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A look at the region

Of Humans and Science. Laboratory of Archaeobotany and Palaeoecology and the Second Decade of Environmental Archaeology at the University of South Bohemia

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ABSTRACT

The Laboratory of Archaeobotany and Palaeoecology (LAPE), of the Faculty of Science of the University of South Bohemia in České Budějovice (USB) was founded twenty years ago. The department is closely linked with the Institute of Archaeology of the USB in terms of staff and projects, which are mainly focused on the issues of paleoecology, archaeobotany and archaeozoology. The present paper discusses the teaching of environmental archaeology and projects focusing on Europe, but also on some areas of Africa. The text provides background information on the teaching and research projects that have taken place over the last ten years, but also on the research and scientific directions that the department is currently pursuing.

1. Introduction

The Laboratory of Archaeobotany and Palaeoecology (LAPE) was established in 2002 at the University of South Bohemia in České Budějovice (USB). The then decision of the Dean of the Faculty of Biology (today Faculty of Science) formally confirmed the activities of specialists who had been conducting archaeobotanical and archaeozoological research at the Department of Botany since 1996 (Beneš *et al.*, 2022). Time is moving fast, and another long decade has passed since the last review of the activities of the Department (Bernardová *et al.*, 2012). How has the lab evolved, and what is its current activity? All this is the topic of this outline. First, it should be said that LAPE has undergone a transformation over the last ten years, especially in developing academic projects and stabilising its activities. The original role of a service laboratory for archaeobotanical and archaeozoological analyses has been transformed into a standard research unit. The increasing number of students has then led to the development of a training centre, not only in the field of doctoral studies for the Department of Botany and Zoology, but in particular its interdependence with the Institute of Archaeology of the Faculty of Arts of the USB.

Another significant technical change took place in 2013, when LAPE and the Centre for Polar Ecology moved to a newly-renovated building at Na Zlaté stoce 3 on the edge

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Figure 1. The building of the Laboratory of Archaeobotany and Palaeoecology and the Centre of Polar Ecology in the University of South Bohemia Campus. Photo Jaromír Kovárník.

of the university campus (Figure 1). LAPE thus gained important premises for its activities. In early 2014, a major formal change in status occurred when LAPE, originally a laboratory within the Department of Botany, was transformed into an independent unit within the Faculty of Science. Thus, LAPE operates as a training workplace for students in botany, zoology and archaeology. The cooperation with the USB Institute of Archaeology has been essential, and the two departments are linked by several projects and personnel ties. While the USB Institute of Archaeology primarily has facilities for studying artefacts, depositories, and field equipment for archaeological research, LAPE is equipped with a chemical laboratory, microscopy facilities, and other necessary equipment for bioarchaeological research and teaching.

2. Education activity of LAPE in 2012–2022

LAPE members have traditionally been involved in teaching botany. Pedagogically, LAPE is still associated with the Department of Botany and Department of Zoology. In the framework of Master's and PhD studies in Botany, LAPE staff are responsible for the specialisation of archaeobotany and archaeozoology. In this regard, the University of South Bohemia is the only educational institution in the Czech Republic where both disciplines can be studied can be studied. In parallel, LAPE members teach these disciplines at the Institute of Archaeology, Faculty of Arts, in a modified way designed for archaeology students. Teaching is carried out in several key courses within the Master's degree. In addition to the Archaeobotany or Archaeozoology courses (Figure 3.), LAPE members teach Historical Ethnobotany, Imaging in Bioarchaeology, and several practical courses. The link with the USB Institute of Archaeology has been implemented since the undergraduate degree started, where LAPE members provide the Introduction to the Environmental Archaeology course. This two-semester course is a major motivational tool to attract new quality students. Already undergraduate students can choose to prepare their student qualification thesis within the environment and facilities of LAPE which is equipped for this purpose with high-quality research microscopes (Figure 8), literature and an archaeobotanical reference collection.

In the field of archaeobotany, which is dominant at LAPE, the department provides training and facilities for botany and archaeology doctoral students. This offers possibilities for developing interdisciplinary relationships: very valuable and enriching for the students of both faculties. The Institute has several international collaborations in the field of archaeobotany, especially with universities in Modena (Anna Maria Mercuri) and La Sapienza Rome (Laura Sadori), as well as with the University of Constantin of Philosopher in Nitra (Mária Hajnalová) and, more recently, with the Johannes Goethe University in Frankfurt am Main (Alexa Höhn). There is a traditional and long-standing collaboration with the Archaeobotany Department of the Institute of Archaeology, University College London (Dorian Fuller).

LAPE has at its disposal a comparative osteological collection of Holocene mammals, birds, and fish that have originated in central Europe. It is continuously being expanded and completed in cooperation with the Department of Zoology at the Faculty of Science USB. Except for the recent animal species, it also includes some skeletal specimens from archaeological excavations. The animal skeletal collection is used for the practical teaching of osteology in courses intended for students of biology and archaeology at the Faculty of Science and the Faculty of Arts, USB (for example, Archaeozoology, Archaeozoology for Archaeologists, Imaging in Bioarchaeology). At the same time, it is indispensable for analyses of animal bone assemblages when needed for dissertations and student projects. Postgraduate qualifications of students in the field of archaeozoology may be evaluated and deepened abroad

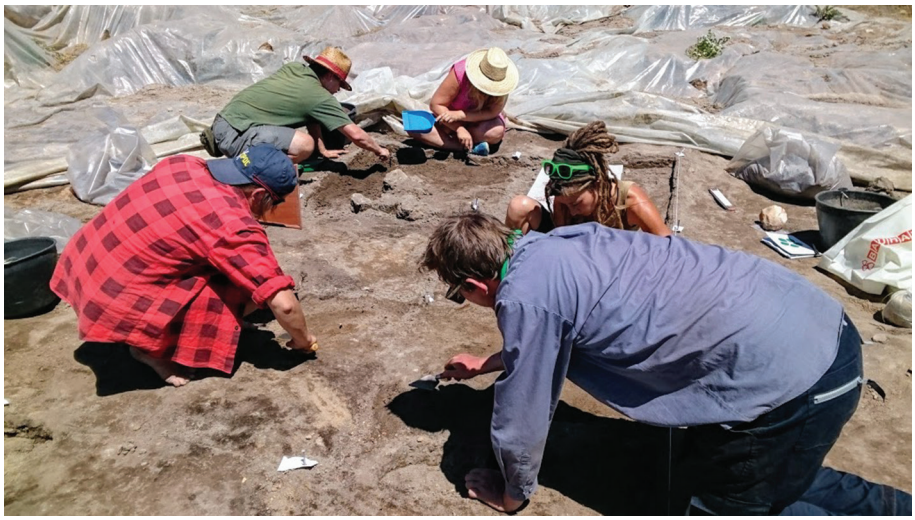

Figure 2. Sampling the Neolithic building floor for botanical macroremains at the Vrbjanska Čuka tell in 2018. From left – Tereza Majerovičová, Jiří Bumerl, Kristýna Budilová, Michaela Vychronová and Jaromír Kovárník. Photo Jaromír Beneš.

