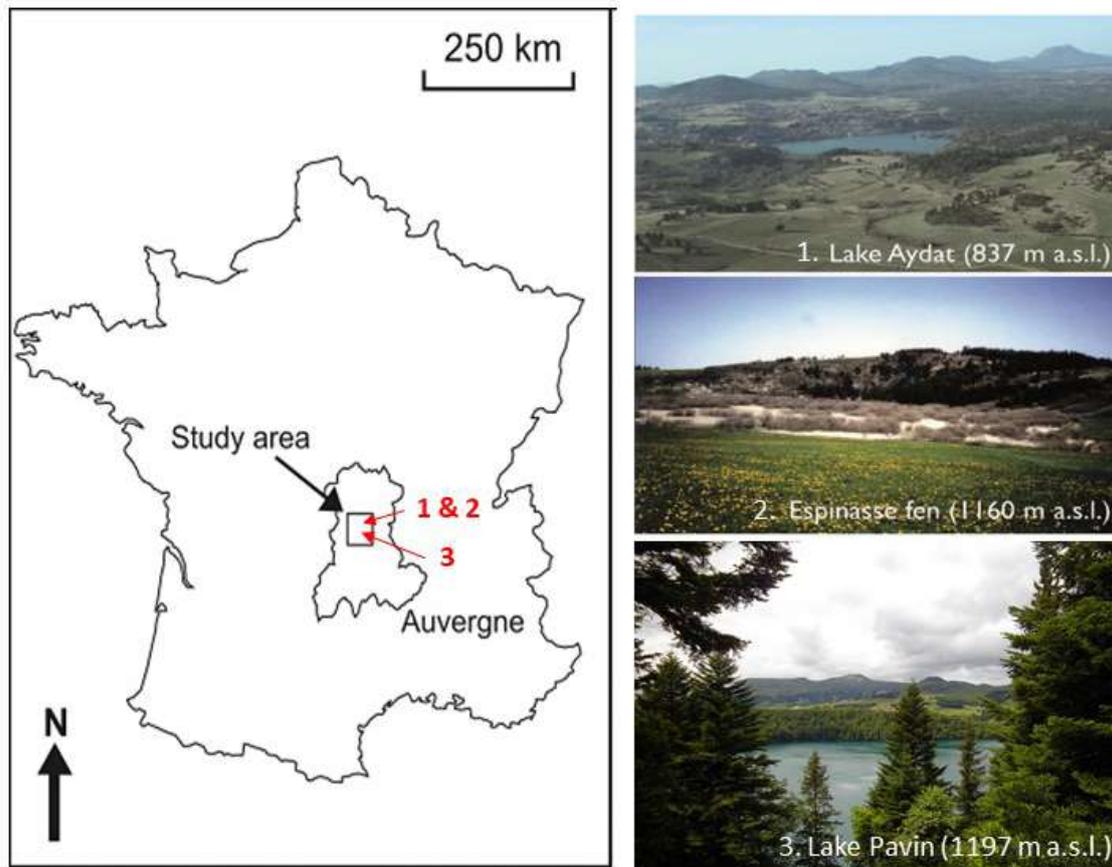


Figure 1 - Location of Auvergne and the study region within France. Current landscapes in the Auvergne mountains and the studied sequences (photo credit: B. Dousteysier, A. Ejarque and Y. Miras).

5300 cal. BP is related to the climatic variation of the mid-Holocene. This highlights that this mountain vegetation is highly sensitive to environmental changes.

(2) determines the origin and the development of the cultural landscape in the Auvergne mountains. Vegetation has continuously been impacted by human activities as early as the Middle Neolithic (c. 6000-5750 cal. yr BP) and some tipping-points have been evidenced as soon as the Late Neolithic (c. 4900-4400 cal. yr BP and 4200-4000 cal. yr BP) or the Early Bronze Age (c. 3900-3,500 cal. yr BP). This ancient and cumulative nature of human impact on plant landscape may also explain the high vulnerability of the present-day landscapes.

(3) set the timing and the extent of Holocene woodland clearances. Since c. 2000-1900 cal. yr BP, the human-induced landscape opening presented a linearly increasing trend which generates an ecological inheritance which must be considered especially in the management of the present-day grasslands and meadows.

(4) demonstrates that past human societies developed complex land use patterns which are irregularly distributed through time and space. The present-day mosaic-like cultural landscapes characterized by a high variability both at micro-local and regional scales results also from such diachronic land use strategies.

(5) furnishes the first long-term study of floristic biodiversity inferred on pollen data for this area. If the sub-recent period is characterized by an important loss of biodiversity and a renewal of forested landscape patches, a higher floristic diversity characterized the Late Holocene. This

increasing richness in landscape units is linked to a parallel rise in human impact and reveals a complex relationship between vegetation diversity and human impact through time.

Conclusions

The long-term accumulation of climate/human impacts and the diverse land use strategies developed through time may have rendered the present-day landscapes more sensitive to further global changes. These long-term changes generated an ecological inheritance which must be considered in the design of mitigation strategies and sustainable policies (Marignani et al. 2017). It appears thus necessary to incorporate palynological data in landscape evolution models. This palaeoecological research demonstrates that the present-day landscape is the composite result of an ancient socio-environmental history. These complex socio-ecosystems constitute a cultural legacy, which should be promoted for the socio-economic development of this territory.

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A mid-mountain landscape shaped during fourteen centuries in the heart of Toledo Mountains (central Iberia): the Bermú peat bog record

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Keywords: *vegetation history, human impact, mid-mountain, Toledo Mountains, Holocene*

Introduction

Mid-mountain ecosystems have been traditionally studied in comparison with high-mountain areas or valleys (Diry 1995), using the type of relief and altitude as the main criteria to define them (Bettinger and Ormaux 2011). As it highlighted by many studies in European mountains (Tremblé et al. 2006; Doyen et al. 2011) these ecosystems present broad resource diversity, heterogeneous relief and a mild climate useful for human interests, allowing strategies such as terracing the slopes and a wide crop diversification. This relationship leads to a parallel co-evolution with human societies, with fire and grazing being the most effective management tools (López-Sáez et al. 2009; Pausas and Keeley 2009; Tinner and Ammann 2005).

This work presents the results from a multi-proxy study of the Bermú peat bog, a minerotrophic mire located in *Quintos de Mora*, at the eastern border of the Toledo Mountains in central Spain and compares the results with other records in mid-mountain environments.

Materials and Methods

A 72 cm-deep core was collected using a Russian peat corer. Eight bulk organic sediment samples were dated using AMS ¹⁴C. An age-depth model was produced using the Clam 2.2 software (Blaauw 2010). All samples were treated according to Moore et al. (1991), using Thoulet solution for densimetric extraction of pollen and non-pollen microfossils (Goeury and de Beaulieu 1979). Palynomorphs were identified and pollen and summary diagrams have been plotted against age using TGview (Grimm 2004).

Results and Discussion

The base of Bermú peat bog dates to the Islamic Period (*ca.* 711-1100 AD) has scarce forest coverage, with deciduous oaks and *Corylus avellana* being the most representative woody species and high presence of shrubs, dominated by *Erica arborea* and *E. tetralix* throughout the period. There is a gradual increase in the herb layer through time but not intense human pressure, especially considering the context of warfare which marks this period. Nevertheless, a human presence is already evident at the end of the Christian Period (*ca.* 1110-1450 AD), particularly in the XIV-XV century AD, when repopulation movements are finally established and the presence of livestock surrounding Bermú peat bog is clearly evident from pasture indicators constituting an open woodland composed of deciduous and evergreen oaks and a broad variety of herbs. This pattern continues into the Modern (*ca.* 1450-1800 AD) and Contemporary Ages (*ca.* 1800 AD-present), when local grazing activities are documented in Bermú peat bog as well as in other mire records throughout the Toledo Mountains, reflecting its importance for the economic and socio-political system. In the last period, pollen suggesting cereal cultivation and the traces of *Olea europaea* pollen allow reconstructing changes such as the increase of crop exploitation. Along with these changes, the forest in the most recent times

includes species such as *Pinus sylvestris* and *P. pinaster*, reflecting the afforestation policies implemented in the area in an attempt to protect and restore a compromised environment, and the changes produced by hunting activities currently supported on the property.

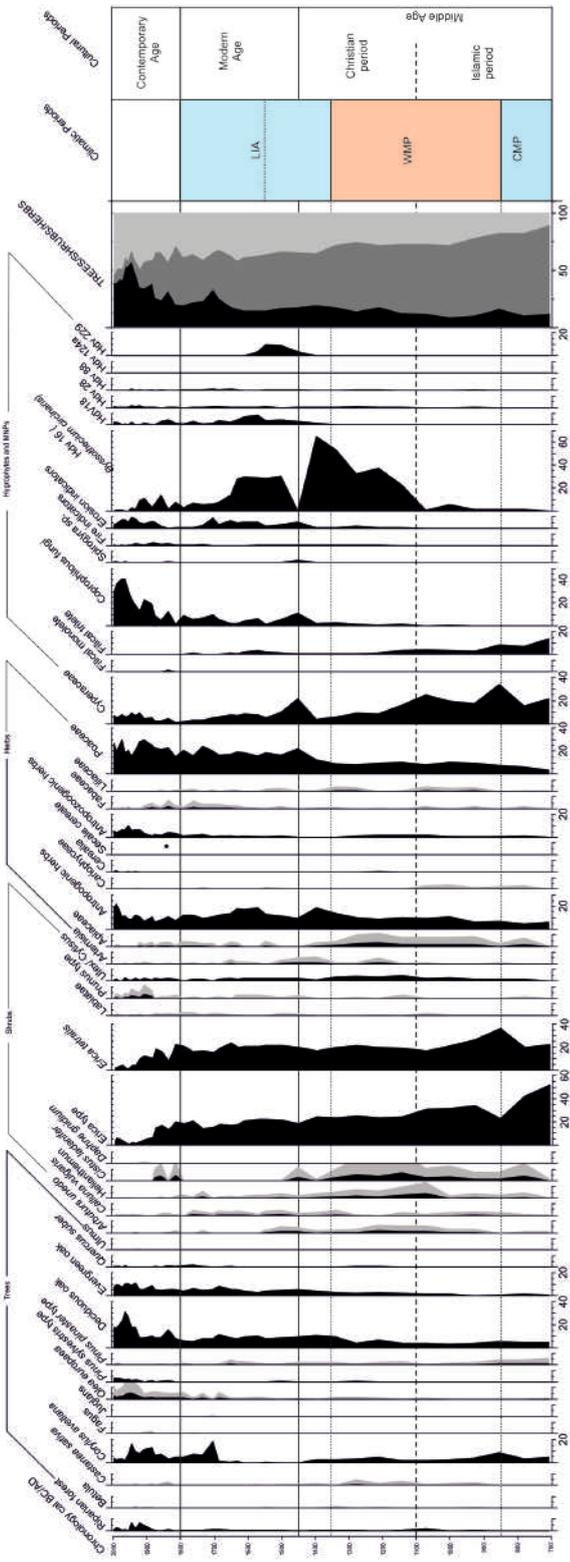


Figure 1 - Synthetic pollen diagram of Bermú peat bog.

Conclusions

It is possible to find an increasing human impact through time in the Bermú peat bog record, with negative consequences when not accompanied by a restoration policy. This mid-mountain area exploitation only increases, as shown in the pollen diagram, when the economic trends change and the demand is so intense that the valleys are not capable of supporting the inhabitants' needs. The landscape was composed of an oak forest which was exploited by human societies opening the canopy and generating open pasturelands for grazing. The comparison with other pollen records in the Toledo Mountains reinforces the fact that there is an increasing trend of exploitation throughout this environment as circumstances led to improved economic conditions or demographic growth, reaching a maximum in the last period. Hence, today's open woodland landscape present in Bermú peat bog is the result of human and environment co-evolution during at least fourteen centuries.

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The disappearance of cultural landscapes: the case of wooded-meadows in the Ligurian Apennines (NW Italy)

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Keywords: *pollen and charcoal analysis, historical maps and documents, natural resources management, Fagus sylvatica L., historical ecology*

Introduction

The management system commonly known as “wooded-meadows” consists in a multifunctional use of vegetation resources widespread in Europe (particularly in the region around the Baltic Sea, and in the mountains of central and southern Europe) since the Neolithic period (Sigaut 1982; Rasmussen 1990; Maggi and Nisbet 2000). Wooded-meadows are generally defined as meadows with trees, or a combination of forest and meadow, where the typical management consists of different tasks (Fig. 1): (a) collection of fallen and dead branches (in spring), later used for fuel; (b) mowing and grazing during the summer; (c) making sheaves from branches and twigs (after hay-making), later dried and used for cattle and sheep fodder in winter; (d) coppicing/pollarding; (e) cut of trees in winter; (f) collection of secondary products (e.g. berries, mushrooms, medicinal herbs, etc.), (Moreno and Raggio 1990; Kukk and Kull, 1997; Grove and Rackham 2001; Read 2006).

In this contribution we present a first attempt to verify on palynological evidences some hypotheses raised by previous historical ecology studies (Cevasco 2007) about the consequences of this traditional land-use practice, well documented in Italy between the Middle Ages and the first half of the 19th century and by now disappeared (Lowe et al. 1994; Davite and Moreno 1996; Moreno and Poggi 1996).

Materials and Methods

Three different sites located in the Ligurian Apennines (NW Italy, Fig. 2) were studied through biostratigraphic analyses (pollen and microscopic charcoal counting) with the aim of identifying specific palynological assemblages associated with the wooded-meadows system in beech (*Fagus sylvatica* L.) woodlands (Fig. 3).

The use of an interdisciplinary approach (field vegetation observations, historical topographic maps, historical photos, written historical documents, oral sources, bio-stratigraphic investigations) helped to better understand the historical dynamics of this past land-use system.

Results and Discussion

Our investigations underlined that the wooded-meadows system was used in the three selected sites mainly between *ca.* 500 and 1600 AD. Furthermore, compared to the post-cultural phase, the period affected by this particular land management was characterized by (1) lower pollen percentage values of trees and higher pollen percentage values of herbs, (2) higher percentages of anthropogenic pollen indicators, and (3) higher values of palynological richness (and thus greater biodiversity).

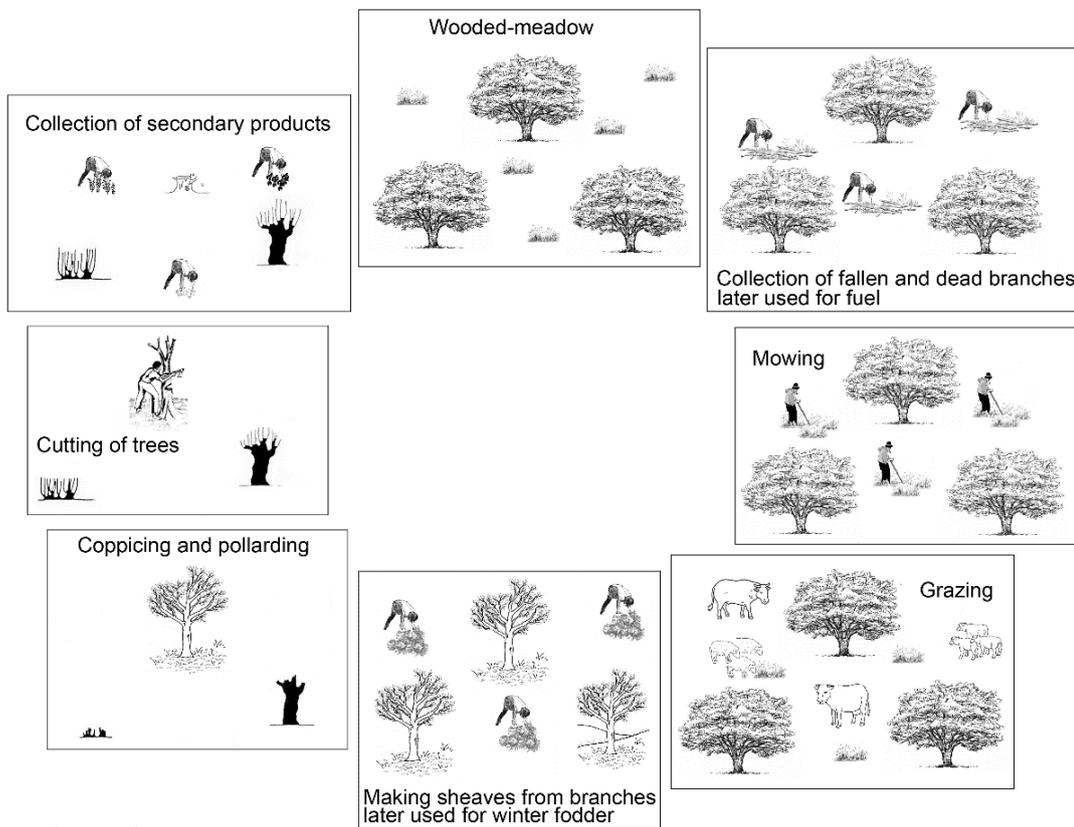


Figure 1 - Different tasks included in the management of wooded meadows.

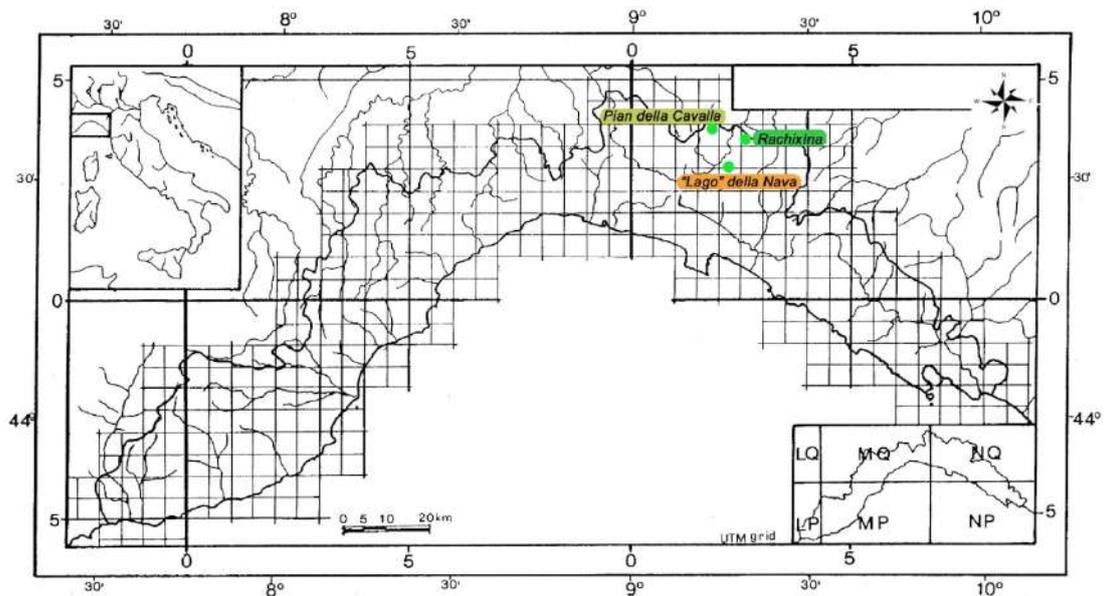


Figure 2 - Location of the study-sites.

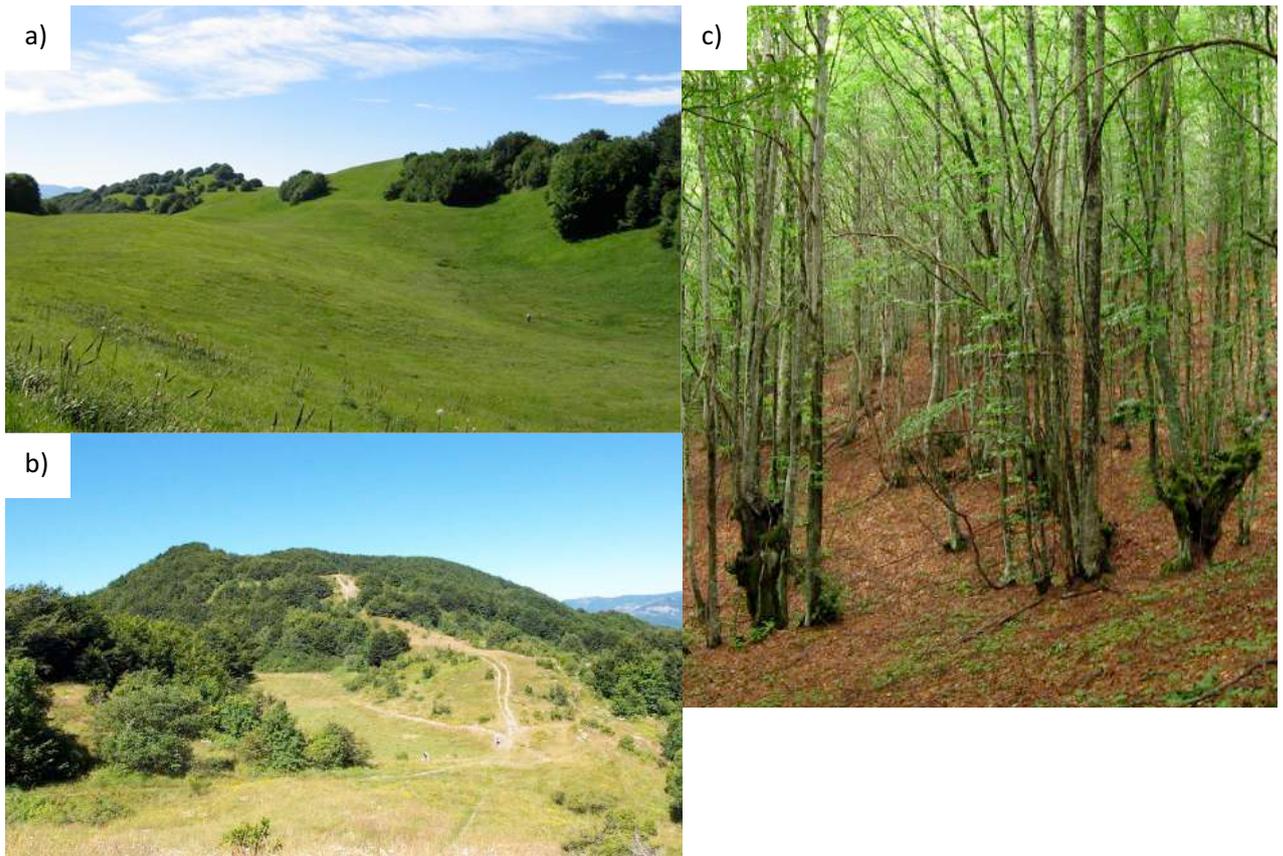


Figure 3 - Present-day situation at the selected *Fagus sylvatica* L. wooded-meadows. a) Pian della Cavalla, b) Lago della Nava, c) Rachixina. Pictures: C. Molinari, 2008.

Conclusions

By demonstrating the necessity of a long-term prospective in environmental reconstructions for a better knowledge and the preservation of cultural landscapes, this research also represents a potential contribution to issues of habitat management and nature-conservation policy, especially because two of the three selected sites are located in protected areas.

Acknowledgements (Funds)

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The past plant ecosystems of Northern Apennines inferred from soil charcoal analysis

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Keywords: *pedoanthracology, vegetation, mountains, landscape, Apennines*

Introduction

Monte Cimone and Corno alle Scale are two of the highest mountains of the Northern Apennines and they are located in the Emilia-Romagna region. They are important biodiversity sites thanks to their geographical location between the phytogeographic Euro-Siberian and Mediterranean regions. The current timberline, formed by coppice beech forest, is located at about 1700 m a.s.l. at Monte Cimone and at about 1600 m a.s.l. at Corno alle Scale, at a lower elevation than other areas of the Apennines. Soil charcoal analysis can identify the past timberline shifts in response to climate change and human impact (Bal 2006; Talon et al. 1998). Above the timberline, *Vaccinium* heathlands and *Nardus* grasslands characterize vegetation (Fig. 1). Main palaeoenvironmental researches carried out in the Northern Apennines are palynological analyses (Vescovi et al. 2010; Watson 1996) showing that important openings of forest cover had occurred during the Late Holocene. These mountains have been exploited by sheep pastoral activity which was largely practiced until the mid-20th century when decreased drastically (Borri 2014). In our study areas the pastoral activity has only weak archaeological evidence (Cardarelli and Malnati 2006). However, we identified some pastoral structures in the current grassland landscape of Monte Cimone.

The research here presented reports on pedoanthracology applied to the study of vegetation dynamics at the scale of the slope and the relationships between pastoral societies and the mountain environment.



Figure 1 - Current pastoral landscape at Monte Cimone and Corno alle Scale (Photos Benatti A.)

Materials and Methods

A total of nine 'pits' or trenches with soil profiles were sampled at the north-west slope of Mt. Cimone from 1650 m a.s.l. to 2078 m a.s.l. Seven pits were located in the current grassland and two pits were situated just below the current timberline. A total of eight soil profiles were sampled at Corno alle Scale; all pits were located in the current grassland, in particular, six pits in the northern slope from 1600 to 1860 m a.s.l. and two pits in the southern slope, at 1700 and 1750 m a.s.l.

Samples were taken every 5-10 cm, from the top part of the sampling point to the bedrock (Fig. 2). The extraction and identification of charcoals followed the pedoanthracological protocol by Carcaillet and Thinon (1996).

A total of 25 charcoals have been chosen for radiocarbon dating.



Figure 2 - Obtaining soil samples from the soil surface to the bedrock (Photos Benatti A.)

About 4000 charcoals were analyzed at Monte Cimone and more than 2000 at Corno alle Scale. As for the taxonomic diversity, we found 11 taxa at Monte Cimone and 6 taxa at Corno alle Scale (prevalent *Fagus sylvatica* and Ericaceae in both sites).

The anthracomass (mg of charcoals/kg of dry soil) is decidedly more abundant in the pits located at the lowest elevation, near or in the current forest. The anthracomass of the pits located in large pastoral spaces (that are flat and with low erosion) is lower than the anthracomass found in the higher pits (that are more subject to erosion). This observation suggests that agropastoral societies might have primarily exploited the most suitable spaces for grazing activity (great flat pastoral spaces) and only subsequently the other, steeper and more difficult to exploit, areas when the increased pastoral activity demanded for more pasturelands. This is shown by previous studies carried out in other European mountains.

Pedoanthracological analysis in association with radiocarbon dates show that, during the last 2000 years, at Monte Cimone, the ancient timberline was located at about 50 meters higher than today, while, during the last 3000 years, at Corno alle Scale, the ancient timberline in the north slope was 175 meters higher than today and the ancient treeline in the south slope was located at about 150 meters higher than today.

Among the 25 radiocarbon dates obtained in this study, only two dates refer to the Early Holocene; all the others are concentrated in the Late Holocene. We assume that the lack of Mid-Holocene datings may be due to two main causes: a problem in charcoal conservation in soils during the Mid-Holocene or the occurrence of high and intense fire activity during the Late Holocene that might have concealed the fire activity occurring in previous periods.

Conclusions

The soil of Monte Cimone and Corno alle Scale provide charcoals fragments dated almost exclusively to the Late Holocene. Our pedoanthracological study shows that, during this period, the plant landscape of Monte Cimone was similar to the present one while it was quite different at Corno alle Scale. Mountains were continuatively used by pastoral societies.

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Land-use changes and exploitation of outfield resources at the Høg-Jæren plateau, SW Norway, during the last 6500 years

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Keywords: *outfield resources, heaths, mowable fens, grassland, long-term vegetation changes by using pollen, LOVE and REVEALS estimated vegetation cover, human impact*

Introduction

During the last decades, efforts have been made to illustrate the use of marginal land as part of an agrarian system in Jæren, SW Norway, in prehistoric as well as historical time (Lillehammer 2005; Myhre 1974, 2004; Prøsch-Danielsen and Simonsen 2000; Rønneseth 2001). Jæren has traditionally been portrayed as a relatively homogenous area in terms of its physical and economic landscape, but geology and the soil map reveal significant variation within Jæren, providing variable preconditions for a host of production practices. The studies of this area show that there is a correspondence between landscape elements and the corresponding production strategies and land-use.

In this study, we investigate the upper coastal region *Høg-Jæren*. Quaternary deposits dominate with dead-ice features and marginal moraines. It is today an outfield area reaching 200-300 m a.s.l. A suite of open vegetation characterizes this area. Today it is regarded as virtually unproductive and uneconomic, though still managed by seasonally grazing animals. It constitutes the inner part of the coastal heathland. The heathland comprises both heaths, large areas with grass or heath dominated peat bogs and former known meadows used for hay-making. The area is also within the limits where haymaking is the driving force for the summer farm practice (Reinton 1969). Farming methods thus seem to be complex.

Today the heathland is a threatened ecosystem in western Norway and heathland and mowable fens are nearly absent in the cultivated and heavy fertilized low-lying Jæren. In that scenario, the remnants of dry heathland and additional grass and heath-dominated bogs at Høg-Jæren are valuable. They serve as cultural historic documents as concerns former agricultural land-use and food production in a marginal area. Using an ecological approach, the present paper explores the landscape history of this marginal area, and as such, it is both a specific case and a general case study of a landscape type seldom investigated.

Materials and Methods

Pollen analysis is applied to six sediment cores along a transect from the low-lying Jæren (Låg-Jæren and Aniksdal farm) to the upper Høg-Jæren plateau to infer the agricultural land-use history.

The LOVE and REVEALS models are used to quantify the land-cover along the transect for 17 pollen taxa in 500-year time intervals from 4500 BC to present.

Results and Conclusions

The open grass and heath landscape at Høg-Jæren is the result of human activity since at least 4500 BC. Prior to this, Mesolithic hunter-gatherers used the area on their way from the coast to the good fishing waters and hunting grounds at higher altitudes. From 4000 BC, the forest was

cleared, and heathland increased. This heathland was probably regularly burnt to improve grazing quality and thus being attractive for wild animals during the hunting season. This probably also applies for the Early and Middle Neolithic period, indicated by *Plantago lanceolata*, which grow on open ground and pastures. Neolithic artifacts are found at drier gravelly sites near lakes and wells in the area.

From 2500 BC, the clearance by fire and the pastoral indicators occur regularly and are identified in all pollen records along the transect from the valley floor to the upper outfields. This pastoralism probably represents a locally adapted transhumance, in which sheep are the dominant livestock. This is also supported by osteological finds from a Late Neolithic site on the Jæren escarpment, with solely sheep/goat remains. Around 1500 BC the farmers started to improve the grassland (recorded at all pollen sites) by using fire, and the good pastures were reserved for dairy animals. No settlements have been found, but the pollen diagram shows clear indications of regular settlement within the infields at Aniksdal. This period might represent the start of a more clear division between settled and cultivated areas and areas used for pastures.

From 500 BC, Aniksdal is permanently settled and a farming system with infields and outfields develops. The supply of manure to the cultivation area is crucial. Therefore the livestock was moved to the outfields in the summer season to avoid overgrazing. This implies that the farmers utilized all ecological niches with available pastoral land in an intensive system of production. We have identified where grass production is particularly high, and one site that was probably also permanently settled as a marginal Iron Age farm.

From ca AD 800, land-use was even more fine-tuned and dairy animals were moved from the main farm to the most favorable grazing areas further up the valley in spring and summer time. At one locality, milking of cattle was carried out in spring- and summer time. In late summer the locality was used for haymaking, and the house was used for storing hay. Another site was used as a summer farm.

In post-Medieval time, in the 17th-18th centuries, a complete reorganization of the land-use took place. Cereal cultivation with barley, oat and rye, dominated in the infield. The summer farm area was situated quite close to the main farm, only 2 km apart. Haymaking was practiced using haystacks and later barns.

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Impact of the Lusatian culture on landscapes of the last glaciation: a case study from the upper Drwęca river basin (N Poland)

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Keywords: Lusatian culture, Wielbark culture, upper Drwęca, river

Introduction

The study area is in the southwestern part of Warmia and Mazury voivodship in Ostróda County in Chełmno-Dobrzyń Lake District in the Lubawa Garb mezoregion (Kondracki 2002). During the last glaciation this elevation separated the Vistula and Mazurian lobe of ice sheet lobes. Relief of the area is formed by an undulating till plain cut by tunnel valleys and sandurs, whose surface is varied by hollows left by dead ice. The study area is located between two parallel tunnel valleys of the NNW-SSE direction. Those tunnel valleys are drained by the upper Drwęca with its tributary, the Grabiczka River. Small fragments of outwash plains are preserved near these two tunnel valleys (Fig. 1).

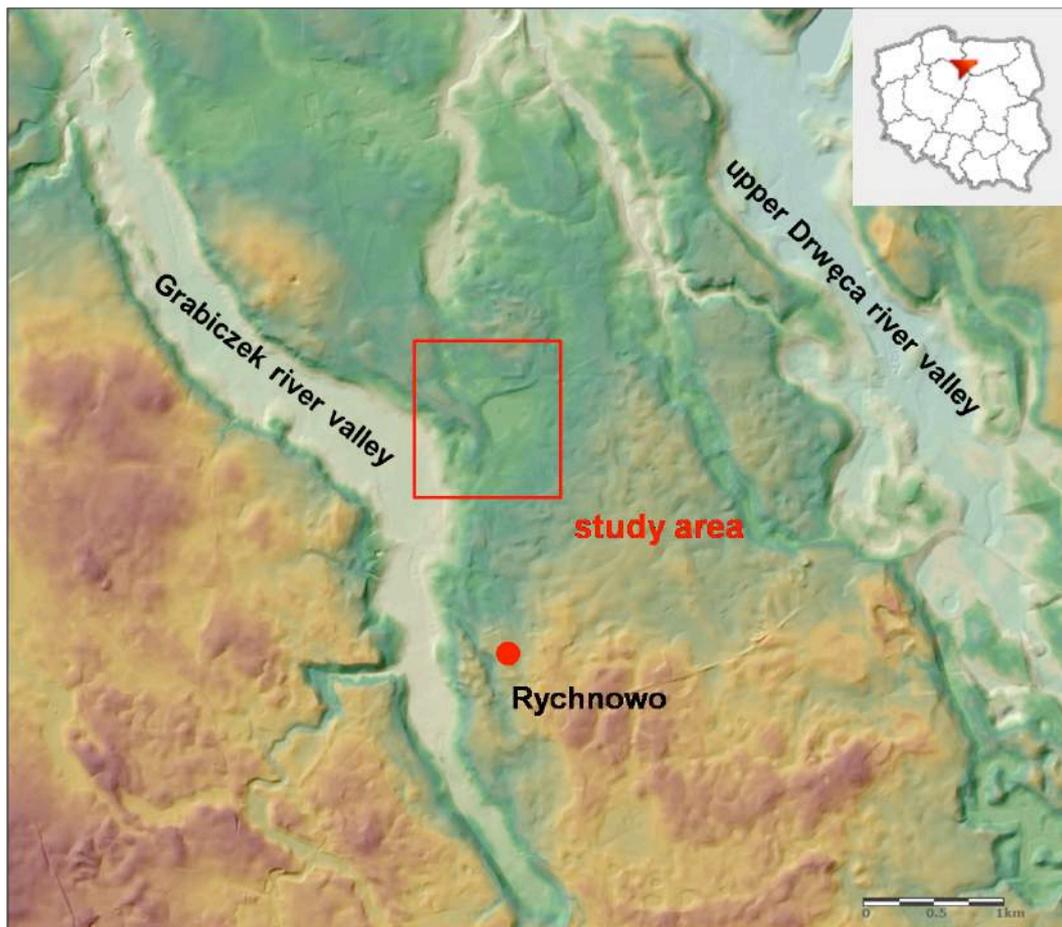


Figure 1 - Location of the study area along the tunnel valley of the Grabiczek River

Results

The site is located on near the edge of an undulating till plain (moraine upland) elevated about 134-140 m a.s.l., which falls into the very distinct relief of the Grabiczek tunnel valley. The height of the flat valley bottom is 116-117 m a.s.l., while on its slopes locally in the NW part of the site are preserved narrow valley outwash plains. Directly northward of the site occurs forested moraine hills with a very varied relief culminating at 155 m a.s.l. The hills and plain were formed during a phase of the Vistulian ice sheet recession around 17 ka BP, before the Pomeranian phase (16,2 ka BP), whose stadial recessional moraines are located further to the North (Mojski 2005). Height differences of relief around the site are more than 40 m. In the upland area there are marked circular depressions, the largest of which is filled by Wyżnieckie Lake. In the smaller depressions, melting of dead ice began at the end of the Younger Dryas, as indicated by a radiocarbon date of $10\,420 \pm 110$ BP (MKL-3134) 10694-9900 BC on bottom of organic sediment one of the depressions (Rychnowo 20). Recent remains of glacial kettles (potholes) are swamps and peatbogs. In the middle of the site on the slope of an endorheic depression, was found a buried soil covered with delluvia (Rychnowo 6). A radiocarbon date from its surface suggests that fossilization took place about 2850 ± 60 BP (MKL-3273) 1210-853 cal. BC (Fig. 2).

