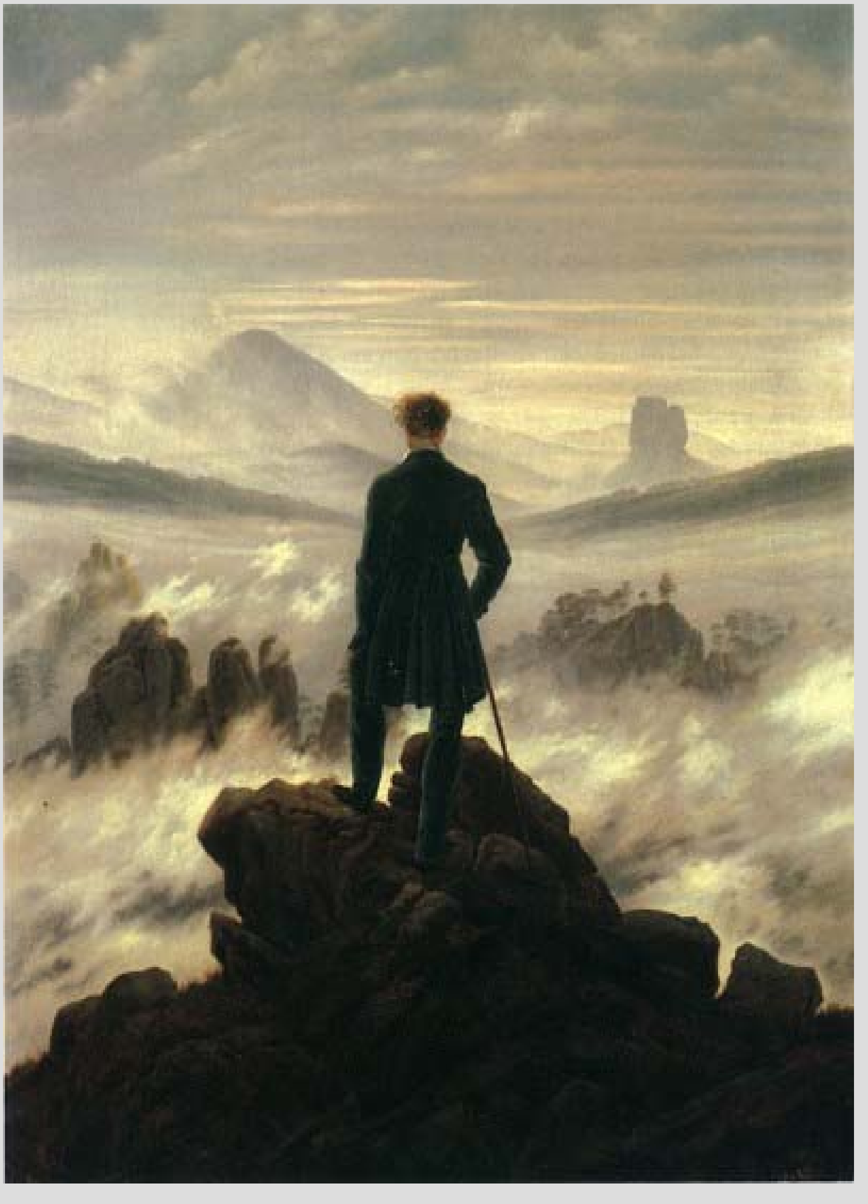
XXXII. Bog Excursion



6. – 14. 9. 2008, Czech Republic

Excursion's organizing team:

Petr Pokorný, Institute of Archaeology, Prague, Czech Republic

Petr Kuneš, Charles University, Prague, Czech Republic

Radka Kozáková, Institute of Archaeology, Prague, Czech Republic

Vojtěch Abraham, Charles University, Prague, Czech Republic

Excursion's invited speakers:

Vlasta Jankovská, Institute of Botany, Brno, Czech Republic

Helena Svobodová-Svitavská, Institute of Botany, Prague, Czech Republic

Eliška Rybníčková, Institute of Botany, Brno, Czech Republic

Jiří Svoboda, Institute of Archaeology, Brno, Czech Republic

Andrea Kučerová, Institute of Botany, Třeboň, Czech Republic

Lydie Navrátilová, Dpt. of Botany, Masaryk University, Brno, Czech Republic

Petr Zahradníček, o.s. Vladař, Loket, Czech Republic

List of the participants:

Brigitta Ammann, Institute of Plant Sciences, University of Bern, Switzerland, Brigitta.Ammann@ips.unibe.ch

Karl-Ernst Behre, Niedersächsisches Institut für historische Küstenforschung, Wilhelmshaven, Germany, behre@nihk.de

Felix Bittmann, Niedersächsisches Institut für historische Küstenforschung, Wilhelmshaven, Germany, bittmann@nihk.de

Camilla Calo, ETH, Swiss Federal Institute of Technology, Zürich, Switzerland, camiclo@yahoo.it

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Paul Henne, Institute of Plant Sciences, University of Bern, Switzerland, paul.henne@env.ethz.ch

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Lydie Navrátilová, Dpt. of Botany, Masaryk University, Brno, Czech Republic, cvilinek@gmail.com

Stephanie Samartin, ETH, Institute of terrestrial Ecosystems, Zürich, Switzerland, stephanie.samartin@env.ethz.ch

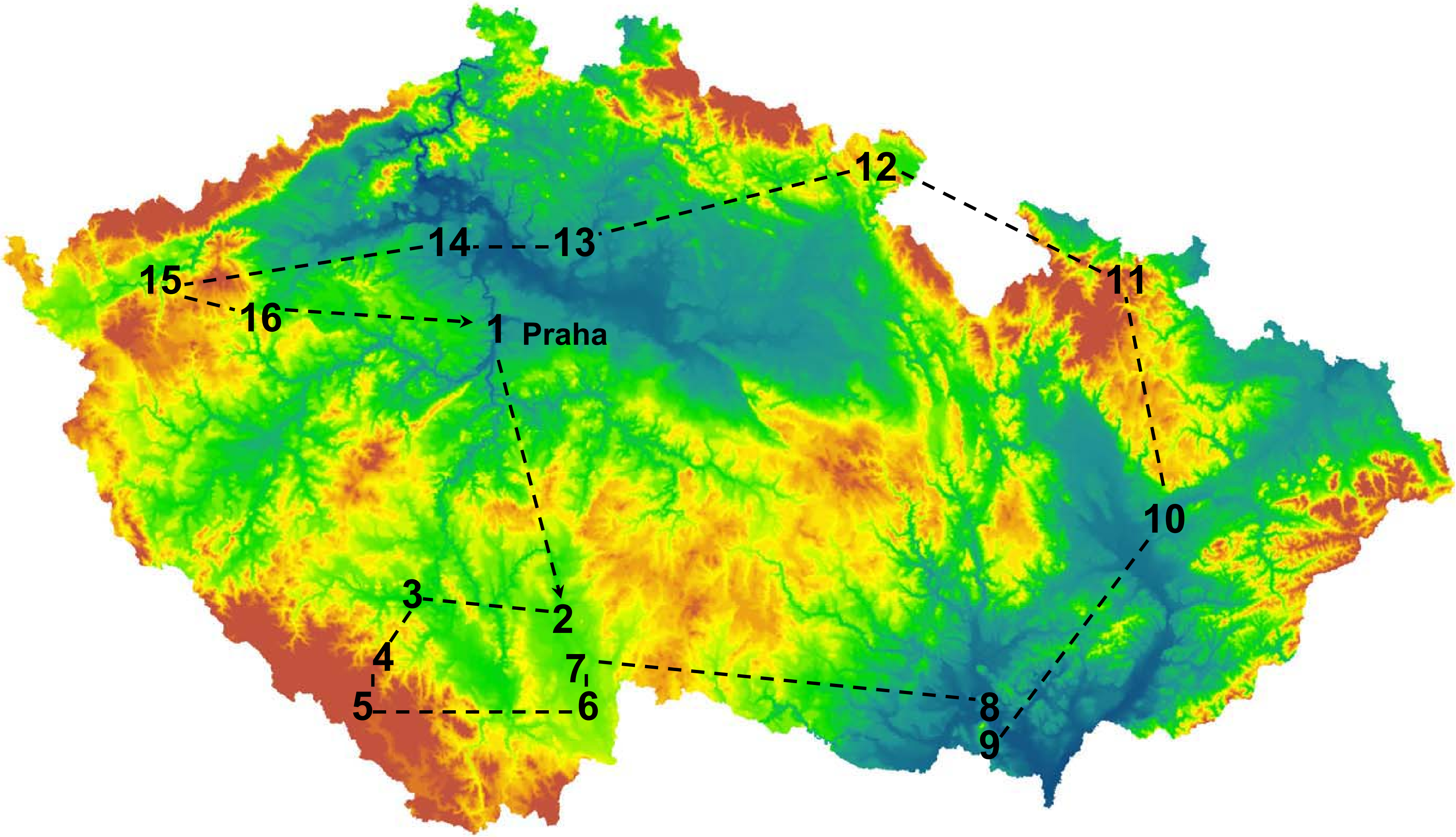
Willy Tinner, ETH, Swiss Federal Institute of Technology, Zürich, Switzerland, willy.tinner@ips.unibe.ch

Elisa Vescovi, Institute of Plant Sciences, University of Bern, Switzerland, elisa.vescovi@ips.unibe.ch

Wang Wei-Ming, Nanjing Institute for Geology and Palaeontology, Nanjing, China, wmwang@nigpas.ac.cn

Julian Wiethold, Institut national de recherches archéologiques preventives, Metz, France, julian.wiethold@inrap.fr

Steffen Wolters, Niedersächsisches Institut für historische Küstenforschung, Wilhelmshaven, Germany, wolters@nihk.de



Map of the Czech Republic with approximate excursion route. For numbers see itinerary on next page.

Itinerary of the XXXII. Bog Excursion

6. 9. 2008

Arrival to Prague (1).
Accommodation in “Masarykova kolej” hotel.
17:00 – meeting at “Masarykova kolej” hotel’s foyer; departure to welcome reception.

18:00 – **welcome reception** in the v Museum of the Charles Bridge. Introductory speeches and presentations**:** „Past and present pollen-analytical research in the Czech Republic“ (*V. Abraham* and *V. Jankovská*) and „Palaeobotany in the City of Prague“ (*R. Kozáková*).

7. 9. 2008

Švarcenberk (2) (by *P. Pokorný* and *P. Kuneš*)
Former lake palaeoecology and Mesolithic archaeology.

Řežabinec (3) (by *P. Kuneš* and *E. Rybníčková*)
Late Palaeolithic to Mesolithic archaeological site and its palaeoecology.

Accomodation at Prachatice (4).

8. 9. 2008

Bogs and glacial lakes of Šumava Mts. (5) (by *H. Svitavská – Svobodová* and *V. Jankovská*)
Palaeoecology of peat bogs and recent pollen deposition. Šumava Mts. glacial lakes.

Červené blato (6) (by *V. Jankovská* and *A. Kučerová*)
Lowland transitional mire.

Accommodation at Třeboň (7). Evening excursion to local brewery.

9. 9. 2008

Dolní Věstonice (8) (by *J.A. Svoboda* and *E. Rybníčková*)
Mammoth hunters of southern Moravia and their environment. Excursion to xerothermic vegetation of Pálava hills.

Accommodation at Mikulov (9). Local wines tasting in the castle.

10. 9. 2008

Předmostí u Přerova (10) – mammoth hunter’s museum.

Rejvíz (11) (by *L. Navrátilová*)
Ombrotrophic mountain peatbog and its palaeoecology.

Accommodation at Rejvíz.

11. 9. 2008

Adršpach (12) (by *P. Kuneš* and *V. Jankovská*)
Sandstone "town" and its palaeoecology.

Accommodation in the castle of Liblice (13).

12. 9. 2008

Zahájí (14) (by *P. Pokorný*)
Palaeoecology and settlement history of the Czech lowland.

Accommodation and a closing dinner at Loket (15).

13. 9. 2008

Special exhibition about Vladař site in the Loket castle (by *P. Zahradníček*).

Vladař (16) (by *P. Pokorný*)
Environmental archaeology of an Iron Age hill-fort.

Accommodation in Prague (1).

14. 9. 2008

Departures from Prague.

<u>The Czech Republic – some basic facts.</u>

The Czech Republic is still all things to all people. From the pulsing capital Prague to the back-in-time villages of Moravia, from toiling up mountains to lounging in spas, from the world-famous Pilsner to the strains of Smetana and Dvořák, there's an experience to suit every taste. Stunning architecture is not limited to Prague; there are plenty of beautiful structures in other towns, and significantly fewer tourists. Among the richest are Kutná Hora, Cheb, Třeboň, Loket and Domažlice in Bohemia, and Olomouc, Telč and Mikulov in Moravia.

(From Lonely Planet)

Pre-20th-Century History

The arrival of the Slavs in the 5th and 6th centuries saw the beginning of the Czechs' chequered history. Its tribes adopted Christianity and united in the short-lived Great Moravian Empire (830-906), which came to include western Slovakia, Bohemia, Silesia, and parts of eastern Germany, southeastern Poland and northern Hungary. Towards the end of the 9th century, the Czechs seceded to form the independent state of Bohemia.

Prague Castle was founded in the 870s by Prince Bořivoj as the main seat of the Přemysl dynasty, though the Přemysls failed to unite the squabbling Czech tribes until 993. In 950, the German King Otto I conquered Bohemia and incorporated it into his Holy Roman Empire. In 1212, the pope granted the Přemysl prince Otakar I the right to rule as king. His son and successor Otakar II tried to claim the title of Holy Roman Emperor as well as king of the Czechs, but the imperial crown went to Rudolph Habsburg. Strong rule under the Habsburgs brought with it Bohemia's Golden Age. Prague grew into one of Europe's largest and most important cities, and was ornamented with fine Gothic landmarks.

The late 14th and early 15th centuries witnessed an influential Church-reform movement, the Hussite Revolution, led by the Czech Jan Žižka, who was inspired by the teachings of Jan Hus. The spread of Hussitism had threatened the Catholic status quo all over Europe. In 1420 combined Hussite forces successfully defended Prague against the first of a series of anti-Hussite crusades, which had been launched with the authority of the pope. Though they were up against larger and better equipped forces, the Hussites repeatedly went on the offensive and raided deep into Germany, Poland and Austria.

In 1526 the Czech kingdom again came under control of the Catholic Habsburgs. On 23 May 1618, the Bohemian Estates, protesting against both the Habsburgs' failure to deliver on promises of religious tolerance and the loss of their own privileges, ejected two Habsburg councillors from an upper window of Prague Castle (they survived with minor injuries). This famous 'defenestration' sparked off the Thirty Years' War. The Czechs lost their rights and property and almost their national identity through forced Catholicisation and Germanisation, and their fate was sealed for the next three centuries.

In the 19th century, Bohemia and Moravia were swept by nationalistic sentiments. The Czech lands joined in the 1848 revolutions sweeping Europe, and Prague was the first city in the Austrian Empire to rise in favor of reform.

Modern History

The dream of an independent state took shape during the 20th century, gaining momentum through the events of WWI. Eventually Czechs and Slovaks agreed to form a single federal state of two equal republics. The First Republic initially experienced an industrial boom; however, slow development, the Great Depression, an influx of Czech bureaucrats and the breaking of a promise of a Slovak federal state generated calls for Slovak autonomy.

Czechoslovakia was not left to solve its problems in peace. Most of Bohemia's three million German speakers fell for the dream of a greater Germany. Hitler demanded (and got) the Sudetenland in the infamous Munich agreement of 1938 and the Czechs prepared for war. Although Bohemia and Moravia suffered little material damage in the war, many of the Czech intelligentsia were killed and the Germans managed to wipe out most of the Czech underground. Tens of thousands of Czech and Slovak Jews perished in concentration camps. On 5 May 1945, the population of Prague rose against the German forces as the Red Army approached from the east. The Germans, granted free passage out of the city by the victorious Czech resistance, began pulling out on 8 May. Most of Prague was thus liberated before Soviet forces arrived the following day.

Czechoslovakia was re-established as an independent state. Attempts to consolidate its cultural identity - and punish its oppressors - included large scale deportations of German and Hungarian inhabitants. In the 1946 elections, the Communists became the largest party, with 36% of the popular vote. The 1950s was an era of harsh repression and decline as the Communist economic policies nearly bankrupted the country. Many people were imprisoned, and hundreds were executed or died in labour camps, often for little more than a belief in democracy. In the 1960s, Czechoslovakia enjoyed a gradual liberalisation. A new president, the former Slovak party leader Alexander Dubček, represented a popular desire for full democracy and an end to censorship - 'socialism with a human face'. Soviet leaders, unable to face the thought of a democratic society within the Soviet bloc, crushed the short-lived 'Prague Spring' of 1968 with an invasion of Warsaw Pact troops on the night of 20-21 August. By the end of the next day, 58 people had died. In 1969, Dubček was replaced and exiled to the Slovak forestry department. Around 14,000 party functionaries and 500,000 members refused to renounce their belief in 'socialism with a human face', were expelled from the Party and lost their jobs. Totalitarian rule was re-established and dissidents were routinely imprisoned.

The Communist regime remained in control after the fall of the Berlin Wall in late 1989. But on 17 November things changed. Prague's Communist youth movement organized a demonstration in memory of nine students executed by Nazis in 1939. A peaceful crowd of 50,000 were cornered, some 500 were beaten by the police and about 100 arrested. The following days saw constant demonstrations, and leading dissidents, with Václav Havel at the forefront, formed an anti-Communist coalition which negotiated the government's resignation on 3 December. A 'Government of National Understanding' was formed, with the Communists as minority members. Havel was elected president of the republic on 29 December and Dubček was elected speaker of the national assembly. The days after the 17 November demonstration have become known as the 'Velvet Revolution' because there were no casualties.

Recent History

In the late 20th century, voices for autonomy in Slovakia were getting stronger, and a vocal minority was demanding independence. Finally, it was decided by prime ministers of both republics and other leading politicians that splitting the country was the best solution. Many people, including President Havel, called for a referendum, but even a petition signed by a million Czechoslovaks was not enough for the federal parliament to agree on how to arrange it. In the end Havel resigned from his post, as after repeated attempts by the new parliament he was not re-elected as president. Thus, on 1 January 1993, Czechoslovakia ceased to exist for the second time this century. Prague became the capital of the new Czech Republic, and Havel was promptly elected its first president.

Thanks to stringent economic policies, booming tourism and a solid industrial base, the Czech Republic saw a strong recovery in the initial years following the dissolution of Czechoslovakia. On May 1, 2004, the country celebrated the traditional day for workers with entry into the European Union. Improved access to European markets, foreign investment, and a solid programme of privatisation of rationalisation of previously state owned businesses has produced robust increases in GDP of around 6% per annum and limited inflation to around 2%. However, the national unemployment rate has risen to almost 10%, and is significantly higher in areas that were previously heavily industrialised. Also with EU membership has come greater numbers of younger, educated Czechs leaving to work and study in other parts of the European Union, creating a shortage of skills in their home country. However despite relatively high unemployment, and a lack of affordable housing, and moderate political instability, the Czech Republic's economy continues to strengthen more rapidly than other more established members of the European Union.

Geography

The Czech landscape is quite varied. Bohemia to the west consists of a basin, drained by the Elbe (Czech: Labe) and the Vltava rivers, and surrounded by mostly low mountains such as the Krkonoše range of the Sudetes. The highest point in the country, Sněžka, at 1,602 m (5,262 ft), is located here. Moravia, the eastern part of the country, is also quite hilly. It is drained mainly by the Morava River, but it also contains the source of the Oder (Czech: Odra) River. Water from the landlocked Czech Republic flows to three different seas: the North Sea, Baltic Sea and Black Sea. Phytogeographically, the Czech Republic belongs to the Central European province of the Circumboreal Region within the Boreal Kingdom. According to the WWF, the territory of the Czech Republic can be subdivided into four ecoregions: the Central European mixed forests, Pannonian mixed forests, Western European broadleaf forests and Carpathian montane conifer forests.

Weather and climate

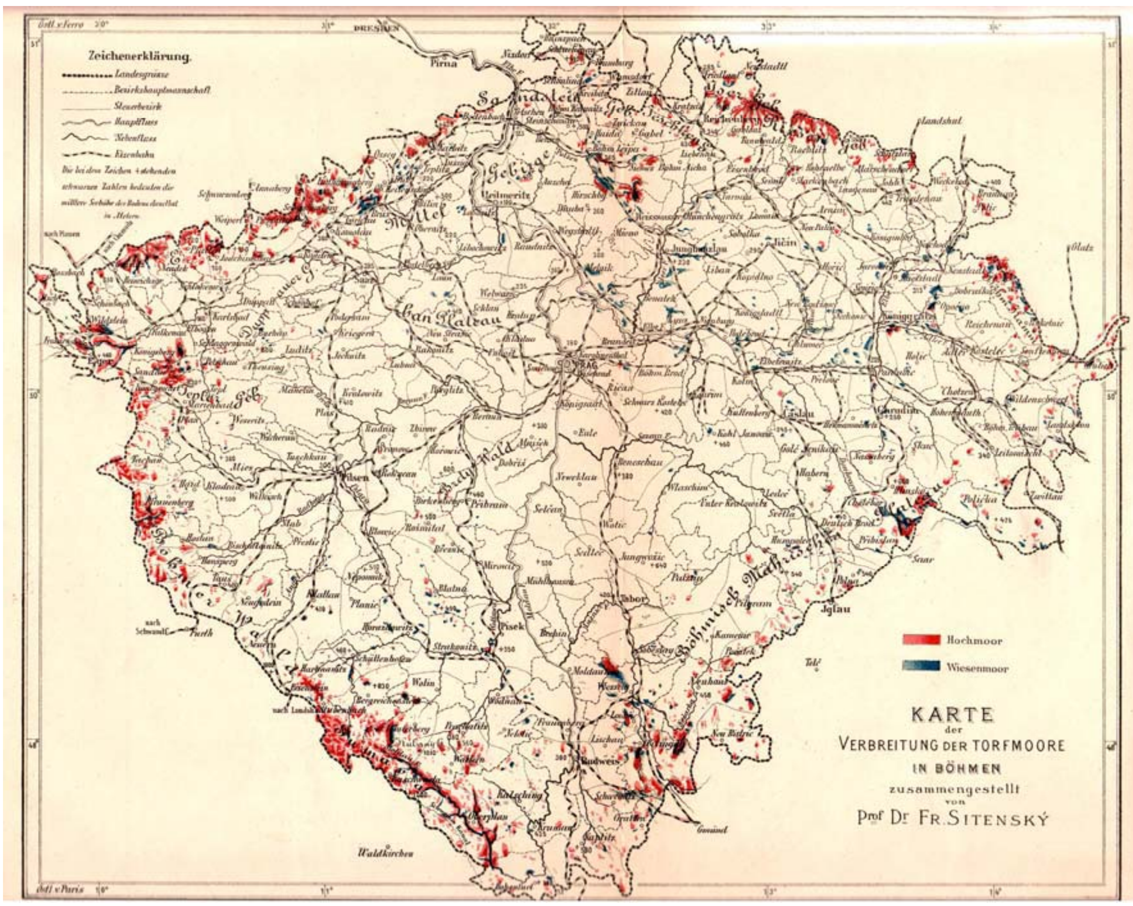
The Czech Republic has a temperate, continental climate with relatively hot summers and cold, cloudy winters, usually with snow. Most rains are during the summer. The temperature difference between summers and winters is relatively high due to its landlocked geographical position. Even within the Czech Republic, temperatures vary greatly depending on the elevation. In general, at higher altitudes the temperatures decrease and precipitation increases. Another important factor is the distribution of the mountains. Therefore the climate is quite varied. At the highest peak (Sněžka, 1,602 m/5,260 ft) the average temperature is only −0.4 °C (31 °F), whereas in the lowlands of South Moravia, the average temperature is as high as 10 °C (50 °F). This also applies for the country's capital Prague, but this is due to urban factors. The coldest month is usually January followed by February and December. During these months there is usually snow in the mountains and sometimes in the major cities and lowlands. During March, April and May, the temperature usually increases rapidly and especially during April the temperature and weather tends to vary widely during the day. Spring is also characterized by high water levels in the rivers due to melting snow followed by floods at times. The warmest month of the year is July, followed by August and June. On average, the summer temperatures are about 20 °C (68 °F) higher than during winter. Especially in the last decade, temperatures above 30 °C (86 °F) are not unusual. Summer is also characterized by rain and storms. Autumn generally begins in September, which is still relatively warm, but much drier. During October, temperatures usually fall back under 15° or 10°C (59° or 50°F) and deciduous trees begin to shed their leaves. By the end of November, temperatures usually range around the freezing point.

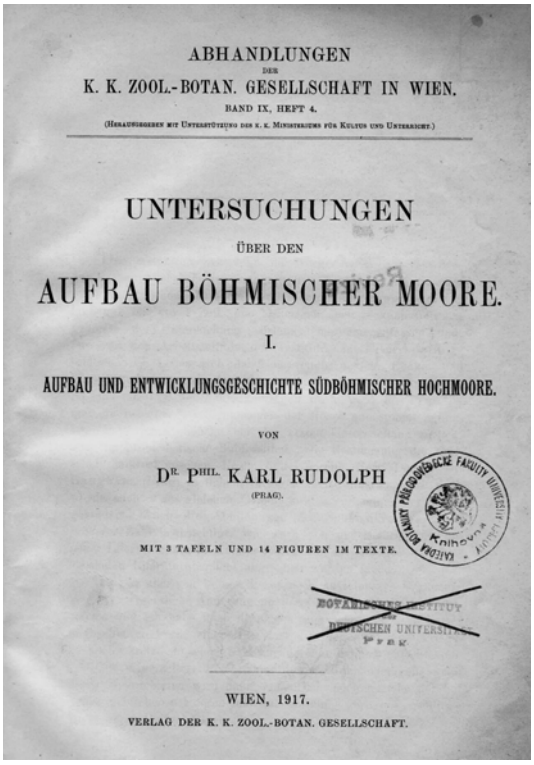
Pollen-analytical investigations in the Czech Republic – past and present

Vojtěch Abraham & Vlasta Jankovská

First investigations were carried out by František Ladislav Sitenský. His peat bog inventory and few macrofossil analyses were published in Czech language (1885, 1886) and then summarized in German (1891) (see map bellow).

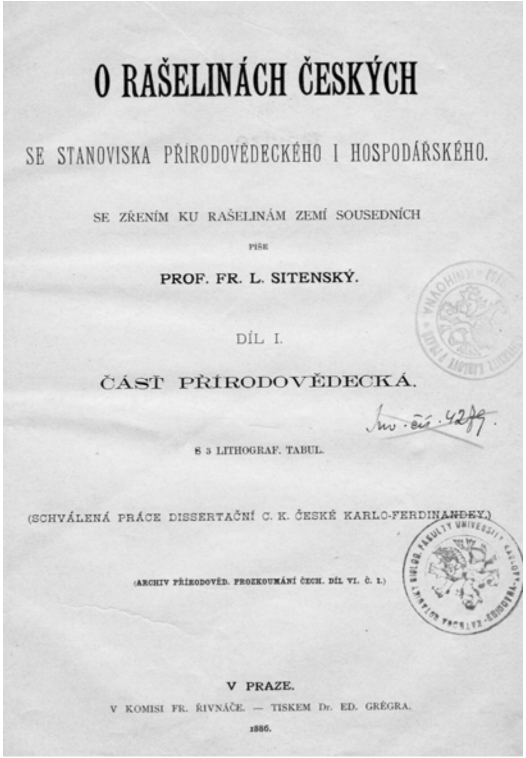
The beginning of Czech palynology is related with Karl Rudolph (born 11. 4. 1881 in Teplice) from the German University in Prague. First impulse to his work came at 1916 during his participation on „IV. Internationale Pflanzengeographische Exkursion" in Scandinavia. For K. Rudolph this was a great opportunity to explore northern-European vegetation and to know L. von Post, the leading pollen analyst of that time. Rudolph's investigations led him to Třeboň basin and his first publications dealed with sites Široké blato, Příbraz a Mirochov (Rudolph 1917). Franz Firbas, Rudolph's first student, focused his work to Ploučnice region (Polzengebiet), from where he published results from 25 sites. His students continued coring in Krušné hory Mountains, Komořany Lake and Krkonoše Mountains. Palynological workgroup under leadership of F. Firbas educated many good students; however the circumstances of II World War were disaster for further development. Some of the students were killed (like Karl Preis; 1941 in Russia) others were expulsed from Czechoslovakia in 1945 - F. Peterschilka, H. Richter, R. Wünsch, J. Plail, J. Sigmond, H. Schreiber, F. Müller. Franz Firbas re-established his group in the University of Göttingen. In 1988, Hans Schmeidl was still giving his lectures on vegetation history in Munich, as probably the last member of the school founded by K. Rudolph. After World War II, Hubert Losert (worked at Komořany Lake and in the Labe Basin) and Hugo Salaschek (worked on Moravo-Silesian peatbogs) did not resumed with palynology but both were teaching at secondary schools.




ABHANDLUNGEN
DER
K. K. ZOOL.-BOTAN. GESELLSCHAFT IN WIEN.
BAND IX, HEFT 4.
(Herausgegeben mit Unterstützung des k. k. Ministeriums für Kultus und Unterricht.)

UNTERSUCHUNGEN
ÜBER DEN
AUFBAU BÖHMISCHER MOORE.
I.
AUFBAU UND ENTWICKLUNGSGESCHICHTE SÜDBÖHMISCHER HOCHMOORE.
VON
D^R. P^HIL. KARL RUDOLPH
(PRAG).
MIT 3 TAFELN UND 14 FIGUREN IM TEXTE.

WIEN, 1917.
VERLAG DER K. K. ZOOL.-BOTAN. GESELLSCHAFT.


O RAŠELINÁCH ČESKÝCH
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V PRAZE.
V KOMISI FR. ŘIVNÁČE. — TISKEM Dr. ED. GRÉGRA.
1886.

In the Czech part of the Charles University, palynological investigations began with Klečka, Štěpánová and Puchmajerová. The last-mentioned author worked till 1950. B. Pacltová, A. Kriesl and V. Križo did their pollen analyses for the purposes of forestry; V. Kneblová-Vodičková worked for purposes of geology. E. Opravil began with palynological studies in Keprník-Jeseníky but than shifted his attention to archaeobotanical macrofossil analyses.