within the inter-university cooperation European Erasmus+ program (*e.g.*, Nicolaus Copernicus University in Toruń, Laboratory for Bioarchaeology at the University of Belgrade *etc.*).

3. Research activities and projects 2012–2022

3.1 Palaeoecology of central Europe. The testimony of former lakes. Archaeophytes

At the beginning of the last decade, attention drawn to the question of the origin of contemporary landscapes has been concentrated on issues of species composition of vegetation in central Europe. Our palaeoecological research has been focused on the vegetation history of the highest altitudes above the upper forest line (Novák *et al.*, 2010), through to the boreal forests formed by fire events (Novák *et al.*, 2012), and all the way down to lowland wetlands. Lake sediments are an ideal natural archive that records past changes not only of the lake itself but also of the surrounding environment. Our palaeoecological team have paid attention to the development of the Late Glacial and Holocene lake ecosystems with the former lakes of Velanská cesta (Nováková *et al.*, 2008; Bešta *et al.*, 2009) and Komořanské jezero (Novák *et al.*, 2011; Bešta *et al.*, 2015; Houfková *et al.*, 2017). Hornomoravský Úval (Upper Moravian Valley) is one of the key lowland regions in central Europe. This biogeographical corridor enabled the spread of species from southern refuges to the Czech Republic and further on to Poland, as well as the early onset of the neolithisation process. Our palaeoecological research has been aimed at describing the crucial shifts that led to the formation of the recent landscape mosaic through multi-proxy investigation (Abraham *et al.*, 2017; Bernardová *et al.*, 2017; Novák *et al.*, 2017; Novák *et al.*, 2018).

Further to the question of the origin of our contemporary landscape, a review focused on the formation of central European grasslands since the Neolithic period, when the typical species composition began to form under significant human influence, has been published (Hejcman *et al.*, 2013). LAPE members were also involved in the question of how and when archaeophytes penetrated the landscape of central Europe and what type of human influence was responsible for this new species influx (Pokorná *et al.*, 2018).

3.2 Dendrochronology and climatology

The focus of dendrochronological research in LAPE is aimed at the South Bohemian silver fir (*Abies alba*) population through the use of archaeological material and the coring of living trees. The dendrochronological material is used in researching South Bohemian silver fir ecology and climatic changes in the past. Dendrochronological research in LAPE is also focused on two other issues. The first is dendroanthracology, which belongs to the newly-developing field of dendrochronology. Charred wooden remains are analysed utilising the dendrochronological means and methods developed at the beginning of the 20th century. However, in the case of tree ring visualisation, there are systems (Keyence) that enable us to analyse these problematic samples. The second approach which is just starting to be used is research on the stable isotope composition of wood samples (tree rings). In this instance, the stable carbon and oxygen isotope signals are a proxy for the climate. We research the assessment of taphonomic factors which artificially affect the isotopic composition of archaeological wood from various wet and dry sites.

LAPE has been involved in research on bat guano in the eastern Slovak Domica Cave, where pollen analysis has played a major role and where the state of the landscape has been captured in the phase of the medieval climatic optimum in relation to the current landscape. A thousand-years-old, one-meter-deep deposit in the Domica Cave (Slovak Karst) has been discovered and analysed. The pollen record captured alder forests between 897–1024 AD and temperate light broad-leaved oak-hornbeam forests between 1522–1800 AD, and, more recently, willow shrubs. The pollen record further indicates that the bats prefer to forage in a forest-steppe landscape with open

Figure 3. Petr Šída documenting the excavation at the Kudrnáčova Pec rock shelter, northern Bohemia. Photo Michaela Ptáková.

Pannonian broadleaved forests and humid, temperate, riparian environments (Svitavská *et al.*, 2015).

3.3 Environmental Archaeology of the Prehistory

3.3.1 North Bohemian hunter-gatherers, farmers, and shepherds

The laboratory has long been engaged in environmental-archaeological research projects on the prehistoric communities of the North Bohemian sandstone rock towns (Figure 3). In this line of research, LAPE strongly cooperates with the Center for Theoretical Study, a Joint Research Institute of Charles University and the Czech Academy of Sciences (Petr Pokorný), the Department of Archaeology at the Philosophical Faculty, University of Hradec Králové and the Institute of Archaeology of the Czech Academy of Sciences in Brno (Petr Šída). Well-stratified layers in rock shelters and adjacent wetlands provided excellent materials for applying an extensive, multi-method approach, including analysis of plant macroremains, charcoal, pollen, phytoliths, vertebrate remains, molluscs, along with archaeological data and radiocarbon dating. The research has traced vegetation development since the Last Glacial Maximum

Figure 4. The excavation of the Neolithic site of Dehtáře. Photo Jiří Bumerl.

to the present day and provides insights into the role of prehistoric hunter-gatherer and farming communities in the changing Holocene landscape (Šída and Pokorný eds., 2020; Pokorný *et al.*, 2022a). Special attention was devoted to the evidence of plant use among hunter-gathers (Divišová and Šída, 2015; Ptáková *et al.*, 2021b; Pokorný *et al.*, 2022b), the issue of the transition to farming (Ptáková *et al.*, 2021a) and the phenomenon of forest grazing of domestic animals in the agriculturally unfavourable, peripheral region of the Bohemian Paradise (Ptáková *et al.*, 2021c)