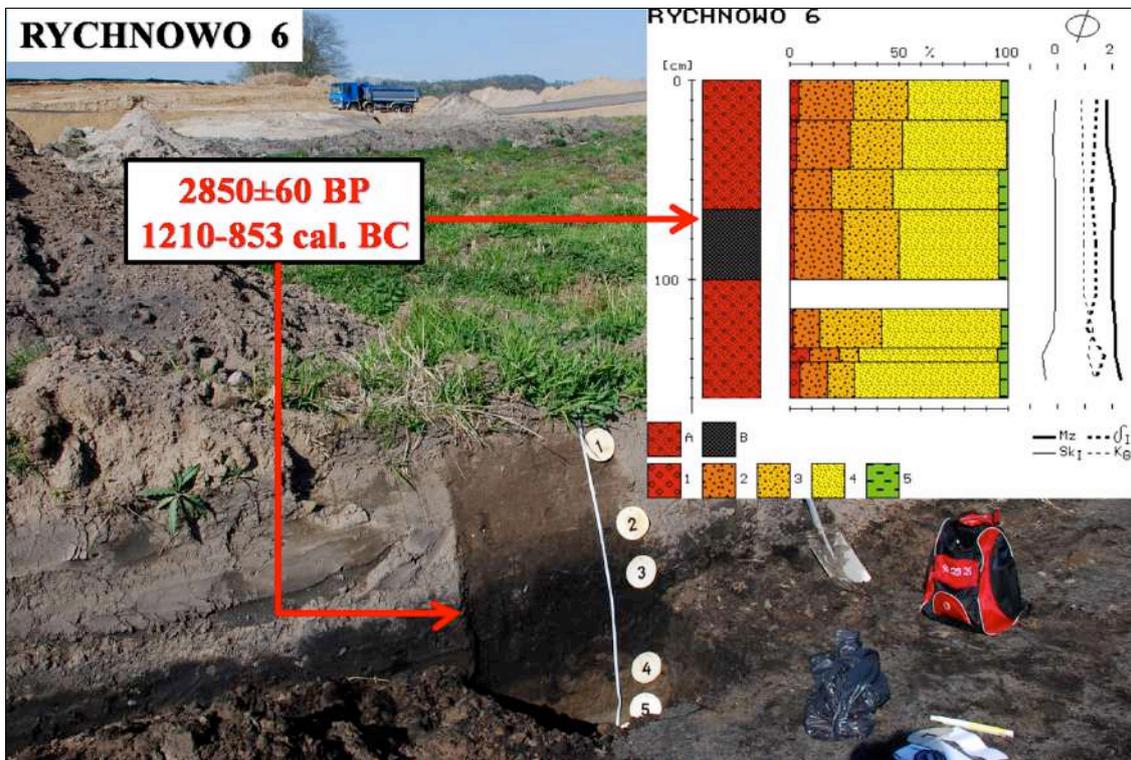


Figure 2 - Geologic profile with buried soil (layer 3) covered with colluvium (layers 1-2)
(photo T. Kalicki)

Several settlement phases were found during the archaeological rescue research of the site (about 1500 ares): Lusatian culture from the Early Iron Age (727 objects, 2470 pottery fragments), Wielbark culture from the Roman period (45 objects, 200 pottery fragments), Early Medieval from the 11th-12th century (4 objects, 11 pottery fragments), the Late Medieval (28 objects, 91 pottery fragments) and Modern time (33 objects, 88 pottery fragments). Permanent or long-term settlements were not found in the site. The site should be considered as group of rather short-lived camps. The most numerous traces of Lusatian culture are not a single phase, but rather multiple periods when people returned to the same area at short intervals (the

homogeneous ceramics). Probably the presence of human groups was related to some economic activity not related to the agriculture (cattle grazing?) and the presence of water reservoirs motivated them to choose this place. However this activity led to soil erosion and formation of a delluvia cover (colluvium) in the endorheic depression.

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SESSION 4

**Northern Africa
archaeo-environmental
changes**

Etaghas: an unprecedented evidence for agricultural landuse in the hyperarid central Sahara

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Keywords: *Etaghas, recession cultivation, Tadrart Acacus, Central Sahara*

Introduction

Rainfall in the hyperarid Central Sahara is unpredictable; but occasionally it may originate ephemeral ponds, which can stand for several weeks (e.g. Fantoli 1937, Davies and Gasse 1988; di Lernia et al. 2012). In the Tadrart Acacus massif (SW Libya), for instance, recent ethnographic interviews have disclosed the complexity of the social perception of rainfall and scarcity of water availability, highlighting the existence of unexpected subsistence strategies related to the systematic exploitation of limited water resources and deeply rooted in the local historical and possibly archaeological background (di Lernia et al., 2012). Among the many abilities accomplished by the local Tuareg people to preserve surface water and maximise benefits coming from occasional rainfalls, we discovered the possibility to cultivate small patches of the desert after the main rainfalls. This form of traditional cultivation, up to now only occasionally reported for a few Tuareg groups in Mali and Algeria (Nicolaisen and Nicolaisen 1997), is represented by the exploitation of these temporary ponds, locally called *etaghas* (Bourbon del Monte Santa Maria 1912).

Materials and Methods

The *etaghas* of the Tadrart Acacus massif have been surveyed in details thanks to the help of local people that illustrated the main traits of this feature. Four localities devoted to occasional agriculture were visited and test trenches were dug to collect samples for botanical, geoarchaeological, and radiometric analyses. Detailed mapping of surrounding rock art contexts was also part of the fieldwork. Finally, a questionnaire was used to interview several members of the Kel Tadrart, particularly focused on the use of this subsistence practice. Evidence for historical and archaeological exploitation of the same areas has been also mapped.

Results and Discussion

The *etaghas* are evident in satellite imagery thanks to their high reflectance (Zerboni et al. 2015); they corresponds to inter-wadis shallow depressions, of medium size, with quite flat surfaces, where flooding connected to occasional rains can stagnate for longer periods of time (Fig. 1). The surface of these features is stone-free and covered by a silty to clay crust, up to several tens of centimetres thick, sealing the sandy substratum. The sedimentary sequence of each *etaghas* displays the same cyclic sedimentary motif, consisting of superimposed centimetric silty layers, occasionally enriched of very small charcoal fragments and interlayered by thin sandy lenses. Under the microscopy, the layers show an upward fining trend, as each layer formed after decantation in shallow water after a flooding event. On the contrary sandy layers correspond to discontinuous inputs of aeolian sand. Micromorphological analyses highlight that along the whole sequence microlayers are vertically cracked and in many cases displaced (Fig. 2). This pedofeatures is commonly associated to agricultural practice

(ploughing). Radiocarbon dating of charcoals collected along the stratigraphic sequences yielded historical ages, thus suggesting that the etaghas were cultivated at least in the last few centuries.



Figure 1 - General view of the two etaghas in the Tadrart Acacus before and after occasional rainfall.

Human presence connected to the etaghas is mostly typified by seasonal Tuareg Kel Tadrart campsites, fields facilities (walls, ditches, fences, stone markers), low density presence of artefacts, rock art markings and, at least in the cases of ethnographic interest, presence of areas for plant processing. The etaghas are used after abundant and prolonged rainfall, allowing the saturation of water several centimetres below the ground surface. There is no favoured period (confirming locally the unpredictable and erratic nature of rains): Kel Tadrart can sow after summer or winter rains and crops are chosen accordingly. Seeds are sown in the wet soil after digging a small hole (Fig. 1). The favoured crops are *Sorghum* and *Panicum* but in certain periods the cultivation is more diversified, including barley and beans. The cultivation is of social relevance and each etaghas is coordinated by the local Amghar (head): normally the elder, whose presence seems to be requested in order to minimise the risk of conflicts and discussions between different families, especially as regards the yields. Depending on crop yields, the process of seeds separation could take several days; plants are placed on small carpets and camels trample on them in order to separate the seeds. These functional sectors are sub-circular in shape, with the edges slightly raised due to stone clearance and marginal straw accumulation (Fig. 2). The etaghas of Itkeri (one of the most exploited) shows several anthropic signs: field partitioning made of stones and fences, Tifinagh and Arabic inscriptions, grinding stones, fireplaces, pottery, and an area for plant processing. A few potsherds point to Final Pastoral – Early Garamantian contexts. It has to be underlined that the area of Itkeri surface material might be connected to the etaghas function, therefore setting the beginning of cultivation activities during (at least) Final Pastoral – Early Garamantian times. At this locality, a small rock shelter preserves a sequence consisting of a small dune covered by a 10 cm thick straw accumulation (Fig. 2) and finally sealed by a charcoal-rich dung layer. The dung and charcoal layer encrust the straw accumulation and is radiocarbon dated to the 3rd-4th century

AD (Garamantian phase), supporting a possibly early historic exploitation of the area for cultivation.

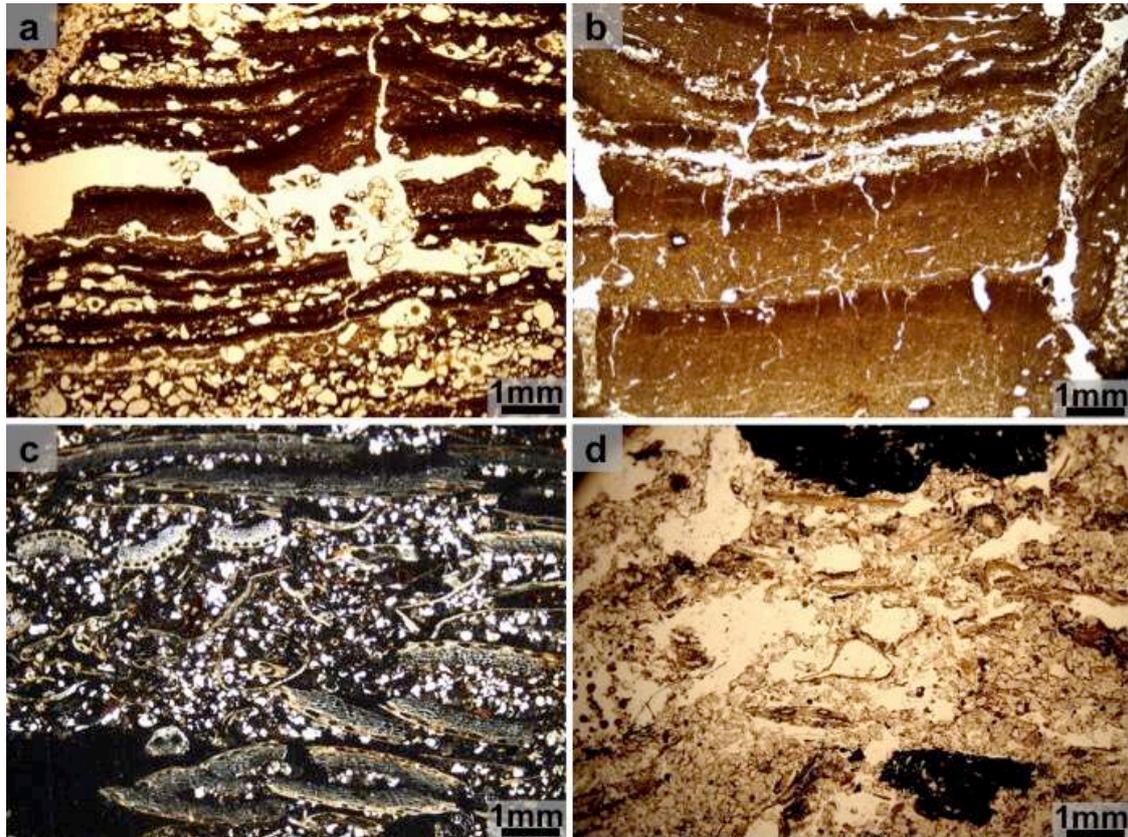


Figure 2 - Photomicrographs of thin sections from investigated sequences. (a, b) Upward fining trend of sedimentation within the flooding areas and sedimentary laminae (decantation crusts) disrupted by agricultural activities (PPL). (c) Straw accumulation at the margin of areas for seeds separation (XPL). (d) Dung encrusting charcoal and a straw accumulation at Itkeri (PPL).

Conclusions

The *etaghas* are well-defined areas whose physiographic features make recession cultivation possible and allow people living in the Tadrart Acacus massif to obtain directly, today as in the past, occasional yields (di Lernia et al. 2012). Radiocarbon dating and the occurrence of a complex archaeological landscape surrounding the *etaghas* suggest that this subsistence practice dates back at least to early historical times. Finally, in a cultural landscape dominated by the oasis-desert vs. agriculture/pastoralism dichotomy, this kind of landuse offers new perspective in the interpretation of the Pastoral-Neolithic exploitation of the central Sahara.

Acknowledgements (Funds)

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"Mind the Gap" to Reconstruct Patchy Records of Archaeology & Environmental Changes in the NE Sahara

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Keywords: *North Africa, Sahara, geoarchaeology, Quaternary*

Introduction

Conducting integrated archaeological and paleoenvironmental field research in Saharan North Africa faces particular and difficult geopolitical and logistical complexities. Due to the harsh conditions in such remote and inaccessible areas, vast portions of this hyperarid region remain under-explored. Only some “postage stamp” areas have been surveyed, and few specific areas have been studied in detail. Many of our archaeological discoveries are surface scatters and *plein air* sites that lack sufficient stratigraphic contexts, which makes it difficult to publish about them. Moreover, excavations and interpretations suffer from the variable quality and “patchiness” of continuous organic-rich sedimentary records, extensive removal of sediments by wind erosion, and the paucity of well-preserved, dateable material in deserts. Despite these obstacles, archaeological, chemical, palaeontological, and geomorphological investigations have yielded a corpus of data from the Sahara that includes chronostratigraphic analyses of sediments and their associated flora, fauna, and cultural artifacts. Given that interpretations of these records are *inherently biased* by geographical location, limited geochronological control, stratigraphic incompleteness, and poor preservation -- this presentation queries what we can (and should probably not) conclude from published works from this highly continental region of Egypt and northern Sudan.

Materials and Methods

Building from a synthesis of archives from the NE Sahara, I aim to reassess and critique models of a “Green Sahara” during the “African Humid Period (AHP).” I develop regional correlations based upon stratigraphic succession, archaeological remains, and chronologies of dated cultural and environmental contexts (Nicoll 2004). I then reconstruct a landscape process-response model for the changing hydro-climate conditions and geomorphology. Through this framework, I demonstrate how spatio-temporal “gaps” in the records provide insights about droughts, surface water availability, paleoecology and cultural activity (Nicoll 2001). Then, I consider how available records of environmental conditions and material culture for Egypt and N. Sudan reflect the pace and tempo of the African continent's changing hydroclimate throughout the Quaternary.

Results and Discussion

Across this broad region (Fig. 1), the timing of the transition from Late Pleistocene aridity to ameliorated conditions during the Holocene period is not well constrained. Radiocarbon chronologies frame the temporal context of cultural activity, especially during wet periods ~8100-6000 BP. Data from northern Sudan are well distributed throughout the Holocene, but Egyptian data cluster ~8100-7900 BP and ~6900 BP. Data from Egypt show variability on a spatial and sub-millennial scale, indicating local geographic controls and a sensitive landscape response to Rapid Climate Changes (RCCs). The precise timing of arid phases is bracketed by “gaps” or 'windows' in the wet chronologies; these *lacunae* are characterized by a dearth of radiocarbon dates due to cultural abandonment and/or depositional hiatuses, aeolian processes,

and erosion. Gaps reflect drought phases. The middle Holocene was characterized by regionalization of surface water storage and recharge. Patterns of sub-millennial variability indicate that water supplies waned ~7500 BP (~ 8100 cal yr BP), accompanied by enhanced aeolian sedimentation, which peaked after 5400 BP (~6700 cal yr BP). After this interval, regional megadroughts persisted.

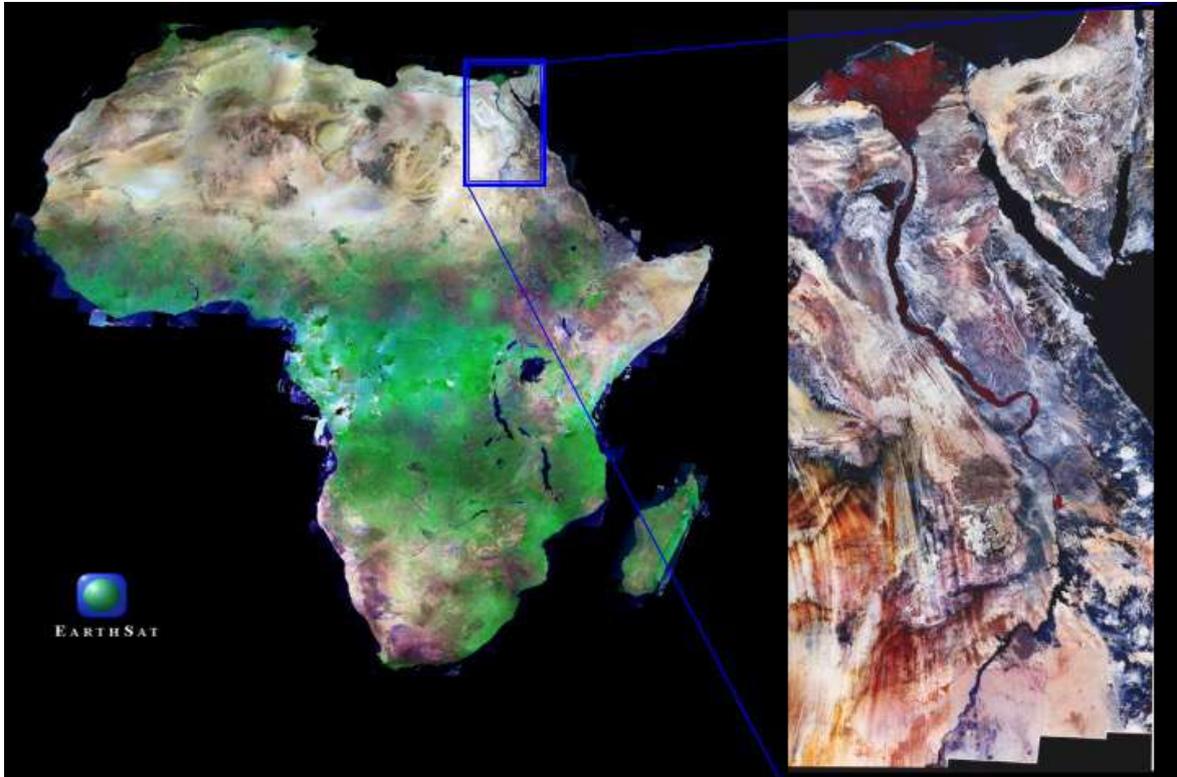


Figure 1 - General study region in North Africa.

Figure 2 is a landscape process- response model that summarizes interactions of the dominant landscape processes during wet conditions and phases of aridity in the NE Sahara. During "pluvial" wet conditions, surface water collected in playa-lakes and rivers, and paleosols formed. "Pluvial" times are characterized by enhanced runoff rates, leading to increased erosion, dissection, vegetation growth, water ponding, and water-table recharge. During times of greater effective moisture, surface sediments were metastable, subjected to weathering, bioturbation, pedogenesis, and partial reworking by fluvial and biotic processes. During wetter intervals, human activities are evident at sites with sufficient water. During arid intervals, the desert was less hospitable; wind erosion (*i.e.*, aeolian deflation) persisted and sands were mobilized and deposited. Arid time periods are characterized by diminished runoff, limited fluvial erosion, falling water-tables, high deflation rates, playa desiccation, evaporite formation, and cultural abandonment of sites, rivers and lake shores.

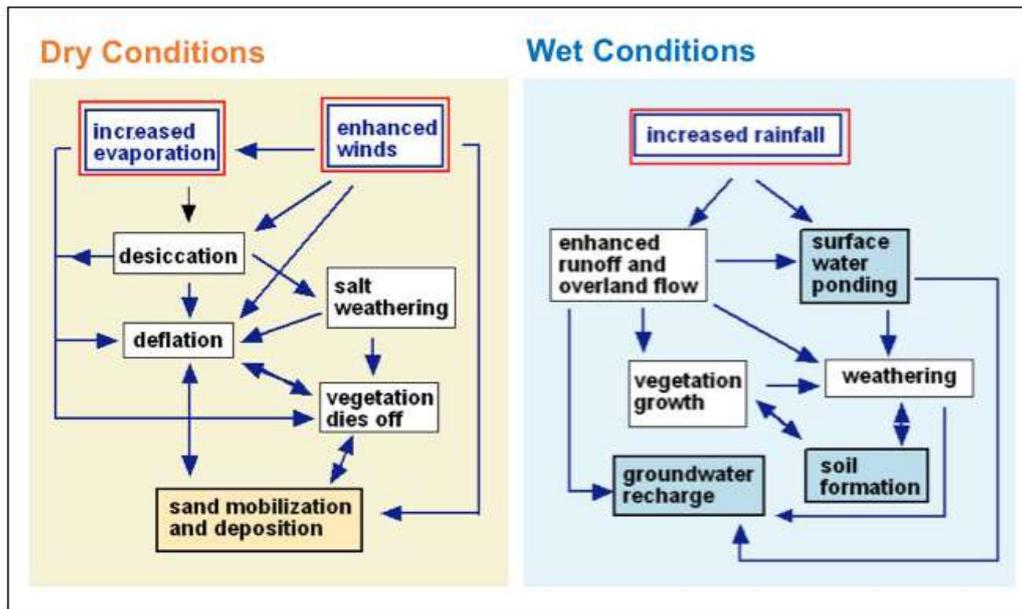


Figure 2 - Landscape Process-Response Model for NE Sahara

Conclusions

Drought and rapid hydroclimatic changes have been important in the geomorphic evolution and human history of Egypt and N. Sudan. Syntheses of prehistoric records indicate: (1) the NE Africa region has been drought-prone throughout much of the Quaternary; (2) even during its “wettest” interval during the AHP, surface water and vegetation were localized and scarce across the NE Saharan landscape; and (3) the area west of the Nile (the Egyptian Western Desert) located within the modern hyperarid core of the Sahara was *only marginal* for sustained human activities.

During its wettest phase, the onset of the monsoonal rains in Egypt and N. Sudan lagged behind the rest of Africa; paleovegetation records indicate that the NE Sahara probably only received <200 mm of rainfall/year. During its “optimum” the NE Sahara was probably not very green – it was sandy and reddish-brown, with occasional discontinuous and ephemeral patches of vegetation and surface water.

The notion of a continuous “Green Sahara” zone across North Africa during the AHP is incorrect and oversimplified. Offshore records from the Atlantic margin of Africa do not evince the dynamics of the NE Sahara environment, or its people. The monsoon was stronger in the western Sahara.

Although Africa’s water balance reflects global hydroclimatic patterns and insolation-forcing of the Afro-Asian Monsoon, specific mechanisms of RCCs are not well understood. The NE Sahara archives show short-term, sub-orbital changes and a dynamic early-middle Holocene period. The mechanisms of aridification at ~7500 (~ 8100 cal yr BP), and 5400 BP (~6700 cal yr BP) merit further consideration.

Gaps in cultural and environmental records support the inference that opportunistic populations followed the sporadic rainfall, and congregated at campsites and oases fed by groundwater. Across this enormous and unknown region, our reconstructions are hampered by the under-documentation of *plein air* remains that may be Neolithic transhumance campsites. As a result, the population models developed for Saharan North Africa are aliased and overlook the complex resilience strategies of desert-adapted people.

To sum the lessons learned: Mind the Gap(s), and All Scatters Matter.

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Herding Barbary Sheep in Early Holocene Sahara

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Keywords: *Holocene, Sahara, Late Acacus, coprolites, spatial analysis, palaeoenvironment, palynology, hunter-gatherer-fishers*

Introduction

The Early Holocene in North Africa and in the Sahara, is characterized by climatic fluctuations which affected human behavior and cultural trajectories regarding occupation, food procurement and resource management (e.g., Cremaschi and di Lernia 1999; Kuper and Kröpelin 2006).

The excavation of the Takarkori rockshelter in the Tadrart Acacus Mountains (Southwest Libya, Central Sahara) offers a unique context with a long and well-preserved Holocene archaeological deposit. In fact, the chrono-cultural sequence of human occupation spans from the hunter-gatherer-fishers (HGF) of the Late Acacus (LA) period up to the Late Pastoral Neolithic (LPN), lasting from approximately 10,200 to 4600 cal. BP in radiocarbon chronology (Biagetti and di Lernia 2013). Late Acacus HGF occupation is characterized by various archaeological remains which indicate different environments, availability of resources and rather complex subsistence strategies, involving selective and intensive plant exploitation (Cremaschi et al. 2014; Dunne et al. 2016; Olmi et al. 2011). Moreover, there are hints of corralling wild animals (Biagetti and di Lernia 2007) and a large amount of well-preserved animal droppings, coprolites, both as part of thick and laminated layers, and as isolated pellets in more loose sediments, were recovered in the stratigraphic sequence. Given the highly informative nature of this kind of evidence for palaeoenvironmental and cultural reconstructions (e.g. di Lernia 2001; Linseele et al. 2010; Mercuri 1999), coprolites from Early Holocene levels have been examined along various lines of investigation with the aim of shading new lights on animal management strategies among Early Holocene Saharan foragers.

Materials and Methods

Coprolites systematically sampled from the levels of occupation of the Takarkori rockshelter have been analyzed by their morphometric and spatial features. Dimensional measurements, coupled with spatial investigation, through descriptive statistical methods and GIS software, have been applied for synthetizing and highlighting some specific patterns of the sample. Ongoing palynological studies of part of these specimens add supplementary information about floristic and vegetational composition of the landscape and on plant resource exploitation, including possible intentional feeding with selected fodder (e.g. di Lernia 2001; Mercuri 1999).

Results and Discussion

Our multidisciplinary analysis confirms forms of wild animal management among the last HGF societies using the Takarkori rockshelter.

Differences and variations in distribution pattern and dimensional attributes permit inferences about modalities and choices involved in corralling Barbary Sheep (*Ammotragus lervia*) among

Saharan HGF. The spatial distribution of coprolites in the LA levels, highlights specific structures and facilities linked to animal management and organization.

The presence of coprolites both from the upper and lower layers of the sequence makes Takarkori a unique context where directly compare and evaluate the different data referring to HGF and Pastoral Neolithic horizons in respect of animal husbandry in a single locale.

The study broadens interpretations about complex forms of planned and delayed use of resources among LA dwellers (di Lernia 2001), immediately before the onset of a pivotal change in subsistence strategies, namely Neolithic food production based on a full pastoral economy.

Conclusions

The study highlights how animal dung is a valuable archaeological proxy, providing information about animal husbandry, exploitation and reconstruction of the past environment, activity area, site structure, economic and cultural transformations in past societies (di Lernia 2000; Mercuri 2008). The evidence collected confirms the sophisticated forms of managing wild animals, likely Barbary sheep, among Early Holocene HGF of the LA phase. Not only feeding the animals with selected fodder as seen at Uan Afuda (Mercuri 1999), but also building and organizing specific facilities accordingly their dwellings.

Acknowledgements (Funds)

This research is part of the activities of ‘The Italian–Libyan Archaeological Mission in the Acacus and Messak’, directed by Savino di Lernia. Funds come from Grandi Scavi (Sapienza University of Rome).

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(Pre)colonial urban sustainability in coastal Africa: environmental and social aspects

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Keywords: *urban environment, spatial structure, urban sustainability*

Introduction

This paper explores the notion of urban environment as an inclusive theme, which encompasses the natural, the built and the social aspects of urban space. The large variety of urban environments in Africa have sometimes been ascribed to the equally varied ecological conditions and ethnical diversity on the continent. African coastal environments in particular represent a suitable laboratory for examining the diversity as well as similarity in the urban form and structure over centuries. Coastal regions have always been major meeting points, as centres in what is essentially a liminal zone, which have flourished from access to trade routes. This paper aims to highlight what constituted urban sustainability on African coasts, and how the aspects of transition and permanence which characterize the social life in this ecological zone were translated into the context of urban space.

Materials and Methods

This paper brings an interdisciplinary perspective on the development of urban environments on the coasts of Africa, considering both the Northwest and Northeast of the continent. It makes use of satellite imagery, GIS and various spatial analyses such as space syntax, network analysis and visibility analyses (Hillier and Hanson 1986; Vis 2009; Fladd 2017). The analyses show how the material evidence preserved today in the spatial structure of urban layouts can shed light on how specific characteristics of urbanism in coastal environments came to be defined over centuries – especially how the natural elements in urban settings are incorporated and elaborated upon through building and in social structures.

Results and Discussion

The presented analyses show that coastal towns in Northwest and Northeast Africa were based on similar economies, which largely rested on facilitating trade and exchange. The towns in both parts of the continent displayed similarities in constituting plurality and competition in their layout, for which natural features such as elevated ground and coastline were used.

On the other hand, there were differences in how these economies were represented spatially in the organization of towns of various time periods. The analyses of the urban structure show, how they promoted either direct movement through the town, or more complex intra-town communication.

The natural elements in the urban landscape were hence actively used and complemented with development of the built environment to materially constitute and negotiate people's access to trade and spaces associated with trade. Differences between precolonial and colonial urban environments are also contrasted to highlight how colonialism affected the spatial management of urban environments.

Conclusions

This paper brings insights into how various types of spatial data might be interpreted from an archaeological perspective on materiality of urban environments. The equilibrium between competition and cooperation which made the social life in coastal towns sustainable over the long-term is shown to be realized in urban spatial structure.

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SESSION 5

**Mediterranean
archaeo-environmental
changes**

Adding Fuel to the Fire: Archaeobotanical evidence for olive pomace use at Roman Utica

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Keywords: *Utica, archaeobotany, olive, Roman, kiln*

Introduction

The production of olive oil results in the production of olive pressing waste, or pomace. For every ton of olives pressed, 200L of olive oil and 350-400 kg of pomace are produced (Mekki et al. 2006; Niaounakis 2011). This paste, made of a mixture of olive skin, flesh and broken stones, contains between 3.5-12% oil and 20-30% water (Karapmar and Worgen 1983). After drying, the pomace becomes a viable biofuel that can be used for both industrial and domestic purposes. Archaeobotanical evidence, in the form of fragmented carbonized olive endocarps, indicates that pomace was used in antiquity to heat the water necessary to extract olive oil, fire pottery and lime kilns, heat bakery ovens and cook food in domestic residences (Rowan 2015).

During the Roman period, North Africa was an important exporter of olive oil, fish sauce and pottery. Olive oil was produced on an industrial scale (Mattingly 1988a, 1988b; Hitchner 2002). The presence of hundreds of carbonized olive endocarp fragments attests to the use of pomace as a fuel source at several sites in North Africa. In Lepcis Magna it was used to fire the kilns while in Carthage it was used for both kilns and domestic cooking and heating (Ford and Miller 1976; Hoffman 1981; Smith 1998). Utica, in modern day Tunisia, was similarly an important port and pottery production site. From 2012 to 2014 a lime kiln and eight pottery kilns, dating from the 1st-2nd century AD, were excavated at this site (Jerbania et al. 2015). Large quantities of carbonized olive stones found surrounding the kilns attests to the use of olive pomace, in addition to charcoal, as kiln fuel. These finds situate Utica firmly within the Roman tradition of using this alternative fuel source in North Africa.

Today, the Mediterranean remains the world's major producer of olive oil with an output of roughly two million tonnes per year (IOOC). As the global demand for fuel and resources continues to rise, despite the decreasing amount of available fossil fuels, many countries are attempting to make greater use of biofuels. This paper focuses on the ways in which the Romans linked olive oil and pottery production in order to sustainably maintain high levels of production in an arid environment. The paper will examine the important lessons that can be learned from these ancient practices and how pomace is slowly beginning once again to be recognized as a crucial source of energy.

Materials and Methods

The Tunisian-British Utica project, led by teams from Tunisia and the University of Oxford, undertook extensive excavations at the site between 2012-2014. In addition to the kiln complex, the forum/basilica and the House of the Large Oecus were also explored (Jerbania et al. 2015). Archaeobotanical samples were taken from all contexts with a high likelihood of remains, namely floor surfaces, hearths, pits, and kiln rake out pits. Flotation took place at the excavation house next to the site and all flot samples were brought back to the UK for sorting and identification. A total of 32 samples were collected from the kiln area. A rifle box was used to separate the larger samples into quarters.

Results and Discussion

The finds of thousands of carbonized olive stones confirms the use of pomace fuel in the kilns. A single 12L sample, for instance, contained only 4 whole olives but 4776 endocarp fragments. The number of fragments is far too high to be table waste or olives used in burnt offerings (Rowan 2015).

While environmental sustainability was unlikely to have been one of the Romans' conscious objectives, the use of this fuel was vital to the continued production of North African ceramics, particularly in more arid areas. Enormous quantities of ceramics were produced in Tunisia with little evidence for permanent environmental damage (Kaplan et al. 2009; Lewit 2011). Often times pottery production centres were located next to olive groves for the explicit purpose of using the pomace (Lewit 2011). Consequently, the use of pomace decreased pressure on woodland resources and allowed for several fuel intensive activities such as pottery production, metal production and the heating of large bath complexes to occur simultaneously with any environmental damage (Rowan 2015).

Today, some olive oil producing countries have begun to make use of olive pomace fuel for various industrial activities. In Spain, pomace is used as a biodiesel fuel while in some regions of Turkey it is used in bakeries (Doymaz et al. 2004; García-Maraver et al. 2012; López et al. 2014). Research into the various uses of pomace continues, both because it is slowly being recognized as a crucial biofuel and because the pomace is toxic to the soil and groundwater and therefore cannot simply be left on the ground (Salomone and Ioppolo 2012; Tawarah and Rababah 2013). Linking the production of biofuels and their subsequent use more closely would be of great benefit to the environment and ease the pressure on fossil fuels. Just as the Romans had a pre-planned use for the pomace, so too should countries today, rather than letting it go to waste.

Conclusions

In sum, olive pomace was a hugely important and valuable resource in antiquity from the Bronze Age through to Late Antiquity (Rowan 2015). There is much to be learned from the use of biofuels in the past. The Romans exploited this virtual free resource to their advantage to ensure high levels of production without, consciously or unconsciously, causing harmful and long lasting effects on the landscape. By researching new uses for pomace and linking it directly to industrial activities, in the modern Mediterranean, countries could do much more to exploit this valuable resource.

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Multidisciplinary research in naval archaeology: the shipwreck of Santa Maria in Padovetere (Ferrara, N Italy)

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Keywords: wood remains, biochemical analysis, pollen analysis, pitch, fiber, shipwreck

Introduction

The Late Roman river shipwreck sunk in Valle Pega, an eastward valley near Comacchio (FE), provides a challenging opportunity for a multidisciplinary investigation. Here, we report the results of a combined research on wood remains, of the biochemical analysis on pitch samples, and of the study of pollen, NPP, fibres and macroremains, palaeohydrography.

Materials and Methods

Wood materials were analysed under a low power binocular microscope (10x 20x 50x), comparing samples with specific atlases of wood anatomy. Caulking material from the hull of the ship and a segment (2 cm) of rope were studied. Single fibres and bundles were observed under polarised light in a LM (x1000) (Bergfjord and Holst 2010); the modified Herzog test was applied (Haugan and Holst 2013). Some fibres were enclosed in acrylic resin, sectioned (2 µm), stained and compared with cross sections of fibres of known origin and literature (Catling and Grayson 1982; Ilvessalo-Pfäffli 1995).

One sample of clayey sediment collected from the bilge of the shipwreck was processed for pollen and NPP analysis following the standard pollen preparation method. Description and sampling of the sedimentary succession near the site was carried out through hand augering, radiocarbon dating, palaeohydrographic reconstruction from remote sensing and historical cartography.