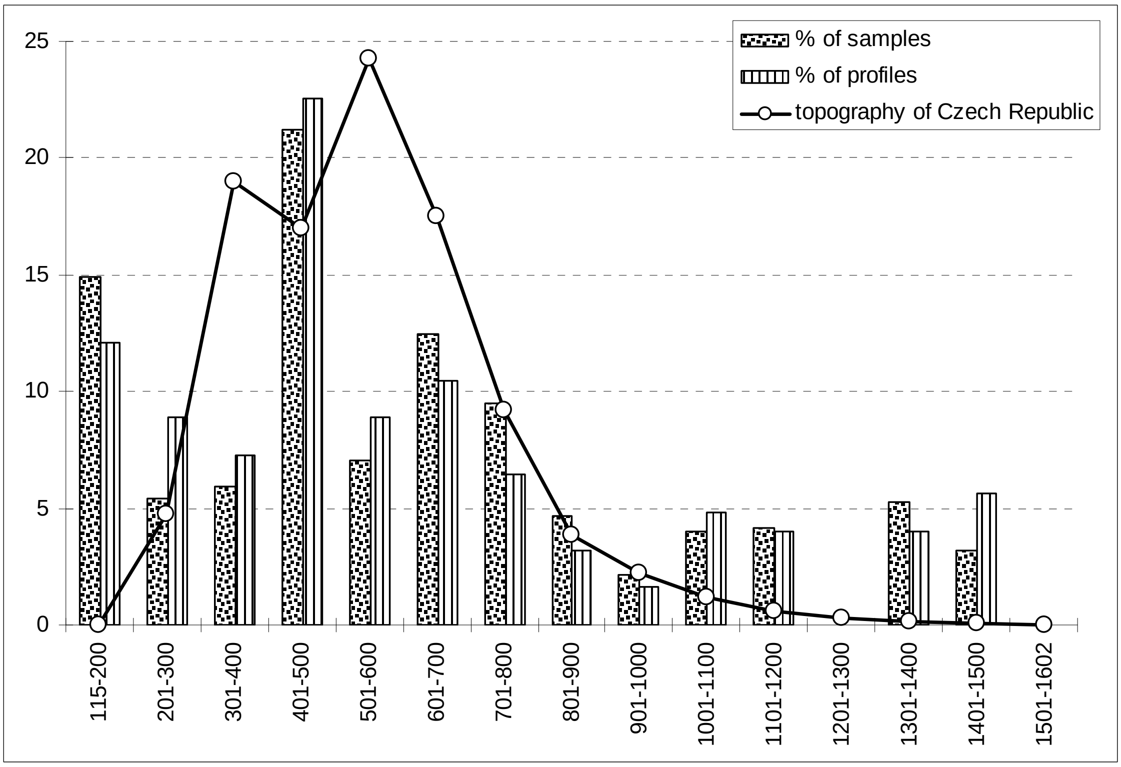
Modern palynological school (using determination of herb palynomorphs and C14 dating) was founded in the Botanical Institute of Academy of Science in Brno by E. Rybníčková, K. Rybníček a V. Jankovská. Since sixties, several palynologists passed through this institute: A. Konětopský, M. Peichlová, Sládková-Hynková, R. Rypl. Helena Svobodová-Svitavská entered in seventies and after she moved to the Botanical Institute in Prague. Eva Břízová still works in Czech geological Survey of Prague.

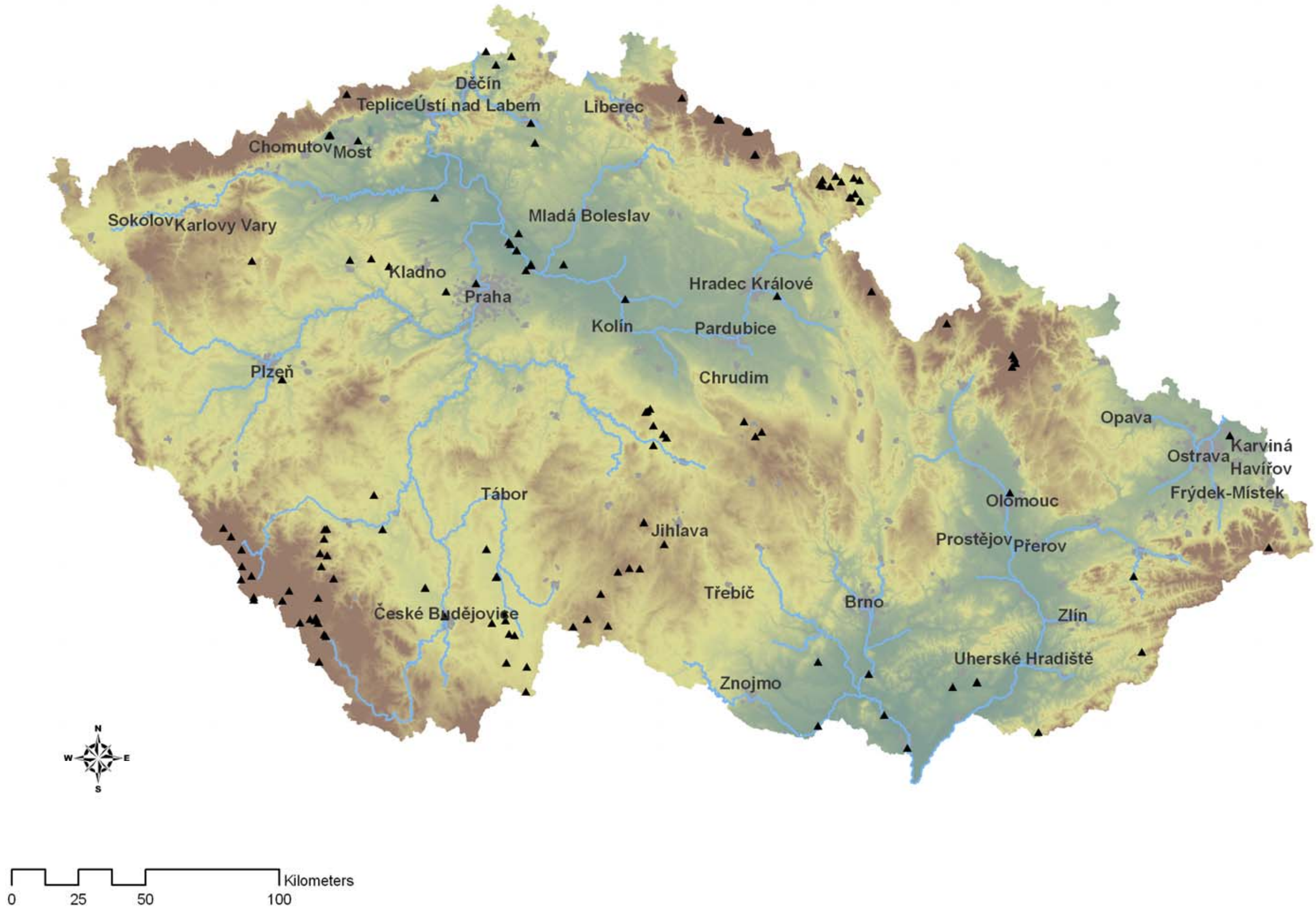

Franz Firbas


Vlasta Jankovská

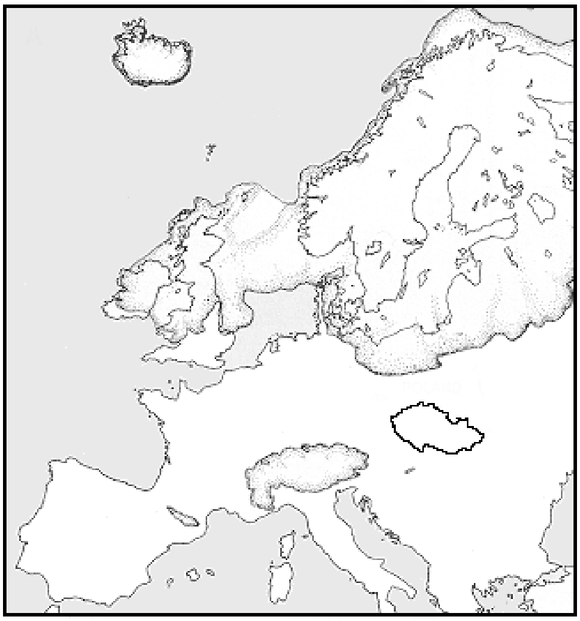
Czech Pollen Database (PALYCZ)

Based on the effort of above-mentioned authors together with the newest generation of palynologists, the Czech Pollen Database was established in this year. It is located in the Department of Botany, Charles University, Prague. By 30th August 2008 it contained 151 pollen sequences with 5808 samples from the Czech Republic, Slovakia and borders of Germany collected by 16 authors between 1965–2008. 84 % were already published in books, articles and manuscripts. Unfortunately, there are only 47 profiles dated by 14C. Coverage of the Czech Republic territory by pollen sites is irregular as the areas with attractive peat bogs are more intensively sampled. Distribution of the sites along altitudinal gradient is shown in the chart below (horizontal axis – altitude; vertical axis – %).

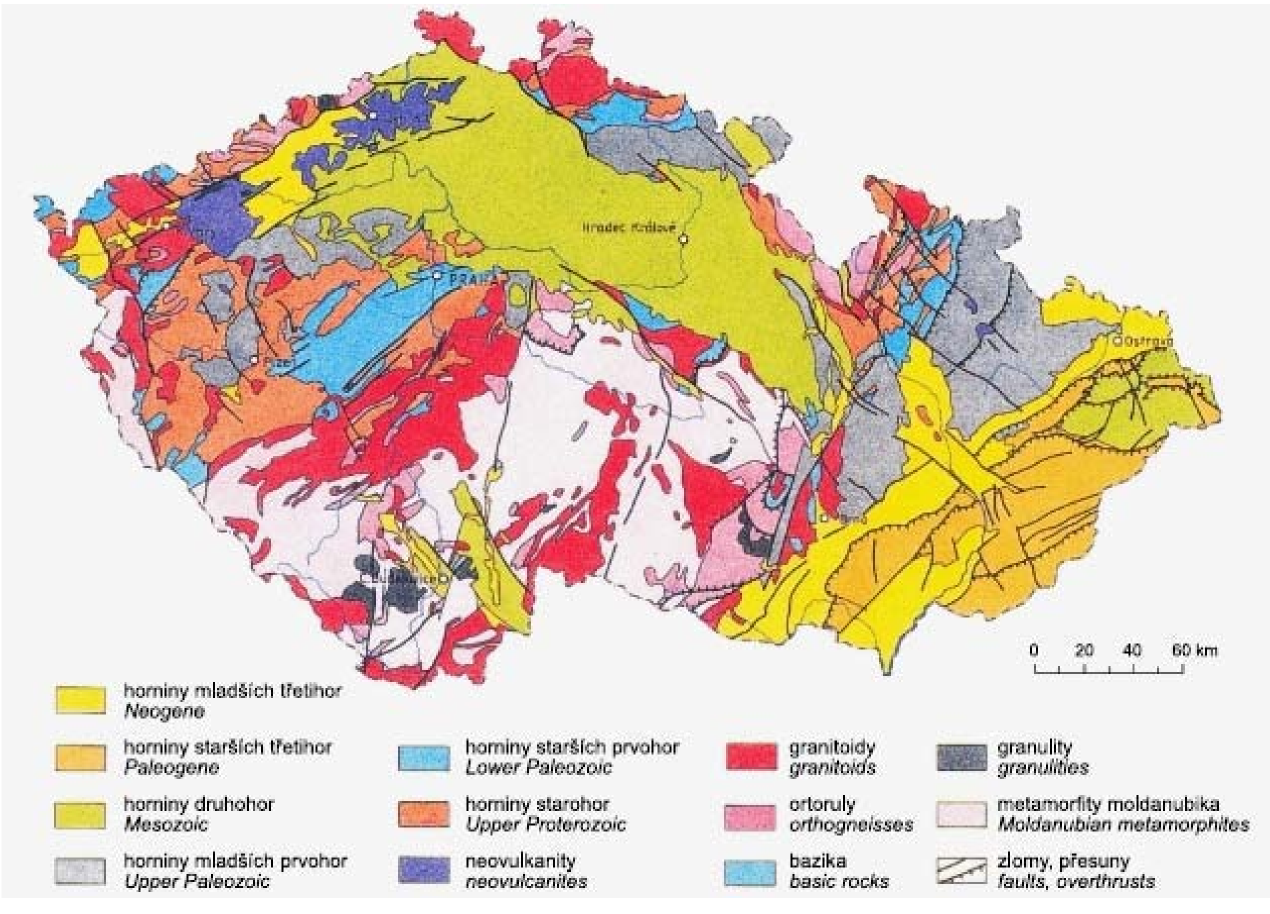




Map of analysed pollen sequences (▲) in the Czech Republic (source Czech Pollen Database)

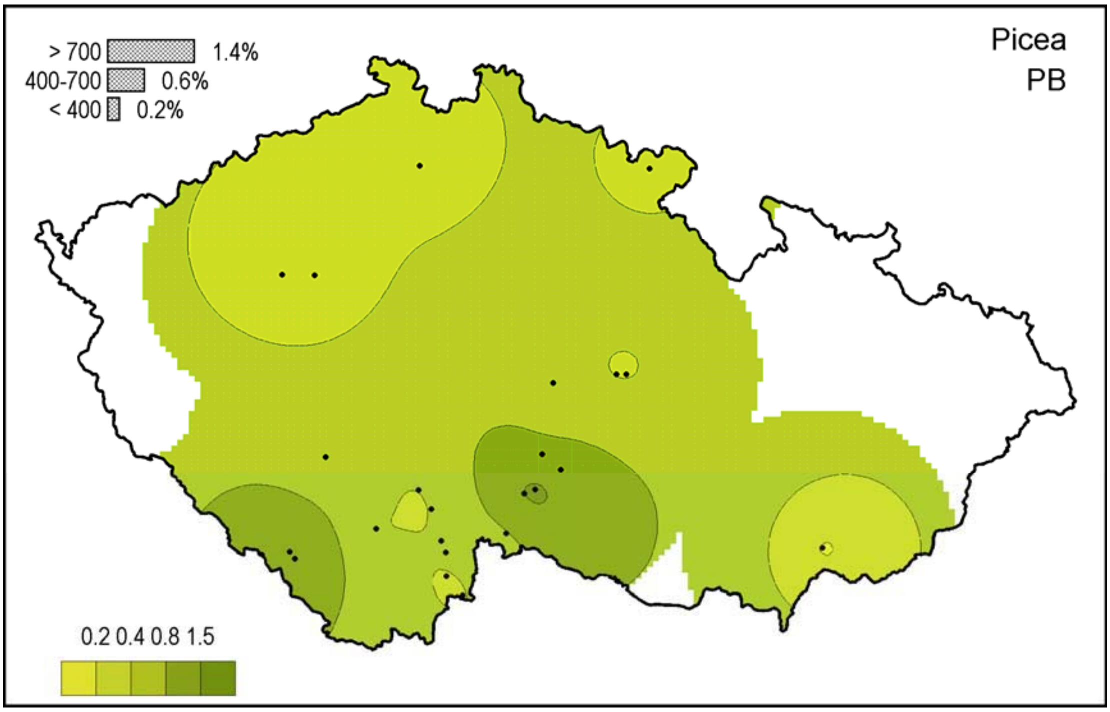


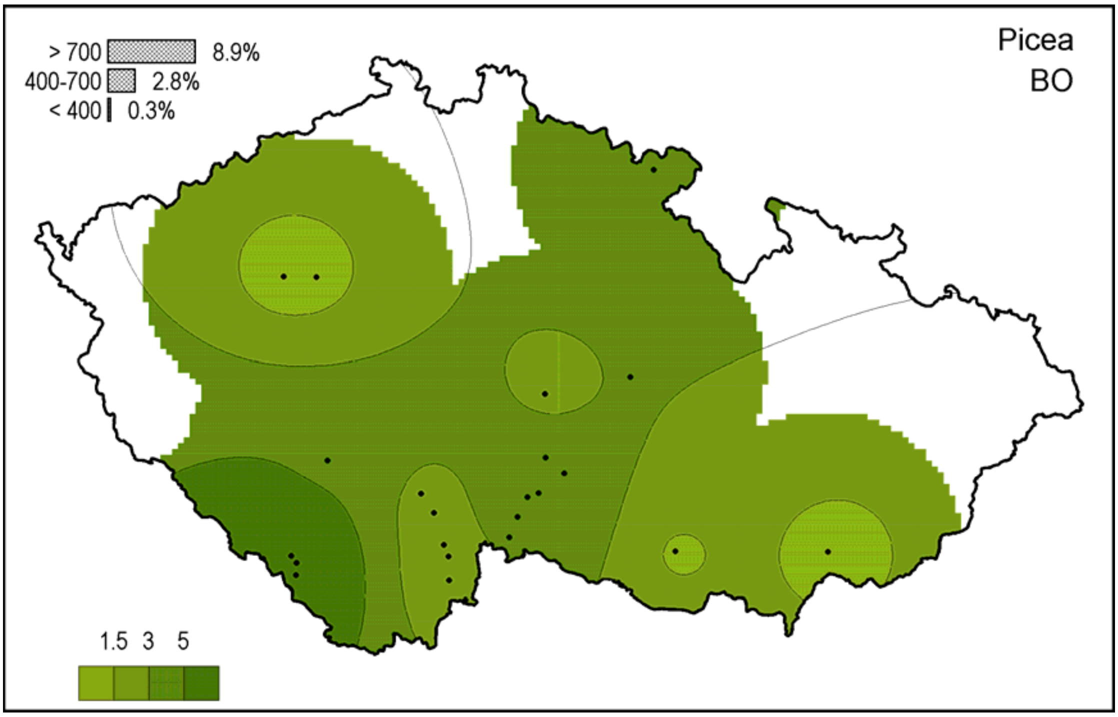
The Full – Weichselian glaciation in Europe and the position of the present Czech republic.

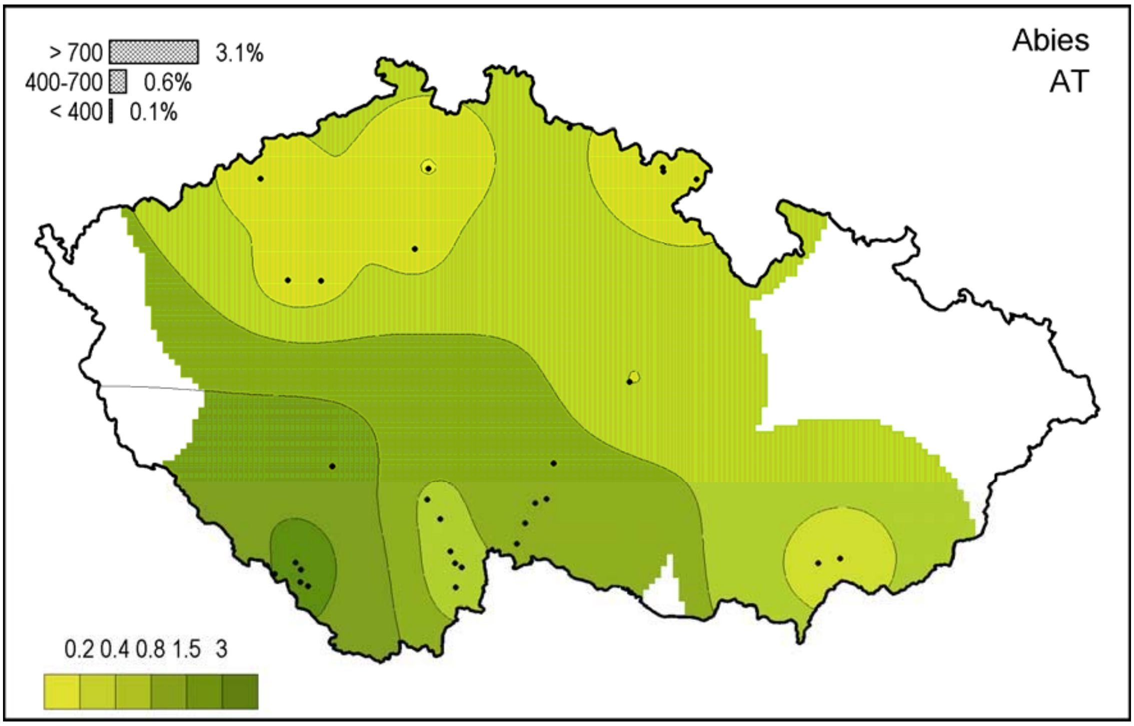


Basic geological formations of the country.

<u>**Selected isopollen maps for the Czech Republic**</u>



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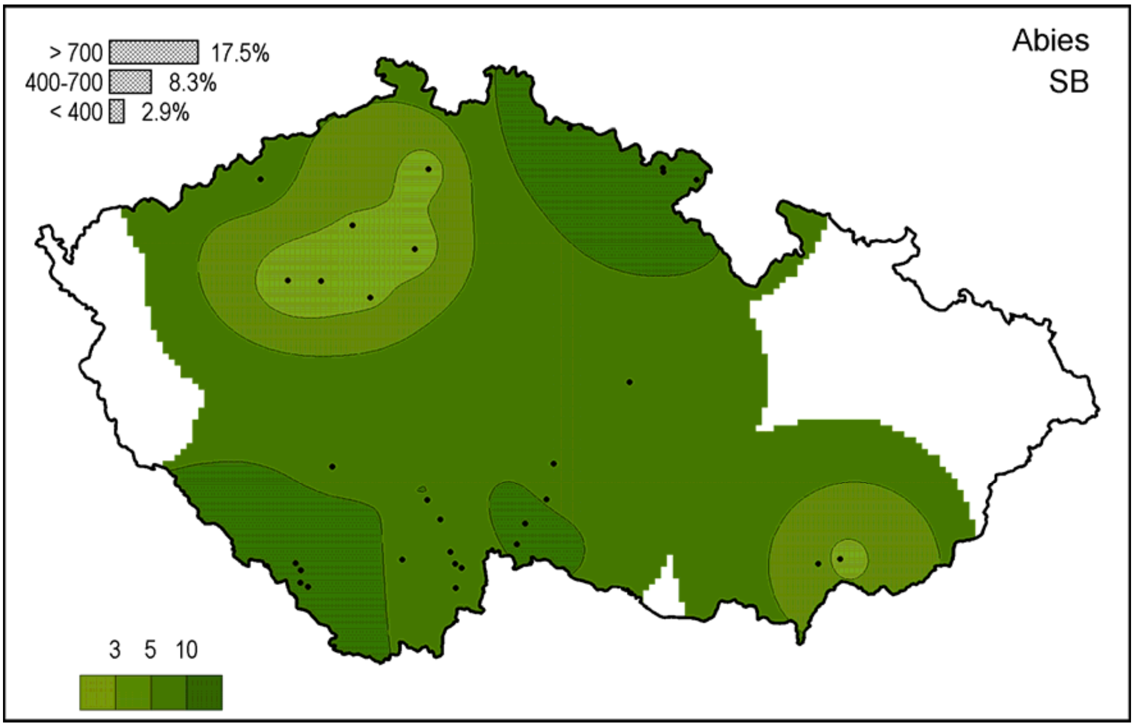
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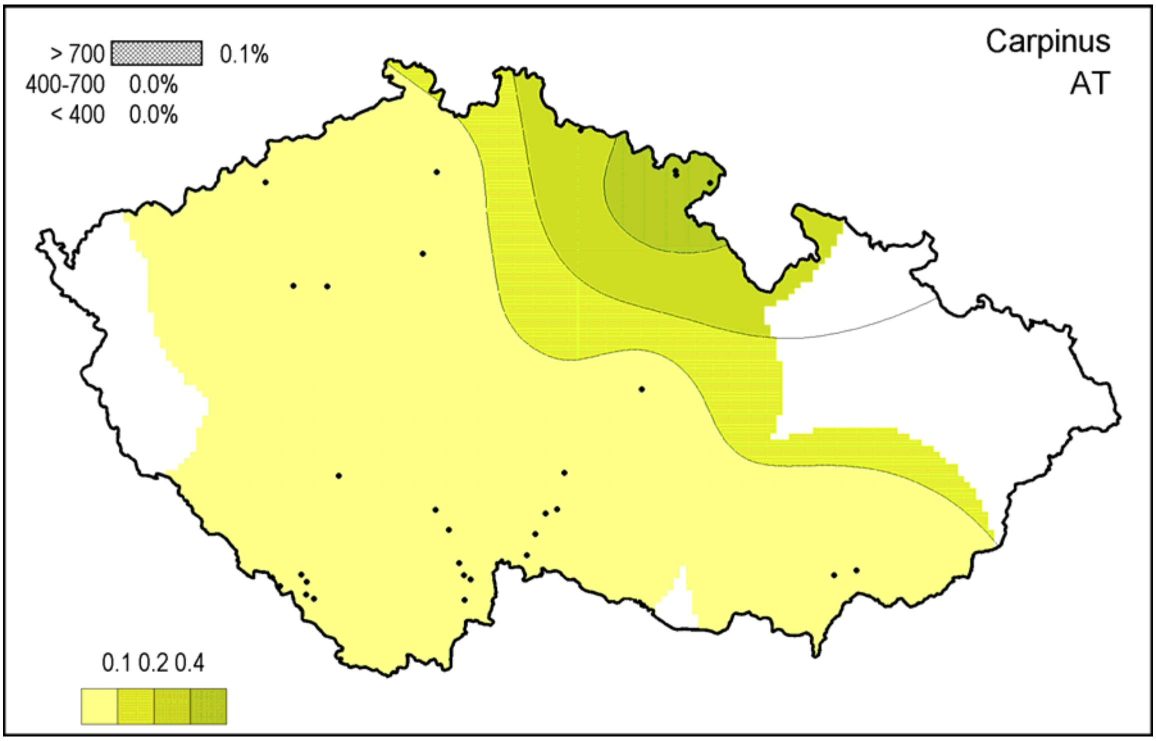

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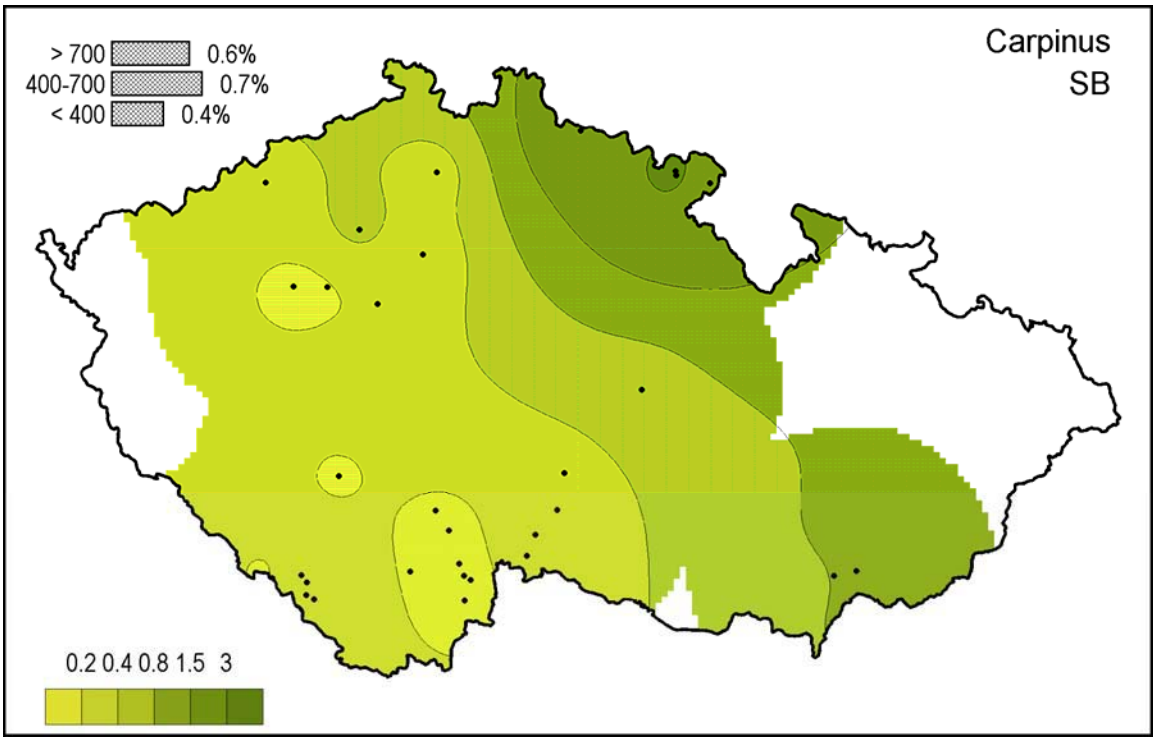

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Saturday, 6. 9. 2008
The city of Prague

Arrival to Prague.

Accommodation in “Masarykova kolej” hotel.
17:00 – meeting at “Masarykova kolej” hotel’s foyer; departure to welcome reception.

18:00 – **welcome reception** in the Museum of the Charles Bridge.

Introductory speeches**:**

„Past and Present Pollen-analytical Research in the Czech Republic“ (*V. Abraham*)

„Cultural Palaeobotany in the City of Prague“ (*R. Kozáková*).

Dynamics of the biotopes at the edge of a medieval town: pollen analysis of Vltava river sediments in Prague, Czech Republic

Dynamika biotopů na okraji vznikající středověké Prahy ve světle pylové analýzy ze sedimentů slepého ramene Vltavy

Radka K o z á k o v á[1] & Petr P o k o r n ý[2]

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Kozáková R. & Pokorný P. (2007): Dynamics of the biotopes at the edge of a medieval town: pollen analysis of Vltava river sediments in Prague, Czech Republic. – Preslia 79: 259–281.

As part of an archaeological excavation in Valdštejnská street in the Lesser Town of Prague, flood sediments in an old channel of the river Vltava were studied by means of pollen analysis. Analyses were performed on a core taken before the archaeological excavation and samples from the layers uncovered by the excavation. The core includes deposits from the era that followed the construction of weirs in the second half of the 13th century up to approximately the 15th century. Some of the sediments are older and from Early Medieval times (the oldest from the end of the 10th century). For the pollen analysis, three types of sediment were studied: flood loams, cultural layers and material deposited on causeways. Thanks to the diversity in the sediments it was possible to study local and regional components of the pollen spectra in more detail. The vegetation growing in the old river channel consisted of ruderal and weed taxa with sedge stands surviving in less accessible places. This locality most probably did not serve as a dumping ground until at least the 14th century, and even then this is not directly indicated by the pollen analysis. The difficulty of interpreting the mixed-origin pollen spectra usually present in urban archaeobotanical deposits is a common problem. Using multivariate statistics, three groups of pollen taxa characteristic for each particular sediment type were separated, and the individual pollen sources (and corresponding taphonomical processes) partly separated. Therefore, it was possible to distinguish autochthonous and allochthonous sources of pollen and draw conclusions about the local vegetation at this site.

K e y w o r d s : archaeological research, cultural layer, flood sediments, floods, pollen analysis, river channel, species and habitat diversity

Introduction

Prague is a city in which natural and semi-natural habitats are still more or less represented (Sádlo 2001). It is located in a morphologically very diverse relief that has a complicated geological structure (Kovanda et al. 2001). Studying the medieval pollen record provides an opportunity to reveal how different the past environment was from that of today.