3.3.2 Early farming among Neolithic communities of central Europe

A further project deals with the strategies of the first farmers of South Bohemia, conducted in cooperation with the Institute of Archaeology of the Czech Academy of Sciences in Prague (Václav Vondrovský), and funded by the Czech Science Foundation (Figure 4). The project's archaeological and archaeobotanical research efforts have expanded upon the phenomenon of the secondary-colonised regions beyond the loess belt, which were not penetrated by the initial wave of farmers and can be understood as peripheral to the LBK settlement located in the fertile central European lowlands. The project seeks to understand the dynamics of occupation in the region, interregional contacts, possible contacts with hunter-gatherer groups, local farmers' subsistence strategies, and their interactions with the regional environment (Ptáková *et al.* 2021a). The laboratory is particularly engaged in archaeobotanical research, which was applied to examine whether crop husbandry in the peripheral areas differs from that of the core regions, as well as to assess the role of wild plant gathering in the agricultural periphery and to explore the spatial and temporal diversity in the plant food economy of early farmers in South Bohemia.

Archaeozoological research associated with Neolithic settlements is mostly related to the low-altitude fertile (core) regions of the Czech Republic, where there are favourable soil conditions for the preservation of animal bone remains. The archaeozoological approach, including stable isotope analysis, applied to large archaeofaunal assemblages presents an effective tool for understanding the role of domestic and hunted animals in the Neolithic economy, animal husbandry practices, and the environment in which livestock were bred (Gillis *et al.*, 2017; Berthon *et al.*, 2018; Řídký *et al.*, 2020a). A specific topic also connected with the Neolithic period is interpreting animal bones found in the late Neolithic rondel ditches (Řídký *et al.*, 2020b). In all the above-mentioned questions, LAPE has for many years been engaged in important projects that cooperated with the Institute of Archaeology of the Czech Academy of Sciences, Prague.

3.4 Environmental Archaeology of the Bronze and Iron Age

Archaeobotanical research of the Bronze Age and Iron Age in LAPE is defined by cooperation with several workplaces, primarily with the Institute of Archaeology of the USB, but also with the Institute for Classical Archaeology of Charles University (Marek Verčík) and the Department of History of Palacký University Olomouc (Martin Golec). The Institute of Archaeology USB is shaped by Ondřej Chvojka's research in southern Bohemia with the participation of analysts from LAPE (Chvojka *et al.*, 2019; Chvojka *et al.*, 2018; Chvojka ed., 2021). Research on the Bronze Age economy and society in the region of South Bohemia (Šálková *et al.*, 2019; Vondrovský and Chvojka, 2021; Šálková *et al.*, 2022) was realised during projects of the Institute of Archaeology USB.

The analysis of starch grains has become a specialised method in the last ten years, in the Czech Republic only carried out in LAPE, originally focusing on the Stone Age (Kovárník and Beneš, 2018). Thanks to the cooperation with the Department of Chemistry of the Faculty of Science of Palacký University in Olomouc (Lukáš Kučera), it has been possible to use the analysis on some starch grains from an interesting metal object. A luxury bronze bucket, dated between the Late Bronze Age (11th–10th century BCE) and the Hallstatt Period (eighth–sixth century BCE), was discovered near Kladina village in the Czech Republic. The starches from this vessel showed traces of heat and enzyme damage. This damage shows that the starch grains have gone through the fermentation process and confirmed the presence and processing of the millet grains (Jílek *et al.*, 2021). The analysis of starch grains helped to conclude that millet beer was brewed in the vessel.

3.4.1 The peculiar Bronze Age settlement site of Březnice in South Bohemia

The settlement site of Březnice, with unusually long features, is interpreted as the ritual remains of a Bronze Age community. Studies of this site were focused on the reconstruction of the settlement structure and the characteristics of the environment from which the site drew resources. The analysis of plant macroremains showed that most feature infills had a waste character. The spectra of plants were often similar (but in some aspects different) in the infills of features located close to each other – the infill of one feature is the result of various processes. Anthracological analysis detected the same spectrum of species in trenches and pits. The assemblages contained charred remains of firewood; a significant part consisting of probably burnt oak-wood constructions. The peculiar long pits (Figure 5) were very probably connected with the closing rituals following the abandonment and burial of dwelling structures/houses (Chvojka *et al.*, 2021; Kuna *et al.*, 2022). In addition to the ritually-buried houses, the background of the settlement was examined in terms of its economics and vegetation ecology. Results of botanical macroremains analyses demonstrated significant deforestation and intensive land use in the vicinity of the study site (Šálková *et al.*, 2022). Specialists from LAPE in this case conducted an analysis of plant microremains. Phytolith and starch analyses detected the remains of various parts of uncharred plants.

Figure 5. The trench-like feature 5/19 from the Late Bronze Age site Březnice in central Bohemia. Archaeobotanical finds from the site provided value contextual information about the features function. Photo Ondřej Chvojka.

3.4.2 Bronze and Iron Age burials in South Bohemia

Archaeobotanical research has also contributed to our knowledge of burial rites of the Bronze and Iron Ages in the South Bohemian region (Šálková *et al.*, 2015, Chytráček *et al.*, 2019). The composition of the plant spectra in the grave components differed from the settlement features. The infills of urn graves and burial-mound mantles reflected the processes at the burial site and were related to fire (Chytráček *et al.*, 2019). A different type of grave context was researched in small-scale excavations of a disturbed tumulus in Zahrádka (Šálková *et al.*, 2019). Corrosion products (copper salts and oxides) from two bronze hollow rings preserved organic material and textile fragments from their filling and surroundings. Interdisciplinary research involving macroremains, pollen, xylotomy, entomology, and archaeozoology analysis brought about the site environment reconstruction, and partial reconstruction of the burial rite and composition of the grave gifts (grape seed, poppy seeds, collected fruits).