Results and Discussion

The construction elements of the river shipwreck were made of *Quercus* sp. and *Ulmus* sp. These two woods, being very hard and resistant in permanently humid environment, are regularly involved in roman sewn boats construction. They are moreover easily available in the natural arboreal vegetation surrounding the site as confirmed by the pollen analysis: the spectra were characterized by the prevalence of *Quercus robur-pubescentis* type and *Ulmus*. In the pollen record components of the plain forest are also present such as *Acer*, *Carpinus betulus*, *Fraxinus*, *Juglans*, *Corylus*, *Cornus*. Pollen analysis on the bilge sediment showed the presence of typical vegetation of the river banks, characterized by Poaceae and Cyperaceae (non arboreal pollen) and *Alnus* and *Salix* (arboreal pollen). It is even attested the presence of *Pinus* cf. *pinia* and of Chenopodiaceae, *Urtica*, Brassicaceae, Apiaceae, *Sanguisorba minor*, *Trifolium*. Hemp pollen grains are also present. As far as the use of ship concerns, the occurrence of coprophilous fungi (*Gelasinospora*, *Podospora*, *Arnium* and *Coniochaeta lignaria*) and pollen of herbs that grow in pastures and meadows suggest the use of the ship for transporting animals (sheeps?). Macroremains of ropes and caulking elements - used to sew planks - were made of hemp. Pitch

was obtained by pyrolytic treatment of resinous pinewood. The boat lies on the left bank of a palaeochannel of the Po River, whose flooding led to the aggradation of the nearby floodplain in 5th-6th century AD.

Conclusions

This multidisciplinary approach shows that the shipwreck was lying in a channel of the Po River probably active in the 5th-6th century AD, that it was made by using local raw materials such as timber, and that the landscape was modified by human impact as suggested by the presence of pine - in pollen spectra and in pitch samples – and hemp.

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Contributions of a multiscale approach to a human-environment relationship reconstruction, around the tell of Dikili Tash (Greece)

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Keywords: *Greece, palynology, human impact, land-use, vegetation change*

Introduction

The archaeological investigations carried out on the tell of Dikili Tash, one of the oldest Neolithic settlement site in the Balkanic region (Northern Greece), improve our understanding of the cultural, social and material evolution of the settlement from the beginning of the Early Neolithic (c. 6500 BC in the region) to the Bronze and Iron Age, the periods of its occupation. While global climate reconstruction research based on the study of the Tenaghi-Philippon marsh, located 7 km from the tell, have focused on forces that drive the environment at the regional or continental scale, we attempt to use the local sediment archives to identify periods of change around the closer inhabited areas. In order to investigate the human and the climatic impacts, the marshy or alluvial sedimentary archives are valuable sources of palaeoenvironmental and geomorphological information.

Materials and Methods

The reconstruction of environmental changes is based on fieldwork and more than 15 cores located in the wetland and alluvial areas near the archaeological site. Two sources of palaeoecological investigations have been conducted: geomorphological investigations and pollen as well as non-pollen palynomorphs analyses. Palaeobotanical proxy data give an overview of “initial environment” before the Neolithisation process and a comprehensive view of anthropogenic impact on the vegetation cover, which can be compared to the sedimentological changes undertaken in the lowland areas. Three relatively new palynological records located respectively 1.75 km (Dik4), 150 m (Dik12) and less than 100 m (Dik5) from the archaeological site were extracted (Fig. 1).

Results and Discussion

The first results from Dik4 covering all the Holocene time until Antiquity give evidence of the role of some of the climatic oscillations on local environmental change during the last 12,000 years. The implications and consequences of these events seem to have probably favored or coincided with some defined process, for example a Neolithic settlement pattern (Lespez et al. 2013; Glais et al. 2016). The Cerealia pollen recorded at the bottom of the archaeological site from the Early Neolithic sequence (Dik12), associated with other pollen and non-pollen indicators, confirm that the first forest clearings were done around 6500 BC, to open the local environment, even while a woodland environment persisted on the edges of the marsh. Furthermore, the Dik4 core provides a continuous overview of the evolution of the vegetation cover throughout the period. The study reveals two phases of decline in land use directly on the edge of the marsh, although indicators of anthropogenic disturbance of the vegetation never entirely disappear. In contrast, four periods are characterized by an increase in land use extension and intensification (Glais et al. 2017). Finally, the Bronze Age and Iron Age records

from Dik5 confirm the consequent anthropisation of the surroundings and supply some information about the diversity of anthropogenic (cultivated) plants.

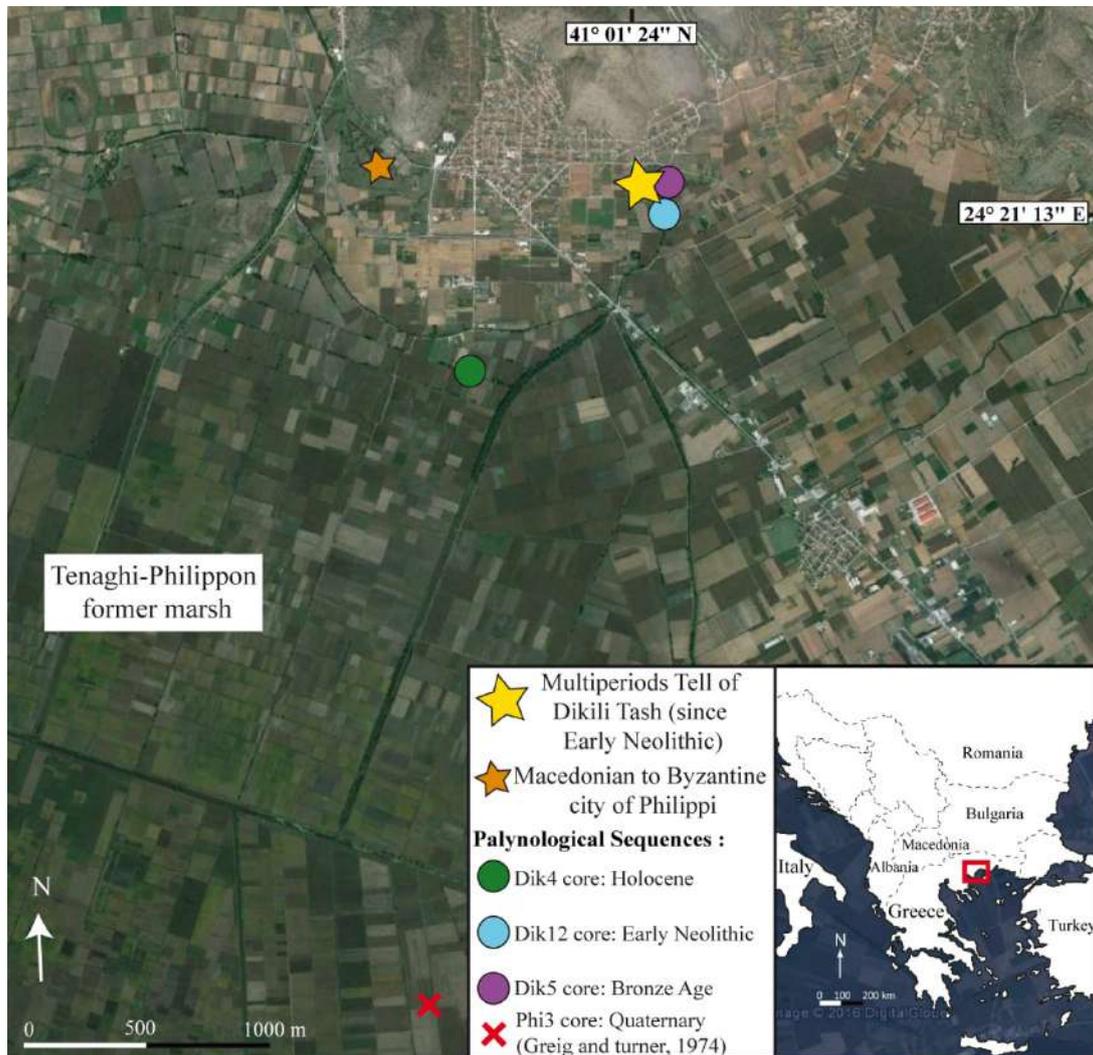


Figure 1 - Palynological sequences location in order to analyze “Human-Environment” relationships around Dikili Tash.

Conclusions

Beyond the limits of interpretation linked to the quality of the pollen record, the analysis shows that the question of the effects of human activity on the landscape during the Neolithic cannot be addressed without an accurate analysis of the local context. This case study highlights the value of combining off-site palynological evidence (Glais et al., 2016, 2017) and on-site data at different scales (Darcque and Tsirtsoni 2010; Darcque 2013; Darcque et al. 2014; Lespez et al. 2013; Valamoti 2015). It points out the necessity to assess the effects of specific farming and herding practices on the dynamics of mosaic landscapes in Mediterranean areas with greater precision and to discuss the question of human society-environment-climate interactions that do not always have the same periodicities from the Neolithic onwards (Glais 2017). It remains difficult to identify cultivated or harvested plant species from pollen taxa recovered but the results obtained in this study clarify the spatial pattern of changes in vegetation cover.

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Dryland Tells in Wetlands of Macedonia: Pelagonia and the site of Vrbjanska Čuka as case study

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Keywords: *Neolithic, Pelagonia, wetlands, tells, landscape*

Introduction

For many decades the tell-sites were considered as part of 'dryland' archaeology and were studied as such. The major focus was on the material culture and architecture and on the determination of archaeological cultures attributed to these sites. In regard to initial stages of prehistoric archaeology in the Balkans this was the important step, but apparently insufficient in order to understand the environment of the first farming communities that established these settlements. The recent study of valleys inhabited by vast number of Neolithic tells indicate that these settlements were disposed around wetland areas that provided a variety of resources for food, building and transport, and initiated a diverse symbolic understanding of the environment. Therefore this paper will give an short overview of bioarchaeological research in the Republic of Macedonia and will consider in particular the environmental issues regarding the establishment of tells in wetlands of Pelagonia with major focus on Vrbjanska Čuka and its landscape, architecture and material culture.

Environmental archaeology is not yet a regular practice in the archaeological research in the Republic of Macedonia (Fig. 1).

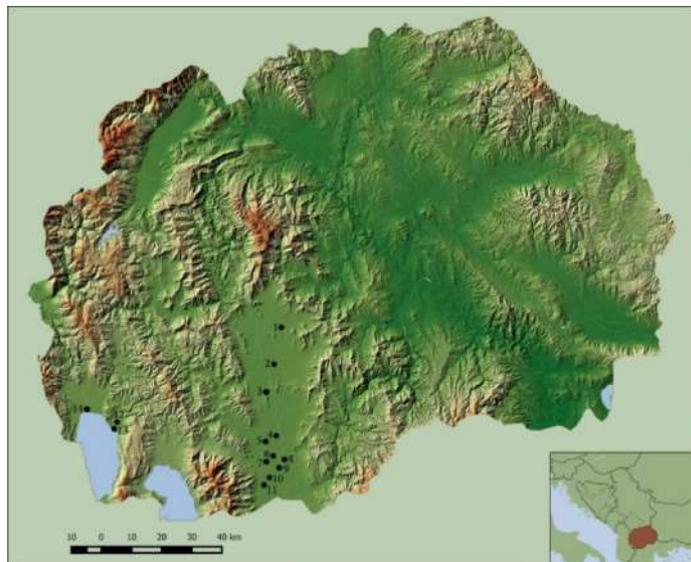


Figure 1 - Map of the Republic of Macedonia with location of Pelagonia.

As result to that there was no particular focus on the landscape and conditions of the natural setting where people dwelled in the past. Consequently, the methods for environmental research were not incorporated except in few exceptions in 1970s that gave initial knowledge on the Neolithic environment in the eastern and southwestern parts of Macedonia. Archaeobotanical research was performed for several sites and particularly the analysis of charcoal, pollen and carbonized seeds that gave initial information for cereals, wood and various species of

vegetation. An analysis of climatic conditions was performed and the knowledge on several changes in the Neolithic was proposed. One of the regions incorporated in environmental research was Pelagonia, the largest valley in the country that has been explored modestly in terms of geoarchaeology and that was a large wetland area until 1960's when it was systematically dried within the melioration process. In the 1970's geological research was performed with the usage of drillings and the Neogene lake was determined, but also the wetland character of the valley in prehistory.

Materials and Methods

New studies were started recently by the Center for Prehistoric Research in order to determine the environment and societies in the Neolithic Pelagonia (Fig. 2). The old maps of Ottoman, Austro-Hungarian and Yugoslavian armies are used to study the wetland setting that in 1960's was significantly changed. These maps indicates the existence of marshy lakes in Pelagonia and consequently the GIS survey was implemented in order to determine the relationship of Neolithic tell sites with nowadays absent wetlands (Fig. 3). The selection of organic samples from several Neolithic sites in Pelagonia was performed and was sent on radiocarbon analysis at the University of Bern where they were determined and dated. Facing the necessity for more scientific based archaeological research in Pelagonia, a multidisciplinary project was launched that integrates excavation of one settlement (Vrbjanska Čuka), as well as the zooarchaeological, archaeobotanical, isotope, radiocarbon, lipid and use-wear analysis.

This project involves several institutions from Macedonia, Serbia, Slovenia, Switzerland, Spain, Czech Republic and Germany in order to provide thorough knowledge on the architecture, material culture and diet of the farming community that settled the tell site of Vrbjanska Čuka (Naumov et al. 2017a), but also intends to understand the natural environment surrounding this Neolithic settlement (Fig. 4). In terms of bioarchaeology, a Macedonian-Czech-Serbian collaboration was established within this project in order to perform archeobotanical and zooarchaeological research and to provide a new knowledge on the vegetation and animals, and their relationship with the natural setting and diet of Neolithic communities in Pelagonia, and particularly of those that established the site of Vrbjanska Čuka.



Figure 2 - Neolithic artifacts from Pelagonia (after Naumov 2016c).

Results and Discussion

The geoarchaeological research from the 1970's indicated that Pelagonia was a wetland in the Neolithic and therefore was not initially included in the Neolithization process (Kitanoski et al. 1980; Naumov 2015). This was further confirmed by the radiocarbon dating of charred wheat in the laboratory at the University of Texas (Valastro et al. 1977).

The samples of cereals sent to the laboratory of University of Bern were attributed to several species and also indicated the Neolithization in Pelagonia at the beginning of the 6th millennium BC i.e. few hundred years later than in eastern parts of Macedonia (Naumov 2016a). The study of Ottoman and Austro-Hungarian maps, as well as those of Yugoslavian People Army before 1960's, demonstrates vast areas of wetlands in the central and northern parts of Pelagonia that are not present nowadays except in days of heavy rains and floods. The reconnaissance and GIS research of Neolithic tell-sites along with the study of old maps confirmed that majority of these settlements were established around the wetland areas (Naumov 2016b; Naumov and Stojanoski 2016; Naumov et al. 2017b). This partially demonstrates that such marshes could be a common landscape in the Neolithic Pelagonia, and sets the direction for further and more thorough study of environmental features of the region in prehistory.

The excavations of Vrbjanska Čuka and the study of material culture indicate a farming community with buildings consisted of complex household features for storing and processing of cereals employing artifacts that witness high level of social relationships and symbolic processes (Naumov et al. 2017a). The recent bioarchaeological international project mentioned above provided data on vegetation and animals associated with wetlands and its major results will be presented by a joint paper in this conference (Beneš et al. 2018).

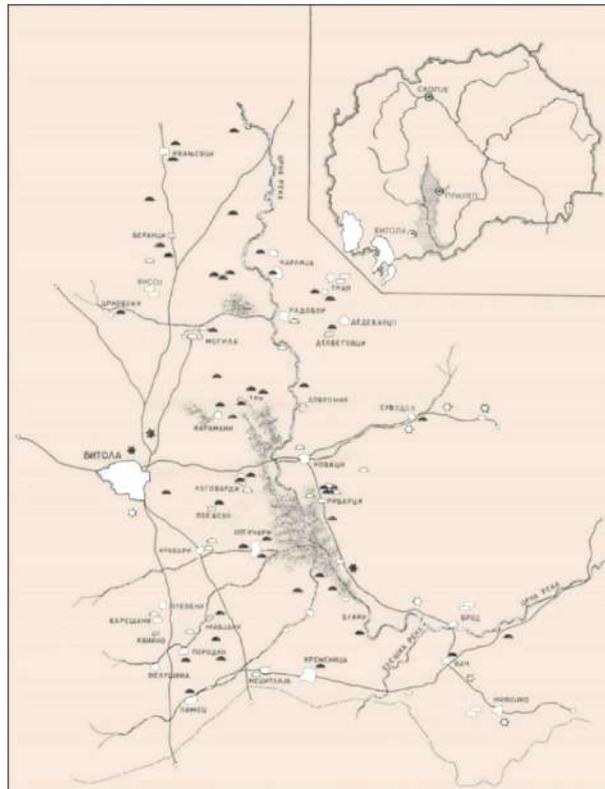


Figure 3 - Map of Pelagonia with disposition of tells around wetlands (after Simoska and Sanev 1976).



Figure 4 - Vrbjanska Čuka is a tellsite located in the northern part of Pelagonia (Naumov et al. 2017).

Conclusions

The current knowledge on Pelagonia environment in the Neolithic is still modest, but could contribute initially in the elementary understanding of now changed landscape of the region. In the last six decades the tell sites were perceived as settlements within drylands due to recent natural setting of Pelagonia (Garašanin 1979; Sanev 1995). But the latest research indicates that they were systematically established in the vicinity of wetlands in order to provide approach to more fertile soil, clay for building, as well as birds, fishes, animals and straw from the marshy lakes (Naumov 2016b). Few of these settlements were functioning as centers that were synchronously and later surrounded by the smaller tells inhabited by farming communities. One of such centers was the Vrbjanska Čuka site, one of the largest tells in the northern parts of Pelagonia that witness a society fully focused on advanced forms of material culture, architecture and economy based on cereals (Naumov et al. 2017b). The ongoing project intends to integrate more specialist oriented research and to provide more thorough knowledge on the social, architectural and symbolic features of the Neolithic community and its interaction with the environment.

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Onsite Bioarchaeological Knowledge of the Neolithic settlements in the Balkans: The case of Vrbjanska Čuka, a tell-site in Pelagonia, Republic of Macedonia

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Keywords: *bioarchaeology, Neolithic, archaeobotany, archaeozoology, phytoliths*

Introduction

The first part of this contribution comprises of an outline of bioarchaeological studies connected with the Neolithic settlements in the Balkans. A substantial proliferation of environmental studies is recorded in the last decade concerning archaeobotanical and archaeozoological evidence. Main attention is paid to archaeobotanical and archaeozoological studies which consider settlements and their bioarchaeological context. The second part is focused on the Neolithic tell-site of Vrbjanska Čuka in Pelagonia, Republic of Macedonia, where authors have been performing bioarchaeological research since 2016.

In this paper, we present the results of the analyses of botanical macroremains and microremains (starch, phytoliths) and faunal remains collected in season 2016 in the broader context of the Neolithic Balkans in order to estimate the bioarchaeological potential of the site.

Materials and Methods

Archaeobotanical material from Vrbjanska Čuka 2016 field season was obtained by test sampling of archaeological contexts. 79 samples and 404 l of sediments were processed. Samples have been taken from different contexts from the site and from the profile in western part of the excavated area (profile W1). Flotation was applied for the extraction of botanical macroremains (Cappers and Neef 2012) and taxonomic identification (van der Veen 2007), including anthracological determination of charcoal (Schweingruber 1978). For phytolith analysis, seven samples were taken from the whole W1 profile and one sample was obtained from a Neolithic context near the profile. Phytoliths were separated from the sediment by following a standard procedure (Albert et al. 1999). Grindstones was sampled for analysis of starch grains (Torrence and Barton 2016). Hand collected faunal remains from the 2016 campaign were analyzed. In addition, faunal remains collected by flotation were provisionally studied in order to gain more information on the taxon/element distribution with respect to sampling techniques, i.e. the information on smaller taxa which were potentially used as food or inhabited the surroundings of the site.

Results and Discussion

Although the most samples were taken from cultural stratigraphic units, the majority of plant macroremains (wild plants) was preserved in an uncharred (uncarbonised) state. Consequently,

there is a high probability of contamination of Neolithic sediments by the later Classical or Medieval activity, or they could represent part of (sub) recent soil seed bank. Charred plant macroremains represent a smaller portion of the sample, and in general, a lot of them were not very well preserved. They represent species common in the Neolithic (e.g. einkorn, emmer, barley, lentil, peas), however, some species like common millet seem to be intrusions from the later phases of the tell occupation. Charcoal analysis detected remains of fuel and timber from the vicinity of Vrbjanska Čuka tell.

Phytolith analysis attest to a great quality of microscopical plant residues preserved in the sediment. Many specific morphotypes were recognized in samples. Skeletons of Poaceae inflorescences are present in various taphonomical states and indicate of crop processing activities at the site. Starch grain analysis was concentrated on grindstones. The samples contained Poaceae starch grains, structures with Fabaceae shape and probably *Quercus* starch grain. Generally, archaeobotanical remains indicate cereal and legume based agriculture, however, there is also some evidence of wild plants procurement.

The hand collected faunal sample, albeit small, is indicative of a predominantly stockbreeding economy. The majority of elements originate from domestic animals – namely cattle and caprines, and to a lesser extent pig and dog. A single element of wild boar suggests that occasional hunting also took place. Shells of freshwater mussel were also identified. Faunal sample collected by flotation consisted of smaller bone fragments and isolated teeth of previously identified mammal taxa. In addition, sporadic remains of rodents, amphibians (frogs), reptiles and smaller fish (small-bodied cyprinids and salmonids) were also found.

Conclusions

Results from the Vrbjanska Čuka tell-site indicate a mixed economy, involving agricultural production/consumption, stockbreeding, and to a lesser extent hunting, fishing and shellfish collection. Such subsistence strategies, reflected by bioarchaeological data, could be regarded as typical in context of Pelagonian landscape (Naumov 2016).

Main recommendation for future research is that macro-and micro archaeobotanical data should be acquired preferably from floor levels of buildings and from undisturbed infills of features spatially related to buildings. The general quality of bioarchaeological material is very good and promising for the future research.

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SESSION 6

Reconstructing past landscape: flora insights from archaeological sites

Growing diversity of archaeophytic flora as a consequence of progressive habitat diversification in Central Europe

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Keywords: *archaeobotany, archaeophytes, Czech Republic, immigration, residence time*

Introduction

The synanthropic flora is generally rich in alien plants. We focus on archaeophytes, i.e. the species that migrated to Central Europe from the Neolithic (5600 BC) to the end of the Middle Ages (1500 AD). It has been demonstrated repeatedly, that the diversity of weed flora increased gradually since the Neolithic in Central Europe (see Willerding 1986; Rösch 1998; Lityńska-Zajac 2005; Brun 2009; Gyulai 2010; Poschlod 2015; Pokorná 2017). Increasing species diversity is a result of both the immigration of aliens and spread of apophytes (native plants that have passed spontaneously to artificial sites, see Sukopp 2006).

Several factors are responsible for the rate of immigration of alien plants: (i) propagule pressure (Colautti et al. 2006), (ii) plant traits, and (iii) suitable biotopes. Functional traits of plants that immigrated in particular periods, as well as their links to various types of habitats can be used for reconstruction of environmental changes taking place near human settlements. Similarly, different immigration rates can give indirect information on intensity of human migration and long-distance movement of various goods (or livestock).

Materials and Methods

We summarise macroremain data from the Archaeobotanical Database of the Czech Republic (Pokorná et al. 2011; Dreslerová and Pokorná 2015). The selected data is based on 202 archaeological sites and cover the time span from the Neolithic to the Early Middle Ages (Tab. 1). We found 123 aliens and 94 native species. All species were categorised according to their residence time (period of their first occurrence in the fossil records). The ecological demands of species were derived from Chytrý (2007–2013) and Ellenberg et al. (1992). To compare residence times of aliens with those observed in other countries, we gained data published in international journals and monographs.

Results and Discussion

The increase of species diversity in the fossil flora was, in the first place, caused by the immigration of aliens. However, the species composition implies an increasing number of co-existing habitats since the Neolithic to Medieval periods. The observed diversity was also ruled by the total amount of available data in the individual periods (Tab. 1) as well as by different preservation processes of macroremains (waterlogged material that was common in the Medieval period, generally gives more numerous and species-rich assemblages than the carbonised material, which predominated in prehistoric sites).

Three temporal phases (Fig. 1) represented by waves of increased immigration followed by their distinct drops were distinguished in our data: (i) the Neolithic to the Eneolithic; (ii) the Bronze Age to the Migration Period; and (iii) the Early Middle Ages. The first phase was characterised by the prevalence of generalist species that are currently abundant in both ruderal and segetal vegetation.

Table 1 – Chronology of examined data. Absolute dating of prehistoric periods for the Czech Republic follows Jiráň and Venclová (2013). The ‘Sum of seeds’ indicates the total number of seeds of species identified and meeting our criteria.

Abbr.	Periods of the Prehistory	Time span	Length (years)	Number of sites	Sum of seeds
NE1	Early Neolithic (Linear Pottery)	5600–4900 BC	600	10	5,894
NE2	Late Neolithic	5000–4200 BC	700	10	2,211
ENE	Eneolithic	4500/4400–2300 BC	2000	17	1,116
BR1	Early to Middle Bronze Age	2300/2200–1250 BC	1000	20	5,127
BR2	Late to Final Bronze Age	1250–800/750 BC	500	44	20,793
IR1	Early Iron Age (Hallstatt)	800–400/370 BC	350	25	17,467
IR2	Late Iron Age (La Tène)	480/460–50/20 BC	450	21	9,653
RMP	Roman to Migration Period	35/25 BC–560/580 AD	580	14	9,941
EM1	Early Middle Ages 1-3	580–950 AD	370	13	71,727
EM2	Early Middle Ages 4	950–1200 AD	250	28	73,870

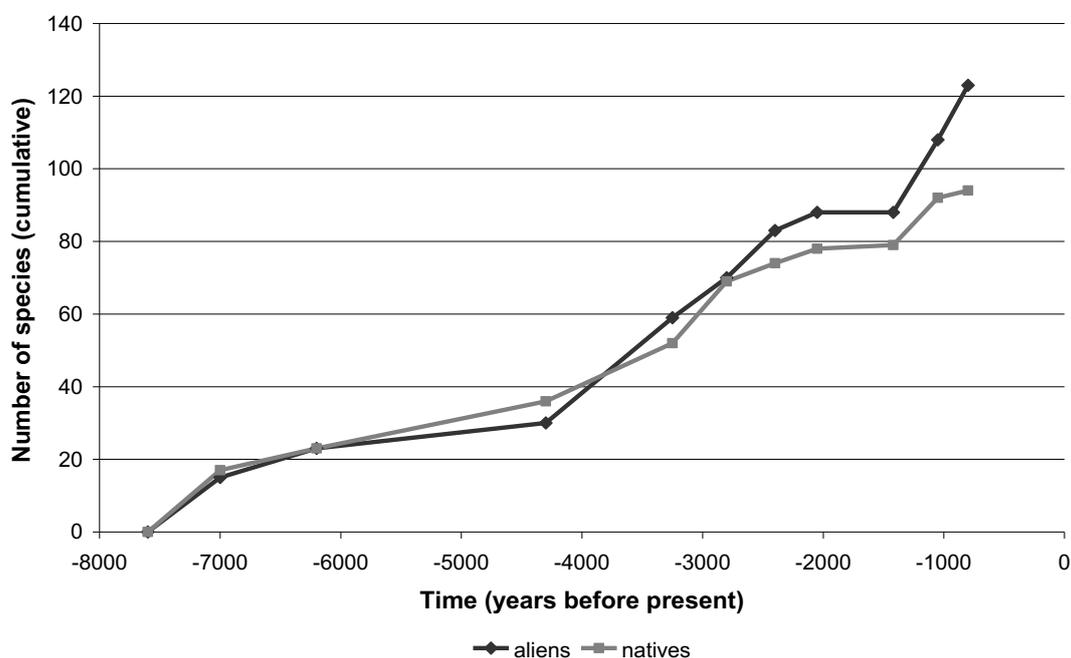


Figure 1 - The cumulative number of immigrated alien species (black line) and native species (grey line) plotted against the time of their immigration.

Since the Eneolithic, specialised weeds of cereal fields emerged. In ruderal flora, the successive development was directed from the predominance of species indicative of less fertile soils to

species of nutrient-rich substrata. The composition of the oldest grassland flora rather corresponded to short lawns of disturbed and/or trampled sites.

The sudden rise of meadow species came from the Late Bronze Age, which requires further study, since the oldest findings of the scythe only date back to the Hallstatt period (Venclová 2013).

Since the Middle Ages, the emergence of new species of pastures indicates the intensive use of floodplains for cattle grazing.

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The wild vascular plants buried by the 79 AD eruption of Vesuvius

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Keywords: *archaeobotanical, biodiversity, carbonized plant, Oplontis, Roman Age*

Introduction

Archaeobotanical reconstructions depend on the level of identification of plant species and on their chance of being preserved in the archaeological record (Jacomet and Kreuz 1999). The chances of a plant species being detected and morphologically identified to a certain taxonomical level are strongly influenced by the type of preservation and by the plant's morphology.

The Vesuvius area in southern Italy was one of the most important regions of the Roman Empire. The AD 79 eruption preserved the daily life of the main inhabited towns, e.g. Pompeii, Herculaneum and other sites such as Oplontis and Stabiae. During archaeological excavations carried out on the second half of last century which have brought to light the remains of these Roman cities, a considerable amount of carbonized but remarkably well-preserved plant remains have been discovered.

In the present study the wild vascular plants buried by the 79 AD eruption of Vesuvius found in Oplontis are analyzed.

Materials and Methods

The study area comprises the site which has been recognized as Oplontis, a complex consisting of the remains of some Roman buildings in the center of the city of Torre Annunziata. Oplontis is located along the bay of Naples, south of Mount Vesuvius.

The material, although completely carbonized, is excellently preserved and, hence, its features and even many details can be easily observed. Since every specimen we could separate and examine, even if well preserved, was incomplete or lacked some diagnostic character, the identifications were chiefly carried out by comparison both with living and herbarium specimens.

Besides the hay material found in the Villa of *L. Crassius Tertius*, many other plant remains, chiefly wood, have been found in the Oplontis' archaeological excavations. In order to give as much information as possible about the plants which actually grew or were raised in this area, we have listed all the taxa that we have been able to identify from carbonized plant remains in the Oplontis' buildings and gardens.

The carbonized plant remains were identified according to *Flora Europaea* (Tutin et al. 1964-1980, 1993) and *Flora d'Italia* (Pignatti 1982). In the floristic list the species are arranged in alphabetical order. Nomenclature follows Conti et al. (2005) and recent updates.

Results and Discussion

Up to now 128 taxa representing 31 families and 79 genera have been identified of which 107 are identified to species, while 19 specimens could be identified only to genus, and 8 only to

family. The richest families are: Fabaceae (38 taxa), Poaceae (22), Asteraceae and Caryophyllaceae (11). While, the richest genera are: *Trifolium* (12 taxa, e.g. *T. angustifolium* L. subsp. *angustifolium* and *T. campestre* Schreb.), *Medicago* (6, e.g. *M. lupulina* L. and *M. orbicularis* [L.] Bartal.) and *Vicia* (5, e.g. *V. disperma* DC. and *V. pubescens* [DC.] Link).

The list must still be regarded as provisional since, for a good deal of plant fragments (such as leaves, leaf remains, branches and stems, fruits and seeds) any attempt to recognize them, at any rank, are, at present, unsatisfactory. In order to identify more of the unidentified specimens, in addition to morphological examinations, further analyses and SEM observations are being carried out to clarify such an important argument.

It may be assumed, as the floristic composition seems to point out, that the material could be given as fodder to the animals yoked to the carriages during loading and unloading. In the Villa in fact some commercial activities were probably conducted, chiefly wine trading. This seems to be supported by the great number of wine amphoras found in this Villa.

Conclusions

At present it is impossible to state with assurance whether both the plants of the hayfields grew in the farmlands connected to the villas in which they have been found or whether they came from elsewhere. It seems, however, likely that at least the mown hay had been collected in the Vesuvian area.

This conclusion may be supported by the comparison with a sample of today's flora which we recorded on the southern slopes of Vesuvius. This sample was collected in an area of approximately 1000 square meters in the neighbourhood of a farm at about 150 m. It can easily be seen that of a total of 34 species growing today in this area, 27 have been found also in the Oplontis plant remains. From these data, it seems that there is no evidence for important climatic and soil changes in this area during the last 2000 years.

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The recent history of cypress (*Cupressus sempervirens* L.) in Italy: archaeobotanical data from the ancient Campania

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Keywords: Roman age, Timber, ancient cypress plantation, Vesuvian area

Introduction

The natural distribution of *Cupressus sempervirens* L. is unclear, due to its long cultural history in the Mediterranean region. The wild populations occur only in the south-eastern Mediterranean basin, probably continental Greece, reaching eastwards the Caucasus and western Iran. Concerning the Italian peninsula it is widely accepted that this tree was cultivated and diffused by the Etruscans (Pignatti 1982). Nevertheless recent studies on genetic records suggest for the past the existence of central Mediterranean wild populations (Bagnoli et al. 2009). Archaeobotanical literature shows the presence of *C. sempervirens* in the recent past, however these studies do not take into account the biogeographical importance of the findings.

The main objective of this contribution is the reconstruction of the biogeographical history of cypress in the ancient Campania through the plant remains recovered from archaeological sites of Roman age.

Materials and Methods

This work consists both in a review of published data and in the recover of archaeobotanical remains of this species. Data from 8 sites located in the Vesuvian area (Fig. 1) were taken into consideration. The overall materials within their context are summarized in Table 1.

It follows a review of the botanical materials in the deposits of the Archaeological Park of Pompeii and in those of the National Archaeological Museum of Naples. 20 samples of charred wood and 2 cones were found. The identification of charred wood has been done following the standard procedure of charcoal identification (Di Pasquale 2010).

Results and Discussion

The cypress is represented by different types of plant remains in the archaeobotanical records (Tab. 1). In all, 307 plant remains were examined and 33 charcoal samples and 2 cones of *C. sempervirens* were identified.

C. sempervirens is represented by a high heterogeneity of botanical remains (Tab. 1) showing that this species was used for many purposes in a large area extended from Naples to the plain south of the Vesuvius during the Roman period (Fig. 1).

The most important information concerns the use of cypress as timber for building attested at Herculaneum and Oplontis (Moser et al. 2013, 2016). Roman forestry engineers and carpenters appreciated this wood (Nardi Berti 2006); this knowledge is confirmed by the use of timber in the Roman shipbuilding, respectively dated to I century AD (ships Napoli A and C), and II-III century AD (Napoli B). It's interesting to note that the planking of ship Napoli B was entirely made by cypress.

The finding of trunks shows the presence of 100 living cypress trees in the Sarno plain (Tenore et al. 1858). Another plantation was found near Scafati. In the same area a single row of cypress was also recorded (De Spagnolis 1994).

Table 1 - Information about: archaeological site, type of botanical remain, quantity, chronology and references. b= beam; j= joist; p= pole; c= cone; s= seed; l=leaf. *= 79 AD eruption. (modified from D'Auria and Di Pasquale in prep.)

SITE	BOTANICAL REMAIN	QUANTITY	AGE	ARCHAEOLOGICAL INTERPRETATION	REFERENCES
Pompeii	Trunk	2	I d.C.*	Plantation	De Spagnolis 1994, pp-54-58
Scafati	Trunk	6	I d.C.*	Plantation	De Spagnolis 1994, pp-54-58
Scafati	Trunk	8	I d.C.*	Row	De Spagnolis 1994, pp-54-58
Sarno plain	Trunk	100	I d.C.*	Plantation	Ruggiero 1879; Tenore 1958
Oplontis	Trunk	1	I d.C.*	Ornamental tree	Moser 2013
Naples harbor	Timber	10	I d.C.	Planking and Ceiling, Ship A	Allevato et al. 2010
Naples harbor	Timber	16	II-III d.C.	Planking, Ship B	Allevato et al. 2010
Naples harbor	Timber	6	I d.C.	Planking, Ship C	Allevato et al. 2010
Unknown	Beam	20	I d.C.*	Unknown	D'Auria and Di Pasquale (in prep)
Herculaneum	Beam, Joist and pole	3 (b), 4 (j); 55 (p)	I d.C.*	Timber for building	Moser et al. 2015
Oplontis	Pole	19	I d.C.*	Timber for building	Moser 2013
Unknown	Cone	1	I d.C.*	Unknown	D'Auria and Di Pasquale (in prep)
Moregine	Cone	1	I d.C.*	Unknown	D'Auria and Di Pasquale (in prep)
Naples harbor	Cone	1	V d.C.	Unknown	Allevato et al. 2015
Naples harbor	Cone	1	II a.C.	Unknown	Allevato et al. 2015
Pompeii	Cone, seed	32 (c) 5 (s)	I d.C.*	Funerary ritual	Matterne 2007
Scafati	Seeds, Cone, Leaf	18 (s), 2 (c), 2(l)	I d.C.*	Drug	Ciaraldi 2000

Thus the cypress was widely used and the most interesting data is the presence of cypress plantations probably cultivated for timber production. This hypothesis is consistent with the large presence of cypress in Herculaneum (Moser et al. 2016).