As a part of a rescue archaeological study in Valdštejnská street in Prague, Lesser Town (Malá Strana), flood sediments of an old river channel of the Vltava river were studied (Fig. 1). To obtain a continuous pollen record (and to compare this with information derived from archaeological layers), and thus study the environmental changes that occurred from the time before the permanent colonization of the Lesser Town basin, a core was taken in the old river channel. During subsequent archaeological research, strata containing Early Medieval causeways were excavated several meters to the north and lying below

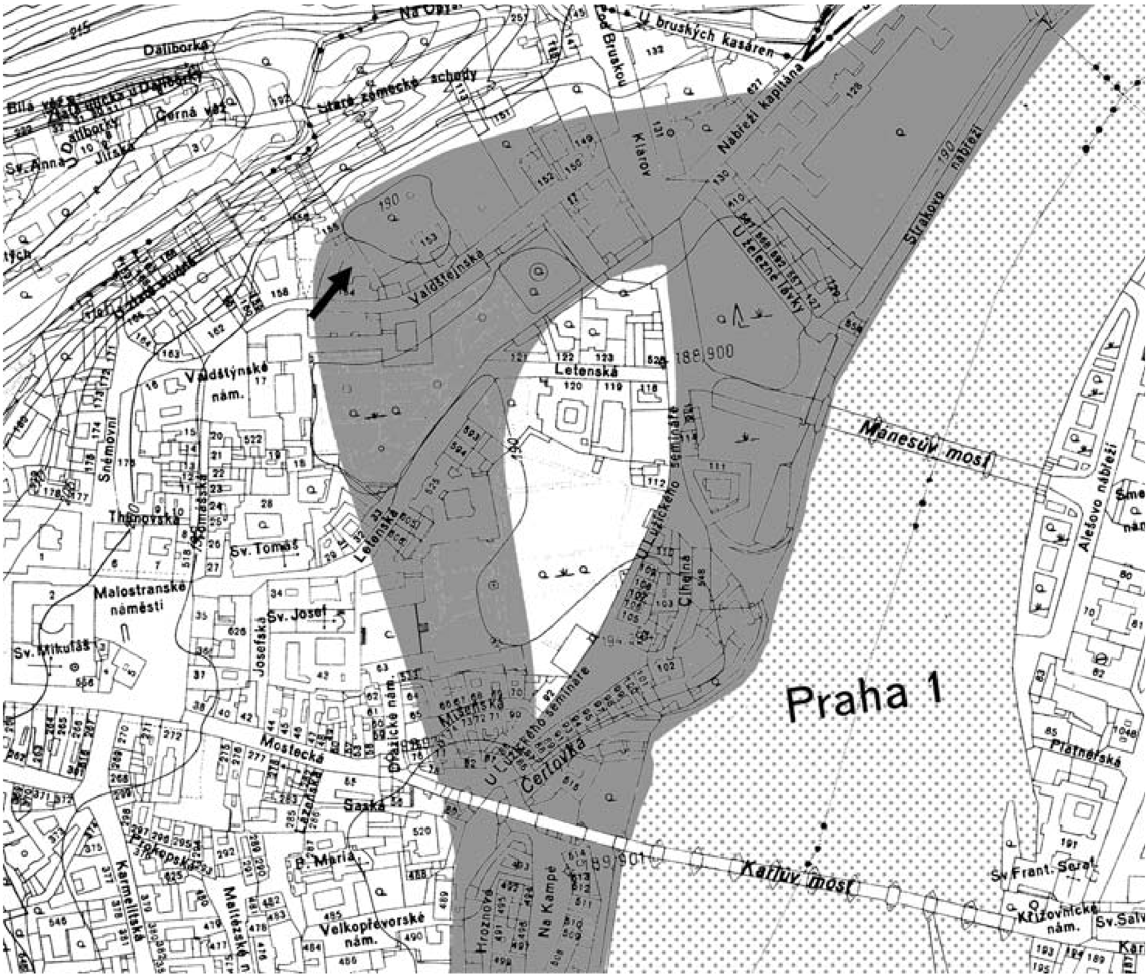

Fig 1. – The Lesser Town, with the location of the old river channel of the Vltava river. The arrow shows the site of the archaeological excavation.

the level of the bottom of the core. However, further coring to reach lower levels of the old river channel was not possible due to the constraints resulting from the building requirements at the study site.

Compared to pollen spectra from the cultural layers, which are typically analyzed for archaeological research in the area of Prague (Jankovská 1987, 1991, Břízová 1998, Pokorný 2000, Beneš et al. 2002), our results from Valdštejnská street are unique. In the old river channel, the pollen spectra come from three types of sediment: the surfaces of Early Medieval causeways (paths made of stones), flood loams and cultural layers deposited mostly on top of the flood loam strata in the profile. These diverse sediments indicate pollen from a high number of sources, which makes it possible to draw more general conclusions about the site and its vicinity.

The locality is within the present Lesser Town in Prague. From prehistory and Early Medieval to High Medieval, the environment in the Lesser Town basin experienced dramatic changes. Although the age of the old river channel is unknown it is certain that in the 10th century the river already flowed in its present-day riverbed (Hrdlička 2001). In the 9th century there was a fortified settlement with the centre at present-day Lesser Town

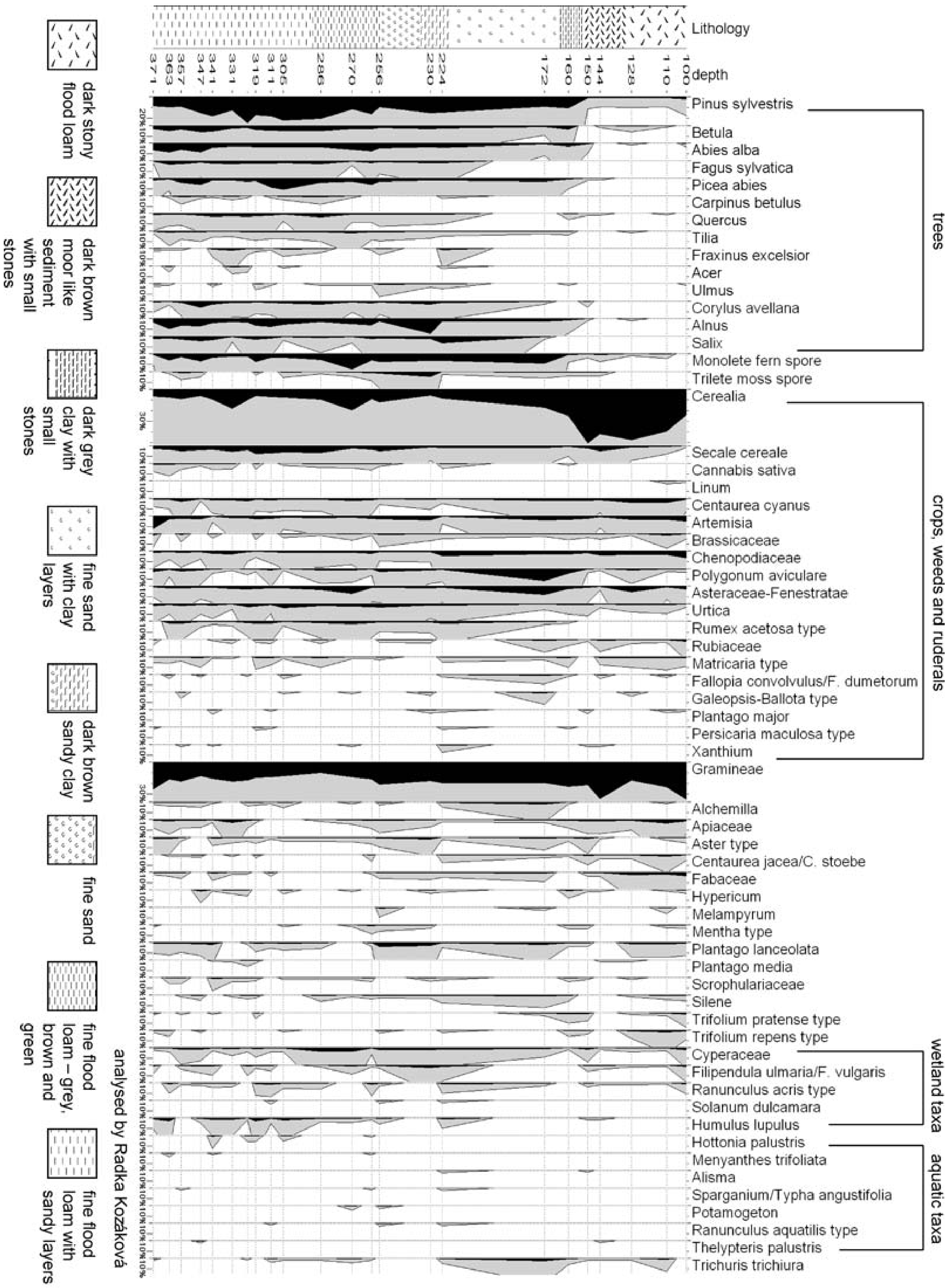

Fig 2. – Diagram of the percentages of selected pollen types. The top 100 cm are expected to be identical with the 100–152 cm layer.

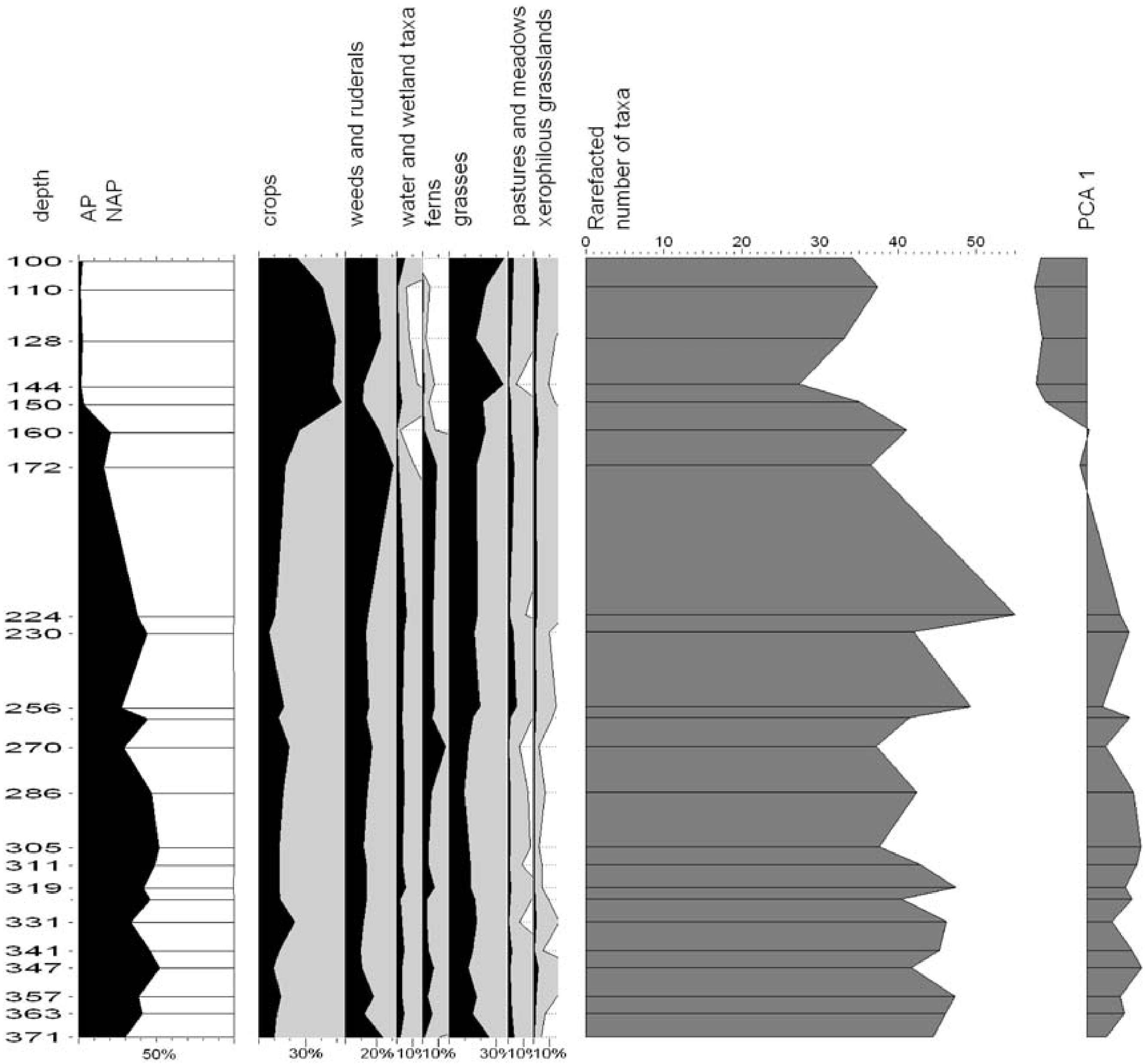

Fig 3. – Summary diagram with defined groups of species and the results of analyses. AP arboreal pollen, NAP – non-arboreal pollen, Rarefacted number of taxa – curve expressing pollen diversity, PCA1 – principal correspondence analysis curve expressing distribution of samples on the first axis. Pollen types included into the defined groups: Crops: *Cannabis sativa, Cerealia, Secale cereale*; Weeds and ruderals: *Adonis aestivalis/A. flammea*, *Agrostemma githago*, *Anchusa/Pulmonaria*, *Aphanes*, *Asteraceae-Fenestratae*, *Brassicaceae*, *Centaurea cyanus*, *Chenopodiaceae*, *Consolida regalis*, *Convolvulus arvensis*, *Fallopia convolvulus/F.dumetorum*, *Galeopsis-Ballota* type, *Matricaria* type, *Papaver rhoeas* type, *Persicaria maculosa* type, *Plantago major*, *Polygonum aviculare*, *Rubiaceae*, *Rumex acetosa* type, *Rumex aquaticus* type, *Sagina*, *Scandix pecten-veneris/Caucalis platycarpos*, *Solanum nigrum*, *Trifolium repens* type, *Turgenia latifolia*, *Urtica*, *Xanthium*; Water and wetland taxa: *Alisma*, *Butomus umbellatus*, *Caltha*, *Cyperaceae*, *Filipendula ulmaria/F. vulgaris*, *Hottonia palustris*, *Humulus lupulus*, *Lythrum*, *Menyanthes trifoliata*, *Ranunculus acris* type, *Ranunculus aquatilis* type, *Solanum dulcamara*, *Sparganium/Typha angustifolia*, *Thelypteris palustris*, *Valeriana officinalis*; Ferns: monolete fern spores together with *Athyrium filix-femina*, *Dryopteris filix-mas*, *Pteridium* and *Polypodium vulgare*; Grasses: pollen type *Gramineae*; Pastures and meadows: *Aconitum*, *Alchemilla*, *Astragalus* type, *Bistorta major*, *Campanula/Phyteuma*, *Cerastium*, *Gentianella*, *Knautia*, *Menta* type, *Odontites* type, *Pimpinella major/P. saxifraga*, *Plantago lanceolata*, *Plantago media*, *Potentilla/Fragaria* , *Rhinanthus* type, *Saxifraga hirculus* type, *Succisa pratensis*, *Trifolium pratense* type; Xerophilous grasslands: *Bupleurum falcatum* type, *Centaurea jacea/C. stoebe*, *Centaurea scabiosa*, *Falcaria* type, *Glaucium corniculatum*, *Helianthemum*, *Hypericum*, *Jasione montana*, *Lotus*, *Melampyrum*, *Orlaya grandiflora*, *Pulsatilla*, *Scabiosa columbaria* type, *Securigera varia*, *Silene*.

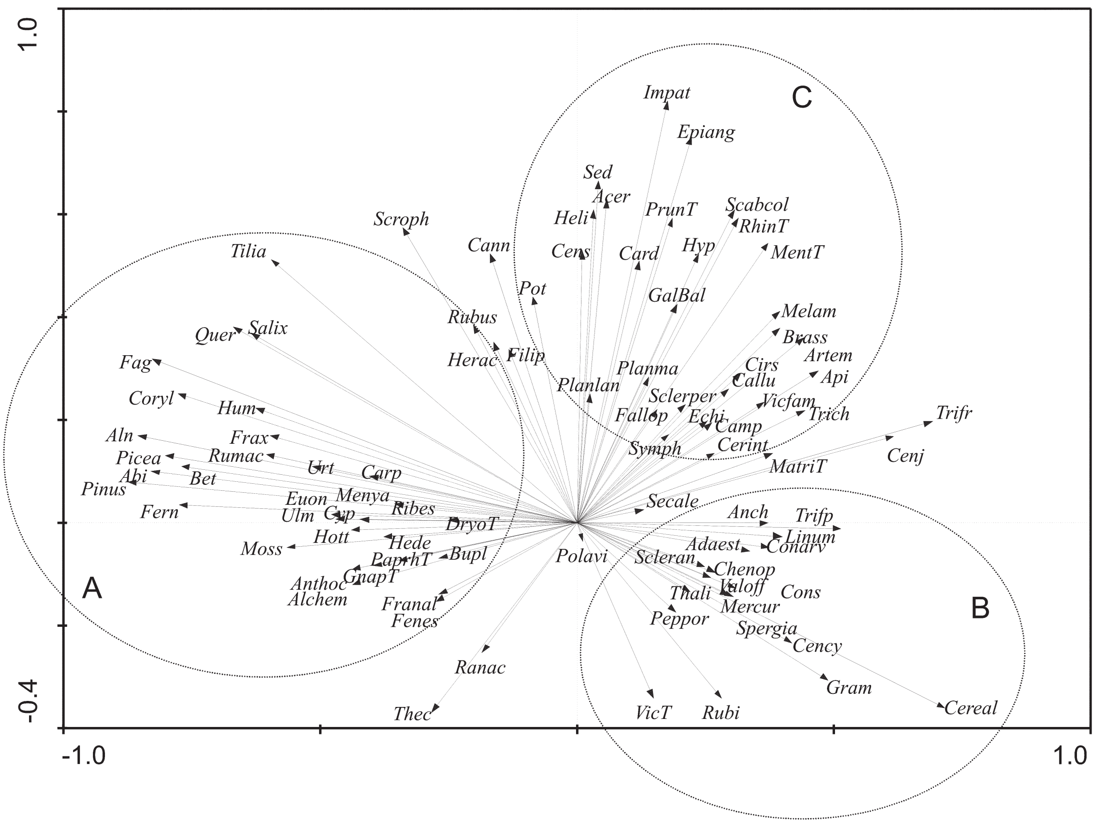

Fig 6. – PCA analysis showing distribution of species. Explained variability: 10.7%, 6.3% and 4.8% for the first three axis, respectively. Only species having a ratio of over 6% are shown. Three groups of pollen types are distinct. The largest contrast is between the two environments separated on the first axis – natural (A group) and cultural (B group). Group A includes trees, aquatic and wetland taxa and some weeds and ruderals. The whole group is connected with the alluvial environment where long distance transport and pollen rain from local vegetation is important. Group B includes above all cereals and weeds. This group represents the environment of cornfields. Group C includes many taxa of dry sunny biotopes, both ruderal and natural. It represents the diverse environment of a town where many taphonomical processes formed the pollen spectrum. See Fog. 5 for species codes.

aviculare or egg shells of *Trichuris trichiura*. Thus, indicators of the cultural environment (town) can be detected even in natural flood deposits (Fig. 2), which is expected since the old river channel formed part of the boundary of the rising medieval town.

A set of samples from Early Medieval sediments deposited in causeways (Table 1). This sediment type is characterized by a great diversity of species (Figs 5 and 6). Pollen types typical of this sediment belong to taxa of both ruderal and relatively natural biotopes associated with dry sunny sites. Typical ruderals are *Artemisia*, *Fallopia convolvulus/F. dumetorum*, *Epilobium angustifolium*, *Plantago major* and possibly even *Brassicaceae*, *Apiaceae* (Greig 1982), *Cerinthe minor*, *Trifolium repens* type, *Cirsium* (if we consider *Cirsium arvense*), *Matricaria* type and *Galeopsis-Ballota* type. Ecologically different are the taxa associated with steppe vegetation. These are above all *Helianthemum*, *Centaurea scabiosa*, *Hypericum*, *Sedum*, *Scabiosa columbaria* type and *Melampyrum.* The fact that the presence of *Melampyrum* is not correlated with that of deciduous trees (expecially *Quercus* and *Carpinus* as the dominant taxa of the *Melampyro-Carpinetum* association; Moravec & Neuhäusl et al. 1991) possibly indicates that the pollen grains were mainly of

The potential of pollen analyses from urban deposits: multivariate statistical analysis of a data-set from the medieval city of Prague (Czech Republic).

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Abstract: In the 12th and 13th centuries, the Czech Republic underwent deep social and landscape changes, defined by historians and archaeologists as a transitional period between the Early- and Late-Medieval periods. This study aims to analyze this transition as reflected by pollen analyses (120 pollen spectra) from urban deposits so far excavated in the city of Prague. Multivariate statistics and critical assessment of the results has brought general conclusions on the potential of pollen analyses for urban archaeological research. It reveals an Early Medieval urban environment as a fine mosaic formed by extensive management and composed of many habitats without sharp borders between them. Since the human impact increased with time, and the use of land became more rationalized and intensive, this mosaic got a relatively coarser structure in the High Medieval period. Our results support the earlier subjective and uncertain characteristics of two differing medieval pollen spectra (Cerealia – dominated with low pollen diversity *versus* those with a higher proportion of arboreal and wild herbal pollen and high pollen diversity) made at respective archaeological sites.

Key words: Early Medieval, High Medieval, urban archaeobotany, archaeological layers, pollen taphonomy.

Introduction

Archaeology of Medieval Prague

Prague is situated in the centre of Bohemia, in a basin formed on both banks of the Vltava River. The settlement history of Early Medieval Prague has been mainly studied from archaeological excavations (as the first written sources occur in the 10th century). However, there is no general consensus about the beginnings of local Early Medieval settlement. Some excavations have documented human activity in recent Lesser Town already by the 8th century. During the 9th century, Prague Castle was gradually established as the seat of the Czech regnant duke. By the 10th century there already existed a fortified settlement over an area of 35 ha directly below Prague Castle. A few other villages spread to the south, west and east of this fortified agglomeration (Čiháková-Havrda *in press*). The detailed structure and organization of Early Medieval settlement on the left bank of the Vltava is not yet clear. So far we can only guess from some excavated foot-paths and the remains of non-agrarian activities such as the production of iron ore, which could have been mined at a site of recent Lesser Town in the close vicinity of the settled area (Havrda-Podliska-Zavřel 2001).

Until the end of the 10th century, the agglomeration which was Prague was spread solely on the left bank of the Vltava. The opposite bank originally served as a place for funerals and by the end of the 10th century it started to be used by ironworkers. At the same time, Vyšehrad Castle became established here. Archaeological excavations at one of the extinct river island have documented an Early Medieval field close to a village (Hrdlička 1972). In the 12th century Prague grew into a large settlement agglomeration in a transition into a High Medieval town. It had two Castles and was built from wood, clay and sometimes stone. There was a stone bridge connecting the old centre of Prague with a yet unfortified right-bank part of the town where the main market at a place of present-day Old Town Square was situated. The 13th century brought many radical changes that gradually affected the whole country and hence are referred to as the Great Medieval Change (Klápště 2006). During this time Romanesque Prague, that had so far developed spontaneously, was being transformed into a Gothic town having a strictly organized structure.

Closely connected with the interpretation of pollen spectra from urban deposits is the disposal of waste. The character of anthropogenic urban deposits reveals much about the approach of previous inhabitants towards their environment. There are two distinct types of urban anthropogenic strata, differing in their way of deposition – an older, spontaneous type and a younger, regulated one. The transition between them refers to the transformation of Early Medieval Romanesque Prague into a High Medieval gothic one (Hrdlička 2000a). In the first phase, waste was deposited in the form of cultural layers in backyards; in the second phase, deep pits for rubbish were being dug instead. Also, many old wells or sand pits were further used for waste deposition. An alternative was to throw waste over the town walls. The deliberate and organized treatment of street surfaces and routes started only in the second third of the 14th century (Ledvinka-Pešek 2000). From then on, streets were paved and regularly cleaned. Throughout the 14th century, the streets of Prague were acquiring their final structure – one that is still the same in today's city centre.

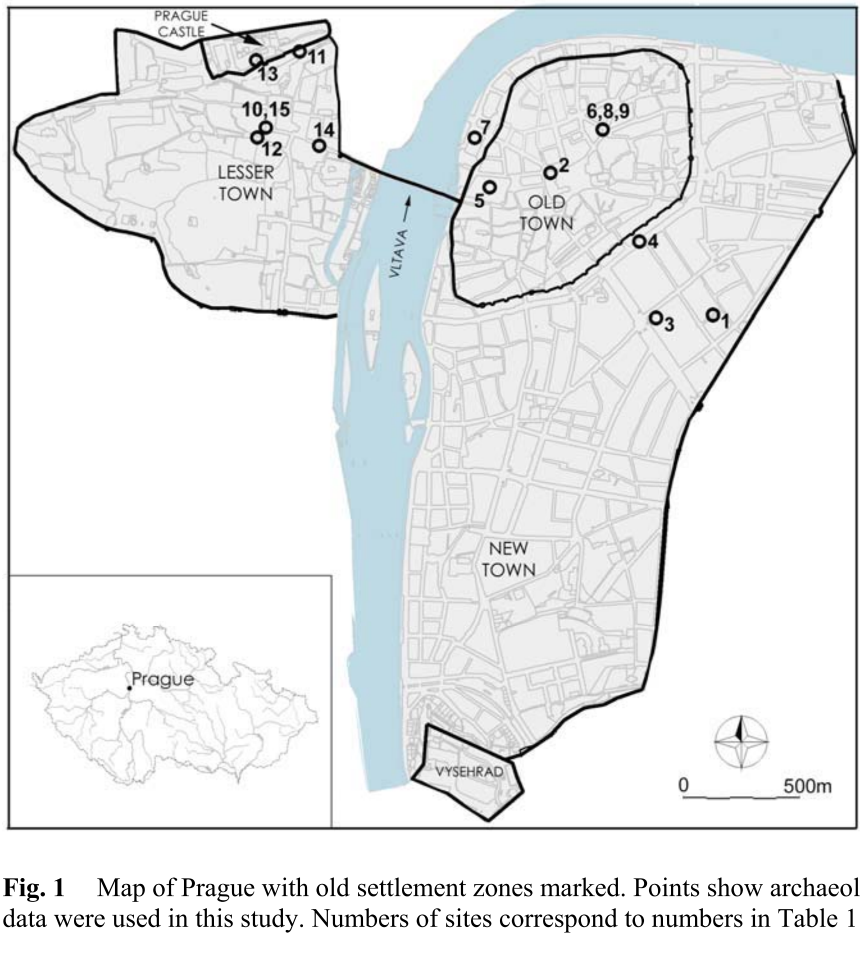


Fig. 1 Map of Prague with old settlement zones marked. Points show archaeological sites from which pollen data were used in this study. Numbers of sites correspond to numbers in Table 1.

Hypericum and *Rhinanthus* type. Furthermore, in Early Medieval samples pollen grains of *Plantago lanceolata*, *Plantago major/P. media*, *Rumex acetosa* type, *Artemisia*, *Mentha* type, *Fallopia*, *Aster* type, *Galeopsis/Ballota* type, Rubiaceae or Apiaceae have higher ratios than in High Medieval samples.

A reliable indicator of High Medieval deposits are the high numbers of *Centaurea cyanus* pollen (Figs. 4 and 5). As cereals probably remained the very main source of nutrition throughout the whole medieval period, its correlation with increasing age is not strong. Generally, it can be inferred that pollen taxa correlated with a High Medieval age are the same as those with a lower pollen diversity and from deposits of a waste character (Figs. 3 and 5). These are again Brassicaceae, Chenopodiaceae, Asteraceae-Fenestratae, *Fagopyrum*, *Arctium*, *Calluna vulgaris*, *Eugenia/Myrtus*, Oleaceae and such non-pollen objects as *Lyccopodium clavatum*, *Trichuris*, *Thecaphora* and monolete spores of ferns.

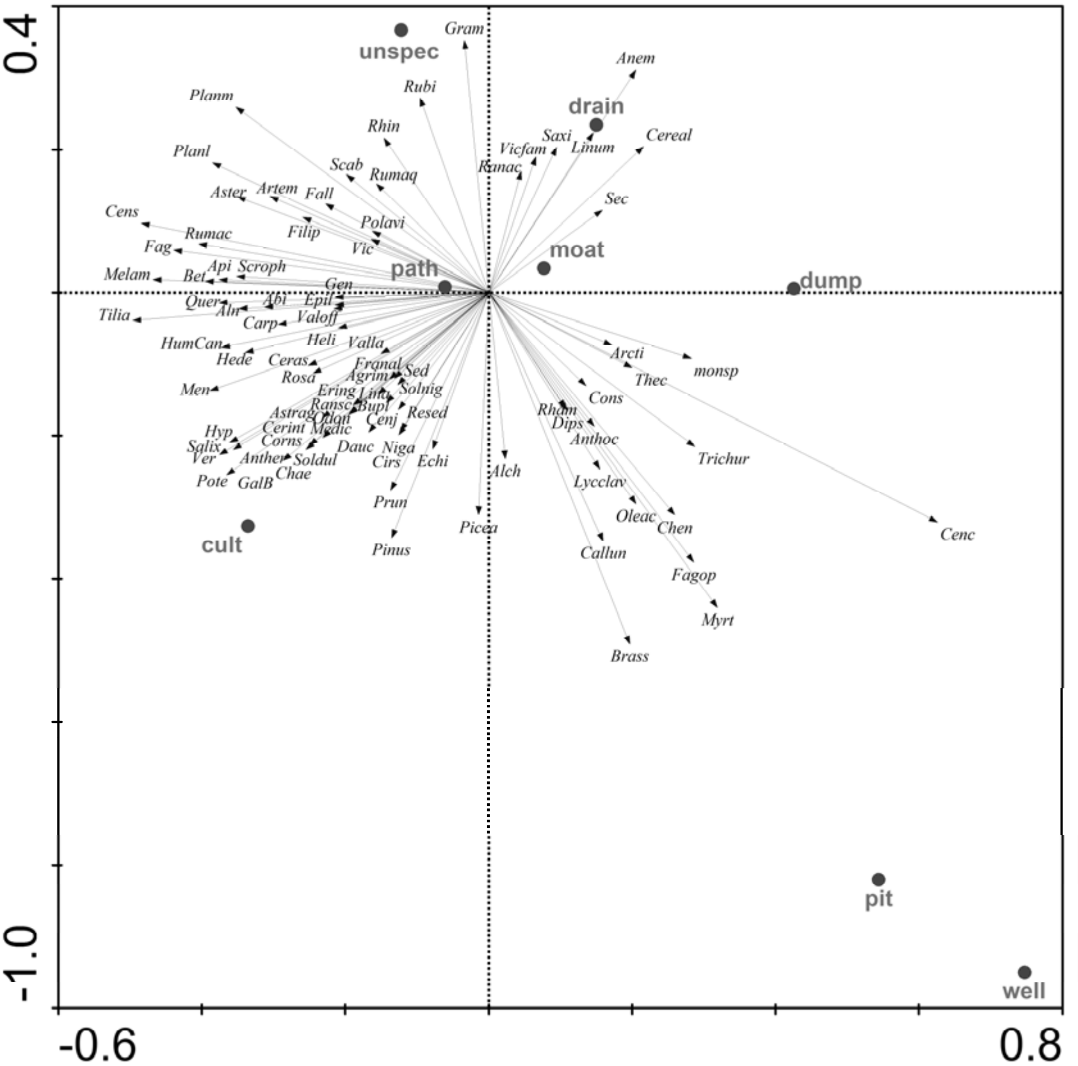


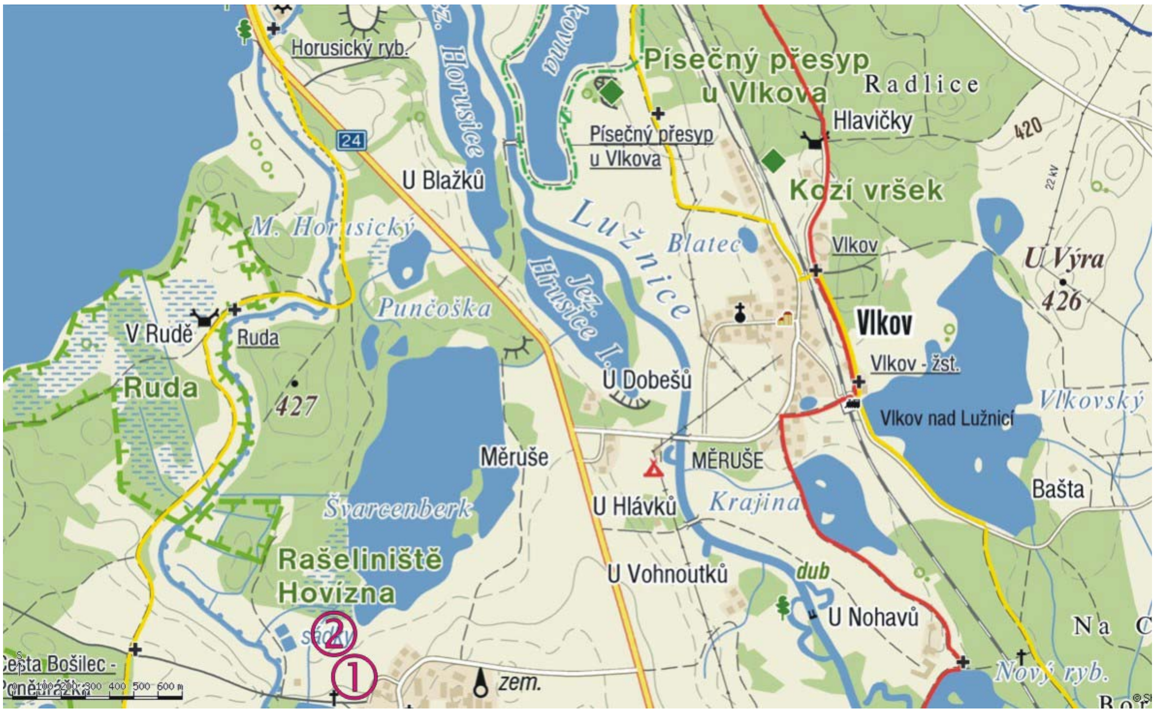
Fig. 3 RDA analysis testing the impact of the archaeological context. Cumulative explained variability: a) canonical axes: 4.4 %, 6.9 %, 8.7 %; b) noncanonical axis: 9.8%. Significance of canonical axes together: F = 1.983; p = 0.002. pit – infilled pit; dump – dump site; moat – infilled moat; drain – sediment from drainage ditch; unspec – unspecified character of archaeological layer; path – deposit from a path; cult – cultural layer.