3.4.3 Archaeobotany at Býčí Skála Cave burial site in Moravia

LAPE is involved in the investigations of the Býčí Skála Cave site, one of the most important central European sites of the Hallstatt period, led by the Department of History at the Faculty of Arts, Palacký University in Olomouc (Martin Golec) and the Department of Archaeology at the Faculty of Arts, Charles University (Zuzana Golec Mírová). The current research aims to revise previous findings from 1872 concerning the Hallstatt discovery in the Entrance Hall of the Býčí Skála Cave, a well-known site thanks particularly to the significant number of human remains and luxury items (Golec, 2017; Golec and Mírová, 2020). The current revision research and excavational project (2020–2021)

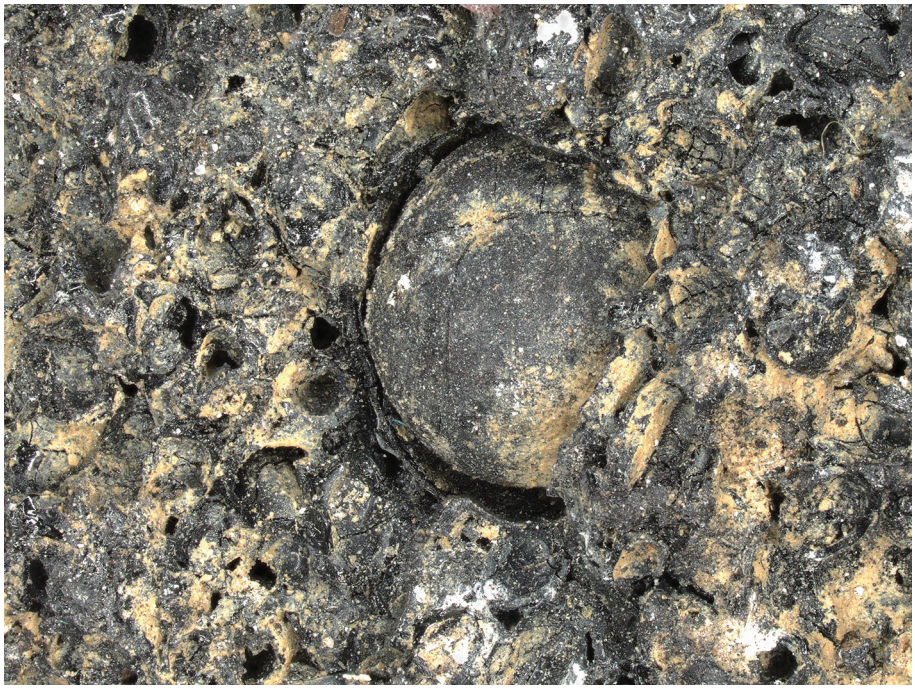

Figure 6. Microphotography of the food remains from the Býčí Skála Cave. The Hallstatt Period. Photo Michaela Ptáková.

employs various natural scientific methods to reveal local environmental issues and bring new insights into past human funerary behaviour and associated material evidence. LAPE is particularly involved in analysing charcoals and plant macroremains, discovering exceptionally preserved deposits of food remains (Figure 6). The archaeobotanical material from the Býčí Skála Cave consists of a rich "burial" layer, which, for example, contains numerous finds of millet, barley, wheat, poppy, and pulses. Among the archaeobotanical material, there are also findings of some aquatic organisms that testify to the aquatic environment (*e.g.*, daphnia) that was associated with burial rituals.

3.5 Environmental Archaeology of the Medieval and Early Modern Period. Historical centres, towns and the landscape of past villages

LAPE is also active in bioarchaeological research of two early medieval hillforts, Netolice and Prácheň, where the laboratory closely cooperates with the USB Institute of Archaeology (Martin Pták). The tradition of domestic summer schools was mainly connected with the research of the early medieval hillfort in Netolice (Beneš *et al.*, 2016). Such cooperation aimed to set the early medieval central places in a landscape context and reveal past human-environment interactions. Moreover, environmental material such as charcoal, pollen, and animal bones from both hillforts and their hinterland has been processed by students for their qualification theses.

The Laboratory of Archaeobotany and Palaeoecology has been permanently involved in archaeobotanical analyses of the medieval period in various places throughout the Czech Republic. However, the most significant results have been achieved in the area of the historical quarters of the capital city of Prague, especially in collaboration with archaeologist Petr Starec. Members of LAPE made a significant analytical contribution to the research of the sediment of the extinct pond in the New Town (Nové Město) of Prague between 2012–2014. A multi-proxy approach that combined the results of macroremains, pollen, diatom, anthracological, archaeozoological and sedimentological analyses were applied to examine the vegetative character of medieval Prague's suburbs and to consider the environmental changes that had occurred before the mid-fourteenth century when the site changed to one of building and construction (Pokorná *et al.*, 2014). The topic of the environmental archaeology of medieval Prague gave rise to a study at LAPE summarising the role of spices as an important food and trade commodity and the role of the Bohemian territory in international trade at that time (Preusz *et al.*, 2015).

At the beginning of the last decade, the results of environmental research on medieval and early modern infills of wells from the South Bohemian towns of Písek and Český Krumlov were published on the pages of this journal with the substantial participation of LAPE members. Two wells were investigated during a rescue excavation of a medieval part of Písek, Bakaláře. The infill of wells was dated to the 14th century. Due to multidisciplinary analyses, it was possible to identify imported materials of various origins and to reconstruct the environment of the town and its background, as well as the common practices for hunting, growing, and waste management in medieval times (Šálková *et al.*, 2015). The South Bohemian town of Český Krumlov, a UNESCO world heritage site, the former residence of the noble family of the Rosenbergs, is a unique mirror of the Bohemian Renaissance and Baroque. The archaeological excavation at a filled-up well at house no. 55 in the area known as Latrán was the subject of interdisciplinary interest. The result of the joint research has become a probe into a burgher household, the rich inventory of which demonstrates that the early modern lifestyle was established in a wide range of both dish-ware (artefacts from glass and pottery) and meal remains, documented by osteological materials and plant macroremains (Preusz *et al.*, 2014).

Another topic concerning the high medieval period in which the members of LAPE participated was environmental reconstruction and research on the effects on vegetation of a short-lived village. Interest focused on the abandoned village of Spindelbach located in the Ore Mountains in North-West Bohemia. The village was established during the second half of the 13th century and abandoned completely in the second half of the 15th century. This several-year project of the Department of Archaeology, Faculty of Arts, Charles University (Tomáš Klír) comprised bioarchaeological methods such as pollen and charcoal analysis, diatom analysis, and macro-fossil analysis. This multi-proxy analysis confirmed the interaction between humans, climate, and vegetation during the medieval period (Houfková *et al.*, 2019).