The knowledge of this tree is proved also by the presence of other macroremains found in some archaeological contexts. Cones and leaves found together with plant remains known for their medicinal properties in a storage vat in Villa Vesuvio (Scafati) demonstrate that they were used for a drug preparation (Ciaraldi 2000). Cones were also used in funerary rituals as attested in a necropolis at Pompeii (Matterne and Derremaux 2008).

Two cones of cypress were found on the palaeo-seabed at Neapolis (II cent. BC and V cent. AD). They could be probably related to the presence of a tree plantation close to the harbour or they were accidental spills from port loading/unloading operations (Allevato et al. 2015).

All these data clearly show that cypress was intensively cultivated and used.

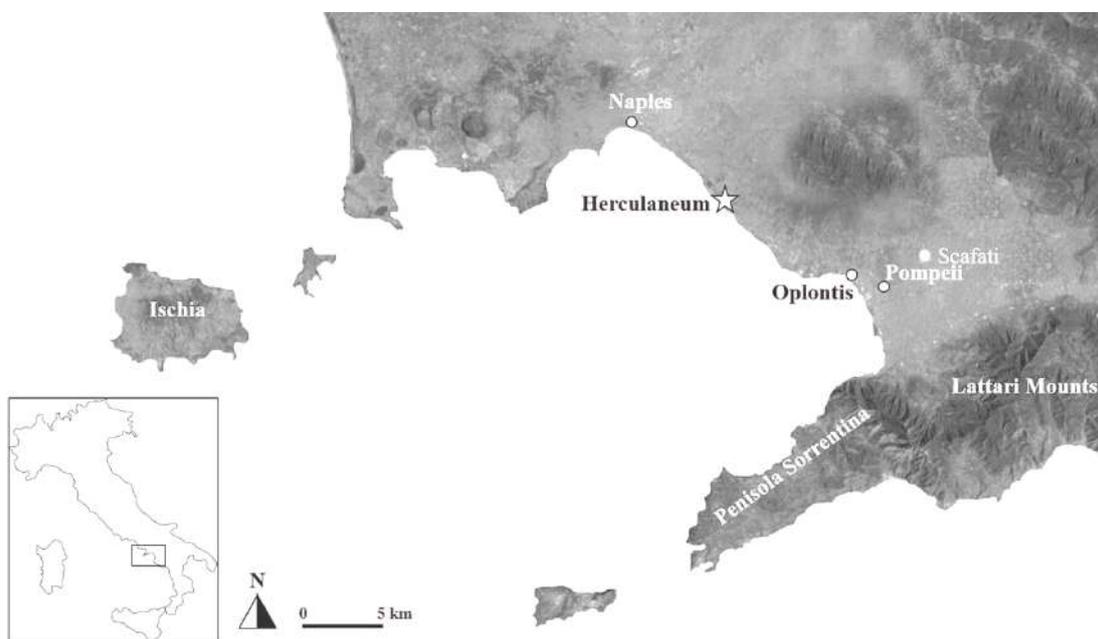


Figure 1 - Location of the studied sites.

Conclusions

Data coming from the ancient Campania demonstrate only that Romans knew very well this tree and started with its systematic cultivation for the purposes described above. More data, in particular molecular ones, are needed to verify whether Roman foresters of Ancient Campania cultivated cypresses coming from local forests or employed plants previously imported from the east Mediterranean.

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Archaeobotanical analysis of a pit in Santi Quattro Coronati, Rome

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Keywords: *carpology, Renaissance, archaeobotany, diet, New World species*

Introduction

The complex of Santi Quattro Coronati is set on the Caelian Hill in Rome, between the Basilica of San Giovanni in Laterano and the Colosseum (Barelli 2009). Dedicated to the Four Crowned Martyrs, Roman soldiers martyred during Diocletian's reign, and first attested in 499 AD, the complex has been subjected to a series of transformations and additions. In the 13th century the complex was divided between a monastery filiated with the Umbrian Abbey of Sassovivo and a vast palace, meant to host the cardinals. In 1564 the complex was assigned to host the Conservatory of the Orphan Girls, run by Augustinian Nuns, who still guard the complex.

The materials object of this study derive from the staircase of the Carolingian tower, found in the eastern side of the complex. After the subdivision of the tower in two parts, a landing was created in correspondence to the first floor. The original function of the bottom part of the staircase was annulled. Therefore, it got readapted into a disposal pit. This was emptied during an excavation in 1996, where five main stratigraphic units were identified. A wide variety of materials dating to the 16th-17th centuries was retrieved. Organic materials were found conserved by mummification. After a first selection, the remaining sediment was collected and stored (Barelli and Pugliese 1996).

Materials and Methods

The favorable thermo-hygrometric conditions present inside the bell tower resulted in an excellent state of conservation of a wide variety of botanical materials. Part of the material belonging to the stratigraphic layers 3 and 4 was selected for analysis. A total of 28 liters of material were sieved. The materials were separated according to their size through dry sieving using a series of piled up sieves, with mesh size of 5, 2 and 1 mm (Pearsall 1989). This process was followed by hand-picking, allowing to separate the different taxa based on morphological characteristics. The abundance and heterogeneity of materials is impressive. The current research focuses on carpological remains. The samples were observed and analyzed under a Leica M205C stereomicroscope. Identification, based on seed shape and size, was performed by comparing the samples against several atlases (Cappers and Bekker 2013; Cappers et al. 2009; Neef et al. 2012). Since not all samples found a reference in the consulted atlases, comparison with modern samples was crucial for identification.

Results

Approximately 6,000 well-preserved fragments of seeds and fruits, belonging to 35 *taxa*, mostly identified at species level and attributed to 18 different plant families were identified in sediments retrieved in two layers. *Pastinaca sativa* (parsnip), *Juglans regia* (walnut) and *Vitis vinifera* (grape) prevail. Besides few wild plants, the botanical assemblage includes diet remains. These are rich in cereals, such as oat (*Avena fatua/sterilis*), legumes, mostly represented by faba beans (*Vicia faba* – var. *major*), fruits, including plums (*Prunus domestica*), chestnut (*Castanea sativa*), pomegranate (*Punica granatum*), and spices, including coriander (*Coriandrum sativum*). Interesting findings include New World species.

The pit presents a qualitatively and quantitatively rich plant assemblage that includes cereals, legumes, vegetables, fruits, nuts and spices. The exceptional state of preservation is evidenced by the conservation of numerous diagnostic morphological features, as well as of the most fragile plant parts, including remains of cereals, including oat (*Avena fatua/sterilis* L.), barley (*Hordeum vulgare* L.), millets (*Panicum miliaceum* L., *Panicum turgidum* Forsk) and bread wheat (*Triticum aestivum* L.). The presence of hay, possibly used to preserve foods (Barelli and Pugliese 1996), may have contributed to such type of conservation. Unlike many contemporaneous deposits, the Santi Quattro Coronati pit was not a latrine, but rather a domestic deposit (Moffett 1992; Bandini Mazzanti et al. 2005; Bandini Mazzanti and Bosi 2006; Bosi et al. 2009).

Discussion and conclusions

The pit reveals details about the dietary habits of the inhabitants of the Santi Quattro Coronati complex at the time in which the pit was used.

The presence of New World species in the studied pit so soon after the discovery of America could identify the site as one of the first landmarks where goods were brought from exotic countries.

The comparison with other pits highlights the good state of conservation of the pit described in this study. Moreover, it is possible to confirm the high social status of the inhabitants of the complex, namely the cardinals and the guests of the Pope.

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Multiproxy approach for the analysis of the Roman funerary ritual in *Mutina* (N Italy)

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Keywords: *archaeobotany, necropolis, ct scan, saxes, Mutina*

Introduction

The research focused on the foodstuffs, the offers that were widespread during the Roman funerary rituals (Toynbee 1971).

An interdisciplinary method involving different disciplines of archeology was carried out on the necropolis of *Mutina* and the *ager Mutinense*, analysing hundreds graves, especially cremation type.

These remains of meals left on the graves (animals bones, seeds and fruit) and of the objects involved in the ceremonies, are evidences resulting from the attendance of the funeral space and their identification necessarily requires a strategy for their systematic collection, during the excavation phase and a focused analysis, in order to reconstruct the activities carried out around the death, which characterize three important moments: funeral, implementation of the tomb and visit to the dead (Ortalli 2011).

Materials and Methods

A total of 142 graves (131 cremations and 11 burials) and 4 structures have been analysed, coming from 8 necropolis, in particular from the site “ex Novi Sad”, an extrarurban necropolis of Modena. A total of over 2131 liters of soil and 26 visual sampling (vs) was sieved and then archaeological and archaeobotanical findings (seeds/fruit, charcoals) were collected.

In addition to traditional methods new technologies (in collaboration with Huddersfield University - UK) helped to study offerings presence.

For this reason, in order to visualize the burned seeds/fruit using a non invasive technique, a CT-scan has been used in 3D reconstructions. In order to investigate the temperature of burning adopted in ancient practices, archaeobotanical remains were analysed using a SAXS approach.

Results and Discussion

In 146 contexts analysed, after sieving a total of 66 contexts (45%) returned archaeological findings. The most represented material classes are *balsamari*, cooking and table ware, decorated bones, nails and animal bones.

Seeds/fruits (9071 sf, 74 taxa) were found in the 64% of contexts and they mostly belong to cultivated plants or, anyway, plants that can be used as food, mostly in the categories of Cereals, Pulses (Fig. 1) and Fruit plants s.l.; findings that can be included in the category of Aromatic plants are very rare. The seemingly predominant cereal in the burial areas in *Mutina* is barley, while fava bean is undoubtedly the most common among pulses. The results have similar patterns with the ones of the North Italy analysis (Rottoli and Castiglioni 2011).



Figure 1 - Seeds/fruits – fruits plants s.l.: **1.** *Phoenix dactylifera* (berries and seeds – 31,8 mm); **2.** *Olea europaea* (endocarp – 12 mm); **3.** *Cornus mas* (endocarp – 18 mm); **4 and 5.** *Vitis vinifera* (pip c – 4,3 mm; pip nc – 6 mm); **6.** *Jugland regia* (endocarp fragments – 3,7 mm); **7.** *Corylus avellana* (nut fragment – 9 mm); **8 and 9.** *Prunus persica* (endocarp c – 25,7 mm; endocarp nc – 28 mm); **10.** *Ficus carica* (syconia – 23,4 mm).

Among fruit an interesting observation is that all peach endocarps found in later buried graves (4th century AD) are not charred, while almost all of other vegetable elements are charred, such as grapevine (*Vitis vinifera*), fig (*Ficus carica*), date palm (*Phoenix dactylifera*) and olive (*Olea europaea*), that are the predominant symbolic fruit (see e.g. Rovira and Chabal 2008). Through the CT-scan analysis maybe it can be inferred that figs and dates were chosen dried, maybe they were preferred because of their availability during the year and so it allowed the repetition of symbolic gestures.

Also an anthracological analysis was carried out as a preliminary essay (in collaboration with Limoges University - FR), considering only some graves (34, those with the most abundant charcoals) of 6 sites, with a total amount of 368 charcoals analysed.

The charcoal analysis identified 6 taxa: ash (*Fraxinus*), maple (*Acer*), Pomoideae, oak (*Quercus decid.*), elm (*Ulmus*) and juniper (*Juniperus* cf.). Maybe the selection of *Fraxinus* as predominant *taxon*, indicates that it was considered one of the best fuel for providing sustained heat.

The SAXS analysis allowed an estimation of the burning temperature between 700 and 900° C. The high temperature could suggest that the food offerings were widespread over the funerary pyre during the cremation process or the *silicernium* rite.

Conclusions

The multidisciplinary approach was essential to have a complete view of the funerary rituals.

Recurring behaviors have been noticed maybe for custom, social rule or emulation, such as the redundancy of fava bean, figs and dates above all, or of *balsamari* and table wares; although some differences in territorial settings or in the same necropolis have been found.

The choice of both food offerings and objects are linked to a funerary symbology.

The criteria that determined the collection of wood are very difficult to establish; it could be assumed that it is likely that both functional and cultural factors influenced the choices of wood for cremation rites.

Acknowledgements (Funds)

The research was carried out as part of the PhD thesis in “Models and Methods for Material and Environmental Sciences” of FMR, University of Modena and Reggio Emilia. Thanks are due to professors Marie Claude Bal of Limoges University for charcoals analysis and Stefano Vanin of Huddersfield University for CT-scan and SAXS analyses.

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Bronze and Iron Age pit-fillings of high-alpine burnt offering sites

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Keywords: *pit-fillings, high-alpine, burnt offering sites*

Introduction

Burnt offering sites are a characteristic phenomenon of the inner Alpine regions during the Middle Bronze Age. Usually situated in the valley bottoms these offering sites were relocated in (sub)alpine environments at the beginning of the Late Bronze Age. The reason for this behaviour change is obscure. So far, the observed structures suggest fire ceremonies including the deposition of artefacts, bones and plant materials in pits. For this study special focus is laid on these pit-fillings. The carpological remains and the charcoals including their qualities should provide further insights into rite and prehistoric land-use in high-alpine terrain.

Materials and Methods

About 30 soil samples from 4 high-alpine offering sites and 1 settlement site (Tab. 1), located in the Ötztal, Zillertal and Deferegger Alps, were investigated. Therefrom 20 samples from 12 pits were floated with sieve mesh widths of 2 mm, 1 mm, 0.5 mm and 0.25 mm. All fractions were analysed for archaeobotanical remains (Jacomet and Kreuz 1999). Specific properties of the charcoal-pieces - diameter, mean annual ring width, fungal infestation and heat damage - were recorded and used for numerical analyses performed with the “Canoco5”, focusing on the most abundant taxa.

Table 1 - Presence (seeds/fruits/leaves) or number (charcoals >2 mm) of plant remains retrieved from the archaeological sites of interest. * inclusive data from Putzer et al. 2016; ** settlement site; *** cultivated plants from Heiss unpubl. data.

Archaeological Sites	Finailgrube*	Jochwiese	Penaud**	Schöllberg-Göge***	Rudlhorn
S/F cultivated plants	x		x	x	
S/F gathered plants	x		x		
S/F wild plants	x		x		x
Leaves	x		x	x	x
Archaeological findings	x		x	x	x
Charcoals (> 2 mm)					
European larch	1140	17	12	62	
Norway spruce	192	362	23	121	
Arolla pine	631		325	742	
Common juniper	25				
Coniferous wood undiff.	188	19	22	8	
Rowan cf.				9	
Green alder cf.				49	
Heath family	99			30	
Deciduous wood undiff.	2		1		
Wood undiff.		2	17	1	
Total charcoals	2277	400	400	1022	

Results and Discussion

Hordeum vulgare (barley), *Triticum* cf. *dicoccum* (probably emmer), *Panicum miliaceum* (broomcorn millet), *Setaria italica* (foxtail millet) and *Vicia faba* (faba bean) are observed in most of the sites. These crops are indicative for the Bronze and Iron Age in the region. Moreover, *Corylus avellana* (common hazel) and *Prunus* cf. *spinosa* (sloe) were offered. All these useful plants were transported to the sites from lower altitudes. However, the spectra of cultural and gathered plants vary between the high-alpine offering sites, possibly affected by different economics, choreography and/or preservation conditions.

Other findings of wild plants like *Alchemilla* sp. (lady's mantle), Cyperaceae (sedges), *Potentilla* sp. (cinquefoil), *Rubus* sp. (raspberry/blackberry) and *Rosa* sp. (rose) are consistent with the potential local vegetation of the investigated alpine environments. That applies to the charcoals ($n_{\text{total}} = 4099$), which are mostly originating from European larch (*Larix/Picea*-type), spruce (*Picea/Larix*-type), and *Pinus cembra* (arolla pine). *Alnus* cf. *viridis* (probably green alder), *Sorbus* cf. *aucuparia* (probably rowan) and Ericaceae (heath family) are recorded in lower quantities (Tab. 1). The relative amount of wood taxa gathered near the offering sites differs due to varying growth conditions, shaped by local climate, edaphic factors and topography. The combination of *Juniperus communis* (common juniper) and Ericaceae wood suggests the occurrence of dwarf shrub heaths in the subalpine altitudes. Such heaths can be facilitated by grazing (Ellenberg and Leuschner 2010), which is documented by pollen analyses indicating first alpine grazing during the Middle and Late Bronze Age (Festi et al. 2014).

Furthermore, the poor mean annual ring widths of the charcoals suggest relatively unfavourable growing conditions and short vegetation periods as they occur at the timberline (Tab. 2). The varying diameters of timber indicate the use of logs, branches and twigs for firing. About 25 % of the charcoals show primary fungal infestation, which indicates the use of dead wood. Heat damage is observed on about half of the charcoals, representative for abrupt, higher and longer burning temperatures as well as firing moist wood. The significant alterations of charcoal-qualities per pit point to a shift of wood preference (Fig. 1).

Table 2 - Qualities of coniferous wood for the studied sites (* settlement site)

Qualities of coniferous wood	Finailgrube	Jochwiese	Penaud*	Schöllberg-Göge
Mean annual ring width [mm]	0,62	0,34	0,65	0,48
Numbers of charcoals	2107	359	351	874
Diameters of timber	[%]	[%]	[%]	[%]
≤ 2.5 cm	18	8	16	32
2.6 - 5 cm	15	29	29	20
5.1 - 10 cm	14	34	17	11
10.1 - 20 cm	17	7	9	11
> 20 cm	36	22	29	26
Numbers of charcoals	1107	223	256	840

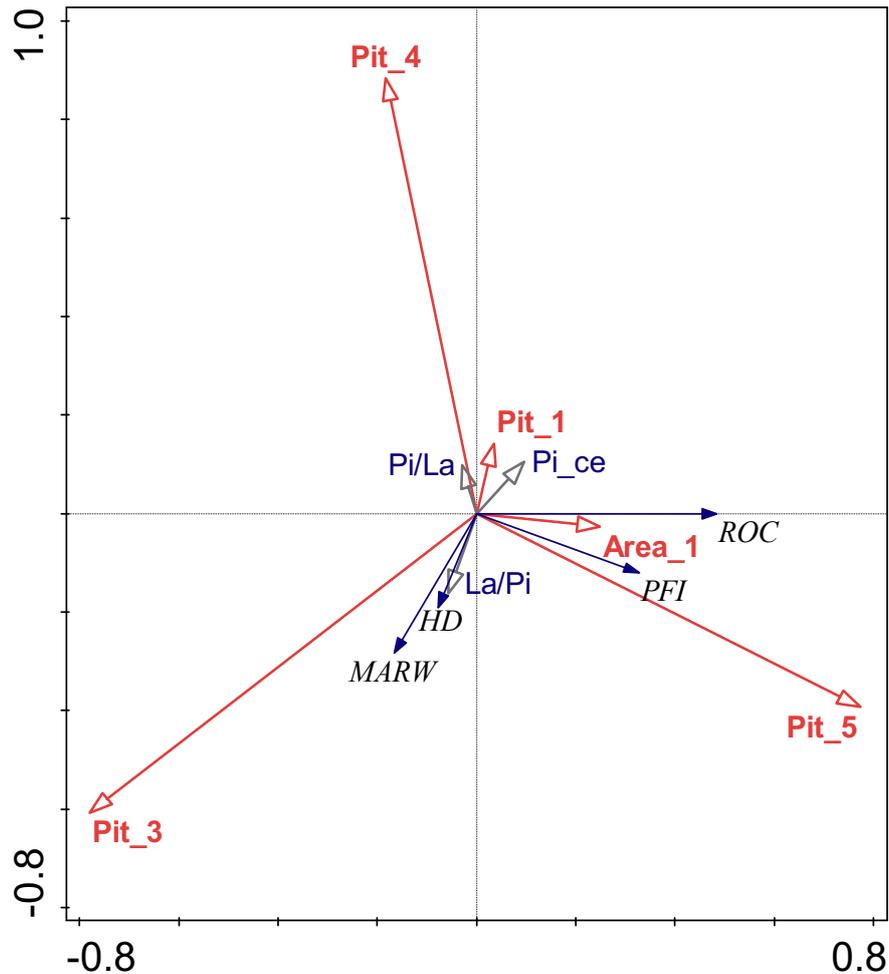


Figure 1 - Charcoal-quality-analysis: RDA with supplementary data for the site „Finailgrube“: Pi/La = spruce, Pi_ce = arolla pine, La/Pi = European larch, ROC = radii of curvature, PFI = primary fungal infestation, HD = heat damage, MARW = mean annual ring widths.

Conclusions

The recorded crops link high-alpine burnt offering sites with valley-bottom agricultural systems. The local differences of offered plants seem to be affected by ecological conditions, economics and trades. Fire wood for the pyre – both green and dead wood – was gathered near the offering sites. The change of charcoals' qualities per pit suggests a shift of wood preference due to steady land-use and a change of environmental conditions.

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SESSION 7

Interdisciplinary methods for Environmental Archaeology interpretation

AMS Radiocarbon dating for the study of past ecosystems: Consolidated tools and recent developments

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Keywords: *radiocarbon dating, isotopes, accelerator mass spectrometry*

Introduction

The detection of ¹⁴C by accelerator-based techniques has celebrated the last year its 40th anniversary considering that the first experimental demonstration was published in 1977. Since then Accelerator Mass Spectrometry (AMS) radiocarbon dating has become a well established and robust experimental technique widely used in several different research areas spanning from traditional ones such as archaeological sciences and geochronology to environmental, marine, Earth and Forensics sciences, just to cite some of them.

When reviewing the tremendous developments seen by AMS radiocarbon dating in the last years one has to account for both the development in the “radiocarbon dating” method and in the AMS techniques.

When reporting the advancement of the method, the calibration curve, the new quality assurance protocols and the set-up of new methods for the processing of “non standard” samples have to be discussed.

The last, internationally accepted, record of the atmospheric radiocarbon concentration was published in 2013 by the INTCAL working group. This was a major breakthrough since it allowed, for the first time, the calibration of radiocarbon ages spanning the whole range of the method up to ~50 ka. Indeed more recently the enhancement of the achievable precision levels and the increase in the sample throughput in different facilities have shown how the curve has a much finer structure. Large and short term excursions have been highlighted by analyzing tree rings sequences in different periods such as those in 774-775 AD (Miyake event) or 993-994 AD or 5480 BC. These new features have already shown a great potential in the reconstruction of solar activities and open new applications such as the use of these “wiggles” for high resolution wiggle matching dating.

With the technological developments in the AMS systems which are nowadays robust and reliable instruments the focus has moved more to the assessment of the quality of the samples (or the fraction of the samples) submitted to dating and to a deeper understanding of (radio)carbon uptake mechanisms. The case of bones is a typical example of this since radiocarbon determination is typically accomplished, routinely, with IRMS (Isotope Ratio Mass Spectrometry) measurements of carbon and nitrogen stable isotopic ratio or elemental analyses of C and N or the characterization of bone collagen through FTIR (Fourier Transform Infrared) spectroscopy.

In the last years, the AMS systems have seen tremendous technological developments with dedicated systems operating at much lower energies than in the early years. This allows stable, continuous operations resulting in much higher samples throughput and higher precision levels.

Methods and Results

In this contribution we will overview these developments by describing the activities of the Centre for Dating and Diagnostics operating since 2001 at the University of Salento in Lecce,

Italy. The Centre is based on a 3 MV Tandem accelerator which is equipped with different experimental beamlines for radiocarbon dating, irradiation studies, compositional Analysis by IBA (Ion Beam Analysis) techniques and the detection of rare nuclides such as ^{10}Be , ^{26}Al , ^{129}I and actinides by AMS.

The centre, through a collaboration network established and consolidated over the years with different groups, has research activities in different fields spanning from Archaeological, Earth, Environmental and Life sciences to Forensics.

The last important instrumental developments will be also reviewed. This consisted in the design and installation of an integrated IRMS (Isotope Ratio Mass Spectrometry) and AMS system which is capable of measuring in a single 20-30 minutes run C and N content, $\delta^{13}\text{C}$, $\delta^{15}\text{N}$ and the radiocarbon age. This important result has been achieved by integrating, through a gas handling interface, an EA-IRMS system to a new hybrid sputtering source which can accept both solid and gaseous samples. The system supports remote controlled and unattended operations and is now routinely used for researches related to climate studies, environmental sciences and cultural heritage diagnostics.

Human mobility across the Last Glacial Maximum: enamel Sr isotopes from Grotta Paglicci (S Italy)

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Keywords: *strontium, isotopes, enamel, LGM, Gravettian*

Introduction

Grotta Paglicci, located on the Gargano Promontory (Foggia, Southern Italy), is one of the most important Upper Paleolithic sites in the Mediterranean Area. Archaeological excavations of the inner cave have yielded a continuous sequence from the Aurignacian to the Epigravettian with the significant finding of more than 140 human remains attributed to *Homo sapiens*. Radiocarbon dates of the site span from ca. 40.9 to 13 ka cal. BP, well across the Last Glacial Maximum, making this site an extremely important case study to better understand *Homo sapiens* mobility in relation to glacial/interglacial periods (Berto et al. 2017).

Materials and Methods

We have sampled 14 deciduous human teeth and 85 animal (69 macromammals and 16 micromammals) teeth from the Early Gravettian to the Early Epigravettian layers of the site and have measured their enamel $^{87}\text{Sr}/^{86}\text{Sr}$ ratios. Human enamel Sr ratio has been analyzed exploiting the micro-destructivity and the high spatial resolution offered by the LA-MC-ICP-MS technique (Lugli et al. 2017a; Lugli et al. 2017b). Animal enamel has been analyzed by dissolution MC-ICP-MS (Weber et al. 2017).

Results and Discussion

The Sr isotope composition of the human teeth varies from 0.7080 in the oldest tooth (Early Gravettian) to the 0.7093 in the youngest one (Early Epigravettian). Through time the Sr isotopic composition shows a monotonic change from lower to higher ratios. Instead, the fauna $^{87}\text{Sr}/^{86}\text{Sr}$ ratios are restricted in a range from 0.7081 to 0.7088, with a few outliers towards lower Sr isotope ratios, and do not show a significant variation with time. The local Sr isotope signature, as measured in rodents teeth, ranges from 0.7083 to 0.7086. The Early Gravettian to the Late Gravettian human Sr isotope ratios, and the fauna and rodents Sr isotope ratios are consistent with Neolithic data from other localities in the Gargano area (0.7082–0.7088; Tafuri et al. 2016). The temporal variation in the $^{87}\text{Sr}/^{86}\text{Sr}$ ratios of the human teeth clearly depict the presence, at Grotta Paglicci, of humans not identifiable with the local Sr isotope signature during the Early Epigravettian. These humans most likely have arrived from a different location or exploited different resources.

Conclusions

We present here the first Sr isotope data for LGM anatomically modern humans from Italy. These data clearly show a diverse mobility pattern between Gravettian and Epigravettian individuals, likely related to a climatic improvement across the LGM.

Acknowledgments

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Insights on some east Mediterranean species of the Italian flora: natural presence or Greek/Phoenician heritage?

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Keywords: *archaeophytes, distribution range, Greek colonization, conservation*

Introduction

Humans, during the migrations of the past have always carried plants voluntarily but also without awareness. Observing the currently wild flora of a territory, it may be rather difficult to understand if a species is truly native or if it has been introduced in more or less remote times. The Italian territory has been crossed by several populations coming from other areas of the Mediterranean basin. In southern Italy and Sicily, one of the most important colonizations was the Greek one. With this civilization, it is likely that several plants have been introduced in Italy, and some of these species, finding in our territory similar conditions naturalized, building plant communities similar to those of the original environments. Having no evidence of macro-remains or ancient pollen, the only clue is the atypical east or south Mediterranean distribution with disjointed locations in Italy. This is the case of *Salvia fruticosa*, *Origanum onites*, *Ferulago nodosa*, *Sarcopoterium spinosum*, and *Platanus orientalis* which for various reasons might have been introduced in ancient times in Italy.

Materials and Methods

The study is based on data from literature, herbarium specimens and field research in order to point out the exact distribution of the species in the Italian territory, chiefly southern Italy and Sicily. Data on plant communities and habitat context were also collected.

Results and Discussion

For some of the abovementioned species, there is evidence of their possible introduction during the Greek period. As regards *Sarcopoterium spinosum*, Rosen et al. (2009) found remains of this plant in a Roman ship, so they hypothesized its use as packaging material and also filter in bilge pumps. The presence of this species around Italian port areas of antiquity such as Taranto, Crotone, Cagliari and Syracuse, would prove the accidental introduction of the species that today persists there in very small areas, except for Sicily where *S. spinosum* covers a wide area (about 1,660 km²) from the northern Hyblaean Plateau to the southernmost point of Sicily (Gargano et al. 2007). In this case, it is difficult to accept the anthropogenic introduction for a species which entrusts the seeds dispersal to barochory and therefore 2700/2400 years BP may not have been able to spread across a territory over distances of several dozens of kilometers. As regards *Origanum onites*, its close connection with Syracuse and its archaeological sites is well established (Minissale et al. 2015, Minissale and Sciandrello 2017). It has a multi-millennial persistence that, through the search for micro remains, could be demonstrated in a definitive way.

The case of *Platanus orientalis* in Italy seems to be resolved; it was introduced by Greeks and Romans (Rosati et al. 2015), although today is naturalized along riverine environments of southern Italy and Sicily. Regarding *Salvia fruticosa*, the introduction in Italy in the Greek period has never been suggested. Although this species is well developed in natural vegetation

both in the Italian Peninsula and Sicily, its distribution is very fragmented and disjointed but always found in territories of former Greek colonies such as Taranto, Metaponto, Sibari, Kaulonia and Syracuse Akrai, Eforo, Solunto in Sicily. Nowadays, *Salvia officinalis* L. is commonly used in Italy as a spice plant, but also *S. fruticosa* was and is used as spice in Greece and many other countries. *Ferulago nodosa* is known for its medicinal properties and was also used in Greece in the past (Demetzos et al. 2000). Outside its distribution area, which is circumscribed to continental and insular Greece, it occurs in Sicily exclusively in the eastern Hyblaean Plateau near Syracuse, Lentini, Megara Hyblea and Akrai. This species is also spread by barochorous seeds, thus an ancient introduction by Greek colonizers is plausible. Finally, there is a group of southern Mediterranean species, e.g. *Rhus tripartita* and *Ziziphus lotus*, whose punctiform and scattered occurrence in very few Sicilian locations is likely due to the Phoenician's naval routes, although other types of transport, such as zoochory, cannot be excluded.

Conclusions

Distribution of native plants is chiefly linked to current and past climatic conditions, existence of suitable habitats and paleo-geographic events. However, especially in the Mediterranean area, pluri-millenary human activities has certainly contributed to the spread of Mediterranean and non-Mediterranean species which in some cases colonized new territories thus contributing to increase the biodiversity of the area and affecting the plant communities composition (structure and floristic set). These ancient human-induced plant migrations represent an important cultural heritage of the Mediterranean civilizations, whose full comprehension would be difficult without a multidisciplinary approach (Marignani et al. 2017).

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"Mediterranean forest": towards a better definition for vegetation history

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Keywords: *plant terminology, plant communities, palynology, geobotany, Mediterranean concept*

Introduction

Palaeobotany and Archaeobotany deal with the reconstruction of flora and vegetation changes over long term time, and this is especially developed by pollen analysis (e.g. De Beaulieu et al. 2005; Jalut et al. 2009; Roberts et al. 2011; Sadori et al. 2014; Magri et al. 2015). Starting from detailed study of limited cases, wide-ranging issues overcome local events to improve knowledge on the cause-and-effect patterns which determined broad palaeoenvironmental events. Indeed, local studies are not only the basis for general reconstructions, but their synthesis can confirm, shape or even modify the current reference schemes of vegetation history. Reaching a coherent reconstruction from diverse reference sources basically requires reassembling different information within the same scheme, a very laborious job that hides many difficulties. One of the biggest difficulties is the inhomogeneity of terminology especially that concerning the references to the vegetation types. The studies of plant remains provide lists of plants that better deal with flora than with vegetation, but plant communities are relevant to landscape reconstruction and their names are commonly quoted in papers. However, several problems arise when these terms are used in a generic way or have different meaning according to the different botanists and palaeoecologists. Several of the most relevant cases were found related to the Mediterranean concept: climate, forest, flora and so on.

This contribution, based on personal experiences, wants to focus on this problem, without making any claims to solve it.

Materials and Methods

Taking as example the palynological investigations carried out by the authors, the problems in the use of controversial terms like Mediterranean forest, Mediterranean area, Mediterranean flora, Mediterranean climate are discussed in the light of the current literature (e.g. Quézel and Médail 2003; Blondel et al. 2010). Several definitions are provided and compared with the current palaeo- and archaeobotanical literature in order to focalize their differences, overlapping and utility. Particular attention will be given to recognise key species belonging to the pollen types commonly detected in pollen analysis.

Results and Discussion

A set of definitions concerns the Mediterranean climate, ecology and forest.

In climate studies, one or more indices are used to delimitate the area where Mediterranean climate is found (e.g. Rivas-Martinez 1995, Mitrakos 1980). Today, pluviothermal stations are used to obtain data on temperature and precipitation, and sophisticated software help to plot data over long time. However, climate maps are developed at geographic scale while the local scale is often missed.

Concerning the bio-ecological properties of species, many plants can live in non optimal climatic conditions if the edaphic characteristics permit them to offset the limiting factors. According to these facts several types of forest can survive in an area with a Mediterranean climate. As for the ‘Mediterranean forest’ *sensu stricto* (e.g. excluding the transition zone of the semideciduous oaks), this is a plant formation dominated by evergreen sclerophyllous oak trees (*Quercus ilex* L., *Q. rotundifolia* Lam., *Q. suber* L., *Q. coccifera* L., etc.). Sometimes this term can include also the pine forest but here further precision to distinguish species is needed. In fact, *Pinus halepensis* Miller/*P. brutia* Ten. can be considered the true Mediterranean pine species, *P. pinaster* Aiton is a Mediterranean-Subatlantic species and *P. pinea* L. could be considered as a species of the dunal ecosystem.

Indeed, we observed that the term Mediterranean forest has been sometimes used to indicate rather different plant communities, which are growing around the Mediterranean. For example, Italian people generally consider the “Mediterranean forest” to be the woods that they are used to see in their territory. Along the most part of the Italian coasts it means a mixed wood with dominance of *Pinus pinea* and both evergreen and deciduous *Quercus* (a mosaic of vegetation types), as it recently happened in occasion of making restoring projects targeting to recover the natural plant cover in strongly deteriorated areas of Tuscany.

Discussing the results of the palynological investigations in the light of the current geobotanical literature, the first problem concerns the geographic scale of the research. These papers generally have a local scale, but they aim to reach a much larger dimension (e.g. Mercuri 2014). Indeed, at local scale, ecological conditions may predominate the more general situation, *making difficult this transition from small to large territories*. From a palynological point of view, another emerging problem consists in the very low pollen representation of many species (often the entomophilous species), which characterize some of the Mediterranean associations.

Conclusions

Dealing with multidisciplinary studies, the use of terms concerning the plant communities is of key importance in palynology applied to environmental reconstructions. This research wants to be a contribution to the use of a precise, common terminology in order to facilitate the legibility of the data and their use in the reconstruction of the vegetation history at large scale.