Sunday, 7. 9. 2008
Late Glacial and Early Holocene lakes in southern Bohemia

Švarcenberk (by *P. Pokorný*)
Former lake palaeoecology and Mesolithic archaeology.

Řežabinec (by *P. Kuneš*)
Late Palaeolithic to Mesolithic archaeological site and its palaeoecology.

Accomodation at Prachatice.



Before terrestiralization, **Lake Švarcenberk** had about the same shape and dimensions as today has a fish-pond located at the same place. Since its discovery in late 70's (V. Jankovská), the former lake became object of intensive palaeoecological and archaeological investigations (P. Pokorný, P. Šída and others). Its origin is dated to about 16 ka BP and is connected with thawing of the permafrost (i.e. termokarst origin). Thick deposits of the Late-glacial age enabled detailed investigation of this period. During Early Holocene, the lake attracted attention of Mesolithic hunters and gatherers. Abundant archaeological traces of their settlements were found all around former lake shores.

Numbers on the map:

1 – Bus stop

2 – Visit of the shore of a former lake where wet archaeological site of Mesolithic age was recently discovered.

PERGAMON

Quaternary International 91 (2002) 101–122

A high-resolution record of Late-Glacial and Early-Holocene climatic and environmental change in the Czech Republic

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Abstract

Recent discovery of thick buried lake sediments in the Třeboň Basin, South Bohemia, presents an exceptional opportunity to study the Late-Glacial history of eastern Central Europe. High-resolution investigation of pollen, plant macrofossils, algal remains, and lithology for the Late-Glacial and Early-Holocene sediments of former Lake Švarcenberk yielded a well-founded palaeoclimatic and palaeovegetational data that can be compared with the results from other parts of a west–east European transect, taking into account the oceanic/continental gradient and its influence for palaeoenvironmental conditions. The results demonstrate that the effect of North Atlantic oceanic changes during the last glacial–interglacial transition extended to the investigated area. Nevertheless, significant differences in timing, intensity, and character of vegetational response to these climatic changes have been found between the area under study and the western part of Central Europe. These differences can be ascribed to increased seasonality, specific regional mesoclimatic and soil conditions, and possible local glacial refugia for pine. The results of sediment chemical analyses indicate a close correspondence between climatic, vegetational, and soil development in lake catchments.

1. Introduction

Organic deposits suitable for palaeoecological research usually began to form about 13 ka BP in western and northwestern Europe, classified into different Late-Glacial phases by pollen analysis. In non-glaciated, continental regions of Central Europe, this subdivision is usually not possible, either because minerogenic sediments contain no pollen or because sediments simply did not accumulate at this time. Particularly, lacustrine sequences are very rare in these regions. The profile under study in the Czech Republic is a unique example with an extensive and well-stratified Late-Glacial record. High sediment-accumulation rates permit the detection of brief Late-Glacial climatic oscillations, so that comparisons can be made with numerous results from western and northwestern Europe, where the basic biostratigraphic and climatostratigraphic concepts have been developed (Iversen, 1954; Mangerud et al., 1974; Watts, 1979). As postulated by Ruddiman and McIntyre (1981) and later recognised in terrestrial records within the areas adjacent to the North Atlantic (e.g. Lowe et al., 1994; Walker, 1995), the rapid climatic changes during the last glacial–interglacial transition can be ascribed to large-scale shifts in the position of the oceanic Polar Front, which have amphi-Atlantic or even global effects (e.g. Peteet, 1995).

The goal of the present study is to test the validity of some of these concepts as applied to the eastern part of Central Europe. The great distance from the North Atlantic and from major ice sheets, as well as the high degree of regional environmental diversity, are the most important factors that could cause certain differences in climate and provoke distinct biotic responses to climatic changes in the area under study. It is well known that the response of populations (e.g. plant populations) to climatic change is likely to be greatest near the margin of their distributional limits (Watts, 1979). Rapid climatic changes during the last glacial–interglacial transition usually affected only local populations and did not permit long-distance migrations (Ammann, 1989). This caused a high degree of inter-regional biological diversity, depending on local availability of species. For example, in the intermontane basins of the Western Carpathians, some 250 km east of the study area, local

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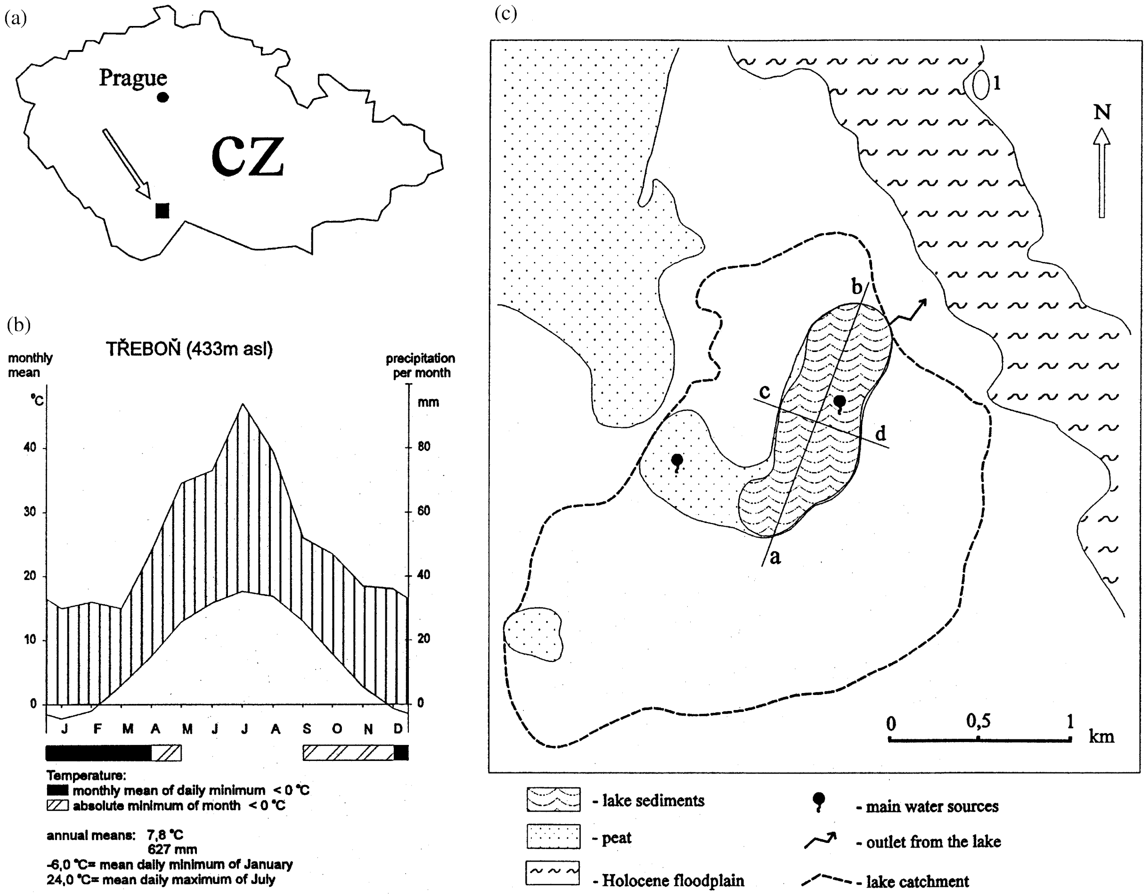

Fig. 1. The study site. (a) Location of the study area within the Czech Republic. (b) Climatic diagram for Třeboň (ca. 15 km south from the site) derived from 50 yr of observations. (c) Quaternary geology and topography of the site. 1—"Vlkovský přesyp" aeolian sand dune, a,b,c,d—two cross-sections used for stratigraphic investigation. Their crossing point is in the centre of the basin, where the "main profile" is situated.

and cannot be used as a climatic indicator. The lake drained into nearby Lužnice River. For evaluating the regional pollen rain on the site, the vicinity to the river floodplain is important.

Numerous aeolian deposits are situated along the river floodplain. One of the biggest and most prominent sand dunes, "Vlkovský přesyp", is situated 1200 m from the former lake basin. Its relative height over surrounding terrain (6 m), its size (60 × 80 m), and the unvegetated character make it a prominent structure on the landscape. According to its morphology, "Vlkovský přesyp" sand dune was formed by easterly winds. The material constituting it is derived directly from the nearby river floodplain (carried by wind for tens or hundreds of meters) according to mineralogical analyses (Chábera, 1982).

The existence of the former Lake Švarcenberk was noted for the first time by Vlasta Jankovská in the late 1970s. In her study, which focused on the vegetational development of Třeboň Basin (Jankovská, 1980), she presents a pollen diagram and macrofossil analysis obtained from an open pit. Her profile comprised about 1.5 m of lake sediments, and she correctly assumed that she dealt with the littoral facies of a larger lake. Unfortunately, no stratigraphic data were obtained. The present study fully confirms Jankovská's original assumption.

3. Methods

3.1. Field methods, sediment description, and subsampling

During the pilot study, the extension and stratigraphy of the former lake basin was studied by coring in a 100m × 100m grid (sampling distances were reduced along the shores). For subaquatic coring, a boat was used. Two right-angle transects across the basin were chosen as reference sections (shown in Fig. 1c and 2). They have their crossing point in the centre of the basin, where the "main profile" is situated. The distances in metres and the geographical position (N, S, E, W) in relation to this zero point is given by the core labels. The cores were levelled according to fishpond water level. The coring was performed with Russian-type corer

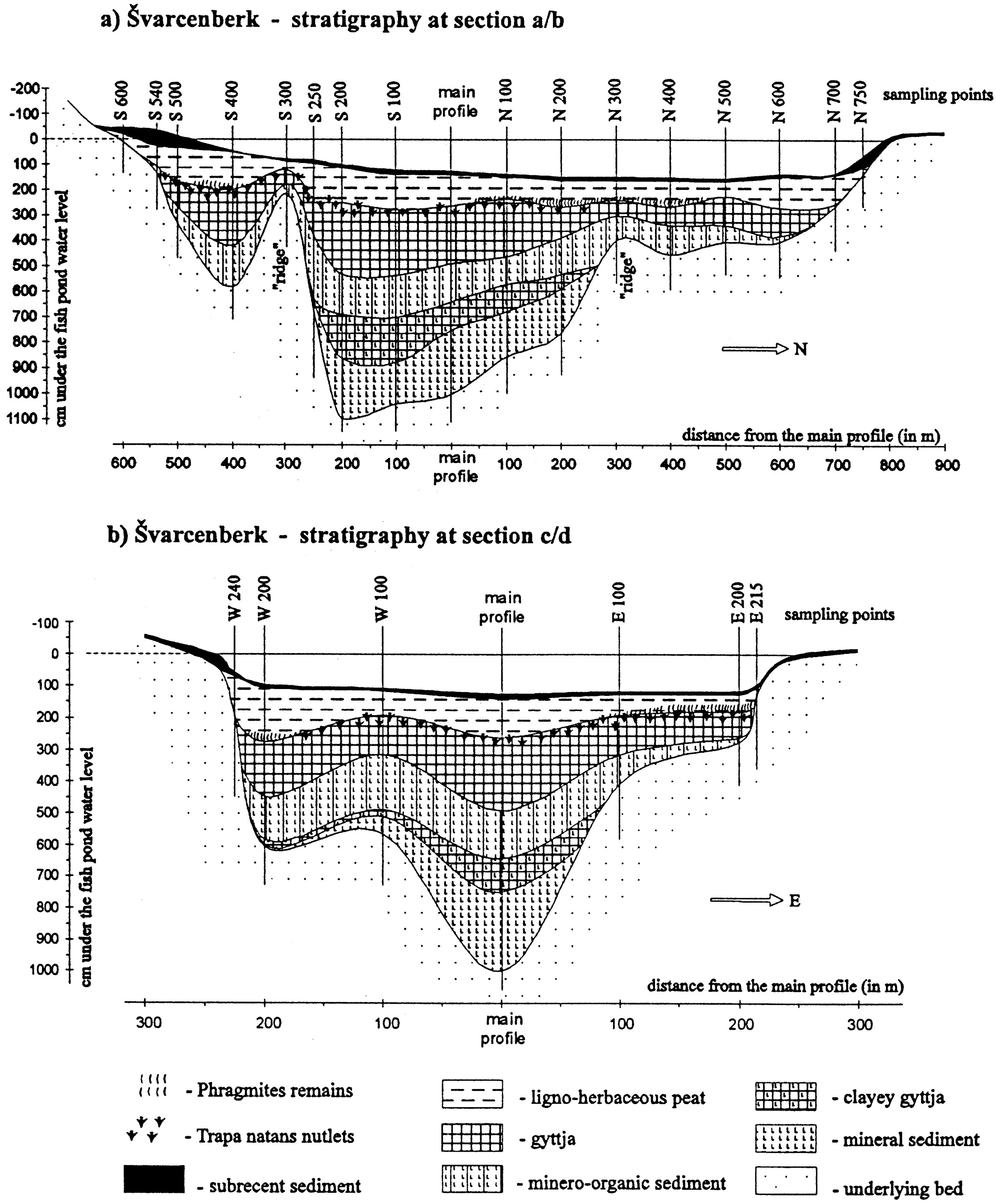

Fig. 2. Two selected orthogonal stratigraphic cross-sections (their position described on Fig. 1) through the Švarcenberk lake basin.

(Jowsey, 1966) 5 cm in diameter. The sampling point S500 was opened by hand-made pit. Correlation of the individual cores across the basin was achieved by visual stratigraphic description and further confirmed by pollen analysis in some cases.

The core in the centre of former lake was selected as the standard profile. The central core will most probably show a continuous record without hiatuses, and it is more likely to give an "average" picture of the events in the basin and its catchment (without the background of local "noise", which is assumed to be greatest along the shores). This "main profile" actually consists of seven separate parallel cores taken close together in order to obtain enough material for all kind of analyses. The coring was performed using the Russian-type corer 5 cm in diameter. This type of device permits complete

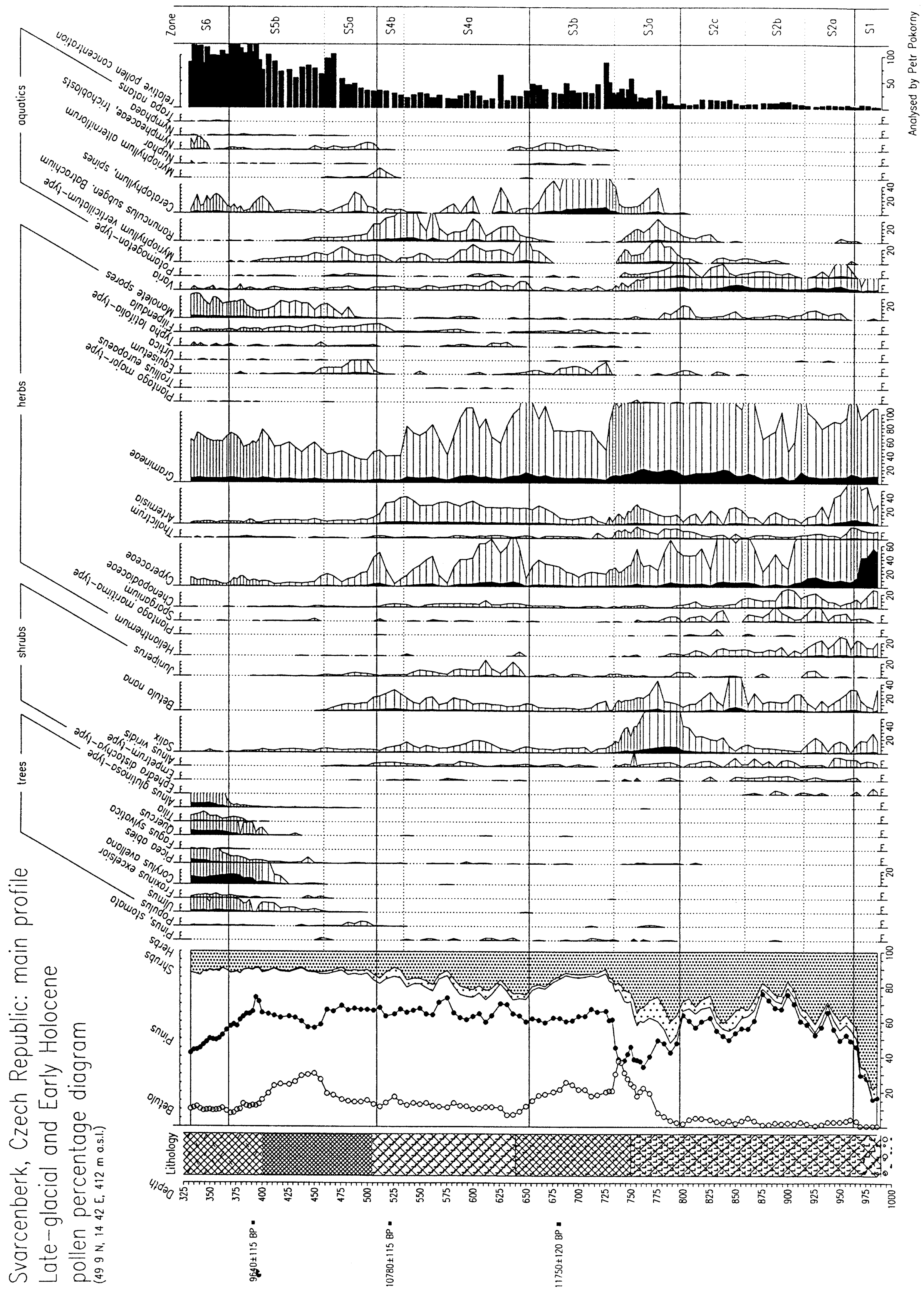

Fig. 3. Late-Glacial and Early-Holocene pollen diagram of the "main profile". Only selected types are included.

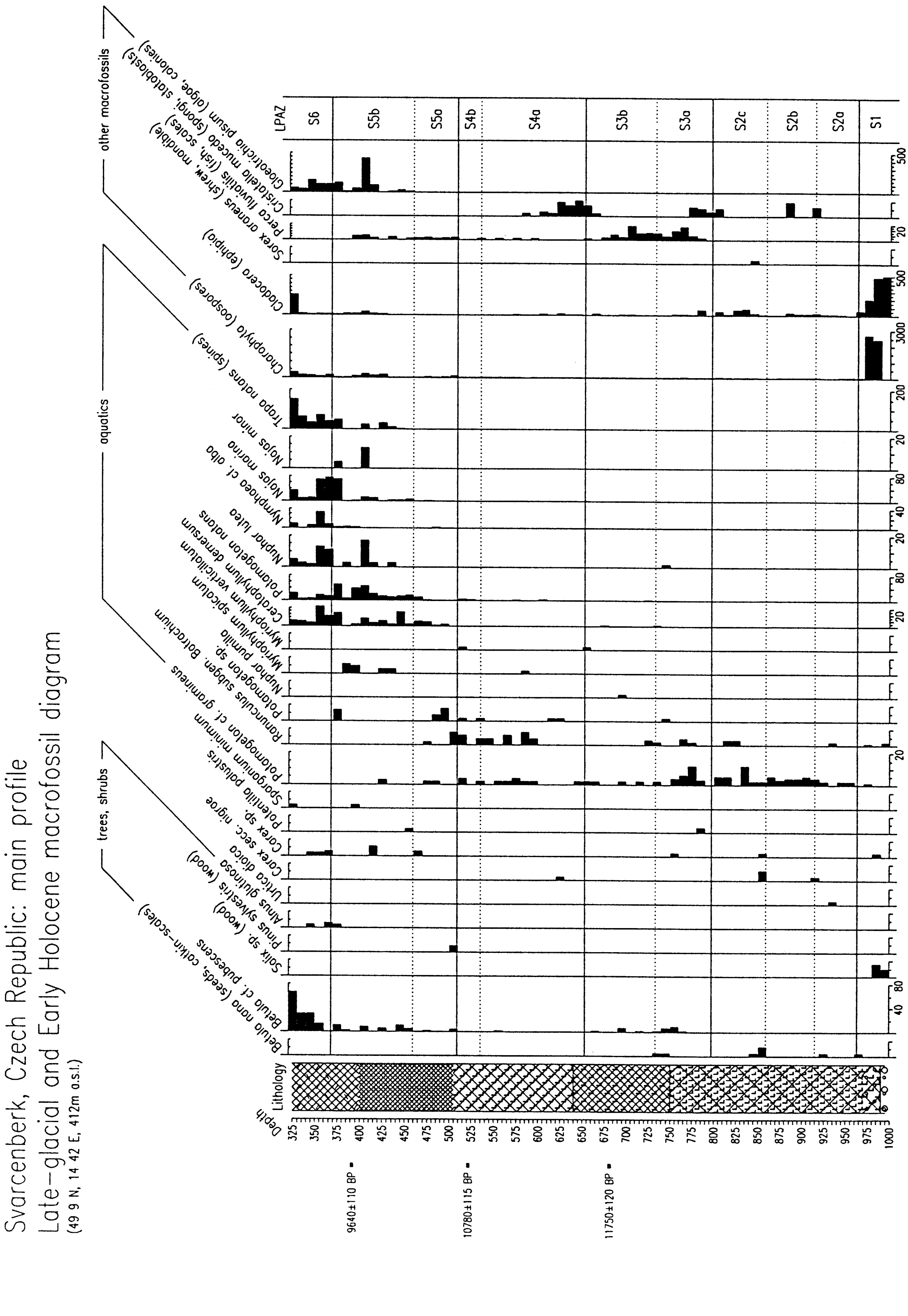

Fig. 5. Late-Glacial and Early-Holocene macrofossil diagram of the "main profile". Absolute numbers of the finds were recalculated to standard volume of 500 cm^3 of fresh sediment. If not stated differently, all finds represents seeds.

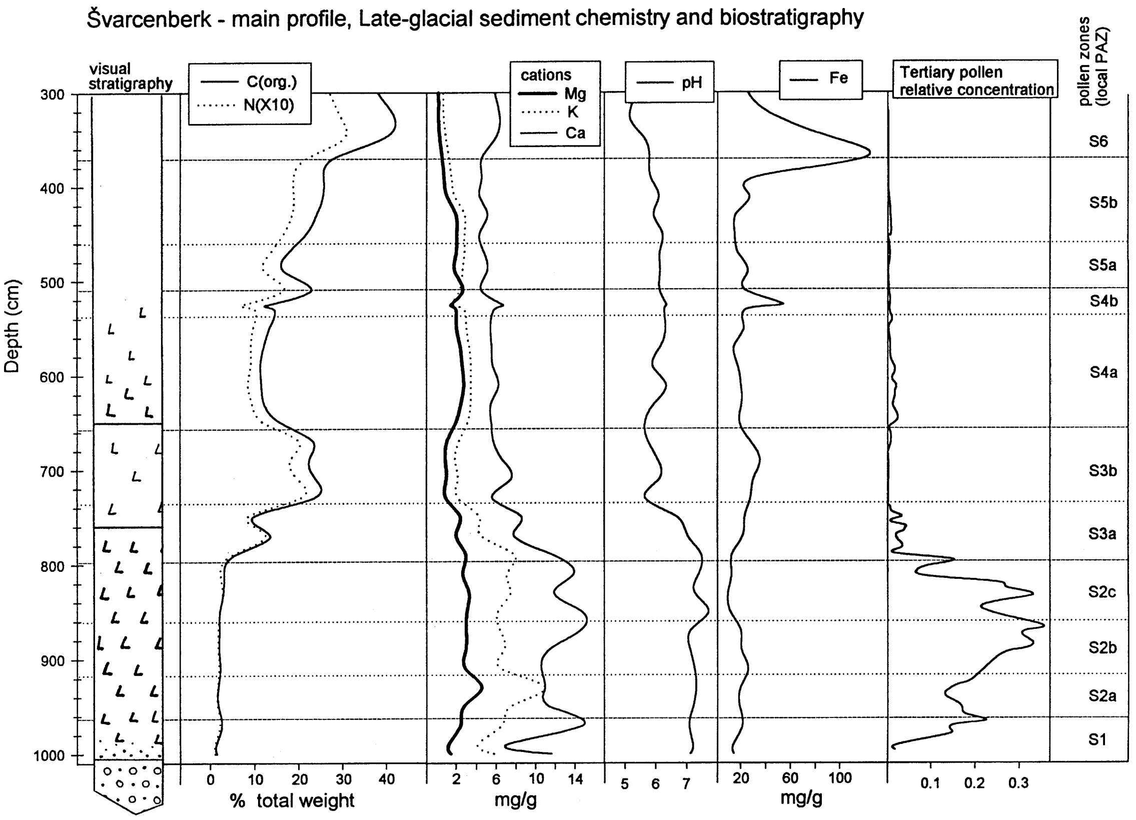

Fig. 6. Sediment composition of the "main profile" correlated with local pollen zonation. Simplified stratigraphic column shows different proportion of sand (dots and circles) and silt (angles) components in organic sediments.

Table 1
AMS radiocarbon dates from Švarcenberk littoral (S500) and central ("main profile") cores and "Vlkovský přesyp" sand dune (LuA-4645)

Lab. no.	Core label/depth	Method	Type of material	Measured ^{14}C age
LuA-4297	S500: 200 cm	AMS	*Trapa natans* nut	6340 ± 110 BP
LuA-4589	"Main p.": 324–327 cm	AMS	*Trapa natans* nut	6350 ± 100 BP
LuA-4590	"Main p.": 390–393 cm	AMS	Woody stem fragment	9640 ± 115 BP
LuA-4591	"Main p.": 520–523 cm	AMS	Bulk gyttja sample	$10{,}780 \pm 115$ BP
LuA-4738	"Main p.": 680–683 cm	AMS	Alkali-soluble fraction from gyttja	$11{,}750 \pm 120$ BP
LuA-4645	Surface of a fossil soil	AMS	*Pinus* charcoal fragments	$11{,}260 \pm 120$ BP

yellowish layers of aeolian material, each about 1 cm thick). The borders distinguished between several litostratigraphic units can therefore be assumed to be roughly time-parallel. In two littoral sampling points, S500 and JC-7B (the latter made and studied in SW part of the basin by Jankovská, 1980), pollen analysis confirmed this assumption. Only the limno-thelmatic contact, marking the time of final infilling of the lake, was expected to be metachronous over the basin. Radiocarbon dating in the littoral part (sampling point S500, with a date of 6340 ± 110 BP directly at the limno-thelmatic contact) and the central part of the lake (the "main profile", with an almost identical date of 6350 ± 100 BP at a level significantly under the limno-thelmatic contact) confirmed this expectation.

The striking features of the basin morphometry are its kidney-shaped form, surprising depth and declivity (the presence of unusually steep slopes), and relatively great age of its infilling. Unfortunately, no radiocarbon date exists from the basal sediments, but their age is estimated around 16,000 BP from the pollen-analytical results. On the basis of these findings, the origin of such structure can be best explained as the remnant of a huge Pleniglacial ground-ice lens—an open-system pingo.

more surprising in case of former lake Švarcenberk is the unusually big size of its depression. Considering this fact and the observation of the "ridges" (Fig. 2) dividing the basin into three main parts, the origin of the lake can be best viewed as the remnant of some kind of a compound pingo structure.

In the littoral parts of the former lake basin, only a thin layer of Late-Glacial sediments is present, completely lacking deposits older than Younger Dryas. This can be explained by intensive reworking of the shores during Late-Glacial rather being the result of lower lake levels during this period. As the lake was fed almost exclusively by artesian water, water-level remained constant over the entire period of its existence, and water-level reconstructions cannot be used as a climatic indicator, unfortunately. After the final infilling of the lake (dated to approx. 5500 BP), oligotrophic peat started to accumulate.

4.2. Main biostratigraphic events and geomorphic processes

Pollen stratigraphy of the "main profile" has been subdivided into six local pollen assemblage zones (PAZ) and eleven subzones, which are used as a framework for the discussion of the results. Because of terminological problems (e.g. Ammann and Lotter, 1989; Walker, 1995) I have decided to subdivide the diagram in this way rather than into Firbas pollen zones (Firbas, 1949), as is traditionally done in Central Europe. The absence of analogous results over a wide region discourages the use of regional pollen zonation. The local PAZ are later compared (Fig. 9) with European climatostratigraphical units according to Mangerud et al. (1974) and Ammann and Lotter (1989) and with the $\delta^{18}O$ curve of the Greenland ice core GISP2 (Stuiver et al., 1995).