Since 2018, a five-year project has been supporting applied research and the experimental development of national and cultural identity (NAKI II) in cooperation with the Czech University of Life Science in Prague (Petr Sklenička and Kristina Janečková). The project is focused on the preservation and protection of the historical remnants of field systems, called "plužina", in the Czech Republic. The project aimed to provide information and develop methods for the protection of historical *plužina* because they are one of the most valuable yet neglected historical and cultural elements in our landscape (Šitnerová *et al.*, 2020). The task of the LAPE team was to obtain detailed archaeological and palaeoecological information, which included dating and description of the constructional and functional character of selected hedgerows of the *plužina* (Figure 7). The project also included the reconstruction and recording of the dynamics of the vegetation cover development based on pollen analysis in selected field systems. A total of five *plužina* field systems were selected for the project, representing different types of landscapes in the Czech Republic (lowlands, highlands, and mountains). Methodological input of the LAPE team to this project was the research of the abandoned village of Malonín in the Šumava Mountains, which for the first time, dated a terrace field in the Czech Republic using radiocarbon obtained from archaeobotanical material (Houfková *et al.*, 2015).

Figure 7. Excavation of the trench close to the Rokštejn Castle in 2019. Sounding through the agricultural terrace to obtain environmental samples. From left – Jiří Bumerl, Jaromír Beneš, Tereza Majerovičová and Ivana Šitnerová. Photo Tomáš Jůnek.

The *plužina* is formed by many complex spatial structures and field shapes that differ because of the strong influence of environmental conditions like terrain, elevation, or size of cadastre (Fanta *et al.*, 2022). Selected systems include Malonín in the Šumava Mountains (Houfková *et al.*, 2015; Janovský *et al.*, 2019), Valštejn in the Nízký Jeseník Mountains (Šitnerová *et al.*, 2020a), Oblík in the České Středohoří Mountains, surroundings of the castle of Rokštejn in the Bohemian-Moravian Highlands and Debrné in the Giant Mountains (Krkonoše). All *plužinas* were radiocarbon-dated using archaeobotanical finds from terraced field hedgerows, also with selected ones using OSL dating. The results mostly confirmed the dating of the *plužina* to the period of formation of the village to which it belonged (Beneš *et al.*, eds., 2022). The foundation of these villages and their field systems covers the period from the early Middle Ages in the case of Malonín and Debrné to the 17th century in the case of Valštejn. The establishment of villages is usually given as the first written mention, but in comparisons between archaeological research and the first written sources it is known that there is a time lag between them. The older the written mention is, the bigger the time lag. In the case of Malonín, it is almost 100 years, and in the case of the youngest Valštejn, there is only an insignificant difference (Fanta *et al.*, 2020). Through the archaeological research of hedgerows, it was found that *plužina* was a sophisticated man-made system, and some hedgerows have a stony construction.

Our department has also dealt with the archaeozoology of the medieval period. The role of animals in the medieval economic system is one of the important issues currently dealt with in LAPE. One of the ways to reconstruct the economic and social importance of animals, changes in breeding strategies, dietary and feeding regimes, or the birth seasonality of livestock, apart from studying historical and archaeological sources, is to focus our attention on the biological waste, predominantly on bone remains, which would have been produced by the inhabitants of towns and rural settlements in the High Middle Ages (13th–15th centuries). Animal bones often excavated from cesspits, disused wells, town ditches, or landfills can be examined through archaeozoological and stable isotopic analysis. The ongoing analysis of animal bone material from Prague (Wenceslas Square) and other towns (Most, České Budějovice) aims to describe the deliveries of animals from other places as opposed to local production, craft activities such as butcher's practices, physical parameters, and the health condition of the animals, composition of the animal fodder, changes in the qualities of the pasture environments, and the access to animals as it varied over time and seasons (Kovačiková *et al.*, 2019; Kovačiková *et al.*, 2020; Starec *et al.*, 2022). Research oriented in this way requires close cooperation with other institutions, especially with regional museums (The Prague City Museum, Regional Museum and Gallery in Most, South Bohemian Museum in České Budějovice), and the synthesis of the large datasets obtained forms a cross-section of the collective and multidisciplinary approach.

Finally, LAPE has also been involved in the discovery and evaluation of a rare historical botanical herbarium. A Renaissance herbarium from 1595 was the focus of some historical botany research. The book is connected to herbaria created by the naturalist Hieronymus Harder (1523–1607). This *hortus siccus* was recently found in the Muzeum Broumovska, Broumov (Braunau), Czech Republic. It is the oldest *hortus siccus* known from collections in the Czech Republic. The volume contains 358 specimens as well as annotations and drawings. Its creator was Johann Brehe from Überlingen. The authors of the research compared representations of plants from the New World and the

inclusion of mosses and lichens. The authors asked how such a work as an herbarium created in a town on the shores of Lake Constance found its way to an eastern Bohemian monastery (Skružná *et al.*, 2022).

4. Research and education projects abroad 2012–2022

4.1 Processing ancient wooden materials from Abusir, Egypt

As already mentioned, between 2005–2010, Jaromír Beneš, Jan Novák and Adéla Pokorná participated in several expeditions of the Czech Institute of Egyptology (Miroslav Bárta, Jaromír Krejčí and others), both to the Czech concession in Abusir and the Egyptian Western Desert and Sudan (Bernardová *et al.*, 2012). Research on the so-called Lake Abusir has yielded knowledge of an artificial body of water that served as part of the transport system in the foreground of the pyramid burial site. LAPE participated in soundings that monitored interdisciplinary the stratigraphy of the deposits in several locations of the former, now-already-earthed water body (Cílek *et al.*, 2012). Analytical work in the Abusir necropolis was mainly related to the mastaba of Prince Werkaure and both Old Kingdom and Third Intermediate Period burials. Mudbricks were subjected to examination, as well as wooden objects and the contents of votive vessels from the burial site. While mudbricks from the Old Kingdom, from the time of the construction of the mastaba, gave information about the environment in the then alluvium of the Nile River and its channels, wooden objects from the much younger tombs embedded in the mastaba testified to the artisanal use of various tree species such as sycamore, tamarisk and other species (Krejčí *et al.*, 2014; 2022).