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Human-induced spread of *Araucaria* forest out of their natural range in the southern Brazilian highlands

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Keywords: *Atlantic forest, Araucaria forest, southern Brazil, southern proto-Je, human-induced forest expansion*

Introduction

The presentation introduces the late Holocene environmental and cultural sequences of the southern Brazilian highlands that indicated that major changes in the socio-political organisation of southern proto-Je groups (increase in number and size of villages, arrival of monumental architecture and the appearance of oversize pithouses [De Souza et al. 2016a, 2016b; Iriarte et al. 2013; Robinson et al. 2017a, 2017b]) are associated with the expansion of *Araucaria* forest at the expense of grasslands around AD 1000 (Behling et al. 2004; Bitencourt and Krauspenhar 2006; Iriarte and Behling 2007; Noelli 2000; Reis et al. 2014). The question remained, “What drove forest expansion? Climate or human impact?” We model the ‘natural’ distribution of *Araucaria* forests and combine archaeology with stable carbon isotopes, charcoal, pollen and phytoliths to show that the spread of *Araucaria* forest beyond the natural range was human-induced. These findings have implications for conservation biology.

Materials and Methods

We develop a predictive GIS model of the natural distribution of forest based on terrain parameters (slope and aspect). The predicted forest distribution is compared to modern vegetation cover using USGS satellite imagery from 1966 to avoid land cover impacts from the last 50 years of regional development. Carbon isotope profiles of the bound, insoluble humin component (Pessenda et al. 1996) of soil in 5 cm increments from soil test pits are used to assess localised vegetation histories against the predictive model. Soil test pits target locations that a) conform to and b) diverge from the predictive vegetation model. Campo Belo do Sul, Santa Catarina State provides an area with a robust archaeological record, and Lages, 60 km to the east provides a control area, devoid of significant past human impact. Results are contextualised against paleoclimate data (Bernal et al. 2016) and regional archaeological data.

Results and Discussion

A significant positive correlation is found between the predicted and the actual forest distribution in 1966 for the Lages control region (Pearson’s $r = .232$, $p < .001$). Carbon isotopes show that vegetation was stable throughout the late Holocene in the Lages control region, with *Araucaria* forest naturally spatially limited to south-facing slopes. However, in the archaeologically rich Campo Belo do Sul region, the pattern is not observed and there is no significant correlation between the model and actual forest distribution in 1966 (Pearson’s $r = .002$, $p = .781$), with forest growing on plateaus and north-facing slopes. Carbon isotopes confirm that forest expanded into these areas at the expense of grasslands synchronous with past human activity, ca. 1200 – 400 cal. yrs BP. Importantly, regardless of climatic fluctuations, vegetation patterns in the control transect correspond with the natural distribution model and remain stable up to the present day. Climatic fluctuations, including a sustained wet period (the wettest in the history of the area) ca. 2000-1750 cal. yrs BP (Bernal et al. 2016), were not

enough to cause a vegetation response that could overcome geographic boundaries to vegetation distribution.

Conclusions

Isotopic results corroborate the model of natural vegetation distribution and confirm that human inputs caused the expansion of the forest at the expense of grasslands in Campo Belo do Sul. Before intensive human occupation, the landscape followed the natural distribution model, with forest patches limited to south-facing slopes in a mosaic with grasslands. In contrast, forest management strategies for the past 1400 years expanded this economically important forest beyond its natural geographic boundaries in areas of dense pre-Columbian occupation. The data presented here provide evidence of a millennia of sustainable resource use that not only incorporated the Araucaria forest into the core of the indigenous economy, but actually expanded the forest beyond natural boundaries of habitat distribution. Conservation strategies that exclude human land use may therefore be misguided and counterproductive (Mayle et al. 2007) when balancing cultural heritage, economic development, and conservation goals.

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"What can pre-Columbian polyculture agroforestry systems tell us about sustainable Amazonian futures? Tales from Amazonian Dark Earths and the 'Geoglyph Builders'"

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Keywords: *Amazon, agroforestry, phytoliths, resilient, sustainability*

Introduction

The presentation introduces the pre-Columbian Amazonian Dark Earths (ADE) and the 'Geoglyphs-builders' polyculture agroforestry systems, their legacy and its implications for management and conservation efforts on Amazonian sustainable futures under current threat from climate change and development. Although ADEs are arguably one of the most compelling evidence of pre-Columbian transformation of the largest tropical forest on earth (e.g., Denevan 2001; Heckenberger and Neves 2009), very little is known about the land use practiced on them.

There is a consensus among archaeologists and geographers that ADEs are cultural deposits created through the decomposition of waste around habitation areas, including plant and animal food wastes, fish bones, human excrement, plant materials used for constructions, among others (Arroyo-Kalin 2010; Woods et al. 2009). However, there is controversy about the exact nature of agricultural practices and the inventory of crops that were planted on them and the spatial extent of forest perturbation resulting from ADE formation and agricultural practices (e.g., Iriarte 2016, 2017).

Materials and Methods

To address these questions, we conducted integrated archaeological, palaeoecological (pollen and charcoal) and archaeobotanical (phytoliths) analysis from three mid to late Holocene records of land use history of ADE in Santarem (Lower Amazon), the Middle-Purus Madeira River (Central Amazonia) and the Bolivian Amazon and compare it with available palaeoclimate (speleothem) data from these regions. Our previous research from the 'Geoglyph-builders' in the Acre state, Brazil is also compared and brought to the discussion about pre-Columbian land use practices.

Results and Discussion

Our preliminary results show that ADEs were used in the context of polyculture agroforestry. All soil-depth profiles and lake cores analysed show a predominance of arboreal taxa evidencing that ADEs were never open-canopy areas; an increase in the abundance of plants of economic importance such as palms and Anacardiaceae fruit trees indicating agroforestry practices; mixed cropping (polyculture), that is the presence of multiple annual crops such as maize (*Zea mays*), manioc (*Manihot esculenta*), sweet potato (*Ipomoea batatas*) and squash (*Cucurbita* spp.) is recorded at most sites analysed; a decrease of weeds, which were likely suppressed by the forest cover and/or weeding is common in most profiles; and, low levels of fire possibly representing fire control practices such as in-field burning.

Conclusions

Collectively, our study evidences persistent anthropogenic landscapes for at least the past four millennia in Amazonia with a long-lasting effect on the modern hyperdominance of edible species in some cases. The low percentage of herbs, the permanence of forest cover and increasing charcoal levels recorded are consistent with shaded agroforestry systems that suppress weeds and practice controlled in-field burning as recorded among several indigenous groups today (Denevan 2004; Hecht 2003). Our results appear to be consistent with a practice of short cropping/long fallow polyculture agroforestry practised with inefficient stone axes characterised by a mosaic of patches in different stages of succession, forming a complex landscape that transitions from forest to field and back to forest again (Denevan 2001; Ford and Nigh 2009).

Importantly, our results show that the economic base for sedentism and population growth seen during the late Holocene relied on neither maize nor manioc staples as previously suggested (Heckenberger 1998; Lathrap 1970; Roosevelt 1999), but rather a diverse polyculture agroforestry system. Through the maintenance of closed canopy forest enrichment of edible plants, with limited clearing for crop cultivation, and low-severity fire management, long-term, resilient, food security was attained despite climate and social changes. As modern deforestation and agricultural plantations expand across the Amazon Basin, coupled with the intensification of drought severity caused by warming global temperatures, these data provide a long-term example of a sustainable anthropogenic landscape in the Amazon that can inform management and conservation efforts on sustainable futures for Amazon ecosystems in the 21st century.

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SESSION 8

Environmental sustainability in a changing world: lessons from the past

Historical ecology and sustainable forest management: revealing key periods in the landscape transformation of the Italian peninsula

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Keywords: *cultural landscape, human impact, forest change, ecosystem services, forest cover*

Introduction

In recent years, palaeoecological analyses are increasingly widespread in various environments and are sometimes developed with particularly detailed temporal resolution providing historical ecology a new multidisciplinary focus (Hjelle et al. 2012; Izdebski et al. 2016). The possibility to compare the dynamics of local and regional landscapes at the decadal scale with climatic reconstructions, historical documents and archaeological data is confirming the long and pervasive land transformation of the Anthropocene (e.g. Marignani et al. 2017; Piovesan et al. in press), and providing alternative scenarios of some classical views derived strictly from interpretation of historical documents (Schoolman et al. in press). The aim of this contribution is to discuss what unites and what differentiates the historical landscape evolution along peninsular Italy on the basis of the available multidisciplinary records.

Materials and Methods

Pollen records from published studies of central and southern Italy have been selected on the basis of high-resolution off-site cores data for the last two thousand years to compare the dynamics of forest cover at different spatial scale (from regional to local). Major trends were related to climate proxies and human history.

Results and Discussion

The Roman period does not seem to have had a profound impact on forest ecosystems which instead undergo significant degradation from the Medieval fortification period (10th century, *incastellamento*). Other interesting results contradict the widespread notion of rewilding during the late-antiquity/early medieval times when there is a continuity in the landscape management despite a demographic crisis, relevant climatic changes and socio-political transformations.

At the same time, important deviations from the dominant regional patterns are also found at a short distance as in the case of the Velino Lakes, demonstrating the complex texture of rural landscape development.

Conclusions

Across all records we examined in Italy, there is a dominant pattern of widespread loss of forest ecosystems and an increase in forest degradation/pioneer communities in modern landscapes as compared with ancient landscapes. While this result is not surprising, the pattern of continuous change with a dominant trend of degradation of forest ecosystems and natural capital raises important questions about the need for future plans of forest management and ecosystem restoration for biodiversity conservation, ecosystem services and renewable products. The paleoecological data can provide critical baseline data for potential restoration efforts. The highest priority for ecosystem restoration is in the lowland wet environments.

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Medieval environmental changes and flood management in the Central Po Plain (N Italy)

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Keywords: *geoarchaeology, geomorphology, medievalage, DEM*

Introduction

The Central Po Plain at the right side of the Po River is characterised by depressions that can be defined as floodplains or back swamps. In the Italian literature, they are also known as “*Valli*” (i.e. Valleys) or, before a few centuries of ground reclamation, as “*Valli-Paludi*” (i.e. Valley-Marshes). The *Valli* landscape has a long-lasting connection with the development of the Po Plain and the anthropic activities of land and water management for agricultural purpose. During the Roman times the Central Po Plain was a well organised cultivated land; but around the 5th century AD, in corresponding to a cooling climate phase, vast farming areas became marshy. The alluvial plain aggraded quickly, and Roman road and ditches were often buried under fluvial and palustrine sediments. The swamps dominated the landscape of the area until the Renaissance when large-scale land reclamation works started. This study aims to reconstruct the evolution of the palustrine environment and its mutual interaction with human activities during the Middle Ages.

Materials and Methods

The research area is located North of the city of Reggio Emilia, in Emilia Romagna region. Two backswamps called *Valle di Gualtieri*, and *Valle di Novellara* are located in this portion of the Central Po Plain (Fig. 1). This study has been performed using both geomorphological tools and archaeological-historical data. Making use of the software QGIS 2.18, we have elaborated a Digital Terrain Model (DTM) and a 3D model of the research area. The landforms detected have been dated and contextualised thanks to archaeological (Bottazzi et al. 1995) and historical records (Affò 1792; Cantarelli 1882).

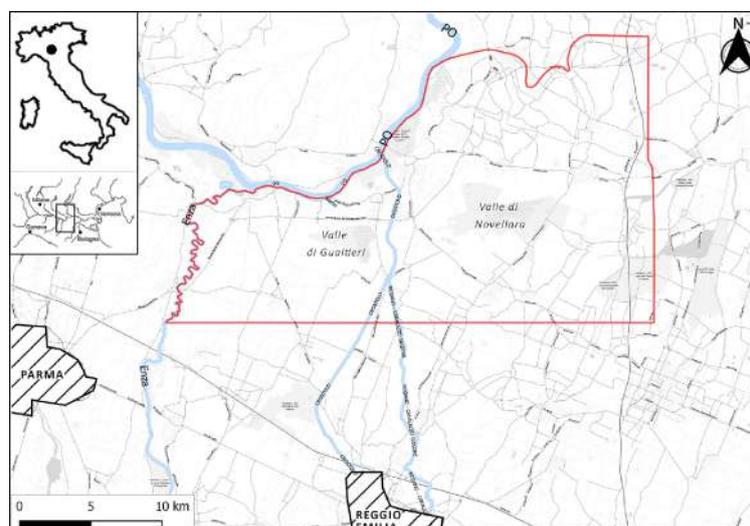


Figure 1 - Research area (OSM modified by F. Brandolini).

Results and Discussion

The multidisciplinary approach allowed us to shed new light on anthropogenic activities related to land and water management in the post-Roman landscape.

The historical documents report that local communities exploited the swamps as food resources (fishing and gathering) and waterway (commercial transports) between the 5th and 10th century AD. Nonetheless, their physical boundaries are not clear. The superimposition of the regional soil map to the 3D model shows that the clayey and silt-clayey soils are concentrated in the lowest areas detected in the DTM, giving us reasonable limits for the Medieval swamps. The most interesting data about anthropogenic activities in the Medieval environment concern the northern limit of the *Valle di Novellara*. According to the DTM, this backswamp is delimited at North by the ridge of the so-called Tagliata Canal. In the current literature (Cremaschi and Marchesini 1978; Castaldini 1989; Castiglioni et al. 1997; Castiglioni and Pellegrini 2001; Cremaschi and Nicosia 2012) the Tagliata Canal is considered as a Proto-historic Po ridge characterised by crevasse splays on both sides; but geomorphological, archaeological, and historical data suggest a fresh interpretation. First, the distribution of archaeological sites in the study area shows an absence of Bronze Age and Roman Era findings (Fig. 2). This suggests that the accretion of Tagliata Canal ridge occurred after the collapse of the Roman Empire. Historical chronicles report that the Tagliata Canal was artificially cut in 1218 for a commercial purpose; the new canal constituted a bypass of the Po River from Guastalla to Reggiolo for the city of Cremona. Moreover, medieval chroniclers reported that the opening of the Tagliata Canal had negative implications for the environment with frequent floods in the surrounding farmland between the 13th and 14th centuries AD (Cantarelli 1882). The geomorphological analyses show interesting details about the shape of the Tagliata Canal. In the new DTM, the morphology of Tagliata Canal ridge seems to be more complex than what represented in Castiglioni et al. (1997) (Fig. 3). The crevasse splays, in fact, show unusual elongated small ridges not compatible only with natural fluvial crevasse splays.

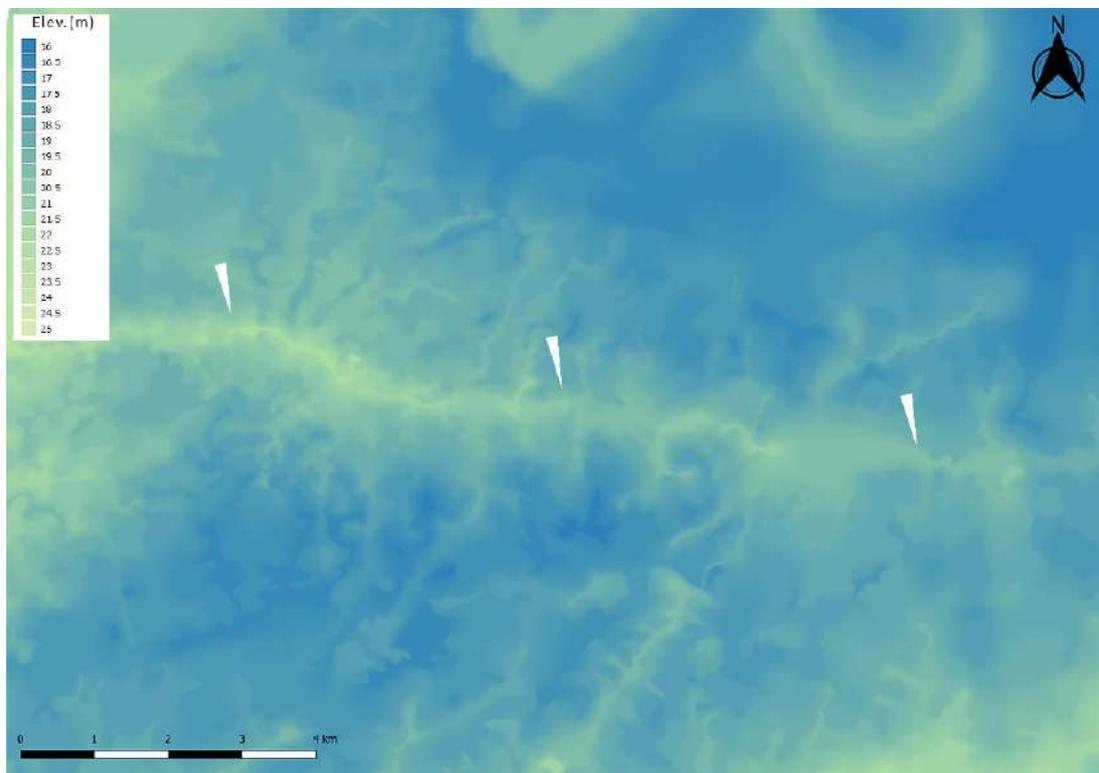


Figure 2 - Tagliata Canal ridge in the DEM (white arrows).

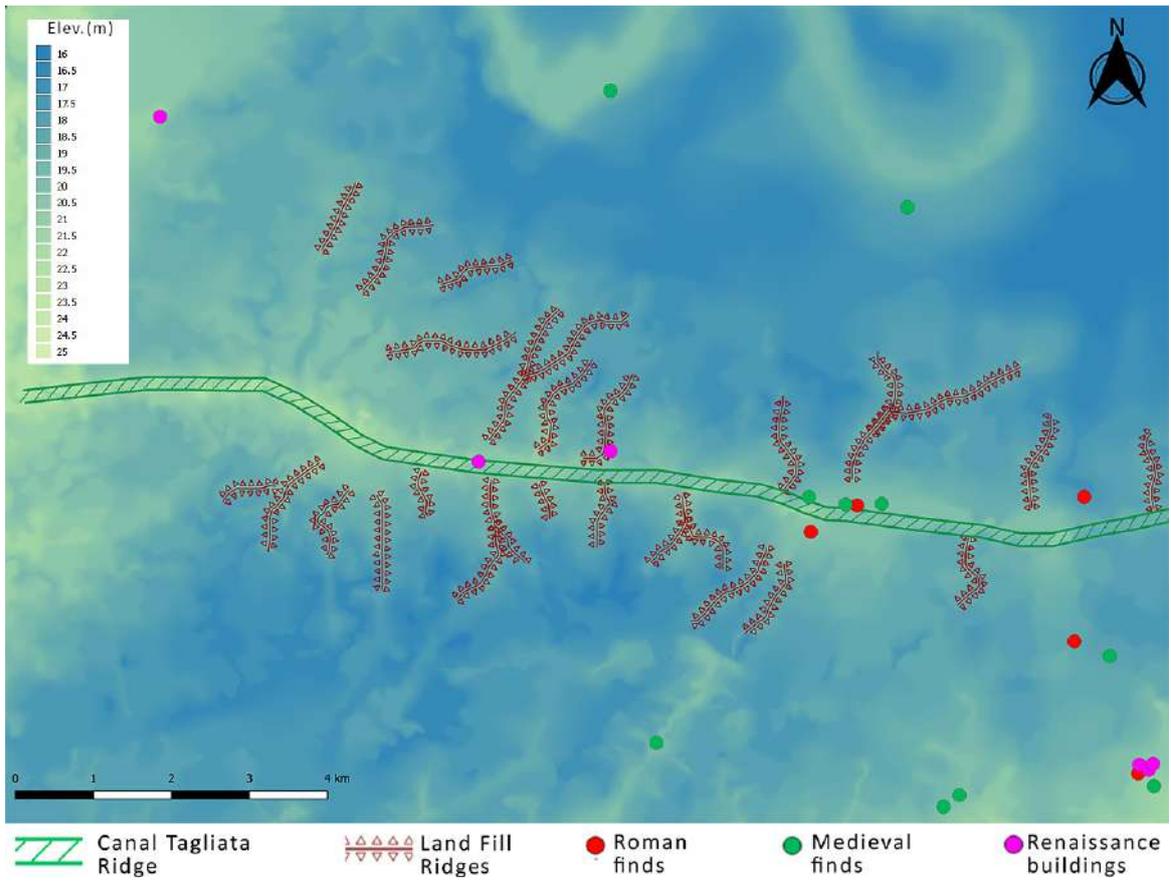


Figure 3 - Tagliata Canal ridge: archaeological data and geomorphological landforms.

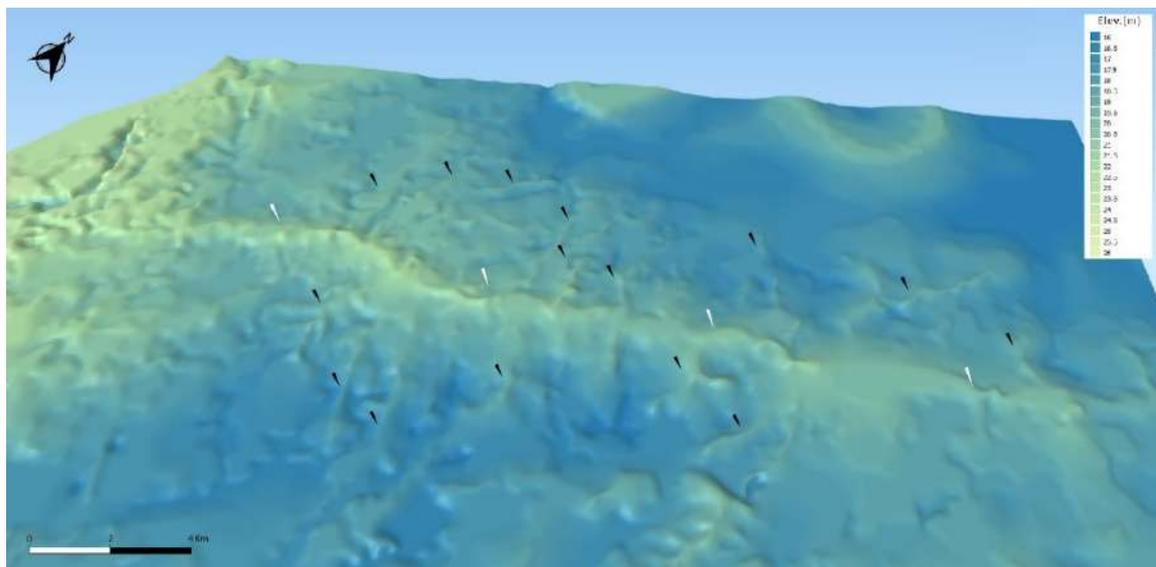


Figure 4 - Tagliata Canal in the 3D model: the Canal ridge (white arrows) and the land fill ridges (black arrows).

In historical documents there is a possible explanation for their genesis: the chronicler Affò (1792) reports that until the 16th century AD, people of Guastalla were allowed to breach the river and Canals levees in a situation of high, muddy discharge. This practice had the effect to fill the swamps with sediments obtaining new farmland. The elongated shape of those unusual landforms could be the results of the landfill reclamation practices described in the historical records. In the geomorphological literature, similar anthropogenic landforms have never been reported: we propose to define those elongate crevasse splays as “Land-fill Ridge” (in Italian, *dosso per colmata*) (Fig. 4). Those landforms are likely to be the results of flood management practices made by the local communities who exploited the fluvial sediments to reclaim new cultivable fields in place of swamps in Middle Ages and since Renaissance.

Conclusions

This study, supported by geomorphological, archaeological and historical data, identifies a new genesis for the Tagliata Canal ridge which landform shape developed in Middle Ages. First, the opening of this Canal had effects on the landscape evolution with frequent floods (crevasse splays), but later its sediments have been exploited by humans for land reclamation purpose (land fill ridges). The geomorphological landforms of the Tagliata Canal constituted an example of sustainable human land and water management in the Central Po Valley during Middle Ages.

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Beginning of a new farming system (mid-9th century AD): local fire events and vegetation changes in southwestern Tuscany

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Keywords: *soil charcoal analysis, Middle Ages, Human impact, fire-affected vegetation*

Introduction

The ERC Advanced Grant 2014 “Origins of a new Economic Union (7th to 12th centuries): resources, landscapes and political strategies in a Mediterranean region (nEU-Med)”, hosted by the University of Siena, is focusing on understanding the archaeology of resource management and commerce in south-western Tuscany. In re-defining the causes of socio-economic development in this region, destined to become an apogee of European economic development during the Renaissance (15th century AD), the project investigates also the evolution of the plant landscape in order to reconstruct (a) uses, (b) changes and (c) time intervals of forest and agricultural resources. Previous archaeobotanical research suggested that the first post-Roman settlements in the area practiced high quality subsistence agriculture, adapting from the mid-9th century AD to systematic cultivation of surpluses of cereals, olives and chestnuts (Buonincontri et al. 2017; Buonincontri et al. 2015; Di Pasquale et al. 2014). Through archaeobotanical analyses, the ERC nEU-Med Project aims to study when and why these changes occurred and what role agro-forestry production played in the processes leading to Late Medieval economic growth.

Soil charcoal analysis was performed in the Pecora river plain, along a section opened during geoengineering work on the left bank of the river. Soil charcoal analysis represents a unique tool to investigate local fire events and vegetation changes with a highly-detailed spatial resolution (Thinon 1978) and possibly without the human selection characterizing archaeological charcoal (Théry-Parisot et al. 2010). Charcoal identification, combined with radiocarbon dating and the sedimentological and stratigraphical analysis of the section, allowed drawing a detailed snapshot of the changes in the forestry conditions between the 9th and the 13th century AD.

Materials and Methods

The investigations have been mainly carried out in a retention basin on the hydrographic left bank of the Pecora river (Fig. 1). The basin allowed the observation of ca. 3 m of the sequence perpendicular to the river flow direction (Sections NW; Fig. 2). Sedimentological and stratigraphical analysis has allowed the identification of palaeochannels with two different depositional environments suggesting changes of geomorphological conditions and alluvial plain landscapes. The oldest, U 3.1, is typical of a gravel-sand sinuous meandering river and filling of abandoned channels. The U 3.2 sediments are typical of deposition by a gravel-bed braided river.

The bedforms were characterised by the presence of very abundant fine to very coarse charcoals. In the U 3.2, 10 soil samples were collected at different levels, ranging from 500 to 2390 ml of volume. The samples were firstly air-dried and weighted, and then they were wet-

sieved through two sieves with 1 and 0.4 mm mesh-size. Charcoal concentration and taxonomical identification were preliminarily performed for charcoal remains greater than 1 mm. Taxonomical identification was carried out with an incident light microscope at magnifications of 100×, 200× and 500× and supported with wood anatomy atlases (Abbate Edlmann et al. 1994; Schweingruber 1990; Vernet et al. 2001) and the reference collection in the Dipartimento di Agraria at the Università degli Studi di Napoli ‘Federico II’.



Figure 1 - Study area of the ERC-ADG nEU-Med Project. Red diamond indicates the retention basin of the Pecora river; white diamonds indicate Medieval archaeological sites; pale blue diamond is Accessa Lake (Late Holocene pollen sequence in Magny et al. 2007).

The presence of abundant charcoals allowed AMS radiocarbon dating in order to assess the chronology of the succession of events (Tab. 1). Samples were collected from U 3.1, the sinuous meandering rivers' sediments, and from U 3.2, the braided rivers' sediments. The preliminary results show that the U 3.1 sediments were left at least until 787-471 BC (Fi3497) whereas the filling of the upper palaeochannel (U 3.2) can be dated between 820-980 AD (Fi3452, from soil sample 2.4) and 1150-1290 AD (Fi3451 from soil sample 2.1).

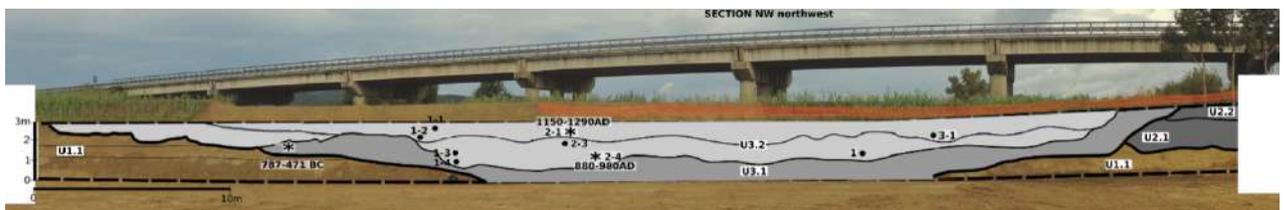


Figure 2 - Northwestern section of the retention basin. Light and dark greys highlight the palaeochannel of the Pecora river. Black circles indicate the soil samples for charcoal analysis; stars indicate soil samples with radiocarbon dating.

Results and Discussion

A total of 13 liters of soil were sampled with ca. 18.4 g of extracted charcoals. To get taxonomical information, 145 charcoal remains were preliminarily analyzed allowing the identification of 22 taxa (Tab. 2). Among the identified taxa, *Ulmus* is the most common (30.3%), followed by *Fraxinus* (12.4%), such as *F. cf. ornus* (3.4%) and *F. cf. angustifolia* (2.8%), *Quercus cf. cerris* (7.6%), *Salix* and *Erica* (4.1%), *Alnus* (2.8%), *Populus/Salix* and *Quercus cf. ilex* (2.1%), *Populus* (< 1%). Unidentifiable charcoals constitute 15.9% of the total.

Table 1 - Radiocarbon and calibrated ages of selected charcoals. Radiocarbon dates have been calibrated by using OxCal 4.2 (Bronk Ramsey 2005) and the Reimer et al. (2004) calibration curve. Samples were dated by AMS at the INFN CHNet in Florence. In bold, the most probable calendar time intervals obtained from the calibration curves.

Sample Id	Lab code		Radiocarbon age	Calibrated age	
				1 Sigma	2 Sigma
2.1	Fi3451	<i>Ulmus</i>	808±50	1185-1270 AD	1050-1290 AD
					1150-1290 AD
2.4	Fi3452	<i>Ulmus</i>	1142±55	780-790 AD	770-1020 AD
				820-980 AD	
	Fi3497	<i>Quercus pubescens</i>	2487±48	695-541 BC	787-471 BC
				766-727 BC	466-430 BC

The percentages of the taxonomical identification of the soil charcoal remains, together with the radiocarbon dating, are presented in Fig. 3. Overall, the most recorded taxa pertained to broad-leaved trees, while Mediterranean sclerophyllous shrubs and trees are scarcely present. In detail, two phases seem to be present, in agreement with the two different time intervals proposed. In the lower samples, dated between the 820-980 AD, the strong presence of trees typical of riparian and mixed flood-forest suggests that fire events occurred mainly along the riverbed and wetlands of Pecora river and its alluvial plain. In the higher samples, trees referable to the thermophilous deciduous forest prevail, suggesting that foothill areas were fire-affected mainly during the mid-12th and the end of the 13th century AD.

The comparison of our data with pollen analysis in the region shows an interesting conformity of the fire signal and forest clearance. In particular, the pollen sequence of Accesa Lake shows a decrease of wild arboreal pollen from ca 850-950 AD whereas pollen of cultivated trees spread, such as olive and chestnut (Magny et al. 2007). Therefore, the mid-9th century AD seems to be a crucial period for the beginning of agro-forestry activities, creating the opening of woodland and the cultivation of new areas for producing surpluses of crops and fruit trees (Di Pasquale et al. 2014; Buonincontri et al. 2015; Buonincontri et al. 2017).

Table 2 - List of charcoal remains recovered. For each taxon the number of charcoal specimens in the soil samples are given. Identified taxa are grouped according to their ecological significance.

Sample ID	Riparian forest					Mixed flood-plain forest		Thermophylous deciduous forest					Broadleaved evergreen forest			Others					Total			
	<i>Alnus</i>	<i>Populus</i>	<i>Salix</i>	<i>Populus/Salix</i>	<i>Vitis vinifera</i>	<i>Fraxinus cf. oxycarpa</i>	<i>Ulmus</i>	<i>Quercus cerris</i>	<i>Q. pubescens</i>	<i>Quercus deciduous type</i>	<i>Crataegus</i>	<i>Euonymus</i>	<i>F. cf. ornus</i>	<i>Sorbus cf. aucuparia</i>	<i>Q. ilex</i>	<i>Cistus</i>	<i>Erica</i>	<i>Prunus</i>	<i>Fraxinus</i>	<i>Quercus</i>		Malloideae	Monocotyledon	Undetermined
1.1								2											1				1	4
2.1							3	5											6	4	4		11	33
3.1				2		3		4	1			2		2		6			6	1			3	30
1.2																							1	1
2.3	4	1				1	9					3	1					1	4					24
4			6	1										1										8
1							31						1						2		1		5	40
2.4							1													1				2
1.4																						1	2	3

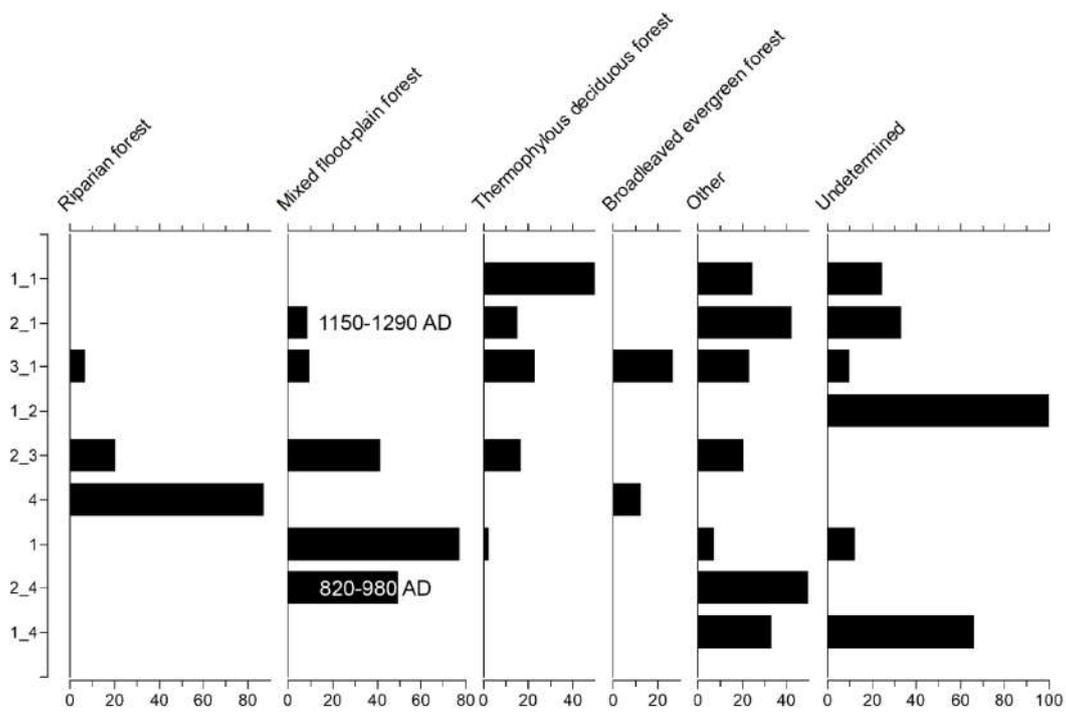


Figure 3 - Percentage bars of the ecological groups calculated over the sum total of charcoal remains in each soil samples. The ecological groups are in agreement with Tab. 2. The most probable AMS radiocarbon dates are presented.

Conclusions

Assuming that the charcoal record is the result of fire-affected forest vegetation, we can argue that the period between the mid-9th and the end of the 13th century AD is characterized by fire activities in the Pecora river basin. At least in the first centuries, according to several palaeoenvironmental data sources, fires were used mainly for clearing and reclaiming woodland for a new farming system characterized by the cultivation of cereals, olive and chestnut groves, that would stabilize in the following centuries. The fire events along the Pecora river are probably the first steps to the beginning of the modern agroforestry landscapes in Tuscany.

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The Environmental Resource Archaeology (ERA) approach: Punta Mesco case study (Liguria, NW Italy)

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Keywords: *environmental resource archaeology, pollen and charcoal analysis, multi-proxy, local production practices*

Introduction

Environmental Archaeology (EA) commonly refers to an archaeological–palaeoecological approach to the study of the human palaeoenvironment: the analysis focuses on the relationship between human activity (and behaviour) and environment (natural ecosystem) in the past (Reitz and Shackley 2012). However, this interpretation is still not shared by many people involved in archaeology or palaeoecology; moreover, misunderstanding (on approach and methodologies) occurs between mainstream archaeology and archaeological science (Albarella 2001; Pescini further coming).