4.2.1. Zone S1

The lowest sediments of the lake-basin sequence consist of fine silt with coarser sand. Absolute pollen concentrations in the sediment are low. The zone is characterised by high NAP values, suggesting open herbaceous vegetation. Grasses, Cyperaceae, Chenopodiaceae, *Betula nana, Alnus viridis, Salix* (most likely some dwarf willow species), *Thalictrum*, and *Artemisia* were important components of the vegetation. Macroscopic stem fragments of *Salix* sp. were found in the sediment. Sporadic pollen finds of *Ephedra* (both *Ephedra distachya* and *E. fragilis* types) are difficult to interpret, as this type of pollen can be dispersed over long distances (Huntley and Birks, 1983; Lang, 1994). *Pinus* values are below 30%, and *Betula* values do not exceed 5%; both can be ascribed to long-distance transport. *Helianthemum* is indicative of bare,

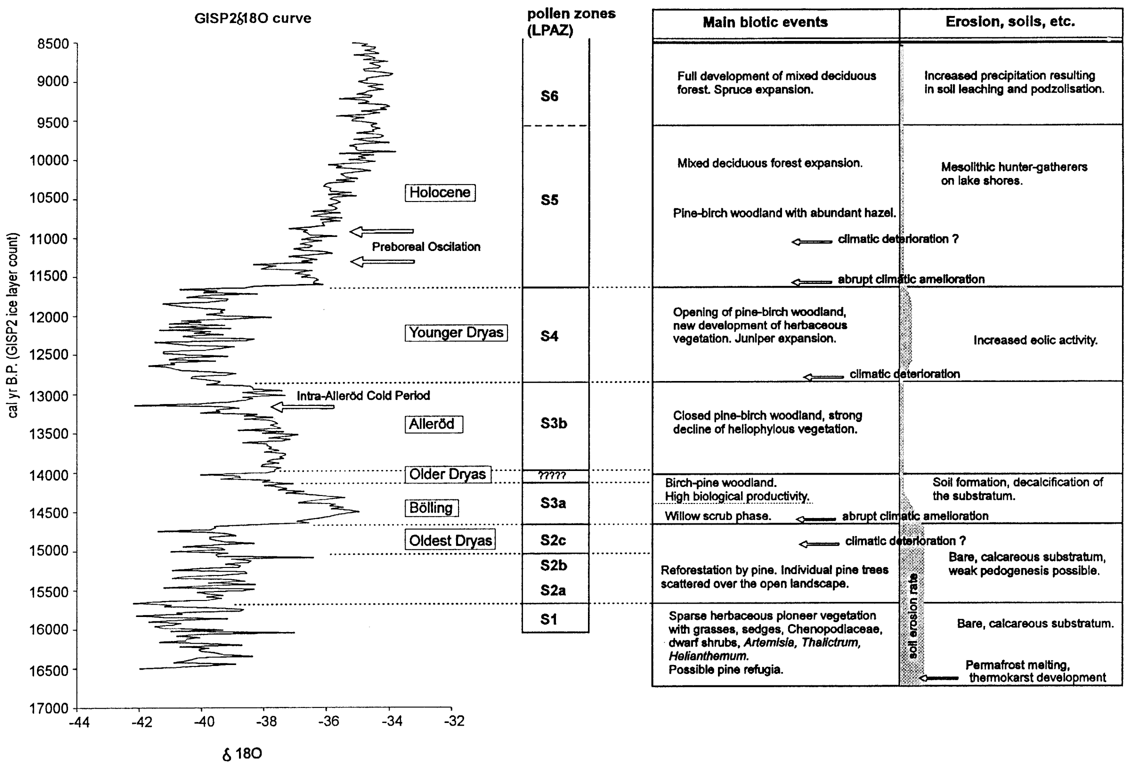

Fig. 9. Local PAZ compared with bidecadal $\delta^{18}O$ curve of the Greenland ice core GISP2 (data measured by hand by W.O. van der Knaap from graph presented at Stuiver et al., 1995). This cross-correlation should be considered as a suggested scheme only. Absolute time scale (cal yr BP; yearly ice-layer counts before A.D. 1950) and chronozones follow Stuiver et al. (1995) with exception of the "Preboreal oscilation" derived from Ammann and Lotter (1989). A synoptic table of the main events for the site of present study is attached from the left.

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LONG-TERM VEGETATION DYNAMICS AND THE INFILLING PROCESS OF A FORMER LAKE (ŠVARCENBERK, CZECH REPUBLIC)

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Keywords: Climatic change, Hydrosere, Lake terrestrialization, Macrofossils, Palaeoecology, Palaeolimnology, Pollen analysis, Subfossil algae, Vegetation ecology

Abstract: Natural lakes are a rare phenomena within extraglacial areas of Central Europe. Almost all have been completely terrestrialized during the Holocene. This paper deals with one such former lake, located in southern Bohemia. Its extensive lacustrine and peat deposits were subjected to a multidisciplinary study that resulted in high-resolution pollen, macrofossil, algal and sediment-chemistry data interpreted in terms of past climate, geomorphology, soil, and regional vegetation development over the last 16,000 years. Against the background of these large-scale processes, local development took place, comprising the lake's ontogeny from an arctic-type ecosystem hosting pioneer aquatic communities, through a highly diversified mosaic of eutrophic hydrosere habitats (shallow pools, *Phragmites* and *Carex* fen, alder carr), towards an oligotrophic mire that started to dome over the terrestrialized lake. At every individual development stage, specific processes characterized ecosystem function and composition: during the Late-Glacial with its rapid climatic changes, external forces induced the major stresses; while during the Holocene, autogenic changes of the wetland ecosystem played the most important role.

INTRODUCTION

The recent discovery of thick, buried lake sediments of former Lake Švarcenberk in the Třeboň Basin, South Bohemia, presents an exceptional opportunity to study the regional vegetation and climatic development, as well as the local environmental succession of a lake basin. A high-resolution investigation of pollen, plant macrofossils, algal remains, and sediment composition for the Late-Glacial and Early to Middle Holocene sediments of the former lake yielded well-founded palaeoclimatic and palaeovegetation data. The profile is unique in the Czech Republic in having an extensive and well-stratified Late-Glacial record. High sediment-accumulation rates allowed the study of brief Late-Glacial climatic oscillations, so that a comparison could be made with western and northwestern Europe (POKORNÝ, in prep.).

The goal of the present study is to describe local vegetation changes against the background of abiotic settings (climate, nutrient cycling in the catchment, geomorphology) in order to reveal their possible driving forces. Thanks to the absence of significant human influence, and water level fluctuations, the Švarcenberk basin represents an ideal site for the study of natural changes in wetland communities. These changes could be the result of climatic stress

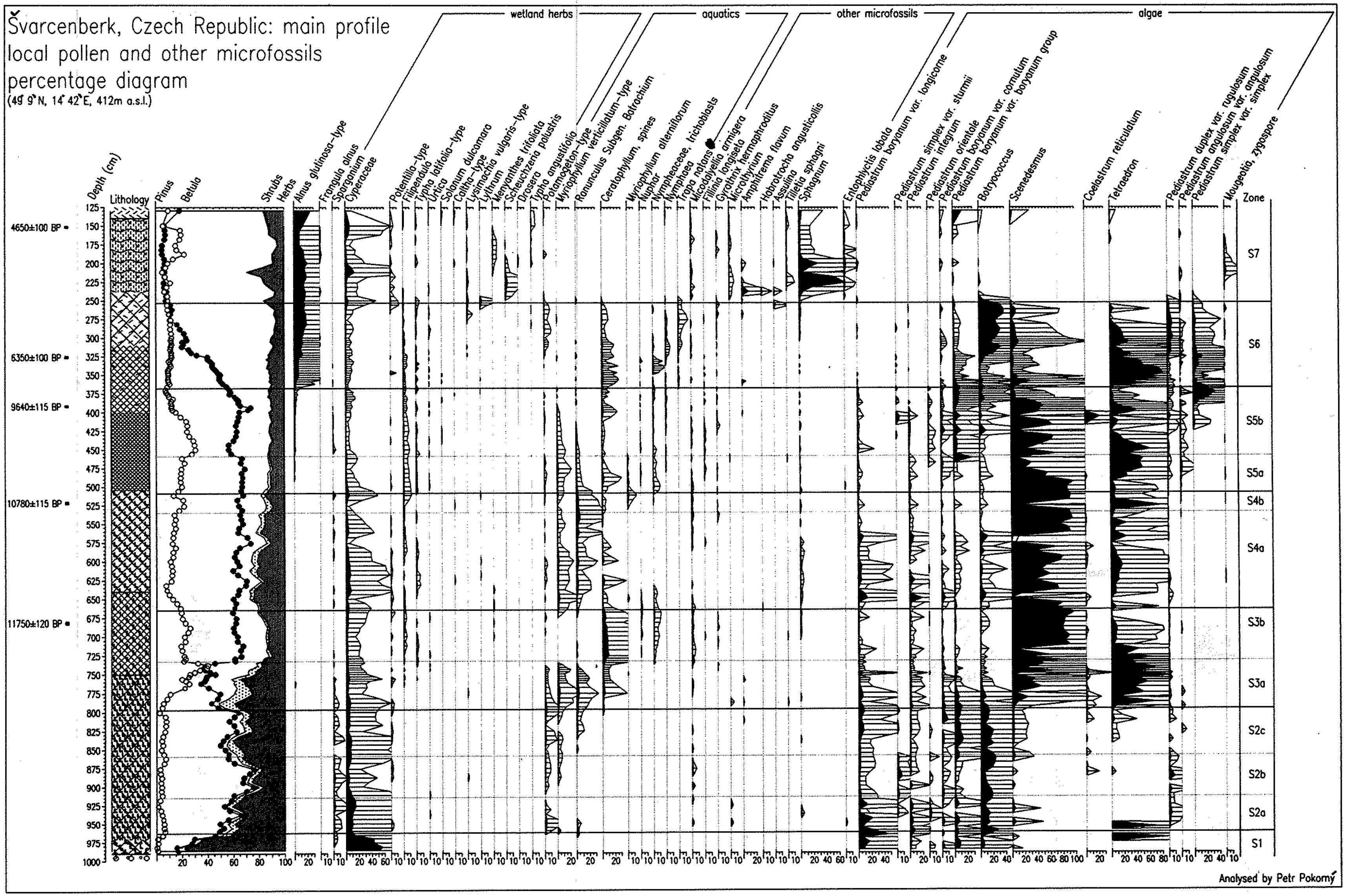


Fig. 5. Late-Glacial and Holocene local pollen and other microfossil diagram of the "main profile". Only selected types are included. For a sediment stratigraphy description, see Fig. 4.

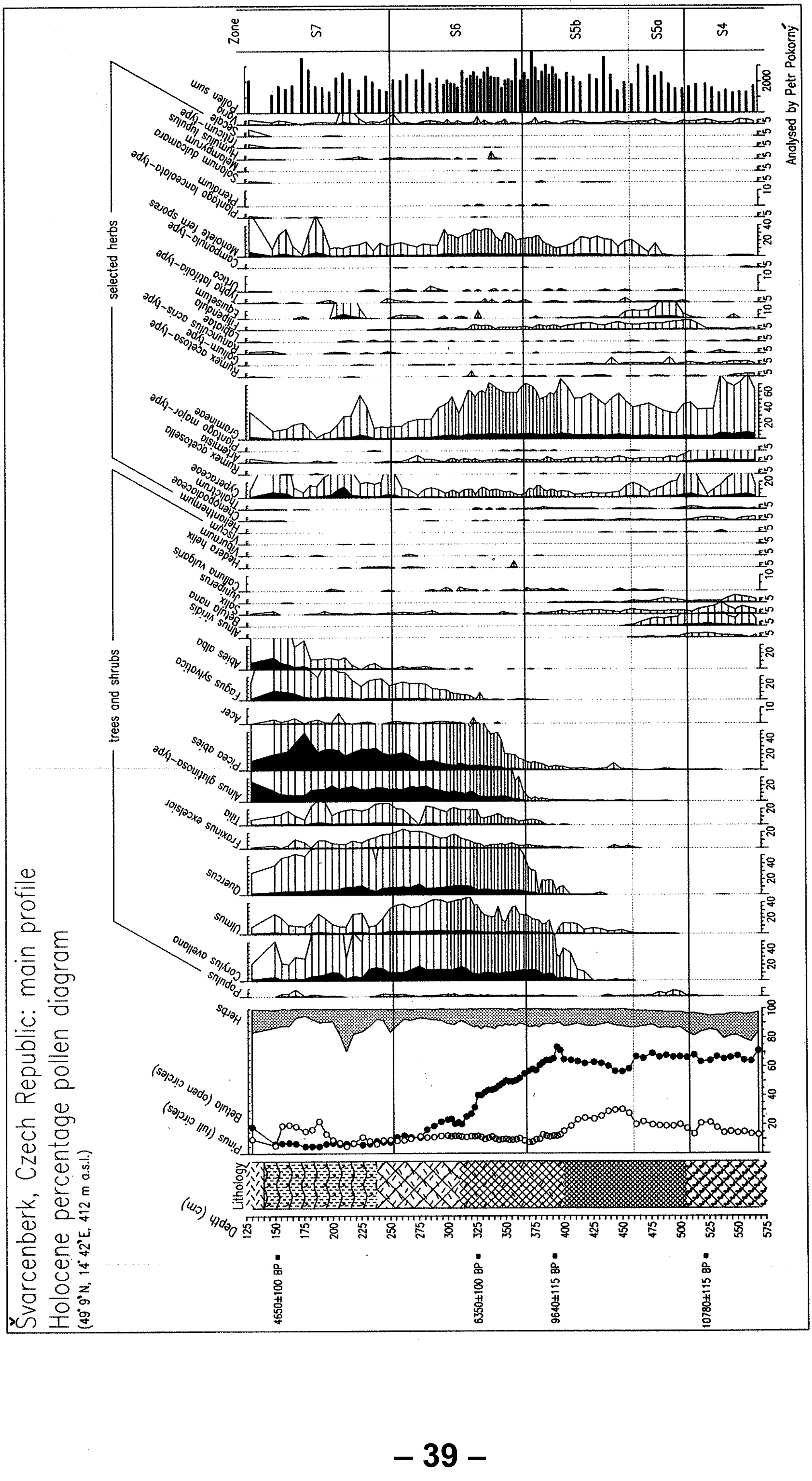


Fig. 6. Holocene regional pollen diagram of the "main profile" used for correlation purposes. For a sediment stratigraphy description, see Fig. 4.

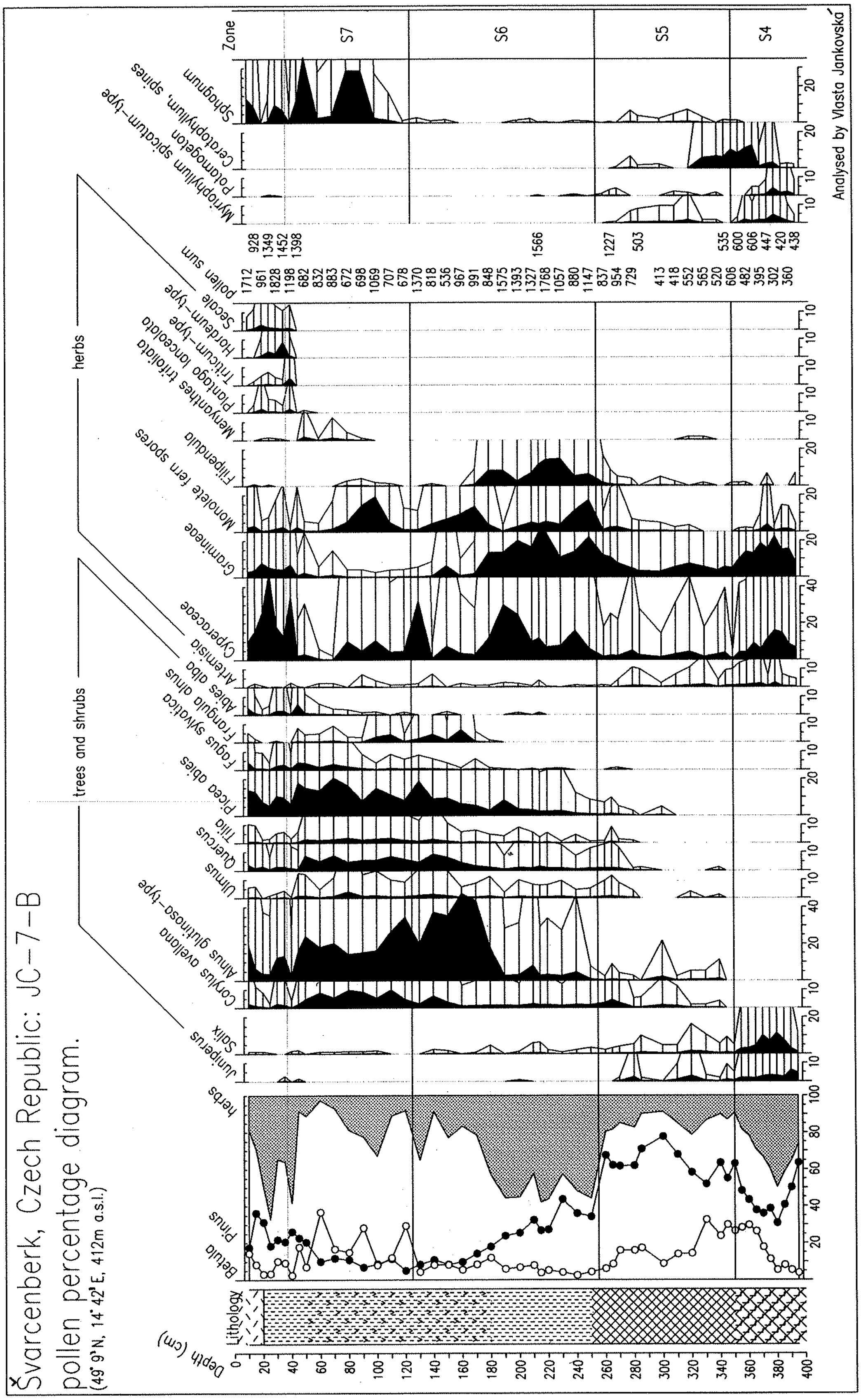
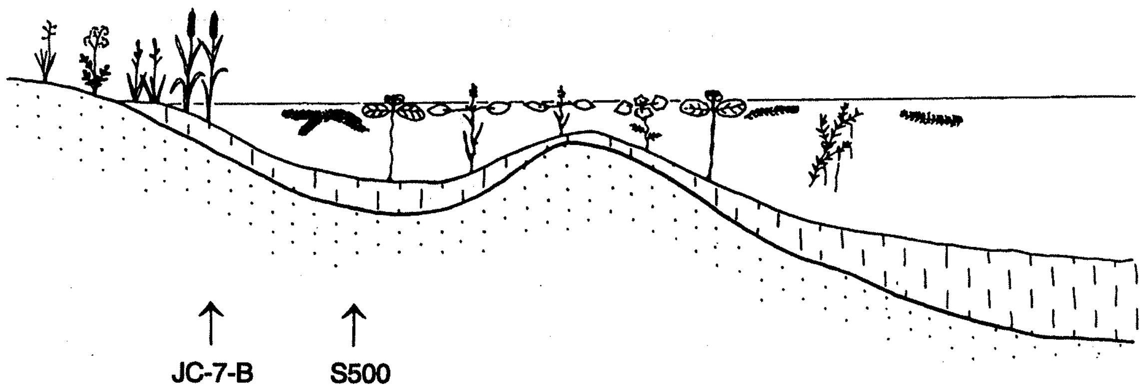


Fig. 8. Pollen diagram of JC-7-B profile. Only selected types are included. For a sediment stratigraphy description, see Fig. 4.

A **subzone S5b, about 9,500 BP**

location (core label):	JC-7-B	S500	"main profile"
characteristic taxa:	*Potamogeton, Ranunculus* subgen. *Batrachium, Ceratophyllum demersum, Myriophyllum verticillatum*	*Nuphar, Potamogeton, Ranunculus* subgen. *Batrachium, Ceratophyllum demersum, Myriophyllum verticillatum*	*Najas marina, Najas minor, Nuphar, Nymphaea, Trapa natans, Potamogeton natans, Ceratophyllum demersum, Myriophyllum spicatum*
Interpretation:	open water	open water	open water



B **zone S6 - first half, about 6,500 BP**

location (core label):	JC-7-B	S500	"main profile"
characteristic taxa:	*Carex, Carex panicea, Viola palustris, Filipendula*	*Nuphar, Potamogeton, Ceratophyllum demersum, Trapa natans*	*Najas marina, Nuphar, Nymphaea, Trapa natans, Potamogeton natans, Ceratophyllum demersum*
Interpretation:	fen	shallow pools	open water

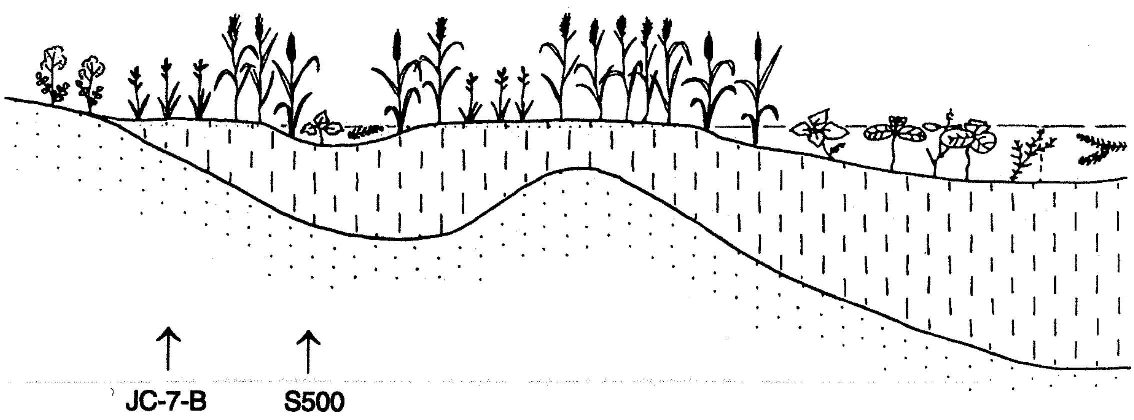
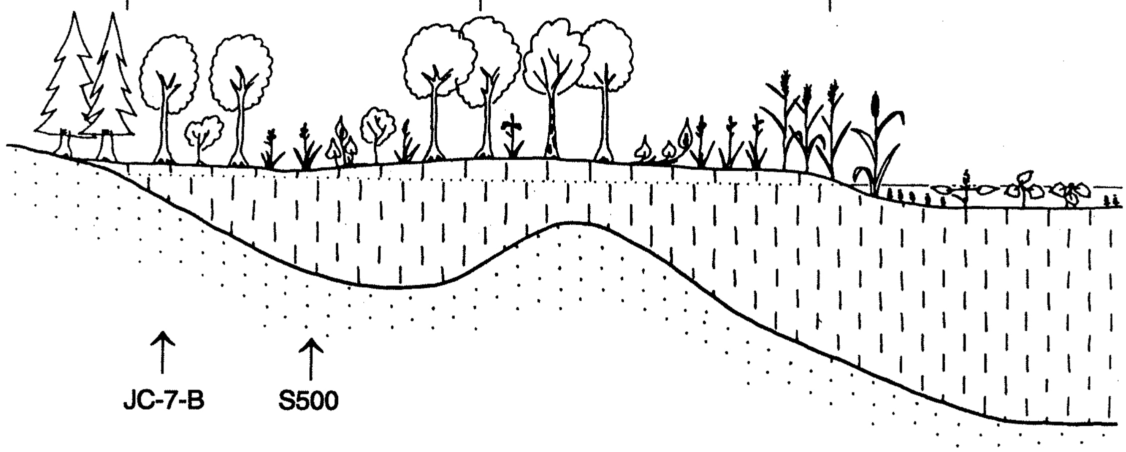


Fig. 13A–B. Time/spatial reconstruction of Lake Švarcenberk basin during the Holocene. Pollen zone labels and absolute time estimates (as BP – years before present) are indicated in headings.

C			zone S6 - second half, about 6,000 BP
location (core label):	JC-7-B	S500	"main profile"
characteristic taxa:	*Alnus glutinosa, Betula pubescens, Frangula alnus, Carex vesicaria, C. panicea, C. pseudocyperus, Calla palustris*	*Alnus glutinosa, Betula pubescens, Frangula alnus, Carex rostrata, C.* sect *nigrae, C. pseudocyperus, Calla palustris, Eleocharis, Solanum dulcamara, Lycopus europaeus*	*Potamogeton natans, Trapa natans, Nymphaea, Ceratophyllum demersum, Charophyta, Pediastrum duplex* var. *rugutosum*
Interpretation:	*Carex* fen / alder car	*Carex* fen / alder car	shallow water



D			zone S7 - first half, about 5,200 BP
location (core label):	JC-7-B	S500	"main profile"
characteristic taxa:	*Alnus glutinosa, Betula pubescens, Picea abies, Frangula alnus, Carex vesicaria, C. panicea, Calla palustris, Sphagnum*	?	*Carex rostrata, C. lasiocarpa, Scheuchzeria palustris, Potentilla palustris, Sphagnum*
Interpretation:	forested fen / bog (?)	forested fen / bog (?)	*Sphagnum* bog

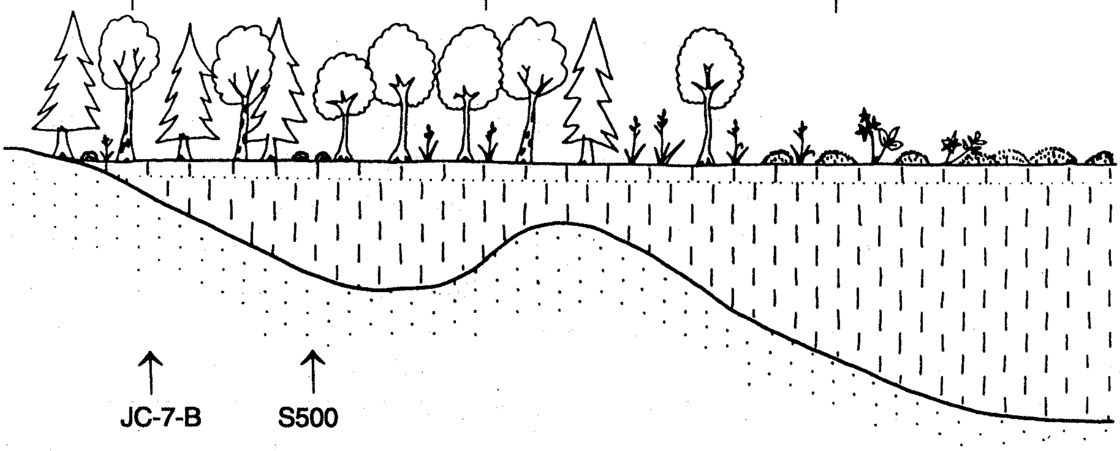


Fig. 13C–D. Time/spatial reconstruction of Lake Švarcenberk basin during the Holocene. Pollen zone labels and absolute time estimates (as BP – years before present) are indicated in headings.

E **zone S7 - second half, about 4,500 BP**

location (core label):	JC-7-B	S500	"main profile"
characteristic taxa:	*Menyanthes trifoliata, Potentilla palustris, Sphagnum*	?	*Potentilla palustris, Carex lasiocarpa, C. chordorhiza, Menyanhes trifoliata, Andromeda polifolia, Sphagnum*
Interpretation:	*Sphagnum* bog	*Sphagnum* bog (?)	*Sphagnum* bog

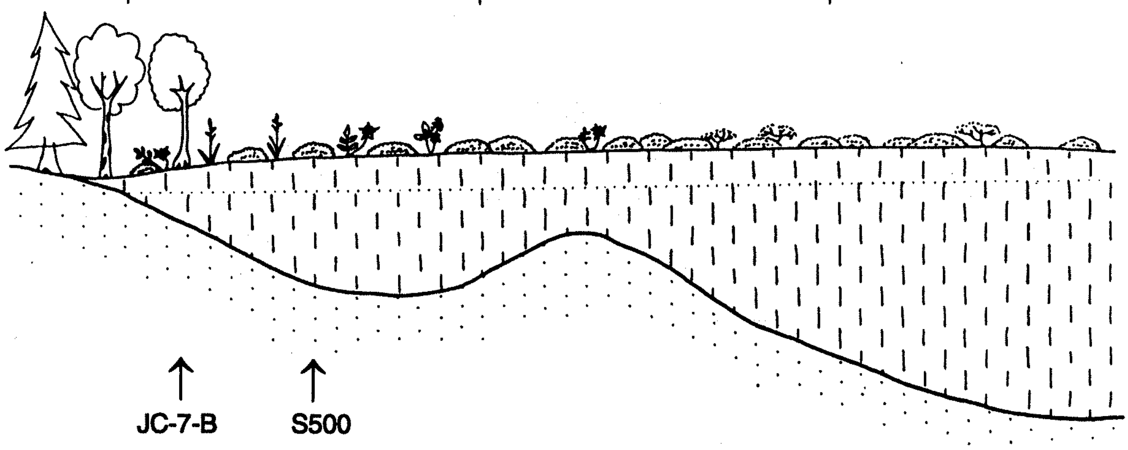


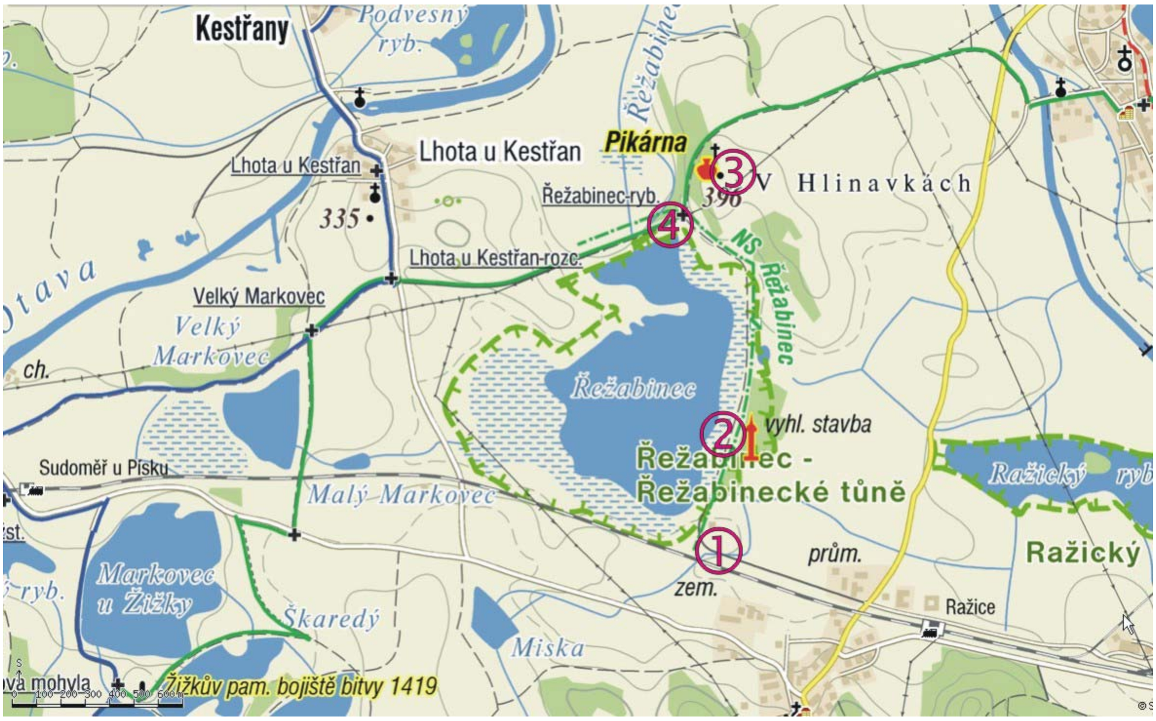
Fig. 13E. Time/spatial reconstruction of Lake Švarcenberk basin during the Holocene. Pollen zone labels and absolute time estimates (as BP – years before present) are indicated in headings.

invasion of *Sphagnum* caused active acidification (TALLIS 1983). *Menyanthes trifoliata, Potentilla palustris, Scheuchzeria palustris*, and *Andromeda polifolia* grew in the *Sphagnum* carpet. In small bog pools, *Mougeotia* filamentous algae formed a surface growth.