4.2 Lazio summer schools and archaeobotany in Santa Severa, Lazio, Italy 2013–2015

As part of the PAPAVER project, in 2013, LAPE started a collaboration with The Museum of Sea and Ancient Navigation in Santa Severa, Italy. For three years, students and teachers from the University of South Bohemia collaborated with archaeologist Flavio Enei in the archaeobotanical analysis of a well from an ancient port of Etruscan Pyrgi, which is now located below sea level a short distance from the coastal castle of Santa Severa. Archaeobotany has yielded interesting findings about the nature of the diet of the ancient Etruscans and the natural environment at the seashore (Kodýdková *et al.*, 2013). During the summer schools in Lazio, ancient amphorae were collected and examined by LAPE staff. Their contents were subjected to chemical analysis by experts from the Institute of Chemistry of the University of South Bohemia (Jan Tříska and his team). Chemical analysis confirmed compounds, typical for resin, which was used as waterproofing material, for amphoras that could be used for transportation and storing liquids. Chemical analyses supported the hypothesis of the resin's origin from trees from the *Pinaceae* family (Preusz *et al.*, 2019). LAPE was also involved in research on the remarkable extinct Roman city of Castrum Novum during the Lazio summer schools (Enei *et al.*, 2014). Here it became clear that the very low concentration and scarcity of archaeobotanical material in the local sediments of the abandoned city did not allow for the full development of archaeobotanical activity. For this reason, LAPE did not continue the archaeobotanical summer schools in Castrum Novum. The Department of Archaeology of the University of West Bohemia later took over the research collaboration with Italian colleagues there.

4.3 Summer schools in Pelagonia, North Macedonia 2016–2018

In 2016–2018, the tradition of summer archaeological schools continued in another new country for LAPE, today's North Macedonia. The impetus was the visit of a group of Czech palaeoecologists and archaeologists to Pelagonia at the invitation of Goce Naumov, who offered to collaborate on research on the Neolithic settlement Vrbjanska Cuka near Prilep. This opportunity was organised by LAPE, which worked on this archaeological research with students from the Faculty of Science and the Faculty of Arts. The task of the teachers and students of the University of South Bohemia was to conduct archaeobotanical research on a selected section of the Neolithic tell under the guidance of Goce Naumov from the Center for Prehistoric Research in Skopje. In the summer of 2016, the floating of archaeobotanical material began in Prilep, which grew into the systematic sampling of Building 2 (Figure 2) and the profile in the western wall of the trench in the summer seasons of 2017 and 2018.

The archaeobotanical research under the guarantee of LAPE had two parts. In the first type of activity, sediments were systematically floated for the analysis of plant macroremains; in the second type of activity, USB focused on the analysis of plant microremains, mainly phytoliths in bulk sediments, but also on the analysis of starches and phytoliths on Neolithic artefacts. The results of the summer archaeobotany schools were published in the IANSA journal by experts and students involved in the research (Beneš *et al.*, 2018). Archaeobotanical material for two diploma theses was also obtained. Michaela Vychronová defended her thesis dealing with the carpological analysis of plant macrofossils (Vychronová, 2022), and Kristýna Budilová completed her thesis on plant phytoliths (Budilová, 2022). From the excavated Neolithic tell sediment, remains of malacofauna were also recovered and interpreted and analysed by Lucie Juřičková from the Faculty of Science, Charles University in Prague. Among the most interesting findings of the Czech team are mainly the site's palaeoecological characteristics from malacological and phytolith analysis, which allowed a detailed description of the natural environment around the Neolithic tell (inhabited since about 6000 BC onwards) and further into the drier environment of an ecological mosaic of grassland and shrubland, combined with a local patch of a wetter environment. The carpological analysis confirmed these findings, as well as defined the

Figure 8. Imprint of cereal on a daub fragment from the Neolithic period depicted on a high-quality microscope. Photo Jaromír Beneš.

common composition of useful plants. The collaboration between LAPE USB and the Centre for Prehistoric Research has produced the first comprehensive findings of Neolithic archaeobotany in North Macedonia (Beneš *et al.*, 2018).

Moving beyond a focus on economic concerns, an application of phytolith analysis on specific archaeological contexts of the Neolithic tell Vrbjanska Čuka aimed to bring a new perspective on past human-plant relationships as well as of the environmental ground around the site. The analysis of phytoliths further confirmed the usefulness of applying the analytical discipline in the archaeological praxis, bringing some of the first quantified observations for the Neolithic period in North Macedonia. New light was shed on the genesis of the archaeological deposits and activities around one of the buildings. Regarding the environmental conditions, the phytolith analysis brought evidence of the presence of grasslands in the critical period of the site's occupation, probably alternating with the seasonal spring shallow water pans surrounded by the river, smaller streams, discrete permanent ponds, and smaller lakes (Budilová, 2022).

4.4 Ohrid summer schools, North Macedonia 2019–2023. Archaeobotany and landscape dynamics

Since 2019, the team from the Laboratory of Archaeobotany and Palaeoecology have been working in the Lake Ohrid area. The Institute for Classical Archaeology of Charles University (Marek Verčík), in cooperation with the National Archaeological Museum of North Macedonia in Skopje (Pero Ardjanliev), has been developing its archaeological research in the charming landscape of alluvial plains and mountain ridges. The Czech Geological Survey (Jan Hošek) and the Faculty of Science of Charles University (Vojtěch Abraham and Petr Pokorný) have also been involved in the research. The project Frontier Studies under the leadership of Charles University investigates identity and cultural contacts in the border area of ancient Macedonia (Verčík *et al.*, 2019). The multifaceted research focuses on the dynamics of the habitation patterns between the Bronze Age and Late Antiquity.