Such misapprehension affects current Environmental Archaeology research but also the approach used by “sub-disciplines” such as archaeobotany, anthracology, palynology, etc. Actually, EA is considered a methodological approach for the study of areas without evident artefacts, the so-called “off-site” (considered less influenced by human activity), while archaeobotany focuses on the “on-site” areas (assumed as archaeological sites); such traditional dichotomy is due to a reductive definition of archaeological sites in which relationship between humans and ecosystems can be detected. Historical ecology studies have proposed a different historical approach: this last consider the vegetation canopy of a given site as a particular kind of artefact. Environmental resources are considered as “social products”, historically defined by activation and production practices, conditioned by forms of control, access and local environmental knowledge (Cevasco 2007; Rackham 1986). In contrast to a purely environmental study, we face precisely to a historical and archaeological analysis since it aims to bring out the localised production/consumption systems and related social practices that have shaped the characteristics of the vegetation land cover and its ecological state over historical time. This approach named “Environmental Resource Archaeology” (ERA) has been developed in the last thirty years by the LASA team (Laboratory of Archaeology and Environmental History) of the University of Genoa in different studies in Liguria (NW-Italy).

This paper presents some results of a multidisciplinary research developed for the restoration of a farm house (Case Lovara) set in a terraced landscape on the Punta Mesco cape in the Cinque Terre National Park (NW-Italy). In addition to other initiatives (e.g. restoration of buildings and recovery of historical crop production) and as a reference for these activities, the study of historical land and environment features of the site was planned by LASA since 2014 and it is still ongoing. Through the reconstruction of the historical landscape dynamics and past rural management, we suggest opportunities for a new approach to sustainable rural development and landscape management policies. The historical approach allows a more precise measurement of environmental sustainability of past and present resources management systems.

Materials and Methods

A multiproxy approach was developed including archaeological investigations, charcoal and pollen analyses, vegetation surveys, radiocarbon chronology, in association with documentary and cartographic studies in order to reconstruct the local past agro-sylvo-pastoral system and its changes. A regressive analysis was produced starting from present day until 13th century AD (at the moment the most ancient age for which we have recovered archive sources). At Case Lovara, stratigraphic analysis of the extant rural buildings and some field surveys in the surroundings were planned in order to reconstruct past settlements and household transformations in relation to the dynamics of the surrounding landscape. Anthracological analysis has been made on sediments containing remains of charred wood, interpreted as charcoal burning sites. Pollen and microcharcoal sampled in soil were analyzed and compared with anthracological results. AMS radiocarbon dates were made at CEDAD, University of Salento. In order to obtain a first multi-temporal analysis of the herbaceous layer composition, lists of species were registered in different sampling sites and compared with the floristic exploration of the promontory conducted by field botanists at the beginning of 20th c.

Results and Discussion

The research documented local production practices and environmental changes that have affected the promontory since almost the Middle Ages up today. A multiple use of the environmental resources is detected: grazing activities dominated/were integrated with cultivation (vineyard, olive growing) and species selection for charcoal production: e.g. branches and needles from shredded maritime pines were used as vegetal manure and for bedding, needles collected on the ground allowed herbs growing under the pine tree, increasing pastureland: a resource completely disappeared from the present site ecology. Actually, pine, which is abundant in pollen record since almost 17th c. A.D., is not documented in anthracological record (mostly consisting in holm oak, heather and strawberry tree). Using sedimentary sources, important change in fire regimes have been detected in correlation with the abandonment of the pastoral economy (19th c. A.D.) and recently following the wilderness policy of the National Park. The local multiple systems have undergone a progressive decline during the last 200-150 years, until the abandonment of almost all environmental control when the National Park was established and the formerly exploited areas have been left to natural dynamics, towards hypothetical future balances. As a consequence, the last stages of the cultural landscape has undergone a spontaneous infilling that has completely hid traces of buildings and terraces and resulting in their partial destruction.

Conclusions

A recent palaeoecological study (Richer and Gearey 2017) suggests the potentialities of using multiple evidence (oral sources, historical documents and local ecological knowledge) in high resolution research. At Punta Mesco cape this approach has been applied, according to the methods of the historical ecology; the sedimentary evidences were considered as fully historical sources informing on local practices, landscape dynamics and environmental systems: a step towards a full Environmental Resource Archaeology which is currently used in recent mountain and commonlands resource archaeology (Stagno further coming). Therefore, a re-definition of the historical factors that produced and maintained individual rural landscapes for centuries is required, moving forward a better understanding and a sustainable management of these landscapes in a way that preserves the cultural and environmental heritage in the future.

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Poster session

The site of San Michele di Valestra: new evidence of Apennines exploitation during the Bronze Age (XV–XII century BC, N Italy)

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Keywords: *Bronze Age, Northern Apennines, geoarchaeology, palaeoenvironment, climate change*

Introduction

The expansion and especially the collapse of the Terramare culture in the Po Plain (Northern Italy) between the Middle and the Recent Bronze Age (XVI–XII century BC) has been a subject of interest to archaeologists for a long time (Barfield 1994; Bernabò Brea et al. 1997; Cardarelli 2009). Their extensive network of trades and traffics had by no doubt a strong influence on the nearby mountain settlements in the northern Apennine, to which they were probably tightly related in lasting commercial relationships. Nevertheless, the nature and extent of Bronze Age human exploitation of the northern Apennine is poorly known, as well as the consequences of the disappearance of the neighbouring Terramare culture on these settlements. The principal reason for this knowledge gap is the scarcity of archaeological excavations in the area, with the few promising sites related to this period left largely ignored during the last decades. San Michele di Valestra, located in the territory of Carpineti (RE), is one of the few Bronze Age settlements investigated in the last decades, but the old studies (Bellodi et al. 1979; Tirabassi 1979) did not highlight the full archaeological potential of the site. In 2017 the archaeological sequence has been re-investigated in the framework of the SUCCESSO-TERRA Project (PRIN-20158KBLNB).

Materials and Methods

The investigation of San Michele di Valestra was prepared following a multidisciplinary study combining tools from a range of different disciplines. The excavation phases were conducted by a team of geoarchaeologists, archaeologists, and palaeoenvironmental scientists. The data and samples collected in the field are currently subject to archaeological, geoarchaeological, geochemical, micromorphological, archaeozoological, and palaeobotanical studies, in a time framework to be obtained from radiocarbon dating of materials from key stratigraphic units. In parallel, palaeoclimatic studies are being conducted on speleothems recovered in the nearby caves, investigated in the past (Severi 1956), but never used as a palaeoenvironmental archive before.

Results and Discussion

The excavation uncovered a sequence of planar levels corresponding to a well conserved stratigraphy (Fig. 1). In its upper part, a series of pedogenised levels lays above a deposit of decimetric to metric blocks. The latter is interpreted as a rock fall event that deformed the top of the lower portion of the archaeological sequence, dating to the Bronze Age occupation. In one

of the levels above the rock fall, archaeological materials dating to the Medieval Age are present.



Figure 1 - The archaeological section at the site of San Michele di Valestra.
At the bottom, a stone pavement.

In the lower portion of the sequence, a series of stratigraphic units marks different phases of settlement. At least seven of these units can be recognised, each characterised by distinctive features of the sedimentary material and by the relative frequency of archaeological materials (mainly pottery fragments; subordinately the most frequent findings are faunal remains). In this part of the stratigraphy, archaeological negative structures (postholes) are also found, starting from the top of two of these units. Approaching the bottom of the stratigraphy, a stone pavement composed by decimetric sandstone slabs with a metric gap in the NE side of the site was found. Below, several units progressively more compact and poorer in archaeological materials are present; they possibly mark a proximity to the natural substrate, not reached during the excavation.

Archaeological and archaeozoological materials testify continuity of the frequentation of the site from the beginning of the Recent Bronze Age (though materials from the previous excavations predate the beginning of the settlement to the Middle Bronze Age; Bernabò Brea et al. 1997) up to the end of the Final Bronze Age. The transition between these two periods is not registered by any discontinuity in the stratigraphy, furtherly indicating uninterrupted activity of the site through and beyond the Terramare crisis.

Conclusions

The site of San Michele di Valestra is probably the longest and best-preserved sequence for the Bronze Age in the Apennines, and offers the opportunity to understand the subsistence strategies in this environment. Evidence shows how the climate event accompanying the Terramare crisis had little influence on Apennine settlements: despite the spatial proximity (only about 20 km), in the site of San Michele di Valestra no hiatus or interruption in the archaeological sequence can be found relative to that event, in opposition to the substantial impact it had on the populations of the Po Plain. It can be speculated that adaptations to the peculiarities of the mountain environment were a key factor in the higher resilience of these settlements, and that a responsible strategy in the exploitation of the natural resources probably allowed their survival. The palaeobotanical analysis of the sequence and the palaeoclimatic studies on speleothems will explain the main climatic changes affecting the area and possibly shed light on the kind of response adopted by human groups to a changing environment.

Acknowledgements (Funds)

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The palaeoenvironmental reconstruction of the Terramara Santa Rosa di Poviglio from the Bronze Age to the XVI century AD (SUCCESSO-TERRA project)

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Keywords: *palynology, land use, environment, multidisciplinary research, Bronze Age, Terramare*

Introduction

Santa Rosa di Poviglio is an archaeological site that has been investigated since more than 30 years under the direction of M. Cremaschi, and recently is at the centre of the national-funded project SUCCESSO-TERRA *Human societies, climate-environment changes and resource exploitation/ sustainability in the Po Plain at the Mid-Holocene times: the Terramara*. In this project, the environmental and land-use changes have been investigated to understand their relationships over the last millennia. The approach is especially based on on-site palynological analyses (Mercuri 2014) integrated with the study of plant macroremains (seeds/fruits, charcoals). First analyses were focused on obtaining detailed comprehension of the adaptive strategies of the Terramare people during the Late Holocene. Santa Rosa di Poviglio was a terramara during the Middle/Recent Bronze ages (1550–1170 BC; Cremaschi et al. 2016). The interdisciplinary geoarchaeological and archaeobotanical research wants now to reconstruct environmental changes that occurred from the onset of the terramara to the following phases, until the XVI century AD, taking this site as emblematic of the land transformations of the southern-central part of the Po Plain.

Materials and Methods

Terramare are archaeological vestiges of banked and moated villages that developed in the central sector of Po River alluvial plain during the Middle and Late Holocene.

Pollen samples were collected from trenches excavated within the moat and ditch surrounding the Santa Rosa di Poviglio site, and connecting the small village to the large village of the Bronze age. A total of 57 samples (from the oldest samples: 31 from VP/VG, 10 from VP/VGII, 16 from VP/VGIII) were taken during the excavation campaigns of 2013 and 2015. Chronology was based on radiocarbon dates (Cremaschi et al. 2016), pottery and stratigraphical correlations.

Pollen extraction included sieving and heavy liquid floatation to concentrate pollen and non pollen palynomorphs.

Results and Discussion

Pollen was common and well preserved. Depositional conditions were especially suitable for good preservation of sediments and their palynological content in the VP/VG section. Pollen concentration was ~80,000 in VP/VG, and ~40,000 in the other two sequences. The reworked pollen was quite common and marked the presence of alluvial deposits.

The forest cover was low and includes oak wood trees like deciduous *Quercus*, *Carpinus betulus* and *Corylus*; the mean value of woody plants decreases from ~50% in VP/VG to ~15% in the following phases showing that the landscape was open. Trees, including fruit trees, and cereals were significant during the Bronze age while their importance decreased in the following phases. A set of anthropogenic pollen indicators, common in the spectra (and in the spectra from other Italian archaeological sites; Mercuri et al. 2013), was considered especially useful to reconstruct agricultural dynamics besides the distribution of wild vegetation (wood and wetland plant associations).

Conclusions

The palynological research showed a transformation in flora composition and plant communities, suggesting a dynamic agricultural economy. The latter was possibly practiced on the basis of wood management and crop fields. At the top of the VP/VG sequence of Santa Rosa di Poviglio, in correspondence with the drying of the moat system, a dramatic decrease of woods may had a twofold causation: increased aridity (natural factor) and intensive land-use (anthropic factor) might have played a fairly synchronous action on vegetation. After the Bronze age phase, the agro-system rapidly decreased or changed typology. In fact, pasturelands spread with much land devoted to grazing. Also the cultivation of hemp is recorded, and a quite expansion of woods during the most recent phases documented by pollen (Grant: PRIN2015 8KBLNB).

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First palynological data from the “Vasca Inferiore di Noceto”, an artificial mire of the Bronze Age in the Po Plain

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Introduction

In the framework of the national-funded project SUCCESSO-TERRA (PRIN-20158KBLNB), an interdisciplinary geoarchaeological and archaeobotanical (pollen and macroremains) investigation has been carried out, aiming at reconstructing the land transformations that occurred at the onset, duration, and end of the Terramare culture in the southern-central Po Plain (Emilia Romagna region). The Terramare are archaeological remains of a unique cultural phenomenon: banked and moated villages that were located in the Po River alluvial plain, dated to Middle and Recent Bronze ages (1550-1170 years BC; Cremaschi et al. 2016).

An artificial basin of the Middle Bronze Age, built and delimited entirely with oak wood, was found in the spring of 2004 in Noceto, in the province of Parma. Due to the unusual and, at the same time, extraordinary character of this site, the intervention promoted by the Soprintendenza per i Beni Archeologici dell’Emilia Romagna was timely. The excavation campaigns that followed, thanks to the cooperation with the Università di Milano and Comune di Noceto, brought to light bio-archaeological materials in a good state of conservation because they were always submerged in the water in a deposit of saturated clay until they were found (Cremaschi et al. 2009). In the 2015 following excavations, it was discovered that this structure (Fig. 1) was built after the collapse of an older and wider basin. The latter is called “Vasca Inferiore” for its position. The use of both structures covered a period of about one century.

Materials and Methods

Pollen samples of “Vasca Inferiore” were collected in 2015 from two vertical trenches, in close succession, excavated in the northeast corner of the site. The samples were treated using a pollen extraction method that also includes sieving and heavy liquid floatation to concentrate pollen and non-pollen palynomorphs.

Results and Discussion

The concentration of pollen was good and pollen was well preserved. This allowed recognition of a high biodiversity: the floristic list includes 204 taxa.

The results obtained from the pollen analysis of “Vasca Inferiore di Noceto” provide a detailed knowledge of the plant cover and the plants available for the various human activities carried out around the basin itself in a century.

The incidence of wet environments (Fig. 2) was low, even though the anthropic origin of the structure and the nature of some plants (like hydrophytes which are known to be low pollen producers) make the palynological image of wet environments overall significant. The characteristic elements of this environment are hygrophilous trees (e.g., *Salix*), hydrophilous herbs with prevalence of herbaceous limno-telmatophytes (like Cyperaceae undiff. and *Phragmites*, the last one distinguishable among Poaceae through the size of its pollen grain

< 26 µm; Faegri et al. 1989) on hydrophytes (like *Hydrocharis morsus-ranae*, *Nuphar* and *Potamogeton*), and algae *sensu lato* (non-pollen palynomorphs).



Figure 1 - View of the excavation campaign 2015.

Data suggest that the artificial mire was continuously and carefully cleaned, probably to facilitate the accessibility to the basin. Interestingly, some hydrophytes represented in pollen spectra (like *Nymphaea alba* type) have ornamental value and this suggests that beautiful flowers were probably cared and not eliminated by cleaning actions. Degradation of organic matter was responsible of an eutrophic state of the water, suggested by the presence of *Lemna* (highly resistant to eutrophic conditions; Radić et al. 2010) and, in particular, of *Rivularia* type Cyanobacteria (Revelles et al. 2016).

There are many evidences of the continuative human pressure and changes in soil composition. The Anthropogenic Pollen Indicators-API group (Mercuri et al. 2013) are significant together with other synanthropic plants in pollen spectra (Behre 1986; Cremaschi et al. 2016; Pignatti 1982). Among these plants, there are nitrophilous species, ruderals and several weeds of cereal crops. Moreover, the presence of humans and animals is also testified by spores of coprophilous fungi and, only in a few samples, by eggs of intestinal parasites.

A peculiar character of this deposit is the presence of pollen of many entomophilous species in the diagram. The entomophilous species are scarce pollen producers, usually have beautiful, sometimes showy, sometimes fragrant flowers, and some of these plants also have medicinal effects, probably already known at the Bronze Age. The abundance and the diversity of these pollen types, combined with the state of preservation of some of them, suggest that flowers and inflorescences were deposited in the water.

Conclusions

This palynological research allows to investigate the relationships between human action and a special artificial wet environment during the Bronze Age by providing biological data to an archaeological context. The results give useful information for a better understanding of current human impact on small mires as they show how much it limits the development of biotic communities and the formation of true ecological successions. The study may be a contribution to conservation studies and sustainable management plans of human environments in the Po Plain.

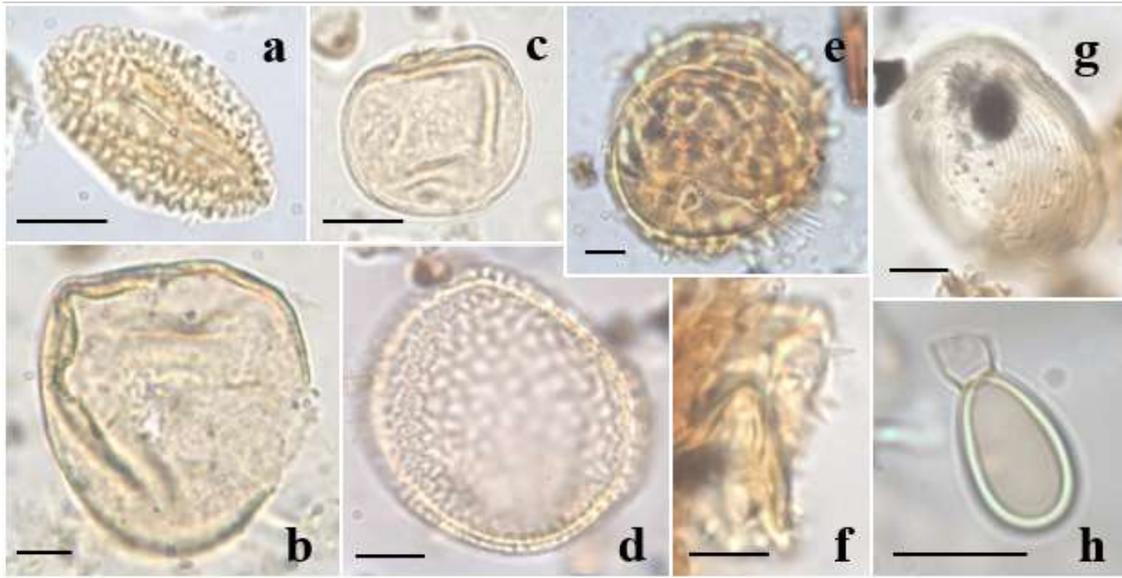


Figure 2 - Pollen from Hygro-Hydrophytes (a-f) and algal elements (g-h) identified in Vasca Inferiore di Noceto: a) *Salix*; b) *Scirpus* type; c) *Phragmites*; d) *Butomus umbellatus*; e) *Nymphaea alba* type; f) *Nuphar*; g) *Pseudoschizaea*; h) *Rivularia* type. The scale is 10 μm .

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Seeds/fruits data from the "Vasca Superiore di Noceto", an artificial mire of the Bronze Age in the Po Plain (N Italy)

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Keywords: archaeobotany, seeds/fruits, Bronze Age, water cult reconstruction

Introduction

The Noceto wooden basin is an huge structure (12x7 m and about 3,5 m deep) situated in the central Po plain near Parma. Discovered in 2004 and it was studied through several archaeological fields from Soprintendenza dei Beni Archeologici dell'Emilia-Romagna with the collaboration of University of Milan (Bernabò Brea and Cremaschi 2009).

This basin was built from the *terramara's* inhabitants of Noceto during Middle Bronze Age (1650-1350 BC) and was originally filled with water. The waterlogged anoxic deposits and the fill characteristics preserved the structure and many wooden objects. Most remarkable are the remains of four ploughs deposited at the corners of the basin. Furthermore, more than 150 whole or fragmented ceramic vases were found, together with miniature vases and figurines. The position of the structure, the type of depositions and their distribution within the basin suggest ritual activities probably linked to agrarian and water cult (Bernabò Brea and Cremaschi 2009).

This condition allowed the good conservation of seeds and fruit remains.

Materials and Methods

The layers considered have been: 5003, 13-66, 66-81, 31, 32A, 66, 66α and 138. The samples from two vases (R.594 and R.798) have been analysed (Rottoli and Castiglioni 2009; Proserpio 2017). Overall, c. 230 litres of sediment were floated.

The soil samples were floated and sieved with a 0.2 final mesh. The identification of seeds and fruit was made with identification keys, atlas and reference collection of the Laboratory of Palynology and Palaeobotany of the University of Modena e Reggio Emilia and the Laboratory of Archaeobiology of the Museums of Como.

Results and Discussion

Overall, more than 60,000 seeds/fruits have been found.

The analysis showed that the Noceto wooden basin was an eutrophic pond. Indeed, there is the presence of *Lemna* sp., *Lycopus europaeus*, *Ranunculus* cf. *flammula* and *Potamogeton* sp.. Around the basin there was an open area of grassland and the high percentage (up to 58%) of ruderal species (*Urtica dioica*, *Rumex crispus/obtusifolius*, *Hypericum perforatum*) suggests the presence of human activities.

The cereal taxa recovered in the basin are frequent in the Middle Bronze Age deposits of the Terramaras: barley (*Hordeum vulgare*) hulled wheat (*Triticum monococcum*, *T. diccoccum*, *T.*

timopheevii) free-threshing wheat (*T. aestivum/durum*), rye (*Secale cereale*) and millet (*Panicum miliaceum*). The remains are all charred and there are more chaff remains than grains.

Only a charred pulse was recognised (*Vicia faba* var. *minor*), while 14 taxa of fruit were found, probably collected in the settlement surroundings (*Corylus avellana*, *Rubus fruticosus*, *Fragaria vesca/viridis*, *Sorbus* sp.). Remains of grape (*Vitis vinifera*) and cornelian cherry (*Cornus mas*) are both partially charred.

The concentration of seeds/fruits into the different layers is significant. The most high remain concentration (1752 c/l) and the most percentage of cereals (34%) and fruits (8%) is in layer 138. In layer 66 remain concentration is 557 c/l and in US 32A is 268 c/l, with low percentages of cereals (about 10%) and fruits (3%).

Conclusions

Ritual practices from Noceto wooden basin are suggested from the different type of evidences recovered. Also, the offers of cereals and fruits were included in the cult activities and the presence of charred remains would indicate the use of fire. The copious amount of chaff remains would suggest deposition of whole spikelets of grain, instead of grains already threshed.

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***Mutina splendidissima*: archaeobotanical data reveal the history of a town**

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Keywords: *archaeobotany, Roman period, Modena*

Introduction

Modena, situated on the via Emilia, was founded in 183 BC. Described as *firmissima et splendidissima* by Cicero, the Roman *Mutina* was one of the most important urban centre of northern Italy.

In 2017, on the anniversary of 2200 years from its founding, many events tried to highlight the strong imprint left by the Roman world in the history of the city to the present day.

The Laboratory of Palynology and Palaeobotany has cooperated for a long time with the Superintendence of Emilia Romagna and with the Archaeological Ethnological Museum of Modena; on this celebratory occasion the Laboratory contributed to different activities planned with a synthesis of the data obtained from the numerous archaeobotanical analyses performed over the last 20 years on urban and peri-urban sites of the city.

Materials and Methods

10 sites already in part or entirely published were considered (Bosi et al. 2015a, 2015b, 2017a and submitted), with dates starting from the 3rd century BC up to the 6th century AD. Archaeobotanical analyses concerned pollen and NPPs (about a hundred samples), as well as seeds/fruits, charcoals and woods (more than 1400 litres of sieved material). The analyzes on woods/charcoals are still in the preliminary phases.

Results and Discussion

Both at a quantitative (nearly 42.000 pollen grains and 180.000 seeds/fruits were counted) and at a qualitative level (about 350 pollen taxa and 500 carpological taxa) data are very significant.

This condition allowed to deal with different issues to attempt to provide answers or integrate information in order to obtain a more comprehensive overview of the Roman period of Modena.

For *Mutina* the topics covered from an archaeobotanical point of view were:

- 1) the environment from the Republican period to the Late Roman and the pasture markers (Mazzanti et al. 2017; Torri et al. 2017)
- 2) the vegetal food and the traces of luxury (Bosi et al. 2017b, 2017c)
- 3) findings related to the presence, cultivation and exploitation of grapevine (Bosi and Marchesini 2017)
- 4) the plant offers in funeral contexts (Bosi et al. 2017d – for this topic see also Riso et al. in this volume).

These researches contributed to the realization of an important scientific-popular book and of two exhibitions, that link the Roman foundation with all the history of the city up to the present day.

Conclusions

Archaeobotanical researches carried out on the sites of Modena provided many information useful to reconstruct the environment, farming practices, diet and ritual uses associated to plants in Roman period. Thanks to these data, in addition to products targeted to the scientific community (papers on international journals and conference speeches), it was possible to communicate the results obtained from a rigorous and exhaustive scientific research to a wider and varied audience.

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Wetland plants from archaeological sites of Ferrara and Argenta (Emilia-Romagna, N Italy)

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Introduction

In the context of the archaeobotanical studies aimed at palaeoecological reconstructions, archaeocarpological investigations play a relevant role because they can compensate for the lack of floristic information persisting at least until the 18th century AD when botanical collections started to be organized within herbaria (see Preston et al. 2004; Wolters et al. 2005). When well preserved, seeds and fruits (= s/f) can often be attributed to a specific or sometimes subspecific level.

It is well known that wetlands contain palaeoecological archives that can provide accurate records of their own history (Muller et al. 2012). Wetlands are particularly suitable for preserving waterlogged s/f, a condition of optimal conservation which facilitates their identification. The city of Ferrara (10 m a.s.l.) grew up around a ford on the river Po about the 7th century AD and its territory, that include also Argenta, therefore has always been characterized by a relevant occurrence of water and wetlands. These deposits are characterized by widespread evidence of plants related to water, constituting a valuable archive to investigate habitats which currently have become very rare and threatened, if they have not completely disappeared. The term “wetland plant” is here adopted in the broadest sense to include all the plants occurring in permanently or seasonally wet environments. This paper aims to reveal the peculiarities of the medieval/rinascimental archaeocarpological floristic lists through a comparison with the flora currently in the area of Ferrara documented by Piccoli et al. (2014). The Ferrara checklists included historical floristic studies carried out over the last two centuries.

Materials and Methods

The 6 sites examined (4 of Ferrara and 2 of Argenta - from the 10th to the 17th century AD) showed different contexts. Over 500 l of material was soaked in water and then washed in a series of three sieves with meshes of 10, 0.5 and 0.2 mm.

Results and Discussion

Among Ferrara and Argenta more than 1.200.000 s/f divided into over 400 taxa were discovered (Bandini Mazzanti et al. 1999, 2005; Bosi 2000; Bosi et al. 2009a, 2009b, 2009c). Between those nearly 80 taxa of wet environments, with about 30.000 records, were identified; a considerable number, giving that the deposits examined are situated in the heart of the urban centre of Ferrara and Argenta and nearly always these are anthropogenic deposit (mainly dunghill).

Based on the comparison with the present flora (= PF) of Ferrara province and with what is known about flora and herbarium collections of the last two centuries (historical flora = HF) (Piccoli et al. 2014), among the species of the floristic list from archaeobotanical analysis (archaeobotanical flora =AF), the following can be pinpointed: 1) species of AF are missing both in PF and also in HF (e.g. *Cicuta virosa*, *Isolepis setacea*, *Schoenoplectus supinus*); 2)

species of AF lacking in PF of the area, but confirmed in HF of the area (e.g. *Baldellia ranunculoides*, *Caltha palustris*, *Fimbristylis annua*, *Rumex hydrolaphatum*, *Ranunculus ophyoglossifolius*); 3) species of AF still occurring in PF of the Ferrara's area, but included in the attention/interest lists or considered in rarefaction (e.g. *Carex elata*, *Cyperus flavescens*, *Mentha pulegium*, *Persicaria hydropiper*, *Teucrium scordium*). As can be seen in all the groups Cyperaceae species occur, a family of plants particularly common in wet environments and that grow mostly in swamps and bogs, in habitats often phosphorus(P)-poor, environments that easily can we expect significantly more widespread and close to urban centres in Medieval/Renaissance age.

Conclusions

As has already happened in case of deposits of the area of Modena (Bosi et al. 2015), also those of the area of Ferrara, although more markedly anthropogenic, provided significant information about biodiversity in the past with regard to the present one. There are some similarities between the species of wet environments of the two areas (e.g. *Cicuta virosa*, *Baldellia ranunculoides*, *Rumex hydrolaphatum*, *Cyperus flavescens*), but in the area of Ferrara appear also different species (e.g. *Isolepis setacea*, *Schoenoplectus supinus*, *Fimbristylis annua*). The carpological records reveal the previous presence of a taxon in a specific geographical area (Birks & Birks 2000). Highlighting the ecology of species we will be able to understand the possible causes explaining the presence or the demise of several taxa, considering also the palaeoecological reconstruction of the environment in which they have been found.

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The environmental perspective from the Late Antique contexts of Villa del Casale and Philosophiana (central Sicily, S Italy)

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Introduction

Villa del Casale and Philosophiana are archaeological sites very close from each other and located in Sicily, southern Italy. They are among the best evidence of rural contexts of the Roman period in the island (Vaccaro 2013). These sites have been recently studied with focus to the end of 3rd until the 7th century AD, a time frame that was critical for the transition of different cultures. Archaeological researches, in fact, attest that human activity has strongly interested central Sicily since the beginning of the Roman Imperial Age, and has reached its acme in the Byzantine period. Based on interdisciplinary projects, the on-site palynological analyses allowed to obtain the reconstruction of the agrarian and cultural landscape of this area in the centre of the Mediterranean basin during Late Antiquity. This poster presents the data which were recently published by Mercuri et al. (2017 online).

Materials and Methods

Among the numerous pollen samples collected from the layers of Villa del Casale (VdC) and Philosophiana (Ph) during several field seasons, pollen samples dating to Late Antiquity were selected to study the plant landscape of the area during about five centuries. Chronology was based on archaeological data, i.e. architecture (building techniques), stratigraphy and, above all, the archaeological findings.

The 27 VdC samples come from 5 trenches unearthed in different points of the site, and of about 50 to 200 cm depth; the 12 Ph samples come from a sequence cut in the northern sector of the site. Sub-samples of about 5–10 g of sediment were treated for pollen extraction with a method including sieving and heavy liquid separation. Pollen sum includes all pollen counted. The ‘OJC’ and the ‘API’ groups are calculated according to Mercuri et al. (2013a, b). The first includes the trees that follow the development of cultural landscapes in Italy (*Olea*, *Juglans*, *Castanea*), and the second includes Cichorieae plus the other six ubiquitous taxa in archaeological sites of Italy (*Artemisia*, *Centaurea*, *Plantago*, *Trifolium* type, *Urtica*, cereals).

Results and Discussion

Pollen shows that the landscape of these sites was characterised by low forest cover (10%) and many signs of human environments. Most of the pollen spectra are dominated, in fact, by anthropogenic indicators of pasturelands/breeding like Cichorieae (>50%) followed by Poaceae-wild group (12%), and other anthropogenic pollen indicators like Brassicaceae (4%) and Chenopodiaceae (3%). Data point to human-shaped environments producing cereal-type (2%) and grassland pollen grains, both included in the API sum with a number of wild synanthropic plants (other API: 6%). Pollen spectra of Philosophiana have a higher presence of cereals (Ph

3%, VdC 1%), showing the important role of cereal fields in the Late Antique economy of the area.

From the pollen spectra is also evident the OJC group (1%), present in many samples. In particular, there is evidence of *Olea* as arboreal crop production in the 3rd century AD (3% maximum value in VdC and 2% in Ph). Concerning *Vitis*, the grapevine pollen record may have a different interpretation in the two sites: an agrarian product in the Philosophiana farmhouse (0.4%), and ornamental lianas with edible fruits in the Villa (Montecchi and Mercuri 2016).

Conclusions

Pollen and archaeological information confirm that this central Sicily area had the role of major producer of cereal foodstuffs. Our data support the idea of continuity of the agrarian landscape during the Late Antiquity. In fact, spreading of anthropogenic environments, where tree crops and cereals were cultivated, probably in alternation with pasturelands, marked the land use of this area. In addition and more specifically, ornamental and shade plants were concentrated in the luxury villa, while fruit trees and agrarian activities were more evident in Philosophiana. We assume that the centuries from the 3rd to 7th century AD represent a key phase to understand changes in the past vegetation to the modern landscape of this island (Mercuri et al. 2017 online).

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- “Land estate and economies in late antiquity: the Philosophiana project (central Sicily)”, e-GAP2 of the British Academy.

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The plant landscape of Roman Tuscany and the peasant agricultural strategies in the Cinigiano area (central Italy)

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Introduction

In Cinigiano (Grosseto, southern Tuscany, Italy), the archaeobotanical study of small rural sites have been investigated to understand the relationships between Roman peasant farmers and the environment of central Italy. The research was carried out within an interdisciplinary project, the Roman Peasant Project, that addressed the lives of Roman rural smallholders (Bowes et al. 2011, 2017). Microscopical and macroscopical plant remains were collected from 8 sites and interpreted in the context of their archaeological and chronological frameworks (Rattighieri et al. 2013; Bowes et al. 2015).

The archaeobotanical material describes a period of intensive land use in the late Republican/early Imperial period, with possible use of convertible agriculture strategies.

Materials and Methods

Pollen, non-pollen palynomorphs (fungi and algae) and plant macroremains (seeds/fruits and charcoals) were taken from seven rural sites. All plant records are important palaeoethnological and palaeoecological indicators for environmental reconstructions. Pollen samples were treated according to the routine method for pollen analyses in use in the laboratory of Modena (Florenzano et al. 2012). Pollen was collected through syringe extraction from newly cleaned sections, as well from non-archaeological contexts to obtain near-site background levels. The treatment of 5–10 g of dry sediment per sample included the sieving through a 7-mm nylon sieve and heavy liquid separation with sodium metatungstate hydrate. *Lycopodium* tablets were added to calculate concentrations per gram.

All stratigraphically significant contexts were wet-sieved for plant macro-remains with sieves of 10, 0.5 and 0.2 mm. Seeds and fruits from each fraction were sorted under a Wild M10 stereomicroscope. The identification was made at 80 x magnifications with the reference collection, atlases and keys.

Results and Discussion

Pollen was found with variable concentration (~9000 p/g on general average) depending on the variable amount of organic matter; low preservation conditions were quite common in these archaeological layers. Pollen spectra show open areas, with scanty woodlands (AP/NAP = 13/87 on average) and presence of wet environments in the area. Grasslands and fields were part of the agricultural system. Cereals (4.5% on average) were distinguished in pollen and macro-remains and included a mixture of types: barley, rye and *Avena/Triticum* group among pollen, *Triticum aestivum/turgidum*, *T. dicoccum*, *Hordeum* group and *T. monococcum* as macroremains. The significant presence of pasture indicator pollen, mainly Cichorieae and also *Aster* type,

Centaurea nigra type, Ranunculaceae and *Potentilla*, indicates specifically pastures and animal breeding that constituted large part of the agrarian economy.

Conclusions

Altogether, the archaeobotanical data from the small agro-processing and farm sites show that the Roman-period occupation was mostly marked by a well-developed and complex agrarian landscape. These archaeobotanical data describe a sophisticated micro-management of the land including intensive agricultural systems with cultivation and breeding activities. Pollen evidence points towards a great importance of the animal husbandry as large part of land was allocated to a grazed pasture (Bowes et al. 2015).

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Archaeobotanical finds from the Brina medieval castle in the lower Magra valley (La Spezia - Italy): first results

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Keywords: Medieval Age, macroremains, Triticum, Vicia

Introduction

Archaeological research carried out from 2000 to 2013, integrated by the study of original sources, enabled us to write the history of Brina castle (Fig. 1) over a time span of almost 2000 years (Baldassarri et al. 2008).

Between the V and IV century BC the site was already inhabited by Ligurians, who built a village of huts. It was abandoned in Roman times and in the IX century AD a new settlement was built at the top, with houses and defences made from perishable materials. Between the late X and XI centuries the *domini* of the place, the *Da Burcione* family, decided to transform the settlement by building a tall tower and a stone wall. Further re-structuring of the castle took place in the XIII century, when the Bishop of Luni won dominion of the castle.