During the next ca. 1,000 years, oligotrophic bog communities spread towards the periphery of the mire. The sedimentary record ends in the middle of the basin, around 4,500 BP, and in the littoral parts it becomes fragmented, probably comprising some hiatuses. The later development of the mire can not be assumed, but a continued existence until the 13th century, when the area was first colonized can be. Peat-cutting and finally fishpond construction interrupted the natural development.

The uppermost sediment sample of the "main profile" represents subrecent fishpond bottom sediment (sapropel). Its chemical composition is directly influenced by management (liming, fertilization, intensive fish production, etc.). Cations and phosphates have penetrated downwards. This explains the rise in P and Ca (together with a pH rise) in the uppermost peat. Deep penetration especially by calcium carbonate (artificially supplied in large quantities), which enrich the peat to a depth of about 1.5 m is observed.

Further details of the vegetation succession during individual stages of the lake basin terrestrialization are shown in Fig. 13A–E. A comparison of pollen and macrofossil analyses in the same profile and among profiles allows methodological conclusions on the suitability of both methods to reconstruct spatial patterns in the vegetation. This is, however, not pursued here.



Řežabinec is an important archaeological site. In 20's of the 20th century, Mesolithic period was recognized here – firstly in the Czech Republic. Latter, Late Palaeolithic settlement was discovered at the same site. Both were located on the top of a small hill, surrounded by dead meanders of the nearby rivers. One old river channel was studied by means of pollen analysis (E. Rybníčková).

<u>Numbers on the map:</u>

1 – Bus stop

2 – Wetland vegetation and bird watching at the shore of the fish-pond.

3 – Visit of the archaeological site and discussion about early human influence to the Holocene vegetation.

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Palaeogeobotanical Evaluation of the Holocene Profile from the Řežabinec Fish-pond

Keywords

Southern Bohemia, Holocene vegetation, Land occupation, Middle Holocene stratigraphic anomaly

Abstract

RYBNÍČKOVÁ E. et RYBNÍČEK K. (1985): Palaeogeobotanical evaluation of the Holocene profile from the Řežabinec fish-pond. – Folia Geobot. Phytotax., Praha, 20: 419–437. – Stratigraphic, pollen and macroscopic analyses of the Holocene limnic and peat sediments from the Řežabinec fish-pond (southern Bohemia, Czechoslovakia) are presented and evaluated. New information on the sedimentary processes (especially the middle Holocene stratigraphic anomaly), the development of aquatic and mire vegetation, the character of the forest cover and human activity in the Řežabinec area during the Preboreal, Boreal, Subboreal and Subatlantic has been obtained.

INTRODUCTION

A fish-pond of Řežabinec near Ražice and Putim, situated in the north-western part of the Českobudějovická pánev Basin (southern Bohemia, Czechoslovakia), and its close vicinity form a very interesting area from the point of view of plant geography (HEJNÝ et MORAVEC 1948), ornithology (PECL 1978), archaeology (DUBSKÝ 1937, 1949; MOTYKOVÁ-ŠNEJDROVÁ 1963, 1967; VENCL 1970; and others) and also as the authors have recently found, a highly important site for palaeogeobotany and palaeoecology in general. The organogenic sediments, rare in the Českobudějovická pánev Basin, were found first by HEJNÝ and MORAVEC (op. cit.) on the southern shore of the fish-pond. Later, the latter of the two authors suggested the place as a suitable locality for palaeogeobotanical investigation; originally, this was intended to solve the remaining problems concerning the composition of pre-cultural virgin forests in the region between the towns of Strákonice and Písek. However, during work on this problem other questions of Holocene stratigraphy and the history of land occupation have arisen.

The investigation carried on, to a certain degree, the work performed by RYBNÍČKOVÁ (1973) in the neighbouring Otavské Předšumaví foothills and at the same time it checks and extends the palaeogeobotanical information available for the central part of the Českobudějovická pánev Basin (RYBNÍČKOVÁ, RYBNÍČEK et JANKOVSKÁ 1975).

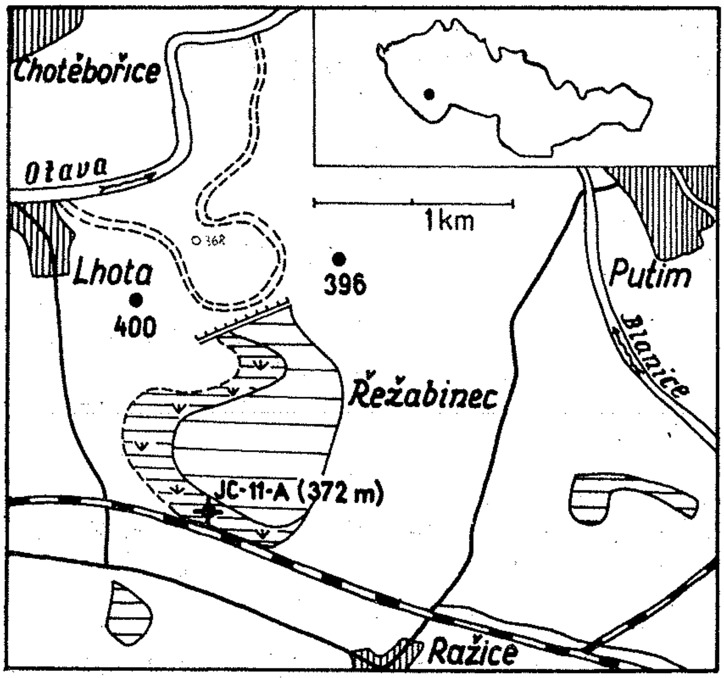


Fig. 1. The localization of the profile JC-11-A and the geographical situation of the surroundings of the Řežabinec fish-pond.

DESCRIPTION OF THE AREA

The Řežabinec fish-pond is one of the medium-size water bodies (about 0.8 km^2, incl littoral) in the north-western part of the Českobudějovická pánev Basin. It is situated ca 8 km south-west of the town of Písek, close to the confluence of the rivers Otava and Blanice. The altitude of the water level varies slightly about 371 m ASL (see Fig. 1), the maximum depth varies between 5 and 6 m, the mean depth between 2 to 3 m.

The fish-pond was built before the beginning of the 16th century (KUČERA, pers. comm.) in a small depression formed probably by the eroding and accumulating processes of an old meander of the river Otava. The river affected the hydrology of the depression by waterlogging the soils and forming a system of periodic pools or small, shallow permanent lakes and abandoned channels. This all brought about favourable conditions for sedimentation of organogenic material during the late Quaternary, especially in the southern or south-western part of the depression. In this area, water springs probably existed, and one was still active recently.

The eastern shore of the present fish-pond is formed by a low and flat sand dune. It represents a natural dam separating the depression of the Řežabinec from the broad valley of the Blanice.

The geology of the close vicinity is very simple. The area is covered by Tertiary sands, clays and gravels which are only in some places broken through by biotite paragneiss; a detailed geological map 1: 5000 was published by ŽEBERA (1955).

Climatically, the small area of the Řežabinec forms the only enclave of warm climate in the whole of southern Bohemia. VESECKÝ et al. (1958) classify it as a warm and moderately humid district with mild winters. The annual mean temperature is about 7.5 °C, the January mean temperature −2.4 °C, the July mean temperature 17.3 °C and the mean temperature for the mentation are separated by a clear stratigraphic discontinuity. For description of sediments in the particular layers see Tab. 1 and the stratigraphic column of the pollen diagram Fig. 3). Absolute C-14 data are presented in Tab. 2; they are also marked on the pollen diagram. The sample at 120—123 cm, dated to 5280 ± 105 B.P., was taken from the contact zone between the two sedimentation phases, where heterogeneous and allochthonous material of uncertain origin can be expected.

Table 2. Absolute C-14 dates from the profile Řežabinec, JC-11-A

Sample No	Depth cm	Age (before 1950)	Year of dating
Hv 10 251	87— 90	2 750 ± 150	1981
Hv 10 252	109—111	3 055 ± 195	1981
Hv 10 253	120—123	5 280 ± 105	1981
Hv 10 254	129—131	8 755 ± 140	1981
Hv 10 255	152—155	9 095 ± 390	1981
Hv 10 256	149—152	8 925 ± 300	1981
Hv 11 537	74— 75	1 220 ± 75	1983
Hv 11 538	114—115	4 185 ± 245	1983
Hv 11 539	125—126	6 860 ± 110	1983

The existence of a middle Holocene stratigraphic hiatus or retardation of sedimentation (growth) is clearly indicated by pollen analyses, by macroscopic analyses and by the different composition and origin of the sediments, and is supported by C-14 dates. The explanation of this stratigraphic anomaly is very difficult. In case of hiatus, this can be a result of erosion activity of the river Otava, which could have flowed, forming a deep meander, through the present Řežabinec depression during the middle Holocene Period. The middle Holocene sediments, if such existed at all, were simply transported away by the water stream. Another possible explanation of the anomaly can be found in the intensive physical and biological humification of the middle Holocene layers under *Alnus* stands (see below). It is, however, interesting that this type of stratigraphy has been observed in two independent places in the same region (Řežabinec and Zbudovská blata). The problem of the middle Holocene hiatus or peat growth retardation thus seems to have wider implications and requires special attention. It has been found that similar stratigraphic discontinuities do exist in other regions too and so the question will be dealt with in a separate paper and in general.

The evolution of local vegetation is shown by Tab. 3. In this combined table micro- and macrofossil finds are ordered according to their time of occurrence and indicator value. The survey clearly shows three developmental epochs with several developmental stages and transitional phases.

The first developmental epoch (1) with one developmental stage (A) is characterized by the predominance of micro- and macrophytic aquatic plants. Planktonic chlorococcal algae (especially several *Pediastrum* species), *Myriophyllum*, *Batrachium*, *Potamogeton*, etc. are the leading fossils of the sediment. Roots of alder penetrated from upper layers and are younger.

APPENDIX 1 RYBNÍČKOVÁ ET RYBNÍČEK: HOLOCENE PROFILE FROM ŘEŽABINEC

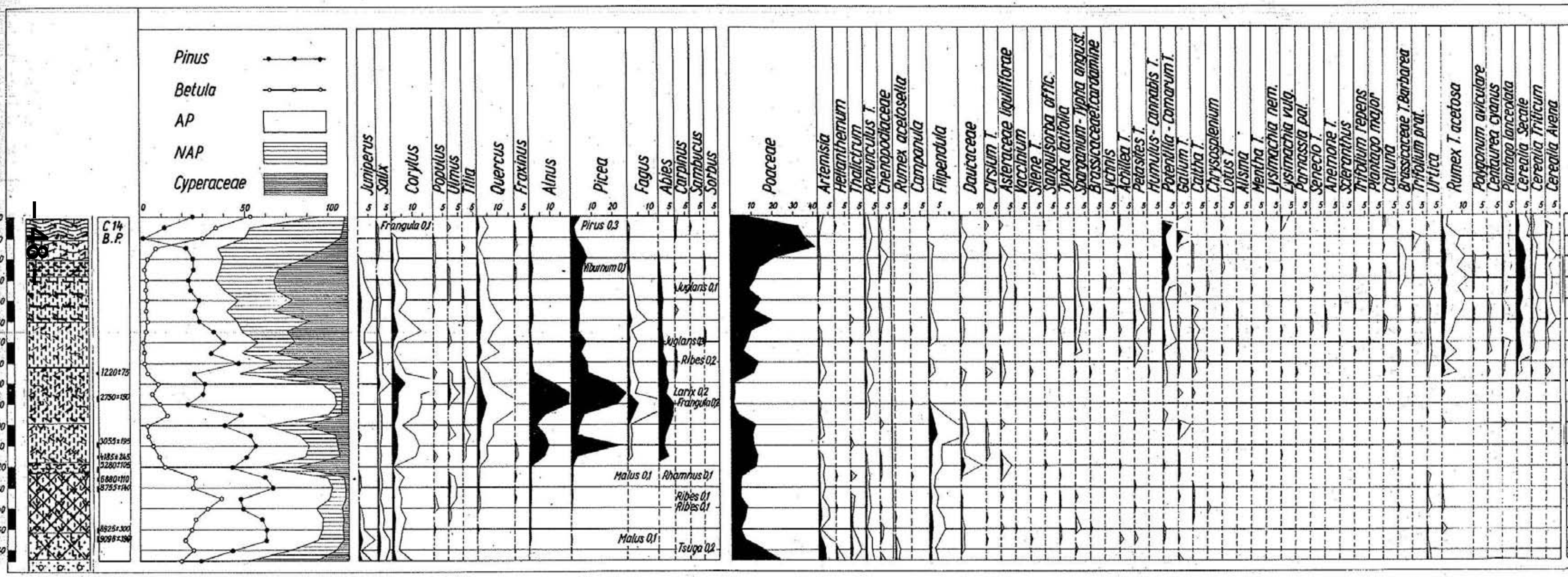
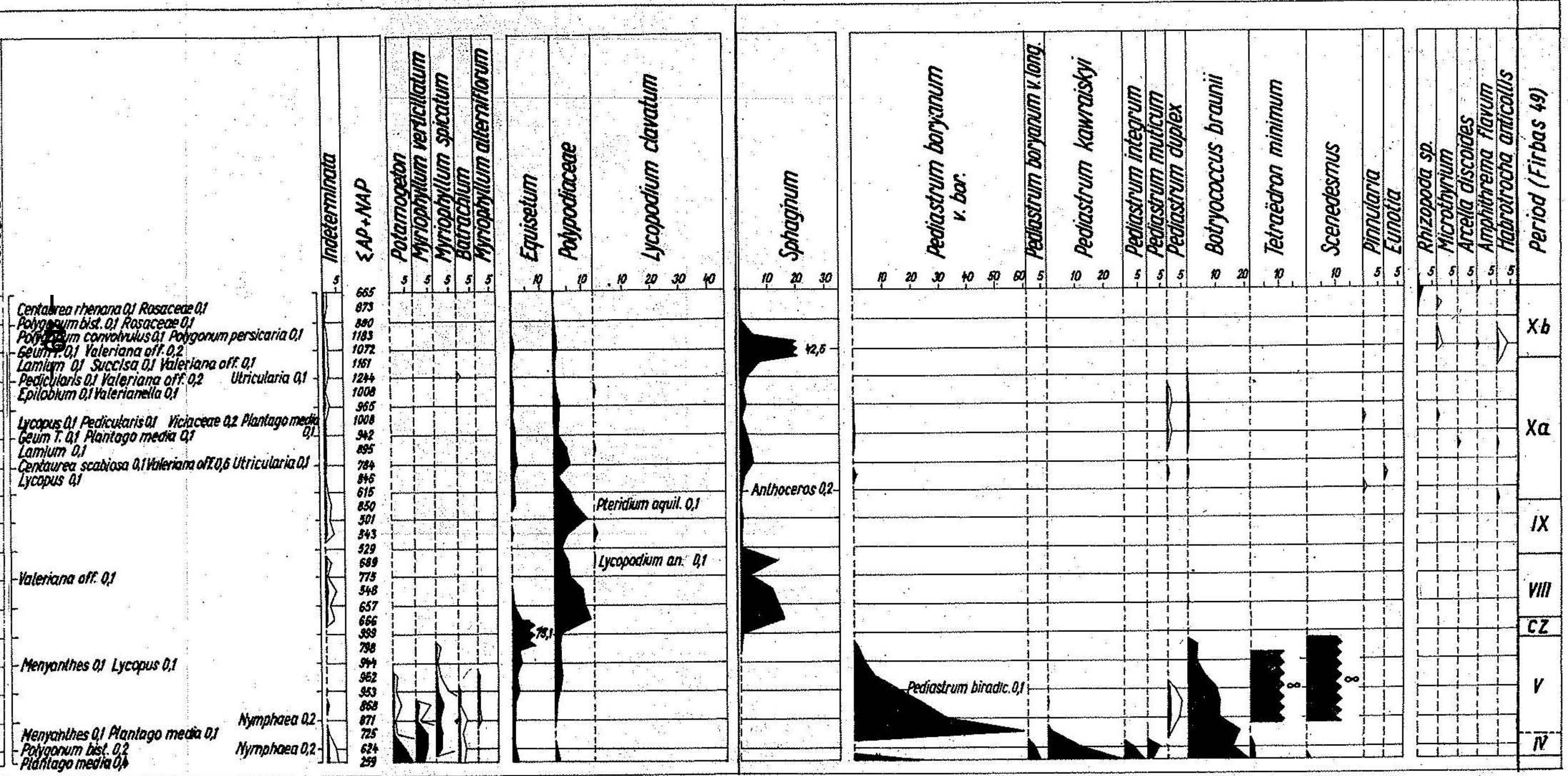


Fig. 3. Total pollen diagram from the Řežabinec mire, JC-11-A


Indeterminata
ΣAP+NAP
Potamogeton
Myriophyllum verticillatum
Myriophyllum spicatum
Batrachium
Myriophyllum alterniflorum
Equisetum
Polypodiaceae
Lycopodium clavatum
Sphagnum
Pediastrum boryanum v. bor.
Pediastrum boryanum v. long.
Pediastrum kawraiskyi
Pediastrum integrum
Pediastrum muticum
Pediastrum duplex
Botryococcus braunii
Tetraëdron minimum
Scenedesmus
Pinnularia
Eunotia
Rhizopoda sp.
Microthyrium
Arcella discoides
Amphitrema flavum
Habrotrocha anticollis
Period (Firbas 49)
Xb
Xa
IX
VIII
CZ
V
IV
Centaurea rhenana 0,1 Rosaceae 0,1
Polygonum bist. 0,1 Rosaceae 0,1
Polygonum convolvulus 0,1 Polygonum persicaria 0,1
Geum r. 0,1 Valeriana off. 0,2
Lamium 0,1 Succisa 0,1 Valeriana off. 0,1
Pedicularis 0,1 Valeriana off. 0,2 Utricularia 0,1
Epilobium 0,1 Valerianella 0,1
Lycopus 0,1 Pedicularis 0,1 Viciaceae 0,2 Plantago media 0,1
Geum T. 0,1 Plantago media 0,1
Lamium 0,1
Centaurea scabiosa 0,1 Valeriana off. 0,6 Utricularia 0,1
Lycopus 0,1
Valeriana off. 0,1
Menyanthes 0,1 Lycopus 0,1
Nymphaea 0,2
Menyanthes 0,1 Plantago media 0,1
Polygonum bist. 0,2
Nymphaea 0,2
Plantago media 0,4
Pteridium aquil. 0,1
Lycopodium an. 0,1
Anthoceros 0,2
Pediastrum biradic. 0,1
42,5
78,1
665
873
880
1183
1072
1161
1244
1008
965
1008
942
895
784
846
615
850
501
543
529
689
775
548
657
666
939
798
944
962
953
868
871
725
624
259

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ORIGINAL ARTICLE

Detection of the impact of early Holocene hunter-gatherers on vegetation in the Czech Republic, using multivariate analysis of pollen data

Petr Kuneš · Petr Pokorný · Petr Šída

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Abstract Pollen data from the Czech Republic was used to detect the early Holocene impact of hunter-gatherers on vegetation based on a selection of 19 early Holocene pollen profiles, complemented with archaeological information regarding the intensity of local and regional Mesolithic human habitation. Archaeological evidence was assigned to simple categories reflecting the intensity of habitation and distance from pollen sites. Multivariate methods (PCA and RDA) were used to determine relationships between sites and possible anthropogenic pollen indicators and to test how these indicators relate to the archaeological evidence. In several profiles the pollen signal was influenced by local Mesolithic settlement. Specific pollen types (e.g. *Calluna vulgaris*, *Plantago lanceolata*, *Solanum* and *Pteridium aquilinum*) were found to be significantly correlated with human activity. The role of settlement proximity to the investigation site, the statistical significance of pollen indicators of human activity, as well as the early occurrence of *Corylus avellana* and its possible anthropogenic dispersal, are discussed.

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Keywords Anthropogenic pollen indicators · Mesolithic · Early human impact · *Corylus avellana* · Multivariate analysis

Introduction

In the Czech Republic the Mesolithic period of human prehistory lasted from the Preboreal to the early Atlantic (i.e. from about 10,000 B.P. to 7,000 B.P. according to the most accepted contemporary view; Pavlů 2004; Vencl 2006). It was a period during which dramatic changes occurred both in the global climate and in ecosystems. Reacting to these environmental changes, Mesolithic human populations adopted various hunting, gathering and fishing strategies, all of which were generally more specialized than those of the big game hunters of the Paleolithic period. As post-Glacial natural afforestation proceeded, Mesolithic populations started to be less mobile and thus they affected local environments around camp sites more intensively. However, this impact was probably only of local character and hence could be easily overlooked in pollen diagrams. Moreover, the occurrence of anthropogenic pollen indicators in the sedimentary record may be strongly dependent upon the distance between the settlement and the sampling point (Behling and Street 1999; Wacnik 2005), as well as upon the type of sediment or local geomorphology.

A number of detailed palaeoecological studies concerned with the wider relationships of Mesolithic archaeology have been made (Simmons et al. 1985; Simmons and Innes 1988a, b; Clark 1989; Simmons and Chambers 1993; Turner et al. 1993; Macklin et al. 2000; Innes and Blackford 2003). Important surveys have come from Scandinavia, showing interesting pollen-analytical evidence for local

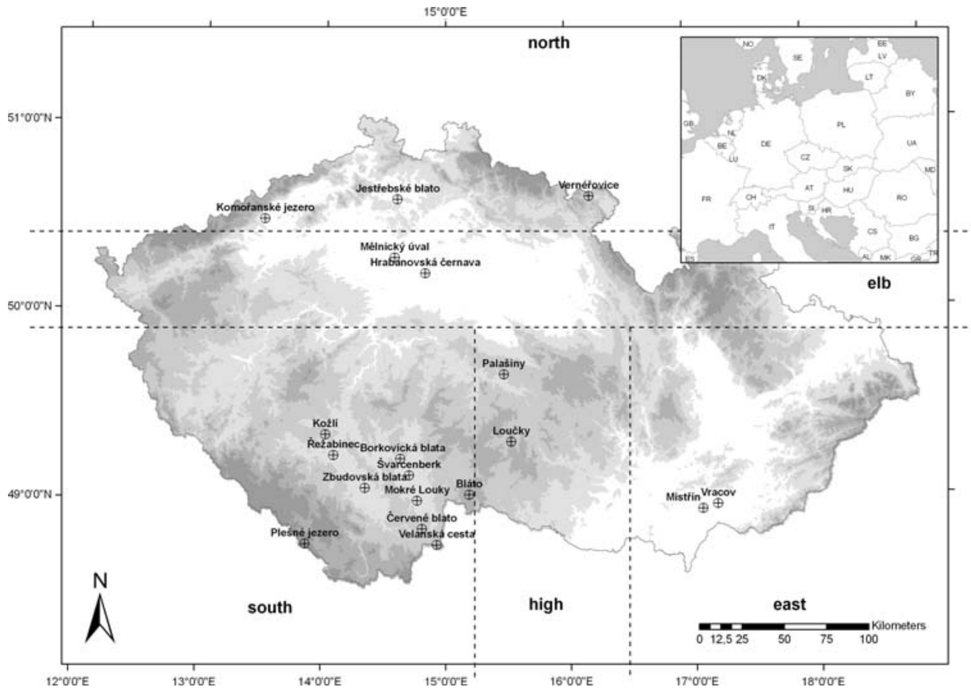


Fig. 1 Map of the Czech Republic with survey sites (*circles*). *Codes* at the *right* and at the *bottom* of the map indicate regions (delimited by *dotted lines*). The *same codes* are used in the ordination diagrams

pollen diagrams had to be unified (achieved using the POLPAL2005 Tabela program, Walanus and Nalepka 1999). The pollen-taxonomic nomenclature used follows Beug (2004) and is partly modified in the case of some plant taxa that are characteristic of the flora of the Czech Republic (Kubát 2002). The total sum of upland AP and NAP together was used to calculate percentages. Local pollen and spores (incl. aquatic and mire taxa) were excluded from this total sum. The percentages of taxa excluded from the total pollen sum (i.e. local pollen) were calculated based on each respective pollen type count in relation to total sum.

Subsequently, the zonation of all pollen diagrams was made in the POLPAL Diagram program using Constrained Single Linkage analysis (ConSLink) and Principal Component Analysis (PCA) (Nalepka and Walanus 2003). This means that zones were determined by biostratigraphic patterns and their denomination was made according to Firbas (1952). In those cases where available, ^{14}C ages were also used in determining zones and their precision. For each pollen diagram, two main pollen-assemblage zones (PAZ) were distinguished that covered the early Holocene period. These were early and late Mesolithic time slices. For those sites where some part of the record was missing, only one pollen assemblage zone was distinguished.

All samples from a selected PAZ were analyzed stratigraphically unconstrained in the CANOCO program (ter Braak and Šmilauer 2002) to avoid subjectivity in data interpretation. First a Detrended Correspondence Analysis (DCA) with square-root transformed data was performed. As the data were quite uniform among the dominant taxa, the first canonical axis had a gradient length of only 1.895. This confirmed that linear-based models like PCA (as in Fig. 3) or Redundancy analysis (RDA) can be used in the analyses. To suppress the influence of dominant taxa, we used a logarithmic transformation of the data percentages. All non-pollen palynomorphs (algae, fungi, charcoal etc.), *Equisetum*, Cyperaceae and monolete fern spores were excluded from the analyses.

In order to better visualize and interpret the data in further analyses (as in Fig. 3 onwards), an average for each zone was calculated, labelled with a code (I for the older and II for the younger zone). The data prepared in this way were then processed with PCA, using logarithmic transformation of percentage pollen data. To test for significance between environmental (three categories of archaeological evidence according to their distance from the sampling spot) and pollen taxa, RDA was used with logarithmic transformation, performing Monte-Carlo permutation tests with the reduced model and using unrestricted permutations.

Assessment of the archaeological evidence

Records of human presence near the pollen sites during the Mesolithic period were assigned to three categories according to their distance from the sampling point (Table 2). The first category includes local archaeology, defined as evidence of human presence immediately at the study site, which, in our case, meant only finds at the edge

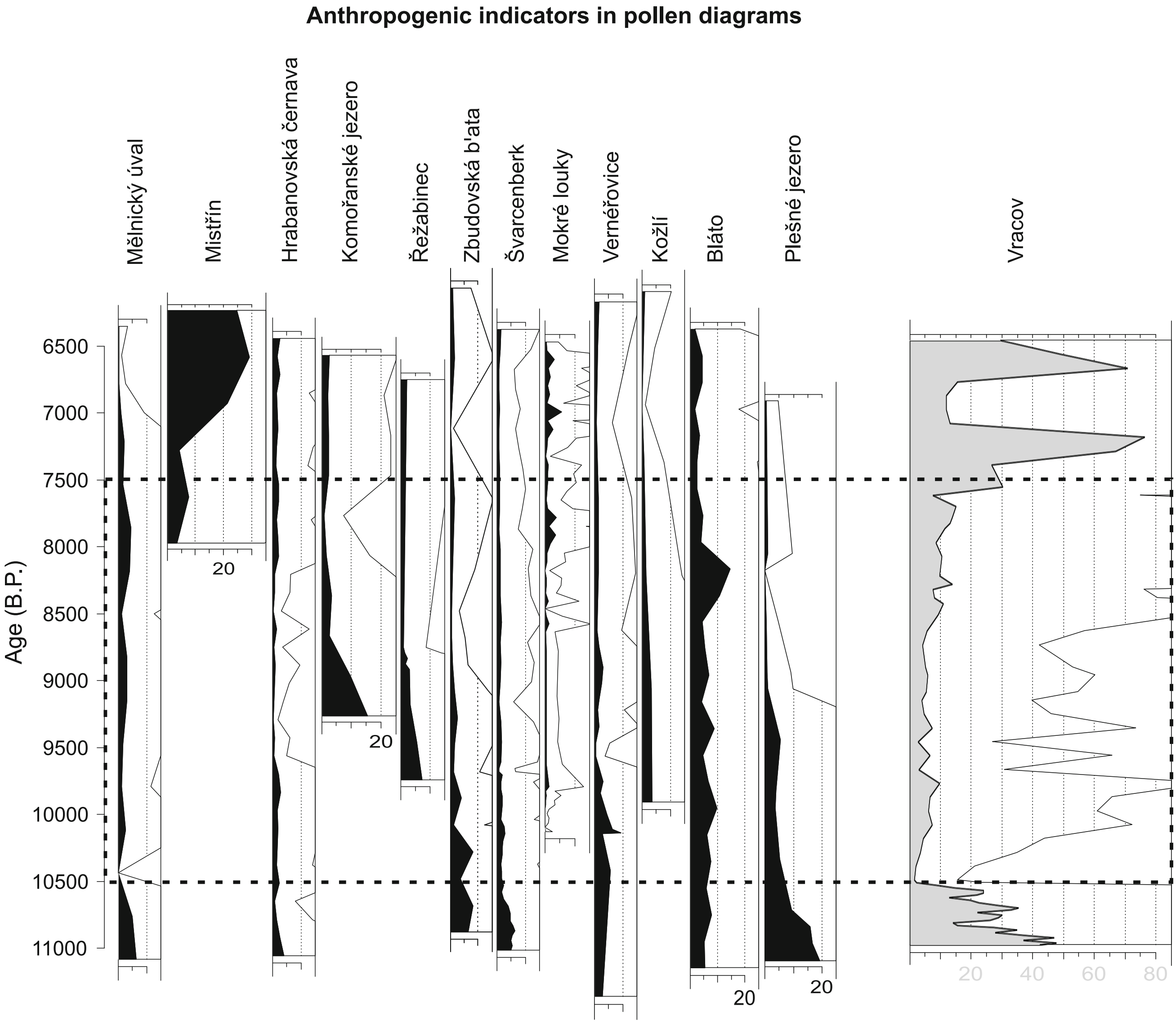


Fig. 2 Percentage pollen curves made from the sum of potential anthropogenic indicators at sites where chronology could be constructed. Sites are ordered according to increasing altitude from left to right (170–1,089 m a.s.l.). The pollen record from Vracov (at *right*) is not well dated; the timescale has therefore been constructed based on biostratigraphy, but it is used here as a principal lowland reference site

focused on sandstone areas for the last ten years. The site Vernéřovice is located in an area that has largely never been investigated. However, during the last few years some single finds of Mesolithic stone manufacture have appeared (Bronowicki 2000), hence archaeological finds are to be expected in this area. Southern Bohemia is the region where rather intensive Mesolithic archaeological research has been undertaken and consequently has a high index of human impact for all profiles. Southern Moravia has been the poorest in archaeological investigations. Although studies have uncovered several localities (e.g. Valoch 1978), the intensity of human presence is not as great as that around comparable profiles in the Bohemian lowlands. This difference cannot be due to dissimilar preferences of the Mesolithic populations, because the landscape provides similar conditions (e.g. Elbe region). It is for this reason that we reconstruct higher values for human habitation intensity in southern Moravia.