People from the University of South Bohemia are also involved in this research, both in the fieldwork and post-excavation analyses of archaeobotanical and archaeozoological samples. The very first joint field research, organised as an archaeobotanical summer school, brought a great surprise in the form of the discovery of buried traces of settlement activity in the coastal area of the alluvial plain near the town of Ohrid. The first sondage in 2019 revealed the stratigraphy in the lakeshore lacustrine zone in Grašnica. Geoarchaeological investigations revealed 3.5 m-thick, deep-water lacustrine sediments overlying terrestrial vegetation macroremains, including useful plants, worked wood and abundant potsherds dated to the Late Bronze Age (LBA). According to the radiocarbon data, catastrophic flooding occurred shortly after 1214 BC. Because the area is in a highly active seismic zone, we have proposed that this event's causation was tectonically induced, metre-scale co-seismic subsidence related to faults bordering the Ohrid alluvial plain (Hošek *et al.*, 2021). The central settlement of Ohrid was then surrounded by the water of the lake and coastal lagoons.

The year 2019 also brought an interesting opportunity to investigate the dietary habits of the Neolithic population from Lake Ohrid using microarchaeobotanical methods. The Late Neolithic pile dwelling site, Ustie na Drim, in the northern part of the lake, excavated in 1962, offered ceramic fragments of large, flat, elongated pans. These artefacts could be dated by relative chronology to roughly 5200–5000 BC. According to their shape and technological traits, ceramic pans were probably used for baking. The LAPE team had the opportunity to directly sample Neolithic pottery

pan fragments during summer school at Struga museum (Valentina Todoroska). The sampled material was subjected to various methods of examining microarchaeobotanical food residues. In cooperation with chemists from the Faculty of Science of Palacký University Olomouc (Lukáš Kučera and Petr Bednář) and a number of other specialists, the type of food prepared in the pans was determined. The attached materials on the surface of studied pan fragments were sampled for consequent chemical and microscopical analyses (*i.e.*, analyses of starch, phytoliths, and microscopic animal remains). An immunological method revealed the presence of pork proteins in the samples. The detection of cholesterol confirmed the presence of some animal-origin organic residues. Analysis of detected microscopic botanical objects revealed the starch grains of several plants (*i.e.*, oak, cattail, and grasses). The ceramic pans from Ustie na Drim were used to prepare meals containing meat from common livestock in combination with cereals and wild plants (Beneš *et al.*, 2021).

Efforts in recent seasons have focused on capturing landscape change around Ohrid city (Figure 9). For this reason, during the last summer schools, in collaboration with the Frontier Studies project leaders, the focus has been on obtaining suitable dating archaeobotanical material from the highland settlements of Leskoec and Dolno Lakočerey (Figure 10). The purpose of testing them has been to obtain accurate data on settlement chronology outside of the disaster-affected alluvial plain. We have been trying to reconstruct, together with classical archaeologists, the agronomic potential of the landscape around highland settlements – and settlements located on alluvial terraces. The main objectives for future research are to understand the subsistence strategy during the critical period of transition between the Late Bronze Age and Early Iron Age and to test the hypothesis of whether a fundamental change in the economic base had an impact on the emergence of the phenomenon of princely graves in the Ohrid region.

Figure 9. Researchers observing the Ohrid floodplain during the Frontier Studies project (ICAR Charles University Prague) and the Archaeobotanical summer school (USB) 2019, Gorno Lakocherej, North Macedonia. From left – Jan Hošek, Marek Verčík and Jaromír Beneš.

Figure 10. The flotation facility in action during the summer research campaign at Ohrid 2022. From left – Patricia Ayipei, Markéta Šmolková and Jaromír Kovárník. Photo Jaromír Beneš.

4.5 The advance of agriculture into the Middle Volga basin in Iron Age Russia

One of the new topics LAPE has been addressing is the question of early forms of agriculture in the Volga-Ural region of Russia. The development of agriculture in the eastern reaches of Europe has been studied for more than a hundred years yet remains unclear. Archaeobotanical studies of the Eastern forest-steppe zone are extremely sparse. It has been hypothesised that during 200–300 CE, the Mid-Volga populations practised some form of floodplain agriculture,

which was replaced later by slash-and-burn cultivation and, even later, by ploughed agriculture with permanent fields (Ponomarenko *et al.*, 2020). This hypothesis can be tested by employing archaeobotany. The region spans the transition from the southern taiga to the steppe. The major vegetation zones of the region are, from north to south, boreal and mixed forest, deciduous forest, and forest-steppe. Open landscapes show that steppe plant communities can compete with forests. Agricultural development of these zones during the period under study presumably occurred according to 4 types, following the zoning from north to south: slash and burn, pastures, permanent fields, and agro-savannah. The period 200–700 CE included several eastward and northward human migrations. The migrants were familiar with agriculture, as indicated by finds of cultivars and agricultural implements in some of the archaeological sites of this period (Vyazov and Salova, 2022). However, the sets of cultivated plants and farming techniques could vary according to the agricultural experience of the migrants, their contacts with other agriculturalists, and local environmental constraints, for example, the geomorphological positions of various sites. The social and cultural dynamics in the area could also be affected by the climatic changes that have substantially altered the composition of the ecosystem, and which could be crucial to contemporary agricultural penetration into the forest-steppe zone.

4.6 Archaeobotany of Iron Age in Ghana

Research in sub-Saharan Africa has been strengthened in recent years by adding another topic concerning the Iron Age in Ghana. Little is known about the character of food production. In West Africa, most research on foodways has been limited to documentary evidence. These historical documents create top-down grand narratives that do not consider the ordinary local people and their agency to cause broader societal and economic changes. Despite significant advances in the narratives around the Atlantic trade, particularly the incorporation of American crops into local foodways, archaeobotanical case studies of the adoption and incorporation of American crops in Ghana are few. The study at the Likpe Kukurantumi Earthwork settlement, a Late Iron Age site, seeks to contribute to this discourse on food security during the pre-Atlantic time. This research of the Institute of Archaeology USB and LAPE USB, the African Archaeobotany Department at the Geothe Institute Frankfurt, and the Likpe Kukurantumi community will help to understand the foodways and how the people of the past interacted with their environment. The indigenous knowledge holders are the community of Likpe Kukurantumi. The 2022 November – December archaeological fieldwork has revealed an iron working site which is only 1 km away from the earthwork site, and which probably has a connection with the earthwork site. However, the local people have different narratives associated with the original settlers of the site. Given this, ceramic, archaeobotnaical, and radiocarbon dating of the earthwork and the iron working site will help to check the connectivity between these two sites. This research contributes new empirical evidence that documents some of the evolution of West African food traditions during the past two millennia (Ayipey, submitted) through the analysis of archaeobotanical samples from the study area.