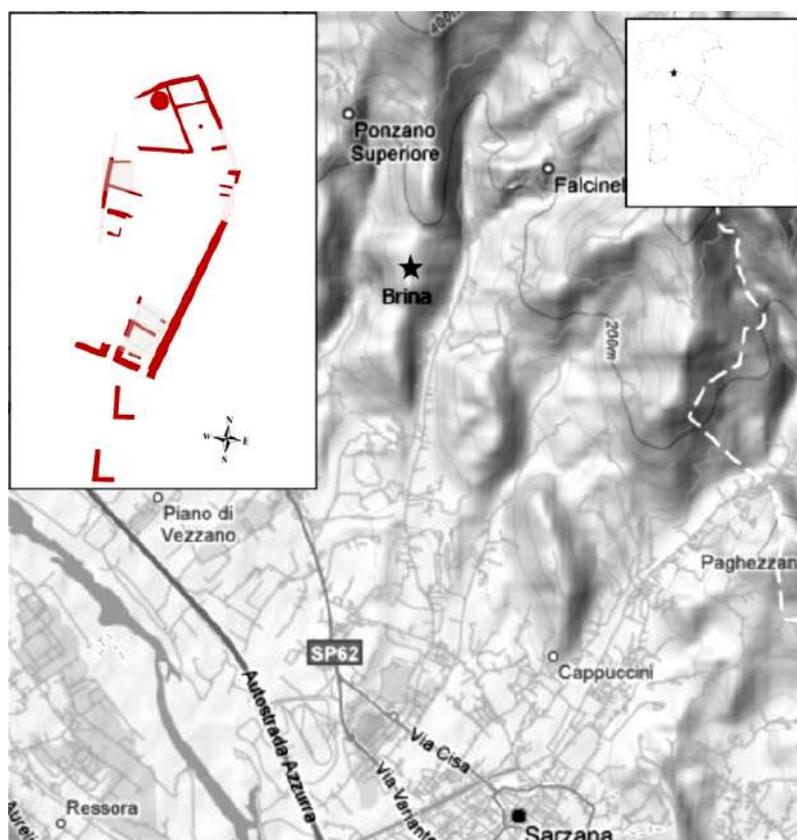


Figure 1 - Geographical location of archaeological site and planimetry of the castle.

A struggle for control of the *castrum* then arose in the early XIV century between the Bishop and the Malaspina family that resulted in the destruction of the upper part: thus, this area of the site was abandoned, while the part around the southern gate of the defensive wall was used as a sentry point by the Malaspina, then later as a Customs post by the Sarzana community up until the XVI century.

The period of the first and major flourishing of the castle occurred in the XI century, suggested not only by the masonry building of all the most relevant structures of the site, but also for the richness and the variety of the finds related to the seigniorial areas. Such findings include all the macroremains reported in this work, which belong to stratigraphic units dating back between the middle and the end of the XI century or dislocated nearby a little later.

Materials and Methods

The archaeobotanical remains here presented were found in two different parts of the XI century castle: a roofed area with a central fireplace used to dry plants, placed in the north-west part of the site, and in pits and postholes in the area of a storage building located nearby the southern gate of the defensive wall. In both cases the remains seemed to be carbonized and that may be the reason why they were abandoned in the soil. To study them in a proper way, we took the entire soil of the stratigraphic units (total sampling), and then we sifted them as follows.

Soil samples were sifted both dry and in water, with 1.80, 2.00, 2.80 mm opening steel mesh sieves. The identification and botanical determination of macroremains was done by stereoscope (Leica zoom 2000). The identification of the taxa (species, genus, family) was carried out by comparing the identifiable morphological characteristics (form, size, and other distinctive key aspects) of the finds, with a reference seed/fruit collection, stored in the seed bank of the Department of Agriculture, Food and Environment, University of Pisa, or samples collected in natural areas, and atlases and literature (e.g., Jacomet 2008). For the botanical nomenclature reference was made to Flora d'Italia (Pignatti 1982).

Results and Discussion

All macroremains, apart some endocarps of peaches, were charred to a greater or lesser extent. This is due to the fact that during the original drying or roasting operations, some were burnt, which resulted in complete carbonization. In any case the analysis of macroremains allowed the identification of the following taxa (in order of quantity) (Tab. 1) (Figg. 2, 3):

1. naked wheat (*Triticum* spp. - Poaceae)
2. *Triticum aestivum/durum* (Poaceae)
3. *Vicia faba* var. *minor* (Fabaceae)
4. *Lens culinaris* (Fabaceae)
5. *Pisum sativum* (Fabaceae)
6. *Vicia cracca* (Fabaceae)
7. *Lupinus angustifolius* (Fabaceae)
8. *Sinapis arvensis* (Brassicaceae)
9. *Prunus persica* (Rosaceae)
10. *Avena* sp. (Poaceae)

Table 1 - Macroremains, location and archaeological chronology (c. = century).

Layer	Site	Period	Seeds/fruits
5684	Deposits linked to the use of the fireplace in the roofed area	1st half XI c.	13 seeds of <i>Vicia faba</i> var. <i>minor</i> ; 2 caryopses of <i>Triticum aestivum/durum</i> ; 1 seed of <i>Pisum sativum</i>
5690	Deposits linked to the use of the fireplace in the roofed area	1st half XI c.	22 caryopses of <i>Triticum aestivum/durum</i> ; 2 seeds plus 6 cotyledon fragments of <i>Lens culinaris</i>
5691	Deposits linked to the use of the fireplace in the roofed area	1st half XI c.	More 5000 caryopses of naked <i>Triticum</i> spp.; 5 seeds of <i>Vicia faba</i> var. <i>minor</i>
5692	Deposits linked to the use of the fireplace in the roofed area	1st half XI c.	More 3000 caryopses of naked <i>Triticum</i> spp.; 8 seeds of <i>Vicia faba</i> var. <i>minor</i>
5694	Deposits linked to the use of the fireplace in the roofed area	1st half XI c.	23 caryopses of <i>Triticum aestivum/durum</i> ; 1 seed of <i>Vicia cracca</i> L.; 1 seed of <i>Sinapis arvensis</i>
5695	Deposits linked to the use of the fireplace in the roofed area	1st half XI c.	63 caryopses of <i>Triticum aestivum/durum</i> ; 2 seeds <i>Vicia faba</i> var. <i>minor</i>
5697	Deposits linked to the use of the fireplace in the roofed area	1st half XI c.	54 seeds of <i>Vicia faba</i> var. <i>minor</i> ; 5 fragments of seeds of <i>Lupinus angustifolius</i> ; 2 fragments of endocarp of <i>Prunus persica</i>
9079	At the bottom of the backfill of storage pits	XI-XII c.	87 caryopses of <i>Triticum aestivum/durum</i> ; 2 seeds of <i>Vicia faba</i> var. <i>minor</i>
9095	Backfill of the postholes where were located the storage pits	End XII c.	217 caryopses of <i>Triticum aestivum/durum</i> ; 18 seeds of <i>Vicia faba</i> var. <i>minor</i>
9096	Backfill of the postholes where were located the storage pits	End XII c.	374 caryopses of <i>Triticum aestivum/durum</i> ; 1 caryopses <i>Avena</i> sp.; 5 seeds of <i>Vicia faba</i> var. <i>minor</i>

A high amount of naked wheat caryopses were found in layers 5691 and 5692 and a detailed analysis of the species it is still ongoing (Tab. 1). In any case, the most represented species appears to be *Triticum aestivum/durum* although for some specimens the presence of both *Triticum turgidum* and *Triticum spelta* is possible. *Vicia faba* var. *minor* is the second species in order of number of remains found, albeit in much smaller quantities than the *Triticum*. The seeds of *V. faba*, together specimens of *Lens culinaris*, and *Pisum sativum*, and in part, *Lupinus angustifolius* are certainly to be included in the food-grade group. The small number of these specimens does not allow us to form hypotheses on the presence of specific conservation practices. The other species are considered to be normal contaminants or, in the case of *Prunus persica*, as food remains unrelated to conservation practices.

Conclusions

The two species most on the site confirm their great importance in the Middle Ages and continuity with the agricultural tradition of the preceding Roman world (Buonincontri et al. 2014). A more in-depth analysis of the two largest grain deposits can provide more detail on the most widely used *Triticum* species in the territory under the control of the Brina castle.



Figure 2 - Caryopses of naked wheat and (a) one caryopsis of *Avena* sp. (Layer 9096).



Figure 3 - Seeds of (a) *Vicia faba* var. *minor* and (b) *Lupinus angustifolius* (Layer 5697).

Acknowledgements (Funds)

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Land cover and land use change in the archaeological sites of the Prato province (Tuscany, Italy)

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Keywords: land cover and land use, human impact, spatial analysis, archeological map

Introduction

Changes of the land cover and land use as a consequence of the human activity are evidenced by archaeobotanical studies which provide useful information for clarifying the spread of plants out of their original territories and the origin of the current plant-cover. The study of the dynamics operating in the present may be a useful tool for a better interpretation of the past events and a more objective reconstruction of the shaping of plant landscape over time. Spatial analysis of land cover is one of the most important tools to detect the recent impact of human activity on the ecosystems: this is indeed the major force in shaping changes through time, in association with other biotic and abiotic factors (Serra et al. 2008). In particular, the Mediterranean basin is one of the most altered area on Earth, as a result of an intensive human exploitation since millennia. It was estimated that only 4.7% of primary vegetation of this region remained unaltered and the landscape has been continuously transformed (Geri et al. 2010).

Materials and Methods

The study area is the Prato province (latitude 43°52'50.93" N, longitude 11°05'47.62" E, datum WGS84), a 365 km² area located in the north of Tuscany, Italy (Fig. 1a). A set of 43 points was selected, according to the Archaeological map of the Prato province (Perazzi and Poggesi 2011) (Fig. 1b) in order to study areas affected by human frequentation since Prehistory. A buffer of 50 meters radius was built around all points and each buffers has been divided into patches

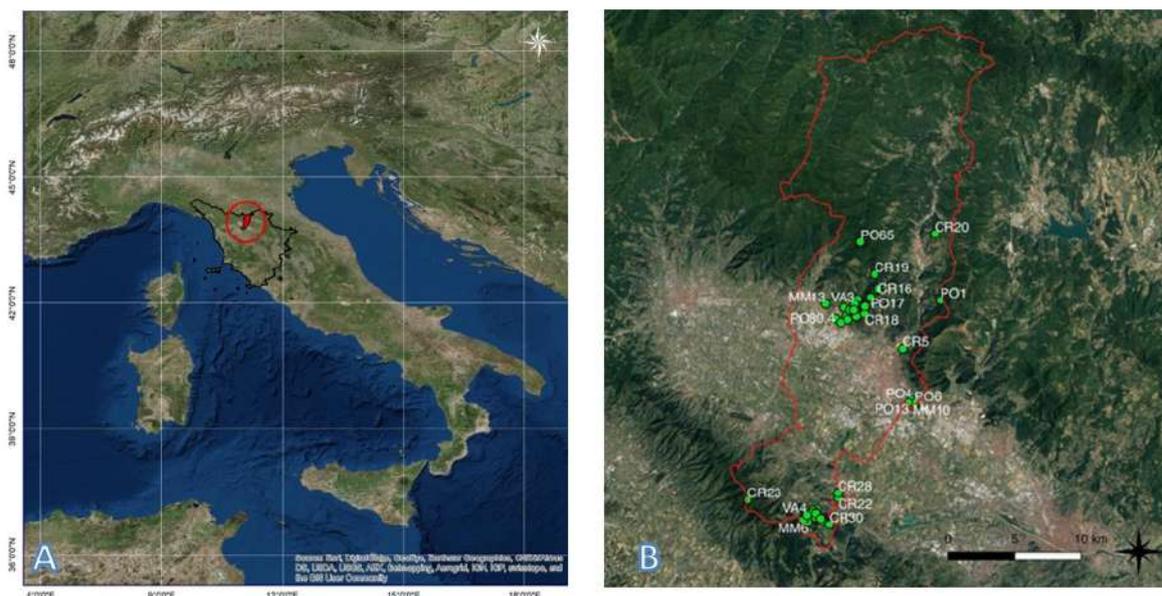


Figure 1 - A) The Prato province. B) The points of the Archaeological map of the Prato province; the abbreviations correspond to the municipalities.

based on the different land cover. These selected points and their buffers have been overlapped with four aerial photographs taken, respectively, in 1954, 1978, 1996 and 2016, georeferenced and digitized within a geographic information system (EPSG 3003 – Monte Mario / Italy zone 1) (Fig. 2), with the aim of reconstructing and analyzing the land cover and its change of use over the last sixty years.

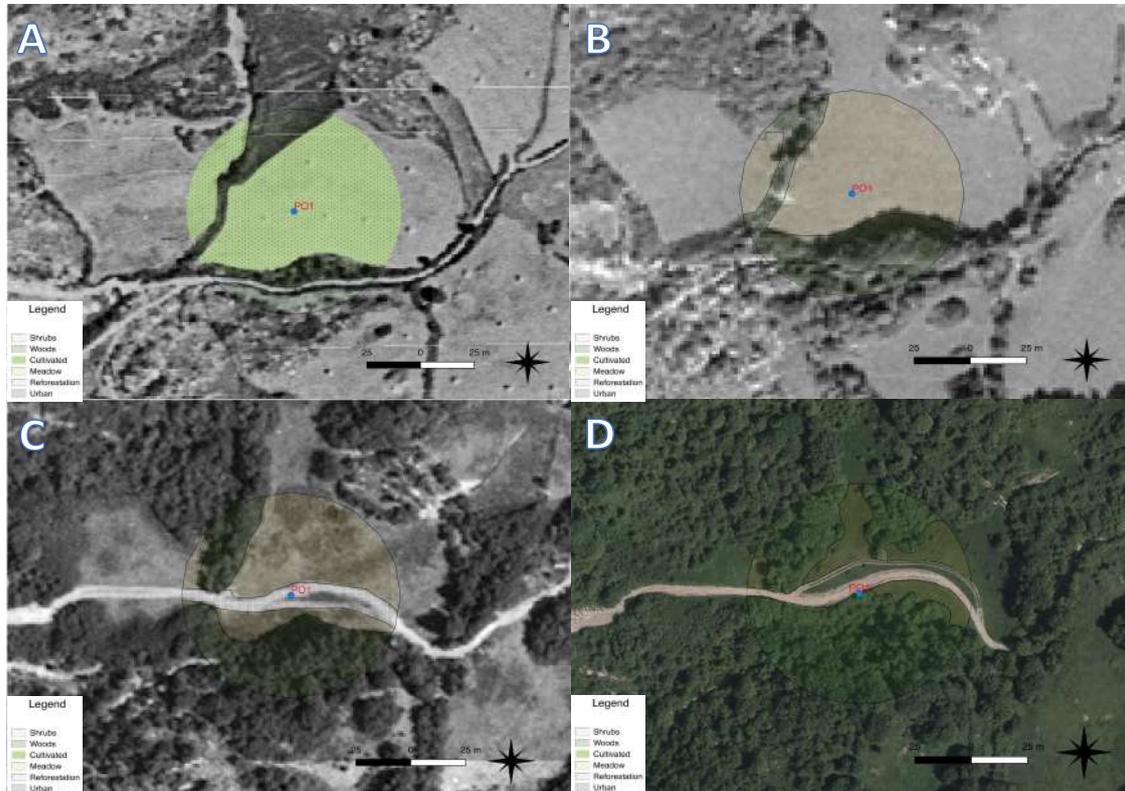


Figure 2 - The PO1 point and the land covers observed over the years 1954 (A), 1978 (B), 1996 (C) and 2016 (D).

Results and Discussion

Spatial analysis evidenced a significant change in land cover and use of the soil in the selected buffers, initially characterized by patches with different coverage. The cultivated areas, abundant in 1954, showed a regular reduction in the following years, lowering their surface by more than half in the orthophoto of 2016. The opposite trend was observed for the urbanized areas that increased regularly tripling their surfaces in the last sixty years. As a whole, urbanized and cultivated areas covered more than 42% of the total area. Human impact is also demonstrated by the regular presence of reforestation areas, often affecting a surface higher than 20% of the total area, while natural areas, characterized by shrubs and woods, showed a different trend. In this perspective 1978 may be considered a year of landscape change. In fact, before this year woodlands are less than or equal to 10% of each buffer, while the shrubs fill a surface of more than 10%; after 1978, woodlands increase their area twice and shrublands decrease their surface by less than 10%.

Conclusions

The land cover and land use in the Prato province during the last sixty years shows the evidences of a constant anthropic impact with a direct anthropic pressure (urbanization and soil exploitation) always greater than 42%. This human impact has undergone some changes over

time, causing reduction of the cultivated areas and increasing of the urbanized ones. As a result of the abandonment of the agricultural activity, woodlands has increased over the years, in particular on the hilly and mountainous slopes, as has been also observed in other areas of Tuscany (Geri et al. 2010). This has also led to a homogenization of the previous landscape mosaic, as can be seen from the reduction in the patches with different coverage.

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The dynamics of a non-forested area in the Ore Mts.: an effect of a short-lived medieval village on the local environment

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Keywords: *bioarchaeology, deserted medieval village, environmental reconstruction, succession*

Introduction

Spindelbach was a short-lived and deserted medieval village located in a marginal area on the ridge of the Ore Mts, NW Bohemia, Central Europe (CE). Colonization of the area started in the 2nd half of the 13th century AD and coincided with favourable climate recorded in 1260-1380 AD during the Medieval Warm Period (MWP) and with the socioeconomic boom in Czech Lands (CL). Spindelbach was established above 800 m a.s.l., more than 100 m a.s.l. higher than other co-established villages. It was abandoned no more than 200 years later at the onset of the Little Ice Age (LIA) in the middle of the 15th century AD when the socioeconomic situation markedly changed in CL. Nowadays, the management in the Ore Mts. prefers expansion of spruce stands, forest planting on the area of former non forested areas, and application of lime to lower acidification. But, as highlighted by Gaillard (2007) processes at long timescales must be known and understood if an ecosystem is to be maintained or restored and similar interdisciplinary studies are still rare and do not precisely cover the area of the Ore Mts. Our aim was (1) to trace the effect of a short-term settlement on the local environment, (2) to describe the dynamics of associated non-forested areas, (3) to distinguish the sustainability of the village's agricultural background particularly during the MWP and at the onset of the LIA.

Materials and Methods

We examined a core of waterlogged sediment located in the former village green by means of multi-proxy paleo-environmental analyses (pollen, seed/fruit, microcharcoal, charcoal, diatom, and element concentration). Our data were further supported by radiocarbon dating.

Results and Discussion

(1) Significant human induced deforestation in the second half of the 14th century AD proceeded sooner than supposed, was comparable to those reconstructed in central lowlands of CL, and did not retreat after 1347 AD as in other parts of Europe. (2) Dynamics of well-insolated spring vegetation and *Calthion palustris* montane wet meadows was driven by fluctuating human impact and grazing intensity. Annual and biennial herbaceous species that peaked after the village abandonment were rapidly replaced by *Filipendula ulmaria* and *Salix* stands. The secondary forest developed towards *Picea* stands with an irreversibly changed structure, more or less lacking *Abies* and *Fagus*. Only lately, mesic montane meadows of medium tall grasses combined with *Meum athamanticum* and mountain dry pastures (*Violion canine*) expanded on

nutrient poor patches. (3) Apart from grazing that created the most significant part of the local agricultural production, we speculate that arable fields probably enabled a basal self-sustaining cultivation of winter cereals for local inhabitants even at such elevation, in good years during the MWP but not any more after the onset of the LIA.

Conclusions

Current forest management does not reflect either the natural vegetation development in Ore Mts. according to Abraham et al. (2016) nor the historical pattern of the cultural landscape.

Acknowledgements (Funds)

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Archaeological evidence of *Pinus halepensis*, *P. brutia* and *P. pinea* in ancient Thrace (Bulgaria)

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Keywords: Thrace, wine, retsina, pine, amphorae

Introduction

Pinus halepensis grows in the Mediterranean region, from Morocco and Spain to Greece and the coast of Libya, Israel, Jordan, Lebanon, and SW Syria. Aleppo pine is closely related to *Pinus brutia* (*P. halepensis* subsp. *brutia* (Ten.) Holmboe), which is largely restricted to the Turkish region and the surrounding East Aegean Islands, Cyprus and Near East. *Pinus pinea* is another coniferous evergreen species of the Pine genus native to the coastal Mediterranean. The scattered evidences of these species in the form of charred remains or organic residues in pottery vessels dated to the Classical and Hellenistic period prove close commercial contacts of ancient Thrace with the Greek area. The pine resin was used as an important preservation material. Together with pitch, resin pine made transport amphorae sealed and impermeable and as curing agent it eliminated potential risks of changing the color and taste of the wine inside the containers during transport. Over the past several decades, there have been growing a big interest in the chemical analyses of the organic residues from the material that had been stored in the vessels.

Materials and Methods

Based on the current state of research in Bulgaria (focused only on the Bulgarian area of Thrace), charred pine nut shells and pine cone fragments are collected primarily from the burial or ritual contexts in the archaeological sites. Furthermore, a large number of ceramic fragments (amphorae, cooking pots, jugs, clay hearth etc.) were submitted for chemical analyses using gas chromatography (GC), gas chromatography-mass spectrometry (GC-MS), high-performance liquid chromatography (HPLC), thin-layer chromatography (TLC), pyrolysis GC, infrared (IR) and ultraviolet (UV) spectroscopy, amino acid analysis.

Results and Discussion

Archaeobotanical evidences of pine products in the territory of Bulgaria come from several significant Thracian well-developed settlements and necropolis, usually interpreted as offerings or luxury food and drink. Also study of organic residues at the site of Pistiros, the Greek emporion on the Maritsa River, has focused on the common sherds of vessels. The identified components of the residues indicate multiple uses of these vessels. Specific abietic acids (diterpenoid dehydroabietic acid) derived from the pine resin support the hypothesis that this resin came from the Aleppo pine and most probably, some of the vessels contained resonated wine (retsina).

Conclusions

In Antiquity, significance of *Pinus halepensis* was predominantly in the production of unique wine retsina prepared by adding resin, which was extracted from the Aleppo pine. Retsina belonged to the major trade objects transported from Greece to Thrace. It has been found

frequently in the ritual contexts such as specific ritual fire hearth altars, burials or other sacred place. The availability of this wine has traditionally been associated with high social status and prestige. The identification of resinated wine dated mostly to the Hellenistic period is particularly significant because it demonstrates the widespread impact of beverage on social habits and religious, culture, and economical relations.

Acknowledgements

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On the question of the grapevine cultivation origin in Moravia

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Keywords: archaeobotany, grape vine, morphometric analysis, Mikulčice, Early Medieval Age

Introduction

The assemblage of grape pips (*Vitis vinifera* L.) from the site of Mikulčice - an important 9th century stronghold, and probably one of the first Christian religious centres - is the earliest and the most abundant early medieval assemblage of archaeological remains of this taxon in east-central Europe recovered north of the River Danube. Various authors hypothesized that it represents the earliest evidence of the local grape wine cultivation in this historically traditional wine region, which (might also) coincides with natural distribution of wild *Vitis vinifera* subsp. *sylvestris* (C.C. Gmelin) Hegi. This paper presents the first attempt to verify, whether the archaeological Mikulčice finds belong to wild or domesticated variety of *Vitis*, and by doing so, also verify the proposed hypothesis.

Background information

Even if the morphological distinction between native (wild) and cultivated grape wine seeds in archaeology is still not satisfactorily solved (lately Bouby et al. 2013), the available results show, that smaller globose seeds with very small/not prominent or even lacking beak can be attributed to the wild *sylvestris* grapevines (Stummer 1911, Levadoux 1956, Rivera et al. 2007), while large and elongated, ovoid and pear-shaped seeds with rather long beak are attributed to the cultivated *vinifera* subspecies (Webb 1968, Zohary and Hopf 1994, Buxó 1997, Terral et al. 2010).

Materials and Methods

At present an assemblage of grape pips from Mikulčice contains over 2000 finds, recovered from various settlement contexts and from the extinct river channel, adjacent to the ramparts. The majority of finds are preserved waterlogged or mineralised, and a few are charred (Opravil 2000, 2003; Látková 2017). The seeds manifest various states of preservation - from complete and very well preserved to fragmented and eroded. They also vary in shape and size – from small and globular to large and elongated, having also both short and long beak. Out of those only the 208 best preserved and complete seeds were subjected to biometrical analyses. In addition to the archaeological material, also 267 seeds of the wild *Vitis vinifera* subsp. *sylvestris* plants collected by the authors in 2016 at three localities in Slovakia (Veľký Les and Mužla) were measured and studied.

Due to lacking equipment and software, we could not apply more recent biometric methods, working with high(er) number of measured dimensions, the overall outline of the seed shape and consequent correlation of the results with data from existing databases of measurements of modern grape varieties (Rivera et al. 2007, Terral et al. 2010, Bouby et al. 2013). Instead, we used traditional methods by Stummer (1911) and Mangafa and Kotsakis (1996) and explore their possibilities in application to our material.

The most important step for the both methods is the correct measurement of four basic dimensions (Fig. 1). This was done by photographing each seed in dorsal (and in lateral) view under Leica stereoscope and measuring the dimensions by the Leica Microscope Imaging Software from those photographs.

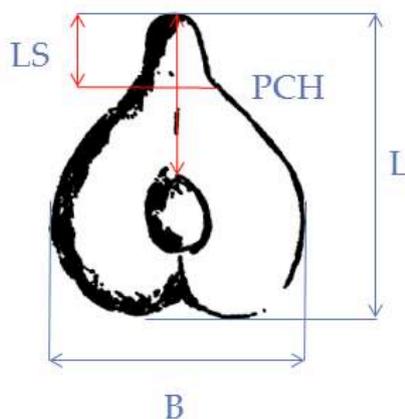


Figure 1 - Obr. 1: Measured dimensions on the seed of *Vitis*. (Legend: L – length, LS – beak length, B – width, PCH – length of the beak to chalaza, after Mangafa, Kotsakis 1996).

Next, the Stummer index ($B/L \times 100$) has been calculated for each seed. The seeds with the index value between 76 and 83 were identified as wild and the seeds with index value between 44 and 53 as cultivated subspecies. The seeds outside these ranges were unclassified.

Similarly the first two formulas of Mangafa and Kotsakis were calculated for each seed.

$$F1: -0,3801 + (-30,2 \times LS/L + 0,4564 \times PCH - 1,386 \times L + 2,88 \times PCH/L + 9,4239 \times LS)$$

$$F2: 0,2951 + (-12,64 \times PCH/L - 1,6416 \times L + 4,5131 \times PCH + 9,63 \times LS/L)$$

Then, the results from each formula were compared to values in literature for the wild and cultivated variety and the seeds were classified. Seeds outside the given ranges stayed unclassified

Results and Discussion

The results of the applied methods (Stummer 1911, Mangafa and Kotsakis 1996) do not fully agree in classification of the grape seeds from Mikulčice. First, the ratio of unclassified seeds is much higher when using Stummer index (80% for the Mikulčice and 70% for the modern wild seeds) in comparison to Mangafa and Kotsakis formula (25% for Mikulčice and 20% for modern wild).

Also, the results differ in classification to wild/cultivated subspecies. Using Stummer index, 8% of the Mikulčice finds were attributed to cultivated forms, and 12% of the Mikulčice and 30% of the collected modern *V. vinifera* subsp. *sylvestris* seeds were attributed to wild forms. In contrast, by the Mangafa and Kotsakis formulae, not only 15% of finds from Mikulčice but also 2% seeds from the wild plants(!) were classified as cultivated forms. By these formulae, up to 60% of Mikulčice and up to 78% of the modern wild seeds were classified as wild forms.

Nevertheless, using a combination of both methods, we see that 50% of the classified early medieval seeds belong to *sylvestris* and (only) 30% belong to the cultivated *vinifera* subspecies.

The seeds of modern wild *Vitis vinifera* subsp. *sylvestris* demonstrate rather strong uniformity of measurements and shape (see also Pagnoux et al. 2015), while our early medieval seeds, classified as “wild”, are quite variable. This is especially evident in the length or prominence of the beak. As pointed out by Negru (1960), under effect of cultivation the beak has grown

unproportionally faster than the seed length. Therefore, this heterogeneity of the “wild” and the presence of cultivated forms in the early medieval assemblage seems to indicate the presence of cultivated variety, rather than the wild stock.

Conclusions

To conclude, the results of the biometrical analyses of the grape pips from early medieval stronghold and the early Christian religious centre of Mikulčice (Czech Republic) are not straightforward. The applied methods enabled to classify less than 70% (when using Mangafa and Kotsakis method) or 20% (if using method of Stummer) of the finds. Among the studied grape seeds, there are both the wild and cultivated subspecies. Even though wild seeds (small, rounded, with small beak) dominate the assemblage, the heterogeneity and divergence from the modern wild seeds (caused mostly by more prominent beak) can be regarded as presence of cultivated varieties, which have been under cultivation only for a short time.

The question whether the cultivated grapes of Mikulčice, from which the studied grape pips originate, were grown locally or imported in the form of wine or other product, awaits further research.

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Could seed image analysis be helpful in the archaeobotanical studies? The case of *Vitis vinifera* L.

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Keywords: archaeobotany, computer vision, seed image analysis, seed morphology, *Vitis vinifera*

Introduction

Application of computer vision techniques in archaeological plant remains, proved to be an effective tool for the identification of both charred and waterlogged seeds (Terral et al. 2010; Bouby et al. 2013; Orrù et al. 2013; Pagnoux et al. 2015; Ucchesu et al. 2015, 2016, 2017; Sabato et al. 2017).

Plant remains can give important information about the relationship between human and plants in the past, related to diet, plant domestication and origins of agriculture (Zohary et al. 2012). In some cases, identification of remains is not easy because of the alteration of the morphology seed shape. Moreover, since the archaeological seeds of many domesticated plants are morphologically very similar to those of wild ancestors, it is very difficult to distinguish them (Hillman et al. 1993). For example, the seeds of *Vitis vinifera* L. ssp. *sylvestris* (C.C. Gmel.) Hegi and *Vitis vinifera* L. ssp. *vinifera* are highly similar (Zohary et al. 2012). In this study, the results about image analysis applied on waterlogged and charred grapevine seeds found in the archaeological sites of Sa Osa (Cabras, Sardinia) and Monte Meana (Santadi, Sardinia), respectively dated to the 12th- 10th century BC and to the 3rd – 2nd century BC (2017–1751 BC), are presented.

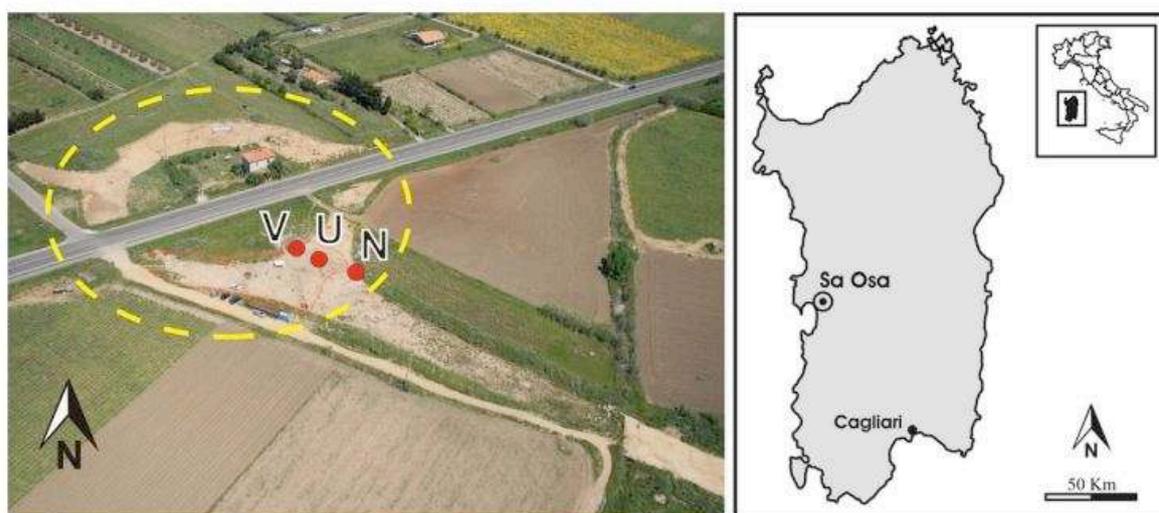


Figure 1 - Sa Osa wells, and location map of the site in Sardinia.

Materials and Methods

A total of 2009 waterlogged pips from the wells N, U and V of Sa Osa settlement were analysed (Fig. 1). Moreover, 8 charred grape seeds in a layer containing other biological remains and a pottery, were studied from Monte Meana found (Fig. 2; Ucchesu et al. 2016).

Modern grape samples consist of 13 accessions of *V. vinifera* L. ssp. *sylvestris* and 41 cultivars of *V. vinifera* L. ssp. *vinifera*, both collected from Sardinia.

Digital images of the modern and archaeological samples were acquired using a flatbed scanner (Epson Perfection V550) with a digital resolution of 400 dpi for a scanning area not exceeding 1024×1024 pixels. The images were processed using the software package ImageJ v. 1.49. To increase the number of discriminant parameters a further 80 Elliptic Fourier Descriptors (EFDs), descriptive of the seed contour shape, were computed using the open source SHAPE software (Iwata and Ukai 2002).

Statistical analysis was performed with the SPSS software package release 16.0 (SPSS 2006), applying the same stepwise Linear Discriminant Analysis (LDA) as described by Grillo et al. (2012). A cross-validation procedure was applied to test the performance of the classifiers, as reported by Venora et al. (2007).

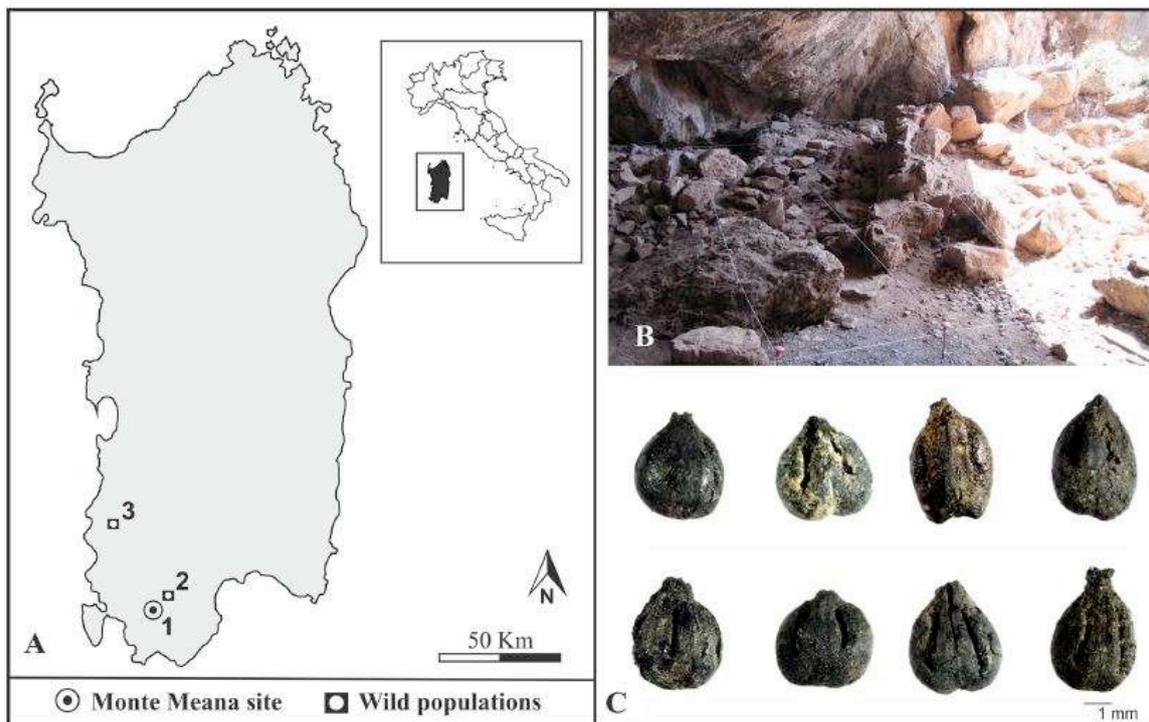


Figure 2 - A: Location of the Monte Meana cave (1) and populations of *V. vinifera* subsp. *sylvestris* from Santadi (2) and Fluminimaggiore (3); B: Archaeological area of Monte Meana; C: Archaeological charred grape seeds discovered.