Table 2 shows the results of the categorisation of archaeological finds. Komořanské jezero, Švarcenberk and Řežabinec could be considered as important Mesolithic settlement sites; all three sites are former lakes. For some of the other sites there is strong regional evidence of Mesolithic occupation. This category is represented by profiles in the Elbe region of central Bohemia (Hrabanovská černava, Mělnický úval), sandstone landscapes

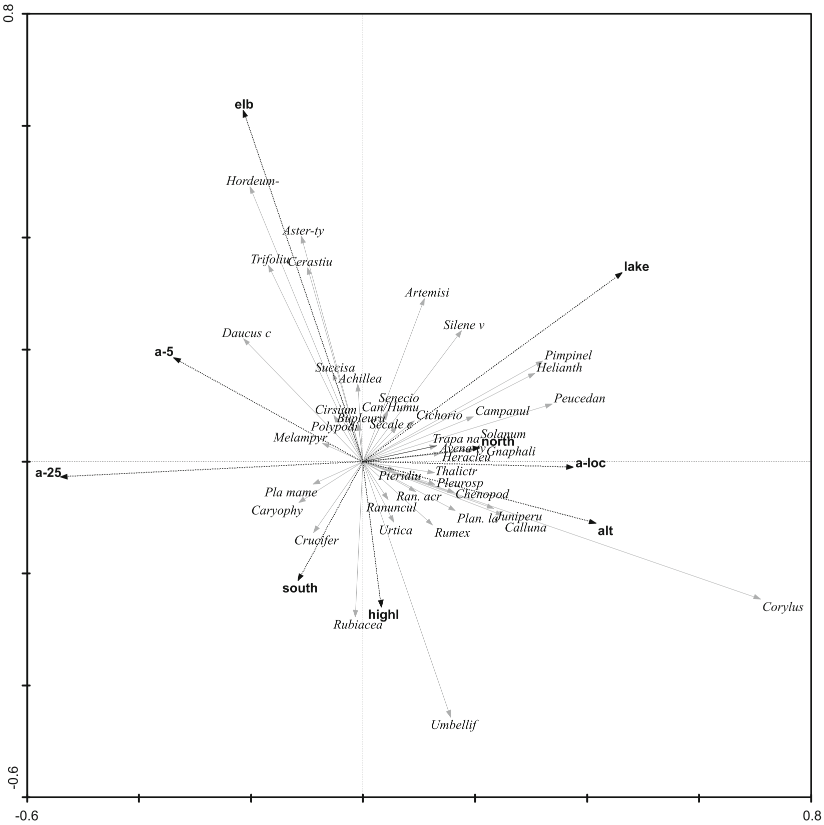


Fig. 7 Redundancy analysis (RDA) biplot of potential anthropogenic pollen indicators found in the Mesolithic period with environmental variables (*a-loc* local archaeology; *a-5* archaeology within 5 km; *a-25* archaeology within 25 km; *alt* altitude; *lake* lake sediment; *elb*, *highl*, *south*, *north* four regions as indicated on map in Fig. 1)

Jankovská 2000). Some deeper analyses were only carried out in studies that aimed at discussing archaeological theories (Pokorný 2005). In contrast, the present study focuses on vegetation development. Here, we found that some evidence for human impact in the early Holocene can be demonstrated using data already collected, i.e. already-existing pollen diagrams, and that there is a certain potential for this approach in future studies.

Settlement proximity to investigated pollen sites

We address the problem of human impact intensity being reflected in the pollen record by utilizing a number of sites over a rather large area. Past studies focussed more on the uniqueness of each locality and described the human impact related to specific archaeological finds of various intensity. This ranged from intentional landscape management, especially in north-western Europe (Simmons et al. 1985; Turner et al. 1993; Macklin et al. 2000; Mason 2000) to the hardly detectable presence of humans (Behling and Street 1999). Certainly the possibility of human activities being recorded in the early Holocene landscape is strongly dependent on the openness of the landscape and on the proximity of pollen sources of anthropogenic indicators (Wacnik 2005). This is also demonstrated by the present quantitative multivariate analyses, where the amounts of anthropogenic indicators are correlated with the local archaeological record (e.g. sediment profiles with Mesolithic archaeological finds on lake shores). At such sites, it then becomes possible to document human-induced changes in vegetation in the form of deforestation and connected events, and to record frequent fires (increases in the input of microscopic charcoal particles) which, in fact, might only have been local in character. On a larger scale, a wider picture of human impact can already be more distorted, with potential anthropogenic pollen indicators being also those of open landscape. Moreover, the distinction between primary and secondary open stands (as shown by the results of our multivariate analysis) is ambiguous.

Even very close distances between sampling points and areas of habitation (Behling and Street 1999) or direct evidence of anthropogenic indicators in pollen diagrams (Fig. 2) may not necessarily represent human activity. Most probably these indicators show a more specific and very weak response that is visually hardly detectable in the pollen diagram. Numerical analyses, as presented here, often show the negative correlation of local and regional archaeological variables. This can support the theory of the very local response of pollen indicators to habitation. At sites having only regional evidence of human activities, specific pollen indicators are generally not present.

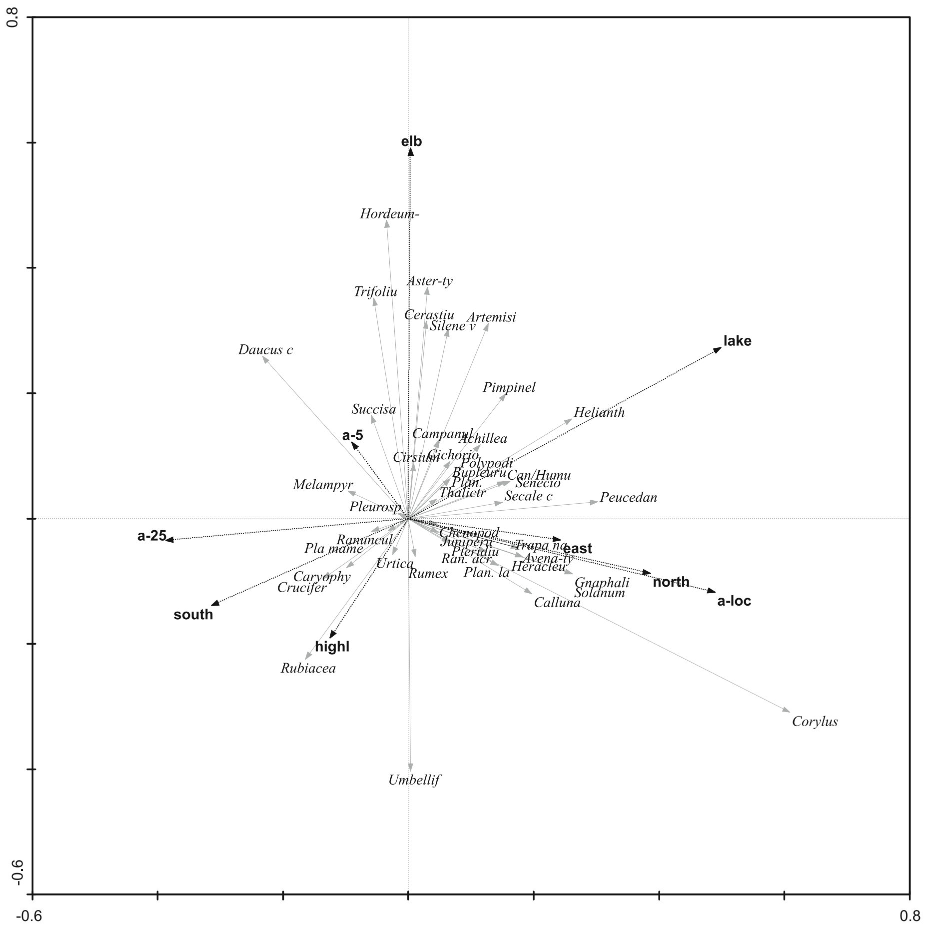


Fig. 8 RDA biplot of potential anthropogenic pollen indicators found in the Mesolithic period with environmental variables as in previous RDA ordination (for *codes* see Fig. 7) but using altitude as a co-variable

Considering the different pollen source areas of sites with varying size and type of sedimentation (Sugita 1994; Nielsen and Sugita 2005), we may expect some scatter of these groups (mainly lakes and mires) in ordination diagrams. Some trends can be depicted in this bifurcation (Fig. 3). There might be a simple explanation for this, namely that Mesolithic populations would not settle around or in the proximity of mires or swampy areas but rather prefer larger lakes. Our detailed comparative study at the important Mesolithic occupation site Švarcenberk (Pokorný et al. 2007) gives supplementary facts about the varying levels of human impact detection. Comparing littoral and central pollen records at this site, the influence of Mesolithic occupation is very heterogeneously recorded in pollen diagrams from different parts of the adjacent lake.

Anthropogenic pollen indicators

In the Czech Republic, correlation with available archaeological data is problematical because of the lack of surveys undertaken. However, recent archaeological excavations show a denser landscape occupation than previously expected (Fridrich and Vencl 1994).

There are several other issues we have to deal with when assessing indicators of early Holocene human impact in pollen diagrams. The majority of plant species are insect-pollinated, having low pollen productivity and very local pollen transport in the mainly forested early Holocene landscape. Moreover, they have an ambiguous ecology when considered as human impact indicators (e.g. *Juniperus*, *Urtica*, *Rumex* etc.). Some studies have used a high-resolution approach (Simmons et al. 1985; Bos and Urz 2003) or non-pollen palynomorphs such as fungal spores or charcoal particles (Innes and Blackford 2003; Bos et al. 2006) in trying to solve this problem. However the studies were mainly undertaken in north-western and western Europe, whereas the central-European landscape at the time was probably more forested. For detecting some differences, rarefaction analysis can also be useful (but see also Odgaard 1999); it can show even a doubling of palynological diversity (Poska et al. 2004), but one can not still be certain in distinguishing between human and natural causes.

By using numerical methods and a network of reference sites, in combination with data about landscape habitation during the Mesolithic, we have managed to verify that the

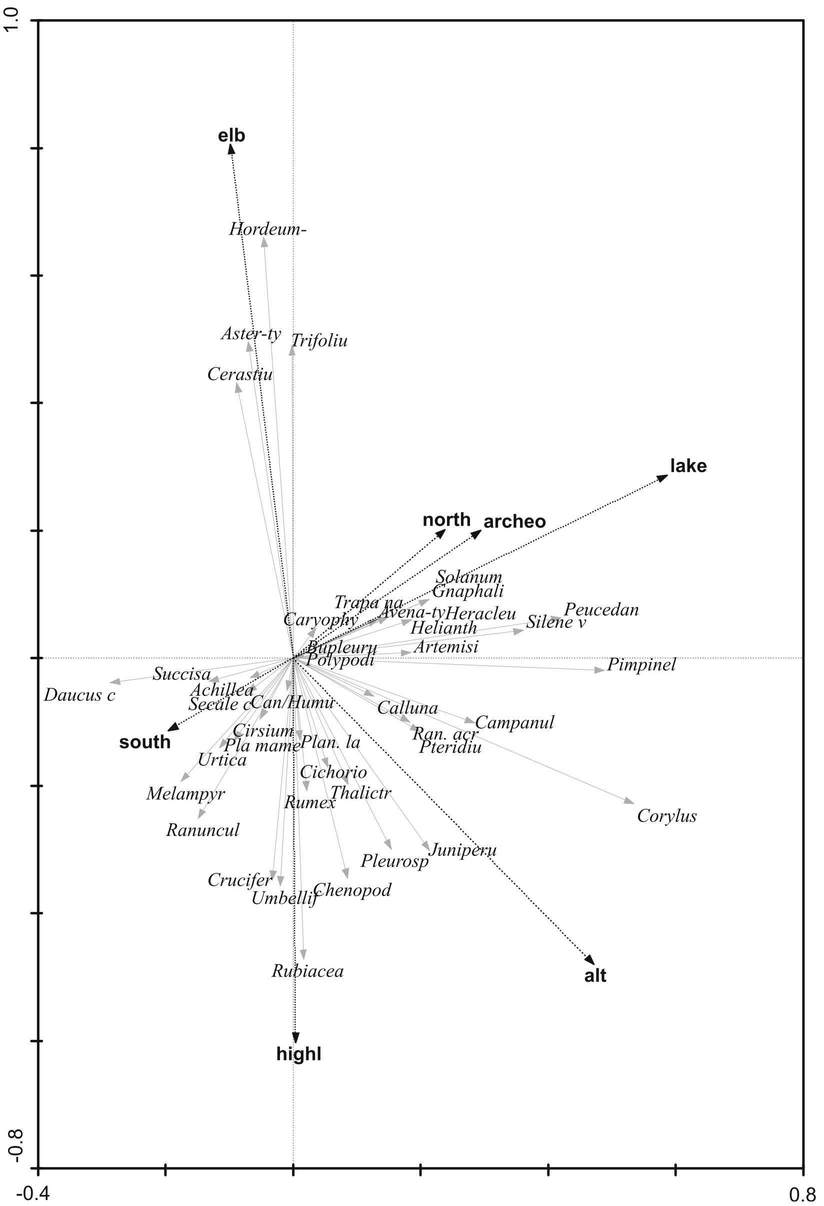


Fig. 9 RDA biplot using environmental variables as in previous RDA ordination (see Fig. 7 for *codes*) but using archaeology (*archeo*) expressed as one variable Human Impact Factor (HIF)

indicator pollen response is dependent on human habitation and distance from the pollen source. The next important result is that only some potential pollen indicator types are correlated with Mesolithic settlement. Others may not have only reflected anthropogenic activities but were more probably responding to natural processes in the ecosystems, even if many studies consider them within the group of anthropogenic indicators (Behling and Street 1999; Beckmann 2004; Wacnik 2005). We consider the following taxa (pollen types) to have an important role in the detection of Mesolithic occupation, at least for the Czech Republic: *Calluna vulgaris*, *Plantago lanceolata*, *Solanum dulcamara*, *Gnaphalium*-type, *Trapa natans*, *Heracleum*, *Ranunculus acris*-type, *Peucedanum*-type, *Helianthemum*, *Cannabis*/*Humulus*-type, *Pteridium aquilinum* and *Corylus avellana*. In spite of the fact that there has been only one single good piece of evidence of microscopic charcoal abundance (Pokorný and Jankovská 2000), the occurrence of all these types could still be explained by deliberate burning and clearances, which subsequently resulted in succession and the occurrence of light- and nitrogen-demanding taxa. Secondary vegetation of open areas is here represented by *Calluna*, *Helianthemum* and *Plantago lanceolata*. Regeneration phases after fire disturbances are best represented by *Pteridium aquilinum* and *Plantago lanceolata*. Other pollen types could be indicators of nutrient-rich and wetter stands (*Solanum*, *Peucedanum*, *Heracleum* and *Ranunculus*), or the result of settlements being established. They could also indicate longer human persistence near a wetland site (in the vicinity of lakes or

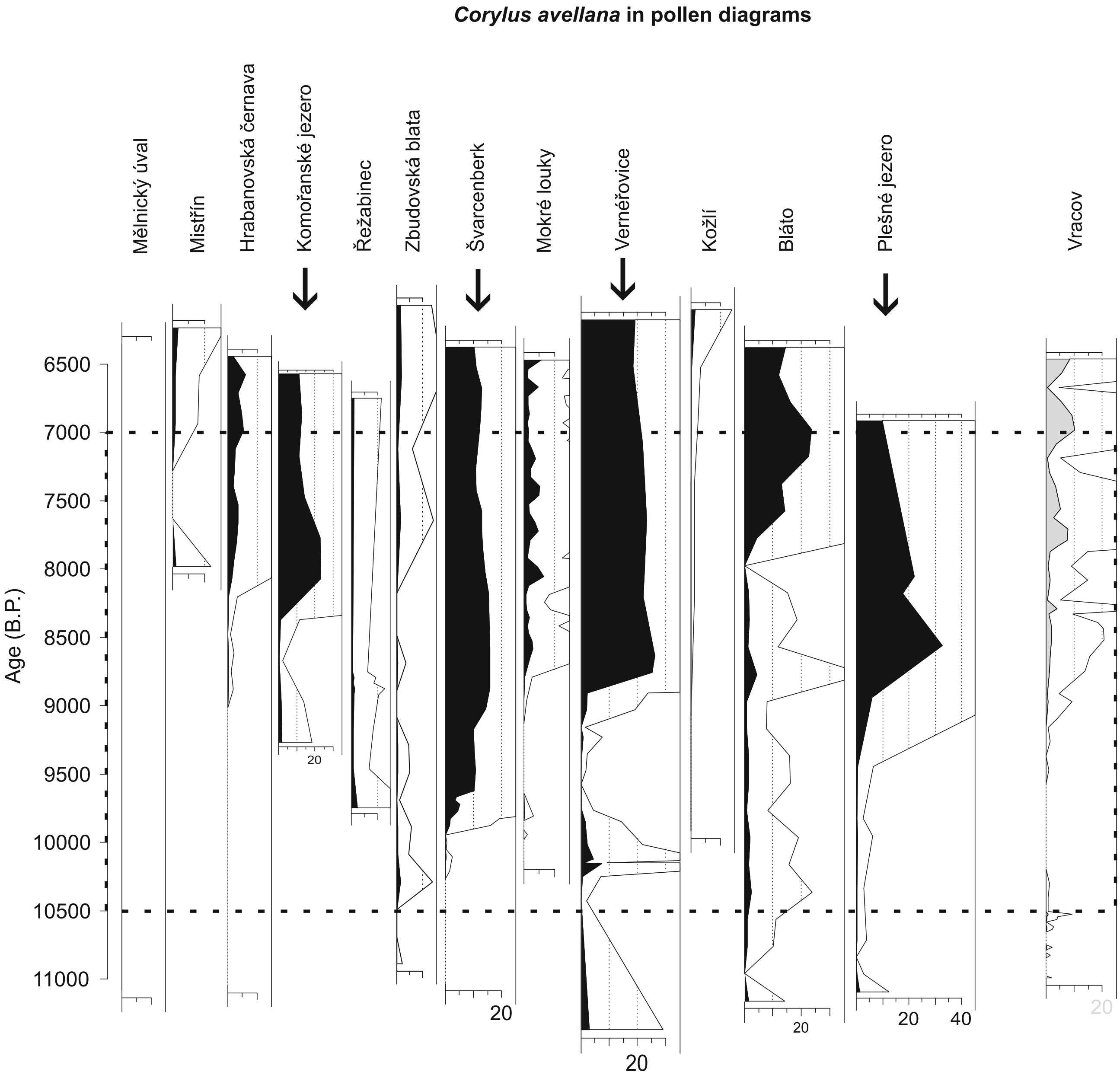


Fig. 10 Percentage pollen curves of *Corylus avellana* from selected sites. The time-scale is tentative since it is in some cases based on a very weak chronology (see Table 1). Sites are ordered according to increasing altitude from *left* to *right* (170–1,089 m a.s.l.). Vracov is not well dated (time-scale based on the Glacial–Holocene boundary and tree-zonation), but is used here as a lowland reference site

palaeochannels) and the creation of environments with prevalently herbs and shrubs to attract wild animals (Mellars 1976; Zvelebil 1994; Bos and Urz 2003). Finally, mention should be made of those species connected with the Mesolithic diet or other kind of plant use (Zvelebil 1994; Merlin 2003), especially *Trapa natans*, demonstrably gathered for nuts. *Corylus avellana*, which played an important role in the Mesolithic diet, deserves special attention (see "discussion").

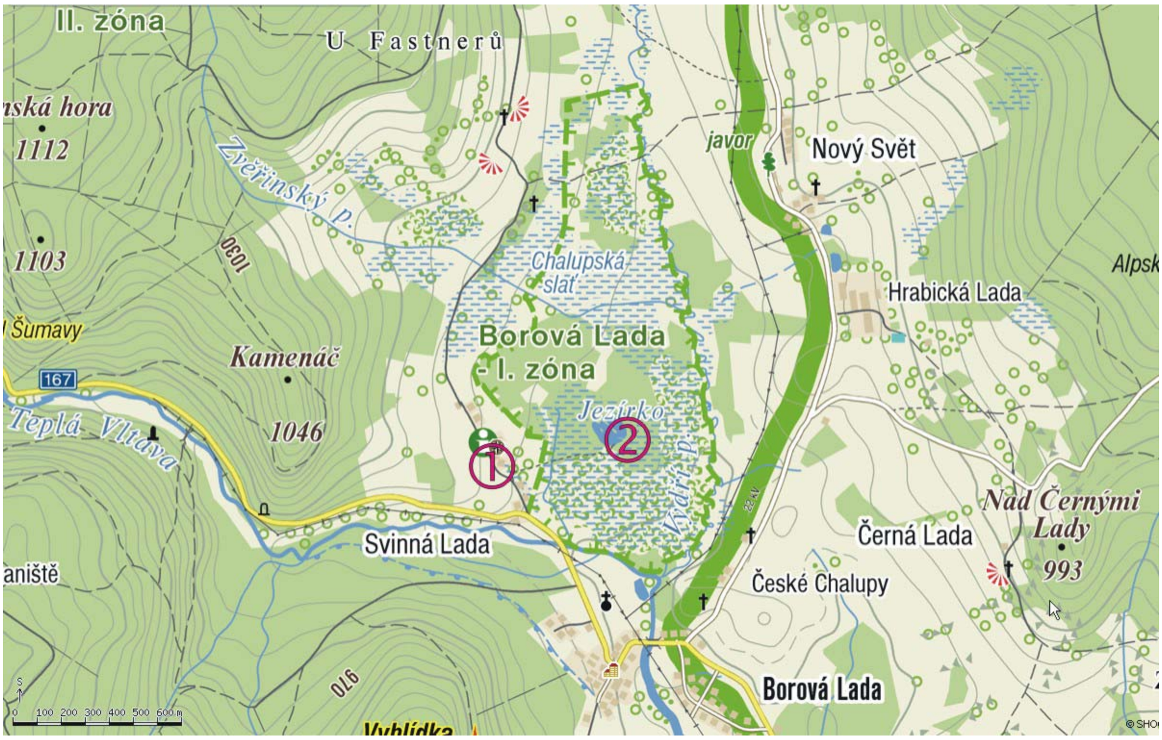
The next group of potential indicators that should be discussed is comprised of *Juniperus*, *Thalictrum*, Chenopodiaceae, Rubiaceae, *Pleurospermum*, *Artemisia*, *Rumex*, *Plantago major*/*media*, *Urtica* and *Silene vulgaris*. These taxa are often used as indicators of mosaic woody landscape or larger open landscape patches, hence also as potential human-activity indicators, e.g. by Beckmann (2004). Taking into account the environment, climatic conditions and vegetation of the early Holocene, we must also consider alternative explanations for the occurrence of these taxa. For example, juniper is also often mentioned as an indicator of dry pastures (Behre 1981), but it was common in the late-glacial and Preboreal patchy landscape.

Monday, 8. 9. 2008
Raised and transitional bogs of southern Bohemia

Bogs and glacial lakes of Šumava Mts. (by *H. Svitavská – Svobodová* and *V. Jankovská*)
Palaeoecology of peat bogs and recent pollen deposition. Šumava Mts. glacial lakes.

Červené blato (by *V. Jankovská* and *A. Kučerová*)
Lowland transitional mire.

Accommodation at Třeboň. Evening excursion to local brewery.



Numerous raised bogs are situated on the mountain plateaus of Šumava (Bohemian Forest) Mountains. One of these bogs, **Borová Lada**, is possible to visit thanks to convenient causeway. Bogs in the region are investigated intensively by Helena Svitavská who also studies recent pollen deposition. As small glaciers were present at highest altitudes of Šumava during last full-glacial, some lakes are present in the region. Vlasta Jankovská will explain her result of paleoecological investigations of one of these (called **Plešné jezero**).

Numbers on the map:

1 – Bus stop

2 – Observation of the bog vegetation and an oligotrophic bog lake. Explanation of palaeoecological investigations.

Veget Hist Archaeobot (2001) 10:185–199

Vegetation History
and Archaeobotany

Past vegetation dynamics of Vltavský luh, upper Vltava river valley in the Šumava mountains, Czech Republic

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Abstract. Six pollen diagrams from peat bogs in the Vltavský luh (upper Vltava river valley) provide new information about vegetation reconstruction, woodland dynamics, and local development of mires during the Lateglacial and Holocene. Vegetation development began in the Oldest Dryas/Bølling with open park plant cover. In the Allerød, woodland with *Pinus* and *Betula* developed, and in the Younger Dryas there was a steppe tundra with plants of open habitats. In the Pre-boreal, woodland tundra grew. In the Boreal, *Corylus* spread, and a major expansion of *Picea* began in the early Boreal. *Picea* spread during the Atlantic probably by two different migration routes. *Fagus* immigrated earlier than in the Bayerischer Wald and Oberpfälzer Wald in the adjoining parts of Germany, and had its major expansion in the early Atlantic. *Abies* expanded in the late Atlantic. The great abundance of *Abies* in this area is remarkable, forming *Abies* or *Abies-Fagus* woods in less extreme habitats. Human occupation started in the Sub-boreal, as shown by both archaeology and palynology. However, human impact is recognized from anthropogenic indicators which appear in the early Atlantic. At the end of the later Sub-atlantic the development of natural woodland was interrupted by plantation of *Picea,* according to historical and palynological evidence.

Key words: Pollen analysis – Woodland history – Late Glacial – Holocene – Šumava Mts – Czech Republic

Introduction

The Šumava is a medium high mountain range in the southern Czech Republic on the borders of Germany and to a lesser extent of Austria, and it continues to the southwest as the Bayerischer Wald in Germany. The range belongs to the Hercynian Mountains. On the abundant mire complexes, endemic plant populations and communities co-exist together with immigrants from the Alps. From a central European point of view this region seems to be a key area for a better understanding of vegetation development during the Late Glacial and the Holocene.

The Šumava mountain chain is an elongated ridge, the highest peaks forming the border with Germany, such as Plechý (1378 m asl), Třístoličník (1312 m), and others. The vast valley of Vltavský luh (upper Vltava river valley) studied in this paper lies just east this range. West of this valley in the central part of the mountain range stretches Šumavské pláně (Šumava plains). Šumava has no natural tree line today. Open rocks are exceptional in Šumava and are the traces of former glaciation.

In Šumava a marked gradient in climate from oceanic to continental and a complex geomorphology have resulted in a large diversity of mire complexes, remarkable for such a southern position in Europe (Schreiber 1924; Holubičková 1960, Pohořal 1964; Sofron and Šandová 1972; Sofron 1980). Most mires lie between 600 m and 1370 m asl, and those in Vltavský luh between 730 m and 1000 m. The mires were of such great importance in the past that they had their own names in the local dialects: raised bogs at high altitudes are called *slat'* in Czech, *Filz* or *Höhenhochmoor* in German; subcontinental raised bogs in valleys with *Pinus rotundata* are called *Niva* in Czech, *Au* or *Talhochmoor* in German (Rudolph 1928).

Very few palynological and palaeoecological studies have been made in these undisturbed mire ecosystems in the Czech part of Šumava during the last thirty years. The late Holocene vegetation succession of waterlogged meadows in the northeastern foothills has been studied by pollen analysis at seven sites (Moravec and Rybníčková 1964, Rybníčková 1973, Rybníček and Rybníčková 1974). Kral (1979) presented a pollen diagram from Boubín forest from the central part of the mountain range and from the nearby Lenora site. Two lakes (Čertovo lake and Černé lake) in former glacier cirques in the western higher parts of Šumava and one mire (Jezerní slat', short core) were studied palynologically, recording human impact during the last two centuries (Břízová 1993; Veselý et al. 1993; Vile et al. 1995). Earlier palynological studies in Šumava are sketchy (Müller 1927; Klečka 1928; Rudolph 1928; Ruoff 1932; Trautmann 1952; Kriesl 1968).

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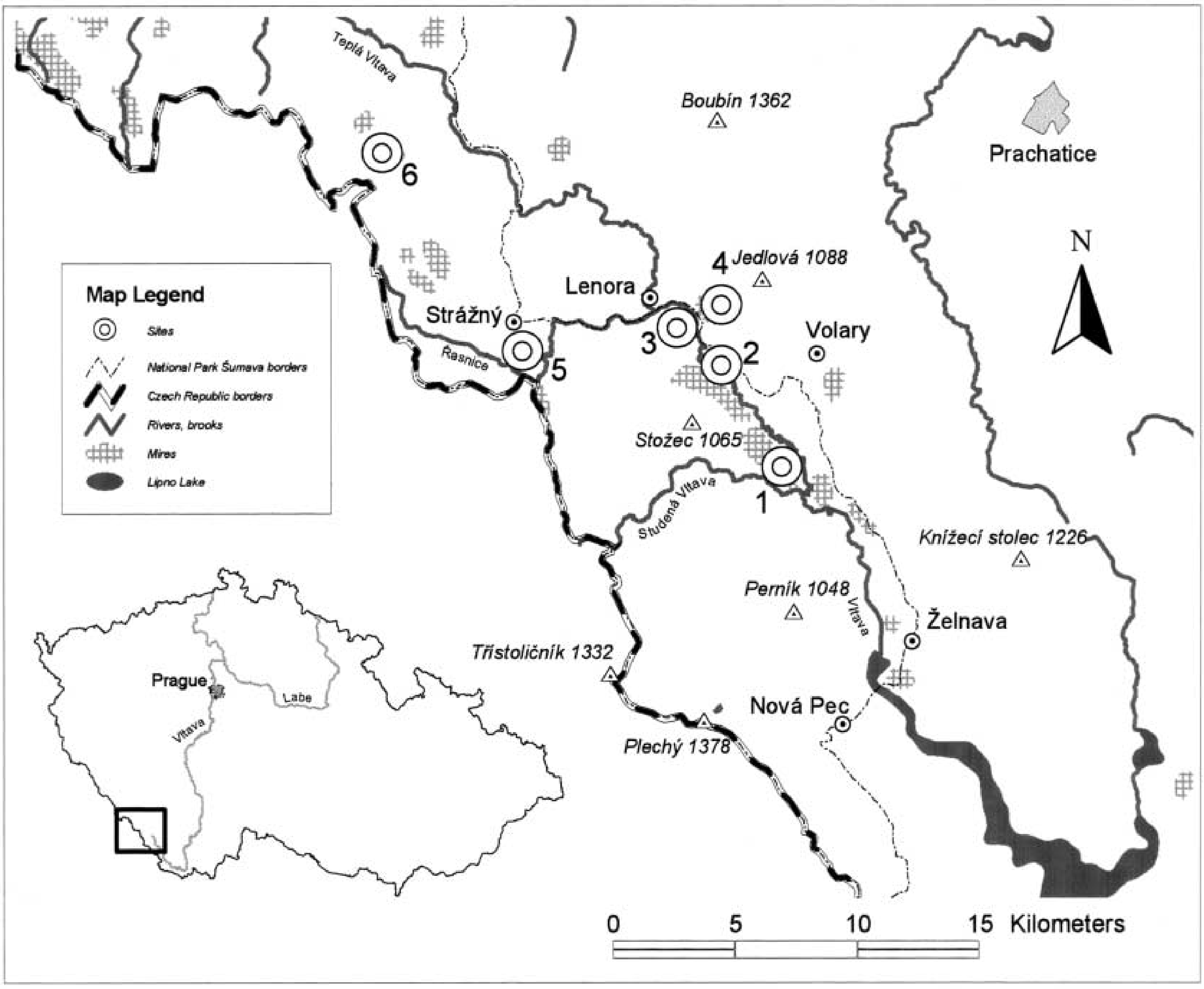

Fig. 1. The study region of Vltavský luh (upper Moldau valley). 1 Mrtvý luh; 2 Velká niva-Volary; 3 Malá niva; 4 Velká niva-Lenora; 5 Stráženská slať; 6 Knížecí pláně

Malá niva (profile SA-21-A) lies at 48^{0}54'N Latitude, 13^{0}49'30"E Longitude, altitude 750 m. The mire lies 0.5 km south of the town of Lenora on the east side of the river Teplá Vltava. The sediment stratigraphy of the studied core is described in Table 3.