4.7 Traces in Savanna. Research project in Niokolo-Koba National Park, Senegal

As with other activities in LAPE, we have conducted ethnoarchaeological and ethnobotanical research on traditional villages in West Africa and their agricultural communities. In 2018, an interdisciplinary project was launched focusing on the effects of abandonment of settlements at the Niokolo-Koba National Park in Senegal (Figure 11). The park was founded in 1954 to protect the rich biodiversity of the area and was further expanded in 1969 to 9130 km². Because of the area protection, 18 villages were abandoned, and their displaced inhabitants either had to establish new villages along the main road networks outside the park limits or joined the old traditional villages around the park (Charest, 1969; Ministere de l'Environnement, 2000). In our aim to understand the sociocultural and environmental changes derived from

Figure 11. Archaeological excavation of the abandoned village of Niemenike, Niokolo-Koba National Park, Senegal. From left to right: Tereza Majerovičová, Ladislav Šmejda (†), Jan Novák and Jaromír Beneš. Photo Idrissa Manka.

the processes of abandonment and establishment, we are combining remote sensing, soil and vegetation analyses, and ethnographic observations. Data collected in both abandoned and living villages provide insight into the customs and livelihoods of local ethnic groups in order to trace the anthropogenic changes in the local environment and the transformation of these rural communities. Our study is also aiming to document the relationship between inhabitants of villages and the surrounding environment by identifying the cultural importance, sources and uses of plants, some of which are endangered species. Thus, the project seeks to minimise an expected loss of native biodiversity and traditional ethnobotanical knowledge in an era of rapid modernisation, and where studies on traditional knowledge are key to preserving a vanishing cultural heritage (Majerovičová *et al.*, 2022).

5. Conferences

5.1 Conferences of Environmental Archaeology

The tradition of the Conference of Environmental Archaeology started in 2005 (Beneš *et al.*, 2022). These small meetings were held in Czech language under the *Archaeobotanical working group* name. In 2010, the Archaeobotanical Working group was transformed into the Conference of Environmental Archaeology (CEA). Later it was decided for it to be held every three years in English, so as to open it up to an international audience. The first international meeting was organised as the 11th Conference of Environmental Archaeology in February 2015 in České Budějovice. February 2018 saw the conference leave its central European "motherland" and head towards southern Europe, Italy. The University of Modena and Reggio Emilia undertook to do the organisation (Beneš and Mercuri, 2018). In 2020 the conference was again international and it was organised by the Czech University of Life Sciences in Prague. CEA is closely associated with the Interdisciplinaria Archaeologica, Natural Science in Archaeology journal. The main purpose of the conference is to have an annual meeting of experts from various specialisations and a lively exchange of information, mainly in Czech and other Central European languages. Notwithstanding, once every three years, the conference is held in English.

5.2 Conference of International Workgroup for Paleoethnobotany (IWGP) 2022 in České Budějovice

The highlight of LAPE's conference activity was undoubtedly the largest world conference on archaeobotany. After three years of preparation, the 19th Conference of the International Workgroup for Palaeoethnobotany (IWGP 2022) took place in České Budějovice. The conference was organised by the University of South Bohemia with the Institute of Archaeology of the Academy of Sciences in Prague. The conference organisers Jaromír Beneš and Michaela Ptáková, together with the team made up mainly of members of the LAPE, prepared a week in June filled up with talks, poster presentations, and social events (Figure 12). Almost 250 delegates from 36 countries and six continents came to South Bohemia to enjoy the meeting with colleagues – especially so after the long period of Covid-19 restrictions and regulations. The organising team and the scientific committee prepared the programme with three main themes: 1) Archaeobotany and ethnobotany as explanatory tools in the archaeocological record; 2) Origins and expansions of cultivated plants; and 3) Landscape change and human transformation of ecosystems.

In contrast to tradition, the emphasis was on the broader scope and greater integration between methods for this year.

Figure 12. The Steering Committee of the 19th International Work Group for Palaeoethnobotany, České Budějovice 2022. From left: Tereza Medová (C-IN), Michaela Ptáková, Kateřina Kročová (C-IN), Alex Bernardová, Marcela Starcová, Kristýna Budilová, Libor Vobejda, Veronika Komárková, Jaromír Kovárník, Ivana Šitnerová, Tereza Šálková, Adéla Pokorná, Blanka Bodnárová, Tereza Majerovičová, Daniel Švarc (C-IN), Jaromír Beneš. Photo Petr Pokorný.

Also, the scientific committee tried to give a chance for oral presentations of young researchers, unusual methods, and many participants from various countries. In total, there were almost 280 oral and poster presentations. Delegates could discuss their finds in two lab sessions – one was traditionally devoted to macroremains and the other, for the first time, devoted to microarchaobotanical remains. Together with the science, the participants also had the opportunity to taste our local beer, Moravian wine and home-made products at the welcome reception held in the premises of the city hall of České Budějovice. For one evening they could all sing and dance with Šukas, the informal university music ensemble, at the Faculty of Science, with the participation of the conference organiser Jaromír Beneš, and another evening at the local brewery Knežínek next to the city, while enjoying a dinner together as well as dancing at the concert of a local music band and later in the night to the DJ performance. On the occasion of the conference, a book mapping the history and current state of archaeobotany in the Czech Republic was published (Beneš *et al.*, 2022). It was rounded off with two excursions, during which archaeobotanists from all over the world experienced the beauty, natural attractions and rich monuments of South Bohemia.

6. Concluding remark

Ten years of teaching and research in fields that we usually classify as environmental archaeology have revealed new directions in research, but, above all else, a previously unusually close connection between natural and social science research. The Laboratory of Archaeobotany and Palaeoecology is now a stable, dynamically-working and well-equipped workplace, operating both in the domestic environment of the Czech Republic and internationally. We believe that the next decade will contribute to the further development of the natural science branch of archaeology.

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