Results and Discussion

Archaeological samples were compared with modern wild and cultivated accessions. The archaeological pips from Well N were identified as *V. vinifera* ssp. *vinifera* in 95.3 % of the cases, while those from Well U were equally distributed between *V. vinifera* ssp. *vinifera* and *V. vinifera* ssp. *sylvestris*. Pips from Well V were identified as *V. vinifera* ssp. *sylvestris* in 66.3% of the cases. The results of the comparison of charred grape seeds showed 81.3% of similarity among archaeological seeds of Monte Meana and wild grapes. Moreover, statistical analyses

showed that the archaeological seeds were similar to wild grape seeds grown near the archaeological site, reaching the 75% of correct identification.

Conclusions

The discovery of many grape pips preserved in waterlogged contexts at the site of Sa Osa allowed investigating the domestication status of grapes during the Bronze Age in Sardinia. Considering the high scientific and cultural value of plant remains, and the availability of a new, accurate, reliable and above all non-destructive technology able to morphologically investigate, characterize and compare archaeological remains, we wanted to prove the usefulness of seed image analysis in archaeobotanical studies.

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Image analysis technique for the identification of archaeological *Prunus* fruit-stones of Sardinia

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Keywords: archaeobotany, image analysis, morphometric features, *Prunus*, Sardinia

Introduction

Fruit remains from the genus *Prunus* L. are frequently recovered during excavations in archaeological waterlogged contexts since prehistoric times. The identification of *Prunus* based on traditional methods is difficult due to the morphological range variation within the different taxa, mainly due to hybridization problems (Woldring 2000). Despite this, some research shows that *Prunus* fruit-stones would be the most stable of the all diagnostic characters used for their identification (Depytere et al. 2007).

In the last two decades, to properly identify the remains found in archaeological contexts and to overcome the manual procedure for the classification of seeds, a morphometric approach based on the image analysis, was performed. Thanks to this technique it is possible to distinguish wild species from cultivated ones using automated system, replacing human visual assessments in a more accurate, reliable and repeatable way also in archaeobotany (e.g. Bouby et al. 2013; Orrù et al. 2013, 2015; Pagnoux et al. 2015; Ucchesu et al. 2014, 2016, 2017).

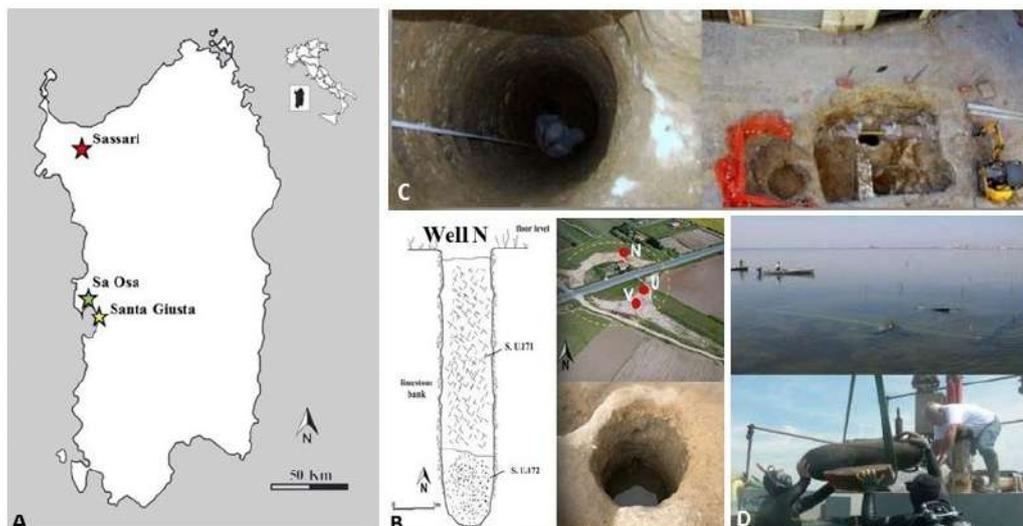


Figure 1 - A) Location of the investigated archaeological sites; B) Sa Osa context; C) Medieval site of Via Satta (SS); D) Santa Giusta lagoon context.

With this in mind, the main goal of this research is to compare Sardinia archaeological fruit-stones with modern one by image analysis system. The results obtained allow to increase knowledge about the origin and use of wild and cultivated *Prunus* fruits in the diet of human communities of the past and to investigate the relationships with traditional varieties still cultivated in Sardinia.

Materials and Methods

The waterlogged *Prunus* fruit-stones analysed in this study came from the archaeological sites of Sa Osa (1286-1115 BC), Santa Giusta (600-300 BC) and Via Satta-Sassari (1330-1360 AD) (Fig. 1). The archaeobotanical remains were extracted from the sediment, cleaned, kept in distilled water and stored at +5 °C in the Germplasm Bank of Sardinia (BG-SAR) (Porceddu et al. 2017). Modern samples consist of 2130 fruit-stones of *P. spinosa* collected in Sardinia and 1663 of *P. domestica* collected from the field catalogue of CNR-ISPA (OR, Sardinia).

Digital images were acquired with a flatbed scanner according to Bacchetta et al. (2008) and processed using the software ImageJ v. 1.49. The morphometric parameters were obtained through a specific plugin able to measure 26 morphometric features and 80 Elliptic Fourier Descriptors (EFDs). Applying the stepwise Linear Discriminant Analysis (LDA), using IBM SPSS software package release 16.0, a morphometrical comparison among the archaeological fruit-stones of *Prunus* and the modern one was performed.

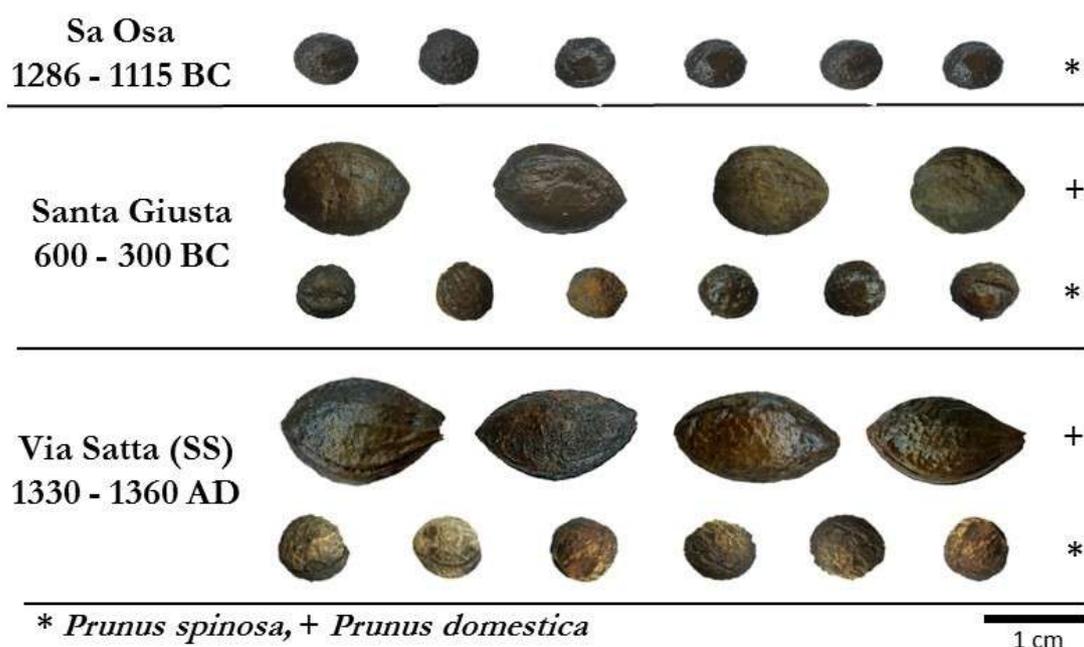


Figure 2 - The identified *Prunus* samples.

Results and Discussion

Thanks to the exceptional state of preservation of the fruit-stones remains it was possible to investigate and identify *Prunus* taxa found in the archaeological sites of Sardinia.

Prunus remains from Sa Osa have been identified as wild in the 100% of the case. The results suggest that since the Bronze Age, Nuragic people had knowledge about the use and consumption of *P. spinosa* proving to be an important complement to their diet.

The analyses conducted on the samples of Santa Giusta allowed identifying 53 archaeological fruit-stones as *P. spinosa*. In fact these specimens showed morphometric similarities in 92.5%

of the cases with the modern wild samples currently growing near to the archeological site (Fig. 2). Likewise, the 11 archaeological fruit-stones identified as *P. domestica* showed similarity with the modern varieties, in particular with a variety currently cultivated in the village of Bosa (OR, Sardinia) called Sanguigna di Bosa (Ucchesu et al. 2017). Furthermore, several modern varieties of *P. domestica*, with yellow drupes, showed similarities in the morphometry of the fruit-stones found in the medieval well of Via Satta (Sassari).

Conclusions

The results presented in this study represent new data about the application of image analysis technique for the identification and classification of the archaeological fruit-stones of *Prunus*. The discovery of several *Prunus* remains in waterlogged contexts of Sardinia allowed to investigate about the use and consumption of these fruits through time. Thanks to the image analysis technique it was possible to identify both wild and cultivated species of *Prunus* found in archaeological sites of Sardinia. These analyses indicated that the use and consumption of *P. domestica* was well established in Sardinia since the Phoenician and Punic period. Therefore, the use and consumption of *P. spinosa* was still a diffuse practice since the prehistory.

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New tool for identification of Mediterranean plant diaspores

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Keywords: atlas, seed, fruit, Mediterranean

Introduction

Archaeobotanical research lies on the correct identification of archaeological remains of seeds and fruits. Reliable identification is crucial to ensure that the interpretation of the data analyzed is accurate and consistent. In this regard, most laboratories have built reference collections of modern plant material to be compared to the archaeological remains. The implementation of these collections is often expensive and time-consuming while seed and fruit atlantes offer an important support to the identification process. Many of the works focused on identification have been published in the last sixty years while many are mostly concentrated on a specific geographical region and/or group of plants (Hubbard 1954; Berggren 1969; Behrendt and Hanf 1979; Davis and Cullen 1979; Berggren 1981; Hanf 1983; Hubbard 1984; Villarias 1986; De Rougemont 1989; Anderberg 1994; Bojňanský and Fargašová 2007, Nesbitt 2006; Jacomet 2006; Cappers et al. 2009, 2012, 2013), and some are also oriented to archaeological remains (Jacquat 1988; Schoch et al. 1988; Neef et al. 2011). These atlantes only partially include taxa native to Mediterranean basin, which can sometimes be disadvantageous for Southern European researchers. In addition, Mediterranean Flora descriptions such as the *Flora Iberica* (Castroviejo 1986-2012) or the *Flora d'Italia* (Pignatti and Anzalone 1982), which are indeed very useful to identify whole plants, only focus on seeds and fruits as long as they are essential for species identification.

The Atlas Project

The archaeobiology laboratory belonging to the CSIC, the Spanish Research Council started building its collection in the '90s thanks to the collaboration with more than 300 worldwide institutions. The laboratory currently holds a seed collection of around 5500 accessions for 3859 different species from 212 families and 1151 genera. It is mainly focused on cultivated (cereals, legumes, fruits, etc.) and wild plants with emphases on Mediterranean species of economic importance and it is one of the largest of its kind. Therefore, driven by our desire to share the results achieved with scientists from all over the world, an idea was born of creating a new database with high quality images of seeds and fruits, especially intended identification purposes.

A total of ca. 2500 accessions were selected using the following criteria: 1) Native wild plants from the Iberian Peninsula; 2) Native wild and cultivated plants from the Mediterranean regions of economic importance (e.g. medicinal, dyes, etc.); 3) Cultivated plants prior to the 15th century AD (excluding thus American species). Some of these seeds and fruits have been never recorded with such a wealth of details, especially the smallest ones. We established a protocol designed to enhance and speed the identification process by primarily dividing the accessions according to size for then organizing intuitive sheets showing the items in the same scale according to the size group (Fig. 1).

This project, which is in the construction phase, is at an advanced stage with more than 3/5 of the selected accessions already photographed. We hope to make it accessible to the research community by the end of 2018.



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Apiaceae



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Figure 1 - Example of a sheet of the atlas.

Acknowledgements (Funds)

This project has been carried out within the PIE project 201710E017 (Atlas de Semillas de la P. Ibérica) coordinated by L. Peña-Chocarro. D. Sabato holds a post-doc position within the above project.

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Environmental conditions of ancient Paphos and the region - geoarchaeological research in SW Cyprus

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Keywords: *ancient, alluvia, Cyprus, geoarchaeology, geomorphology*

Introduction

Since 2014 the research team from Jan Kochanowski University in Kielce has participated in the archaeological research in Paphos in SW Cyprus. The studies focus on the interaction between humans and environment in this region. The human activities were connected with the geology, relief, climatic conditions, water management, soils and vegetation. The main aim of the study is reconstruction of the coastline near the ancient city (study *on site*) and the influence of natural factors on the functioning of the ancient city Nea Paphos and the region between the Ezousas River valley on the the south and the Koskinas River valley on the north (study *off site*) (Fig. 1).

In *on site studies* the surveyed area was the archaeological site in Paphos along with its surroundings. Several route sections were conducted. Underwater survey in several locations around the peninsula enabled the research team to recognize marine relief located in the coastal area. The *off site studies* allows us to examine morphology and alluvia of the two nearest Paphos valleys. One of the valleys surrounds the peninsula from the north (Koskinas), and the second one from the south (Ezousas).

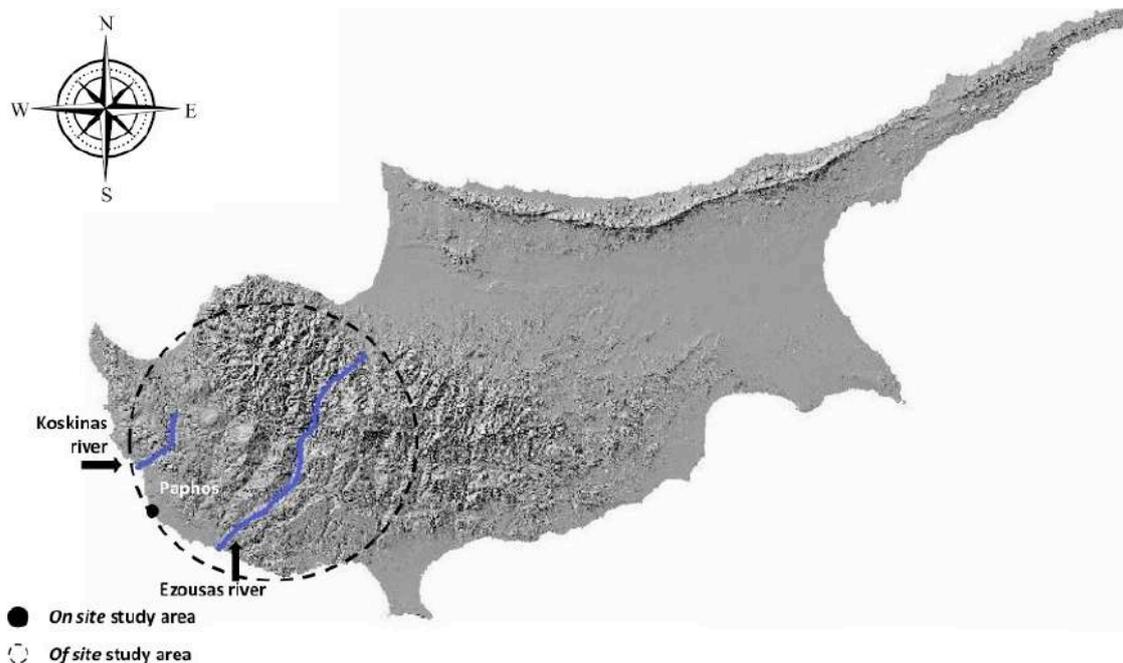


Figure 1 - Map of Cyprus and research area *on site* and *off site* (by S. Chwałek).

Materials and Methods

In 2014-2015 a geophysical exploration of the Agora in Nea Paphos, was made. The results of the research were published in 2015 and 2016 (Kalicki et al. 2015; Chwałek et al. 2016a). The geoarchaeological exploration which was done at the same time was based on geomorphological analysis of the Paphos region. The Rutkowski's method was used for grain size sediments and TL/OSL dating (Rutkowski 2007, Chwałek et al. 2016b; Kalicki et al. 2016).

Results and Discussion

The geomorphological surveying of the Paphos peninsula and its area allowed us to determine the set of morphogenetic processes for modelling coastal plains in the region of Cyprus.

On site studies showed anthropogenic transformation of some edges of the lower marine terraces (MIS 5-7) by ancient quarries (Fig. 2). Also the karstic relief was changed or used by man – the rough karst surface was artificially levelled and in the karst holes were wells filled with Tertiary *terra rossa* i.e. well in Agora dug up during 2014.



Figure 2 - Edge of marine terrace anthropogenically transformed by ancient quarry (photo T. Kalicki).

The geoarchaeological research (*off site* study) let us recognize the morphological levels (some terraces and floodplain) in the valley of the Koskinas and Ezousas rivers. The alluvial sediments derived from these two rivers. Periodically, the rivers transported coarse material. The lower section of the Ezousas alluvia consists of fine-grained material in the lower part of the profile and coarser material in the upper part. The change is probably connected with an anthropogenic factor. Present-day alluvia presented typical Anthropocene deposits (alluvia with garbage). It is a mixture of coarse clastic sediments and anthropogenic rubbish (Kalicki et al. 2016).

Coarse alluvia of the Ezousas River presents a big difference along the river and also on the different morphological levels. The alluvia of the Pleistocene terrace are finer than the Holocene alluvia. In the estuary of Ezousas River (beach) the material is a mixture of fluvial sediments from periodic river flooding, and marine deposits. Gravels came from cliff abrasion. This is one of the important geomorphological processes for the geoarchaeological reconstruction of the Paphos seashore.

In the Koskinas River all sediments are finer than the alluvia of Ezousas. In the middle part of the valley there are intercalations of buried soils and Pleistocene coarse alluvia of the Koskinas River.

In the study, we developed the first model of a functioning environment in the region of Paphos.

Conclusions

Anthropogenic environmental changes in ancient time in Cyprus bring a complete disappearance of natural vegetation and, as an effect, a transformation of erosion-accumulation cycle in the river's valley.

Acknowledgments

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Stable isotope analysis between archaeology and palaeoenvironment: the case of Arslantepe (Turkey)

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Keywords: *stable isotope, archaeobotany, palaeoclimate, Arslantepe, agricultural practises*

Introduction

The main goal of archaeobotany is investigating past relationship between human communities and environment. The study of plant remains from archaeological contexts is traditionally focused on the reconstruction of past vegetation and the way in which plant resources were used and managed by humans. Particularly seeds and fruits analysis looks at the various aspects of plant use related to both cultivated and wild species. On the other hand, wood analysis leads to the reconstruction of evolutionary trends in vegetation and human exploitation. In recent years archaeobotanical research has additionally reached a significant position in the production of palaeoclimatic, palaeoenvironmental and agronomic knowledge thanks to interdisciplinary applications. Plant remains are a powerful tool to explore the role of climate in the evolution of environment and ancient societies. Especially stable carbon and nitrogen isotope analyses on plant remains are recently used to reconstruct past climatic and environmental conditions (e.g. Aguilera et al. 2012; Masi et al. 2013a,b) and reveal agricultural practices (e.g. Riehl 2012; Arous et al. 2014; Masi et al. 2014).

Materials and Methods

Isotopic analysis has been carried out on plant remains recovered at the long lasting site (from 4700 BP to historical time) of Arslantepe, Turkey. The archaeobotanical research reveal a huge amount of plant remains widely studied and carefully selected for the purpose of this research. Both cereals (barley, emmer and wheat) and wood (deciduous oaks and junipers) have been selected and analysed.

There is a physiological relationship between water availability and carbon isotope composition in plants. $\Delta^{13}\text{C}$ in wood is mainly related to climate fluctuations (Farquhar et al. 1989), in cereals is linked with natural or human-induced water supply. Furthermore, soil nutrients constitutes a limiting factor for plant growth (Templer et al. 2007). Stable Nitrogen isotope in cultivated plants is mainly conditioned by anthropogenic activities as manuring practices (Bogaard et al. 2007).

Results and Discussion

$\Delta^{13}\text{C}$ and $\delta^{15}\text{N}$ on barley, emmer and wheat have been obtained to distinguish palaeoclimatic changes from human choices in agricultural practices during the period from 4300 to 2000 BC. A diachronic studies on isotope records from single archaeological sites is a unique possibility and parallels are actually missing. A clear isotopic trend of cereals is evidenced in time both in water supply and in manure application. Results have been also paralleled to the complex history of the site. Barley crops have been irrigated during the rise of centralized political organization at the site, from 4300 to 3100 BC. Successively, from 3100 to 2000 BC, domestic activities are attested and the relocation of barley fields are suggested. $\Delta^{13}\text{C}$ in wheat and emmer points out that they could have been grown close to the site, where abundance of water from natural springs was available.

The marked increase of barley $\delta^{15}\text{N}$ values from 3350 to 3000 BC point out manuring practices and/or cultivation in pasturelands. Moreover, $\delta^{15}\text{N}$ evidences intercropping cultivation during 3000–2500 BC probably related to the increase of pasturelands during herders' occupations (Vignola et al. 2017).

$\Delta^{13}\text{C}$ curves from deciduous oaks and juniper reveal that climate between 4700 to 2000 BC was generally wetter than the present one. The region experienced wet condition from 4700 to 3400 BC when the social complexity at the site increased. After that and until 3000 BC a climatic instability phase occurred and the drought peak registered at ca. 3250 BC coincides with the collapse of the centralized state. The following period characterized by pastoral societies correspond with amelioration of climate conditions. Finally dryness can be related with the social instability phase at around 2300 BC (Vignola et al. submitted).

Conclusions

The interpretation of archaeobotanical data from Arslantepe, aligning isotopic, palaeoenvironmental and archaeological evidences constitutes a successful example of a new approach to archaeobotany and archaeology. A climate trend have been reconstructed with periods of enhanced and reduced precipitation only partly recorded in the charcoal assemblages. Agriculture was characterized by irrigation, fertilization and intercropping practices. The richness of the results complete the archaeological data giving an incredibly detailed drawing of the past societies and their relationship with climate change between the 5th and the 3rd millennium BC.

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A geoarchaeological perspective on human-environmental sustainability in arid lands of North Africa

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Introduction

Geoarchaeology is the application of the methods of Earth Sciences to study archaeological contexts and landscapes. A geoarchaeologist works at the scale of a single site, to understand the depositional and post-depositional processes triggering the preservation or destruction of archaeological layers, and at the scale of landscape, reconstructing the distribution of sites in the ancient landscape of a region and interpreting how this territory changed over time. For these reasons, Geoarchaeology fundamentally contributes to, and informs the field of Environmental Archaeology.

Materials and Methods

This paper considers the many possible contributions of Geoarchaeology for ancient landscapes reconstruction, sites distribution, and natural resources exploitation, including the main issue of human-environmental sustainability in arid lands.

Results and Discussion

Before Geoarchaeology existed as its own interdisciplinary and independent scientific pursuit, some investigations were carried out in North Africa, in the hyperarid central Sahara and along the Nile Valley. Many geologists assisted archaeologists in the interpretation of site formation processes, as well as analysis of ancient landscapes. Among these, it is noteworthy to cite the immense work done by K. Butzer along the Nile Valley of Egypt. Butzer published some fundamental volumes, including *Environment and Archaeology: An Introduction to Pleistocene Geography*, *Environment and Archaeology: An Ecological Approach to Prehistory*, and *Archaeology as Human Ecology*, introducing an *ante litteram* geoarchaeological perspective on Environmental Archaeology (Butzer 1964, 1971, 1982). Pioneering work by Pasa and Pasa Durante (1962) interpreted landscape changes on the basis of the reconstruction of sedimentary and taphonomic processes affecting archaeological anthropogenic cave sediments in context of climatic changes in the Tadrart Acacus region of the central Sahara.

The works of these scholars opened new paths in the study of North African site contexts, highlighting also in this region the necessity to integrate Archaeological Sciences and Earth Sciences. In recent decades, various collaborative research has been carried out in North Africa, from the Mediterranean shorelines to the hyperarid Saharan belt, and the Nile Valley and Levantine corridor. The interpretation of Pleistocene and Holocene landscape changes is directly related to the reconstruction of the availability of natural resources (raw material, water, food sources...) and strategies for their exploitation. In this sense, the geoarchaeologist can interpret in a dynamic, ecological perspective the evolution of the landscape and propose hypotheses on its functional exploitation by human groups over time and across different environmental settings. Moreover, the investigation at the scale of site enables archaeological evidence to be placed into environmental contexts, and to understand how an archaeological site formed and may have changed over time, as a function of the natural and anthropogenic

processes promoting accretion, and the role played by erosion, for example. The latter environmental factor is critical in arid and semiarid regions of North Africa; as therein most of the archaeological sites corresponds to open-air contexts deeply affected by wind erosion (deflation) and landscape lowering. One task for the geoarchaeologist is to reconstruct the pristine setting of deflated archaeological sites. Finally, the most recent investigation in the field of geoethnoarchaeology of arid lands represents a novel tool to reconstruct the exploitation of the limited natural resources by present-day communities, thus offering the possibility to propose new models of land use possibly rooted in the adaptation of the late Holocene cultural groups. For that reasons, a geoarchaeologist should have a strong background in several of the Quaternary Geology-related disciplines, including geomorphology, pedology, and sedimentology.

Today, even though a large part of the region is inaccessible due to political instability, the attention of geoarchaeologists focuses on a multi-scalar approach, starting from the remotely-sensed, geomorphological analysis of landscape units and their evolution, and archaeological sites identification. In this, a main part of the work is the comprehension of the distribution of natural resources, which represented a main environmental factor limiting human adaptation to arid lands and fuelling their resilience. To restate this point, limited resources may have improved human survival in this harsh landscape.

Conclusions

To conclude, we may consider that one of the main challenges for Geoarchaeology in arid North Africa, where erosion is the prevailing surface process, is to detect the invisible and intangible traces of human occupation, landscape exploitation, and climate changes. The Sahara and adjoining semi-arid lands, for instance, are generally considered as empty spaces, and limited attention is given to the occurrence of different landscape units, which today as much as in the past, correspond to different ecological niches. Geoarchaeologists must discuss the considerable geomorphological and ecological complexity of any site located in a desert, and to consider the larger region beyond the site as they very carefully reconstruct past environmental changes that affected the mutual human-environment sustainability.

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Archaeobotany and ancient biomolecules from the Early and Middle Holocene wild cereals in central Sahara

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Keywords: *wild cereals, aDNA, central Sahara, Early and Middle Holocene*

Introduction

An archaeobotanical and biomolecular research has been carried out on wild cereals found at Takarkori, a rockshelter located in the Tadrart Acacus massif (central Sahara, SW Libya), UNESCO area since 1985 (e.g., di Lernia and Zampetti 2008). The site has been excavated by the Italian-Libyan Archaeological Mission (Sapienza University of Rome) from 2003 to 2006. Chronology ranges from c. 10,200 to c. 4600 cal BP. Besides the archaeological evidence, the particular depositional setting reveals a remarkable state of preservation of the organic material (Biagetti and di Lernia 2013). In this context, dried macroremains of wild cereals have been investigated by the classical archaeobotanical approach complemented with ancient DNA (aDNA) analysis, in order to investigate the plant resources which were available for hunter-gatherer first and then pastoral groups who occupied the site.

Materials and Methods

A systematic morphometric analysis was carried out on spikelets of *Panicum*, *Echinochloa* and *Sorghum* that were found as plant accumulations during the excavation field. Spikelets have been measured by means of the software LAS EZ version 3.0.0 (Leica Microsystems). Ancient DNA has been extracted from spikelets of *Panicum* testing ten different protocols, in order to obtain suitable (in terms of yield and purity) nucleic acid to be investigated by the DNA barcoding approach (using specific chloroplast regions: *rbcL*, *matK*, *trnH-psbA* and *trnL*). About aDNA of *Sorghum*, it has been applied the Next Generation Sequencing (NGS) approach (Fornaciari 2017).

Results and Discussion

The morphometric analysis on 2100 spikelets of *Panicum laetum* Kunth (species identification confirmed by aDNA analysis), *Echinochloa colona* L. and *Sorghum bicolor* L. Moench subsp. *verticilliflorum* (Steud.) de Wet ex Wiersema and J. Dahlb. shows that each genus has consistent size. The remarkable uniformity of measures in the same accumulation and among the records belonging to different chronological contexts is noteworthy (Fig. 1; Fornaciari 2017). The wild cereals found at Takarkori, selected by type, are evidence of a deep knowledge of the plants distributed in the region and of the presence of a small group of wild cereals continuously collected in the area for a very long time (about 5,000 years). Human activity, therefore, could have prolonged the survival of these cereals during the climatic oscillations of Early and Middle Holocene, in the mountains of the Tadrart Acacus (Mercuri 2008a, 2008b).

The molecular analyses confirmed the preservation of organic molecules in the macroremains, as also demonstrated by Dunne et al. (2012, 2016), who identified animal and plant fatty acids in samples coming from the same context. In our research, the protocol modified from Kistler

and Shapiro (2011) resulted the best for the recovery of endogenous aDNA from the spikelets of *Panicum*, allowing PCR amplification and sequencing of the barcode regions. The phylogenetic relationships between ancient *P. laetum* and modern species became evident from this analysis



Figure 1 - Plant accumulation n. 9601. It is visible the size uniformity of the specimens, including *Panicum laetum*, *Echinochloa colona*, *Setaria* sp. and *Urochloa* sp. (from Mercuri et al. 2018).

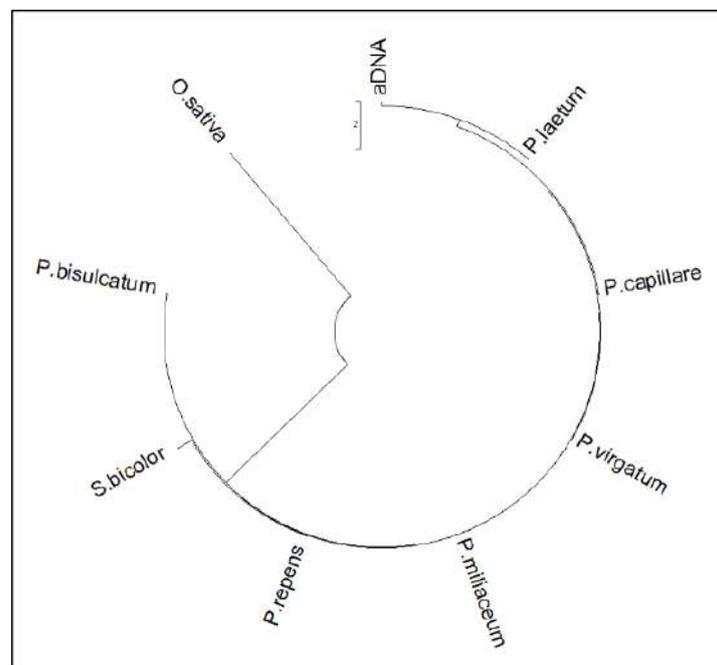


Figure 2 - Evolutionary relationships of taxa based on the combination of the three DNA barcode sequences *rbcL*, *matK*, *trnH-psbA*. Evolutionary analyses were conducted in MEGA7 using the Neighbor-Joining method (modified from Fornaciari et al. 2016).

(Fig. 2; Fornaciari et al. 2016). About *S. bicolor*, morphological data are compatible to a pre-domestication stage not yet visible in the phenotype. It has not been possible to obtain results from the NGS analysis for further investigation of its genome. However, the molecular study of the record from Takarkori is very important for future agri-food applications, because it potentially preserve the genome of the progenitors of the modern crops (Fornaciari 2017).

Conclusions

The analyses confirm that Early and Middle Holocene biomolecules of Saharan wild cereals have survived until today. The set of data obtained from this research allowed a better understanding of both the palaeo-environmental context, made by climate and human actions, and the past human behaviour in exploiting wild cereals. These wild cereals were adapted to the changing environments and their presence changed during the different cultural and environmental phases at Takarkori. The archaeobotanical study, including systematic analyses of the plant accumulations, distribution and contexts, allowed to observe the gathering and cultivation of wild cereals in central Sahara (Mercuri et al. 2018).

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Keywords

A

Accelerator Mass Spectrometry
aDNA
Agricultural practices
Agroforestry
Alluvia
Amazon
Amphorae
Ancient
Ancient cypress plantation
Apennines
Araucaria forest
archaeobotanical
Archaeobotany
Archaeological continuum
Archaeological sites
Archaeology
Archaeopalynology
Archaeophytes
Archaeozoology
Archeological map
Arslantepe
Artificial basin
Atlantic forest
Atlas
Auvergne

B

Bioarchaeology
Biochemical analysis
Biodiversity
Birch bark tar
Bronze Age
Burnt offering sites

C

Carbonized plant
Carpology
Central Europe

Central Sahara
Climate Change
Computer vision
Conservation
Coprolites
Ct scan
Cultural landscape
Cyprus
Czech Republic

D

Databases
DEM
Deserted medieval village
Diet
Distribution range

E

Early and Middle Holocene
Early Medieval Age
Economic change
Ecosystem services
Empty spaces
Enamel
Environment
Environmental reconstruction
Environmental Resource Archaeology
Etaghas
Ethnobotany

F

Fagus sylvatica L.
Farming practices
Ferrara
Fiber
Fire-affected vegetation
Forest change
Forest cover

Keywords-----

Forest history
Fruit
FTIR analysis

G

Geoarchaeology
Geobotany
Geochemistry
Geomorphology
Grape vine
Grassland
Gravettian
Grazing
Greece
Greek colonization

H

Heaths
High-alpine
Historical ecology
Historical maps and documents
Historical processes
Holistic
Holocene
Human impact
Human-induced forest expansion
Hunter-gatherer-fishers

I

Image analysis
Immigration
Integrated approaches
Isotopes
Italy

K

Kiln

L

Land cover and land use
Land use

Landscape
Landscape exploitation
Late Acacus
Late Neolithic
LGM
Local production practices
Long-term vegetation changes by pollen
Longue durée
LOVE and REVEALS estimated vegetation cover
Lusatian culture

M

Macroremains
Medieval Age
Mediterranean
Mediterranean concept
Middle Ages
Mid-mountain
Mikulčice
Modena
Morphometric analysis
Morphometric features
Mountains
Movable fens
Multidisciplinary research
Multi-proxy
Mutina

N

Natural resources management
Necropolis
Neolithic
Neolithic agriculture
Neolithic environment
New plants
New World species
North Africa
Northeast Italy
Northern Apennines

O

Off-site

Keywords-----

Olive
Oplontis
Outfield resources

P

Palaeoclimate
Palaeoenvironment
Palù di Livenza
Palynology
Pasture indicators
Peat bog
Pedoanthracology
Pelagonia
Phytoliths
Pine
Pitch
Pit-fillings
Plant communities
Plant terminology
Pollen
Pollen analysis
Pollen and charcoal analysis
Prague Castle
Prunus
Pxf

Q

Quaternary

R

Radiocarbon dating
Recession cultivation
Renaissance
Residence time
Resilient
Retrogressive succession
Retsina
REVEALS
River
Roman
Roman age
Roman Peasant Project

S

Sahara
Sardinia
Saxs
Seed
Seed image analysis
Seed morphology
Seeds/fruits
Settlement pattern
Shipwreck
Sicily
Site
Soil charcoal analysis
Southern Brazil
Southern Italy
Southern proto-Je
Spatial analysis
Spatial structure
Stable isotope
Strontium
Succession
Sustainability

T

Tadrart Acacus
Tells
Terramare
Thrace
Timber
Toledo Mountains
Topsoil
Triticum
Tuscany

U

Upper Drwęca
Urban environment
Urban sustainability
Useful plants
Utica

Keywords-----

V

Vegetation
Vegetation change
Vegetation history
Vesuvian area
Vicia
Vitis vinifera

W

Water cult reconstruction

Waterlogged settlement
Wetland plants
Wetlands
Wielbark culture
Wild cereals
Wine
Wood remains

X

x-ray microCT

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