Table 3. Sediment stratigraphy of Malá niva, profile SA-21-A

Depth	Description (Troels-Smith (1955)	Type of peat
0 - 7 cm	Tb(Spha.)^{2}2, Tl(Call.)^{2}2	*Vaccinium-Calluna* peat
7 - 15 cm	Tb(Spha.)^{2}3, Th(vagi.)^{1}1	*Sphagnum* peat
15 - 20 cm	Tb(Spha.)^{2}3, Th(vagi.)^{3}1	*Sphagnum* peat
20 - 177 cm	Tb°(Spha.)1, Th(vagi.)^{1}3	*Eriophorum vaginatum* peat
177 - 216 cm	Tb°(Spha.)1, Th(cari.)^{1}3	*Carex* peat
216 - 290 cm	Tb°(Spha.)1, Th(vagi.)^{1}3	*Eriophorum vaginatum* peat
290 - 370 cm	Tb(Spha.)^{3}2, Tl(Call.)^{2}2	*Vaccinium-Calluna* peat
370 - 485 cm	Tb°(Spha.)1, Th(vagi.)^{1}3	*Eriophorum vaginatum* peat

Mrtvý luh (profile SA-16-C; Fig. 3) lies at 48^{0}52'30"N Latitude, 13^{0}53'E Longitude, altitude 735 m. The mire lies about 5 km south of the town of Volary at the confluence of rivers Studená Vltava and Teplá Vltava. It is one of a series of mires that border the upper Vltava. The core was taken from the south-eastern part of the mire. The sediment stratigraphy of the studied core is described in Table 4.

Stráženská slať (profile SA-19-A; Fig. 4) lies at 48^{0}55'30"N Latitude, 13^{0}40'E Longitude, altitude 850 m. The mire lies about 750 m south of the village of Strážný and 250 m from the German border. The rivers Řásnice and Čistá, both tributaries of the Teplá Vltava, flow around the mire.

Knížecí pláně (profile SA-12-A; Fig. 5) lies at 48^{0}57'30"N Latitude, 13^{0}38'30"E Longitude, altitude 1060 m. The mire is situated in the shallow and wide valley of the river Malá Vltava, which runs through the centre of the mire. The sediment stratigraphy of the studied core is described in Table 5.

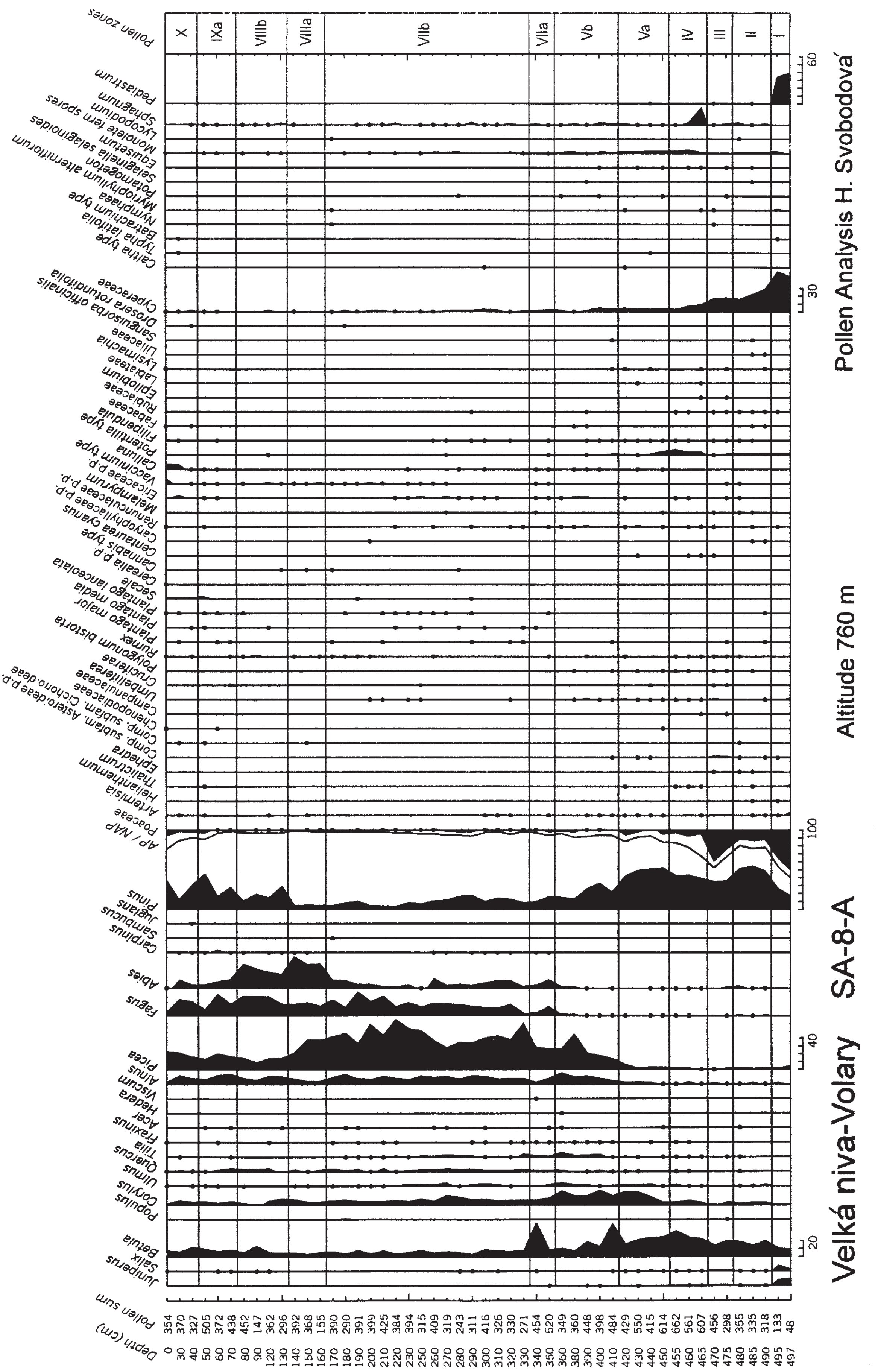

Fig. 2. Pollen percentage diagram of Velká niva–Volary bog, profile SA-8–A. For pollen zones VI and IXb see Table7 and corresponding text Altitude 760 m, Pollen analysis H. Svobodová

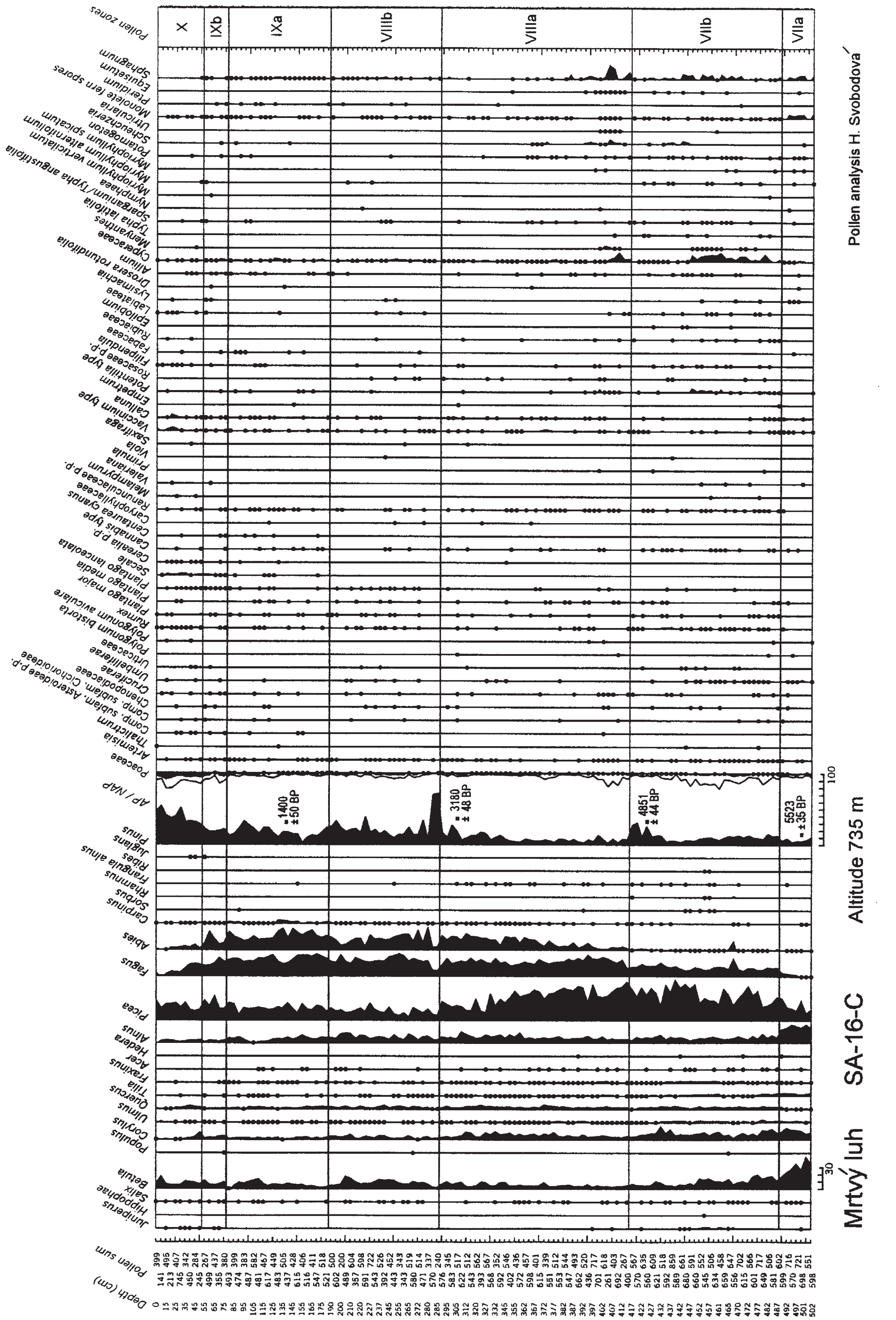

Fig. 3. Pollen percentage diagram of Mrtvý luh bog, profile SA-16-C
Altitude 735 m, Pollen analysis H. Svobodová

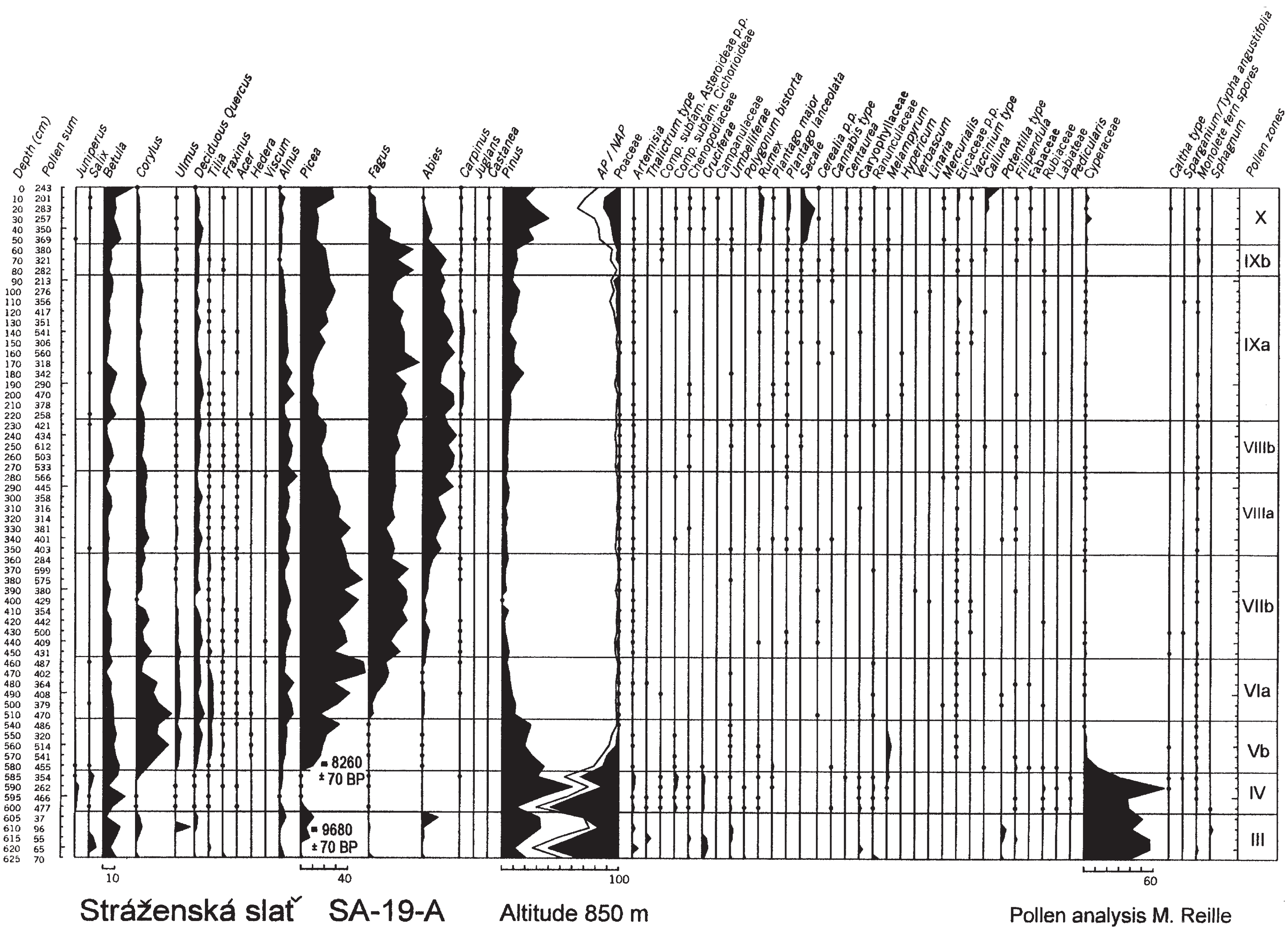

Fig. 4. Pollen percentage diagram of Stráženská slať mire, profile SA-19-A. For pollen zones Va, VIb and VIIIa see Table7 and corresponding text
Altitude 850 m, Pollen analysis M. Reille

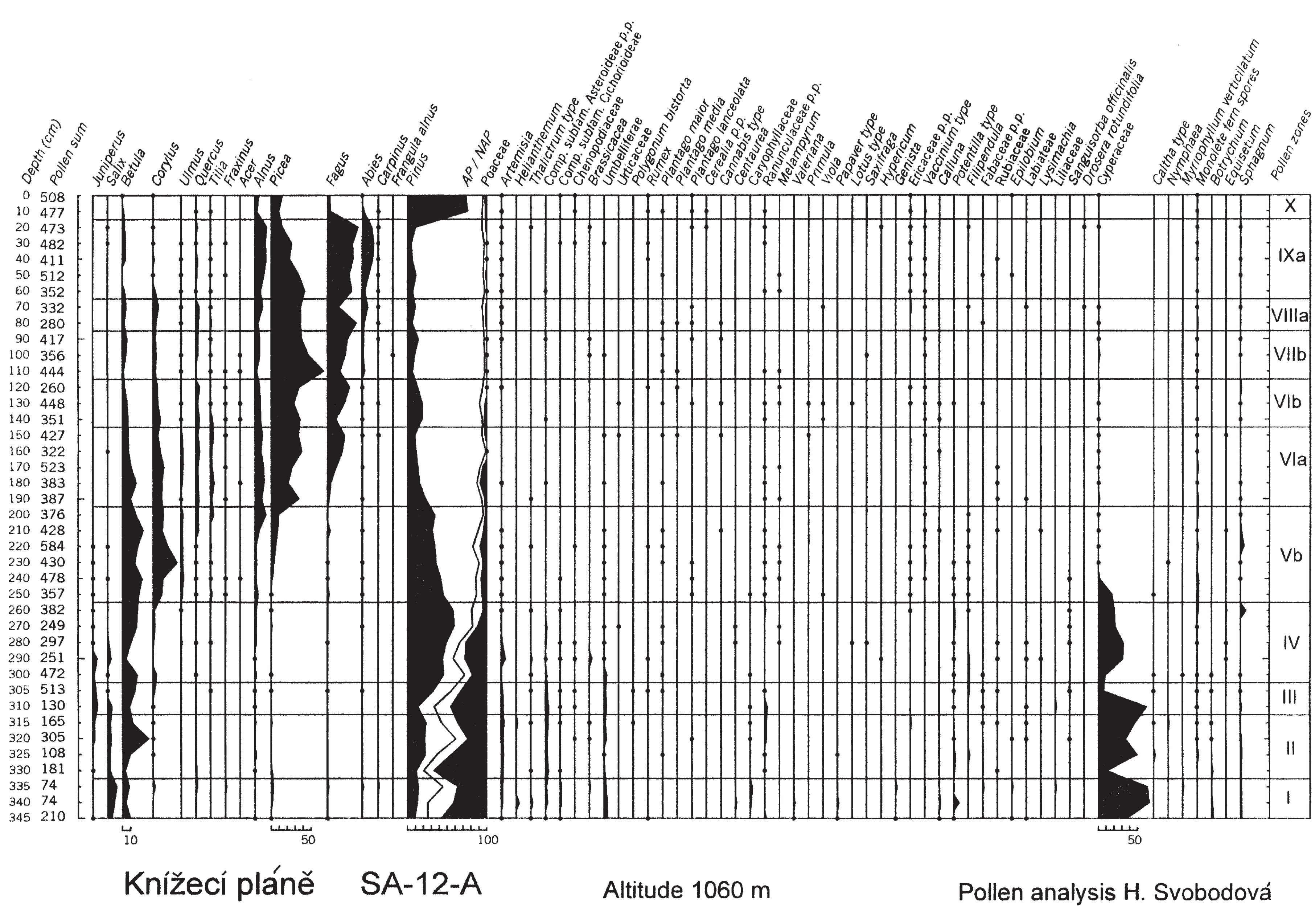

Fig. 5. Pollen percentage diagram of Knížecí pláně mire, profile SA-12-A. For pollen zones Va, VIIa, VIIIb and IXb see Table 7 and corresponding text Altitude 1060 m, Pollen analysis H. Svobodová

PERGAMON

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Diversified development of mountain mires, Bohemian Forest, Central Europe, in the last 13,000 years

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Abstract

Plant cover and past vegetation development of five mires were analyzed in different orographic and mesoclimatic situations along the NW–SE transect through the Bohemian Forest, Central Europe. Bogs at various altitudes (m), precipitation total (mm) and mean annual temperature (°C) were compared among: (1) wet windward cooling upslope plains at 860 m, 807 mm and 5.1°C, (2) very wet, cold and wind–exposed summit plains at 1120 and 1060 m, 1337 and 1100 mm, 3.2°C and 3.7°C, respectively, and (3) downwind rain-shadow valleys at 750 m, 757 mm, and 6.2°C. The mires of summit plains differ from the others by both present-day plant cover and past vegetation development, which began as late as the Preboreal, 10,000 years ago. Plant cover of their margins is predominated by the krummholz *Pinus x pseudopumilio* and open central mire expanses are noted by remarkable biodiversity and surface patterning. Mires of lower elevations are represented by domed raised-bogs forested by *Pinus rotundata*. According to pollen analysis, their development in the NW followed a typical sequence of the Bohemian Forest from the Late Glacial, with steppe-tundra prevailing 11,000 years ago, to the Boreal, with open *Pinus* and *Corylus* forests. Since the Atlantic period 6000 years ago, the surrounding forests were formed mainly by *Picea*, then by *Picea* and *Fagus*, and later by *Abies,* which became dominant in the whole Bohemian Forest since the Subboreal, 4000 years ago. *Pinus* expanded in the last 300 years. At present, herb and moss communities with scattered *Betula pubescens* occupy wet lagg, and closed–canopy bog-pine forest of primeval appearance covers the entire mire. In the SE bogs, the development started earlier, 13,000 years ago. Vegetation history here was slightly different; *Alnus-Betula* carrs have developed since the Atlantic period. At present and in spite of NE, the very centers of these SE bogs remain open, in lagg woods of *Betula pubescens* with the undergrowth of *Phragmites australis* prevail. The analysis confirmed that development, vegetation and mire types correspond to the differences in mountain mesoclimate. In extrapolations of paleoecological data from mountain areas the diversification of biotic development has to be taken into account.

1. Introduction

Ecological balance of peat–forming processes responsible for the development of mires (Jeník and Soukupová, 1992; Karofeld, 1998; Malmer and Wallén, 1999) is predetermined by environmental setting of several factors, such as geological bedrock, macro and microhydrology, amount and seasonal distribution of precipitation, long- and short-term temperature courses, and occurrence of dominant plants. Differences in environmental setting result in diversification of mire biodiversity (e.g., Ruuhijärvi, 1960; Sjörs, 1983). Prevalence of peat accumulation above its decomposition is a prerequisite for trapping of pollen grains preserved in chrono-stratigraphical sequence (Berglund, 1986) that allows the examination of changes at more local levels, the behavior of individual species and the comparison of regional developments of vegetation communities (Svobodová, 1998). As a result, mire ecosystems store information on past vegetation communities and ecological conditions that can be dated, so that the evolution of the mire itself and of its surroundings might be portrayed (Frenzel, 1983).

In Central Europe, a variety of mires has developed from forested raised-bogs and saline or calcareous fens in lowlands and river basins to open-patterned mires in mountains and kettle-hole bogs in glacial cirques (Neuhäusl, 1972; Succow and Lange, 1984; Steiner, 1992; Soukupová et al., 2000), occupied by a conspicuous variety of plant communities (Rybníček et al., 1984). Their history is dated back to the beginning of the Late Glacial (Klaus, 1960, 1961; Peschke, 1977; Jankovská, 1980; Kral, 1980, 1983; Küster, 1988; Rybníčková and Rybníček, 1988; Knipping, 1989,

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1997; Lang, 1994). At present, the majority of growing mires is represented by ombrotrophic bogs confined to the Hercynian middle-mountains, namely to the Bohemian Forest (Kaule, 1973; Sofron, 1980) Black Forest (Dierssen and Dierssen, 1984; Rösch, 2000), Ore Mts. (Kästner and Flössner, 1933), the Sudetes (Rudolph et al., 1928; Jeník, 1961; Hadač and Váňa, 1967; Soukupová et al., 1991), and Harz (Müller, 1999). Their mire vegetation as a whole was distinguished as extrazonal Central European upland province (Steiner, 1997) and includes a number of mire communities as well as endemic plant species and communities mentioned in the above-mentioned regional studies.

Despite numerous biogeographical similarities among mires in different Hercynian mountains, individual ranges include a variety of different mire types (e.g., Rudolph, 1929; Kral, 1979). Their relation to the mountain georelief and oroclimate has not been analyzed so far, and therefore, we examined the range of Bohemian Forest (in Czech Šumava, in German Böhmerwald) as one of the mountain ranges noted for abundant and various bogs (Soukupová, 1996). In this study, vegetation of basic mire types in the Bohemian Forest and development of their environments during the Late Glacial and the Holocene is compared for different altitudinal, geomorphic and mesoclimatic situations across the mountain range (Fig. 1).

2. Site description

The Bohemian Forest, a middle-mountain range reaching up to 1456 m, is situated between 49°20′N, 12°58′ E and 48°38′N, 14°13′ E and astride the boundaries of Czech, Germany, and Austria. It represents one of the most important peatland regions in Central Europe, where mires cover more than 15% of the area. The orography and geomorphology and the associated climatic gradients from suboceanic to subcontinental (Nekovář, 1969) predisposed an altitudinal and geographical differentiation of its numerous mires (Rudolph, 1929; Kral, 1979; Soukupová, 1996), in which relic boreal populations co-exist with species immigrated from the Alps, resulting in endemic plant communities (Sofron, 1980; Šula and Spitzer, 2000). Comprehensive vegetation description for individual mire types was completed recently (Soukupová et al., 2001). Although the first paleoecological fragmentary research on mires in the Bohemian Forest was carried out already around the 1930s (Schreiber, 1924; Müller, 1927; Klečka, 1928; Rudolph, 1929; Ruoff, 1932), little modern paleoecological data have been gained from so many well-preserved mire ecosystems during the last thirty years, except for the south-facing Bavarian slopes (Stalling, 1987; Knipping, 1989). At present, altogether 17 new pollen profiles have been analyzed in the summit areas

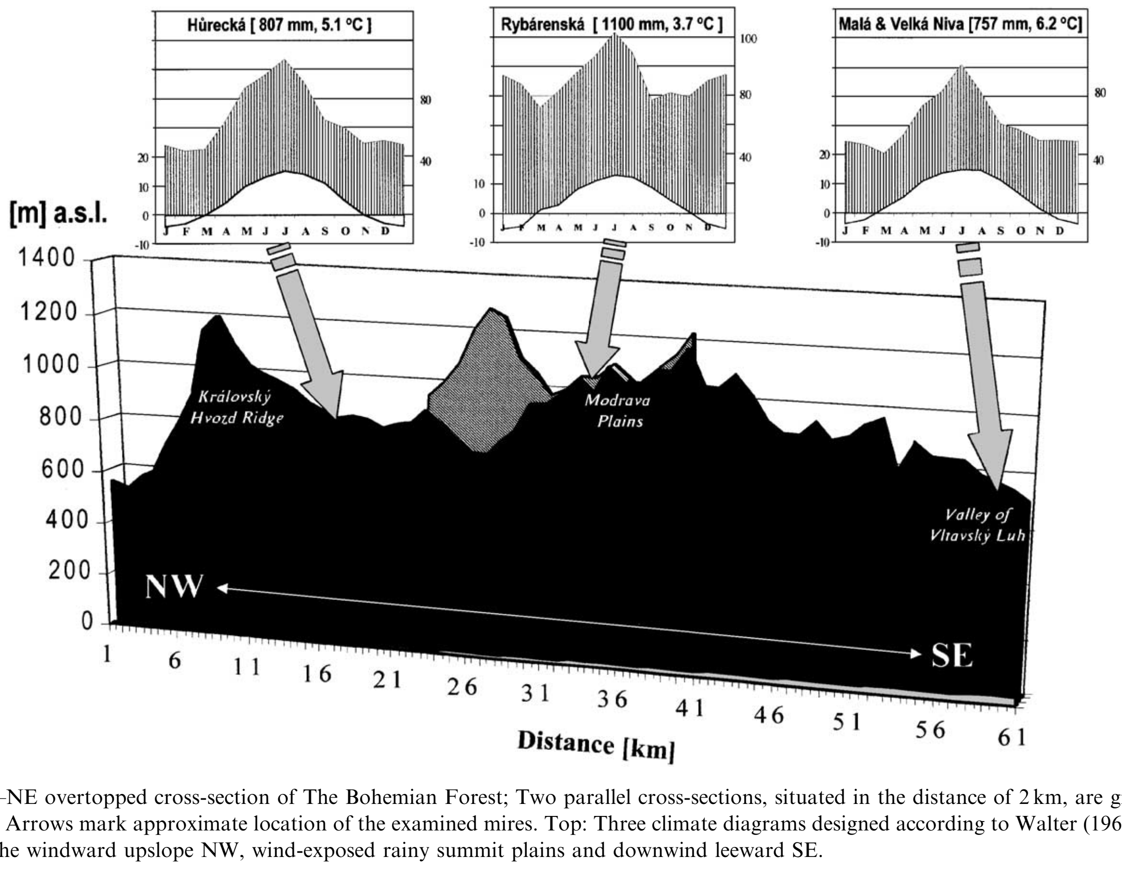

Fig. 1. NW–NE overtopped cross-section of The Bohemian Forest; Two parallel cross-sections, situated in the distance of 2 km, are given for the central part. Arrows mark approximate location of the examined mires. Top: Three climate diagrams designed according to Walter (1964) for mires situated in the windward upslope NW, wind-exposed rainy summit plains and downwind leeward SE.

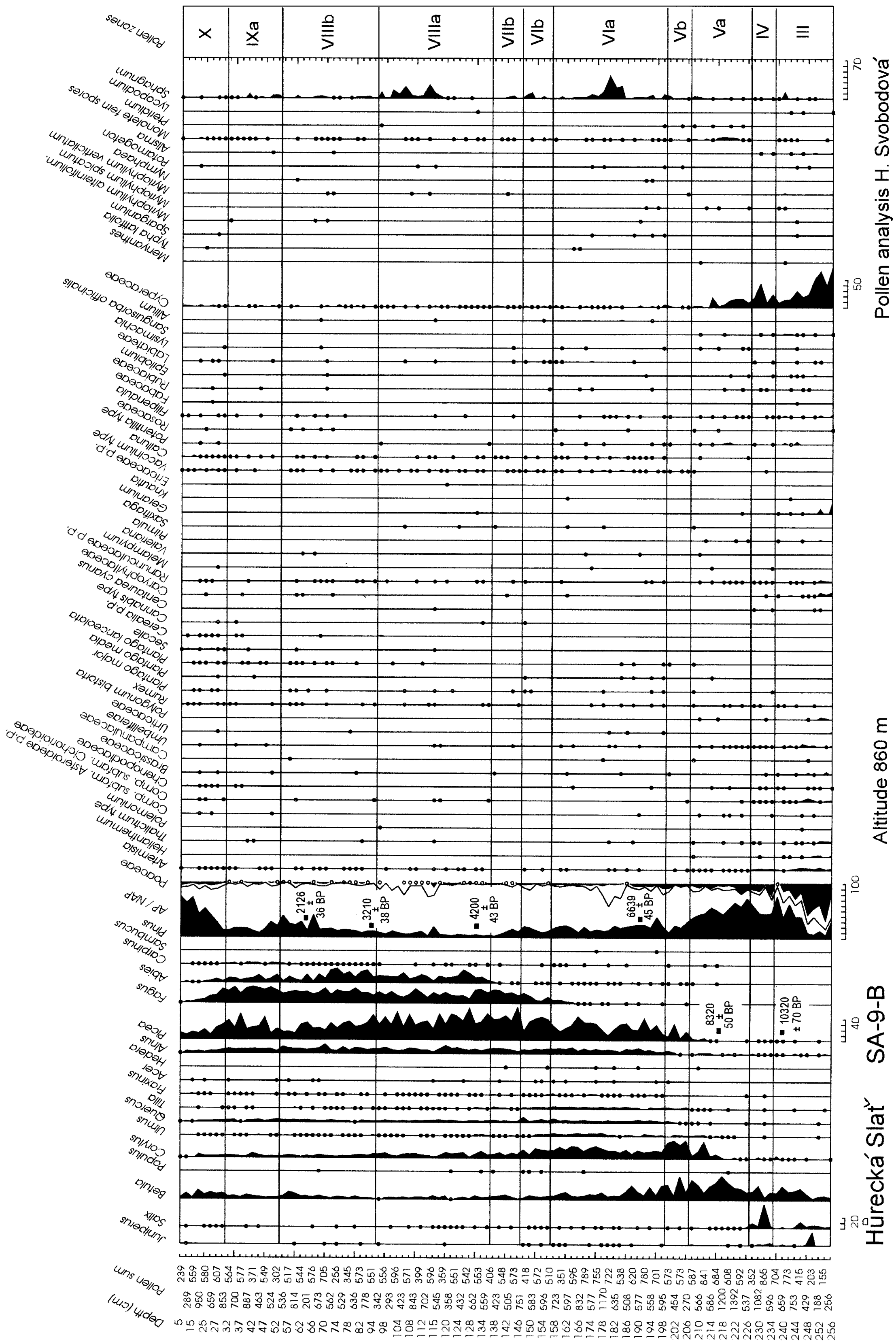

Fig. 2. Pollen percentage diagram of Hůrecká Bog.

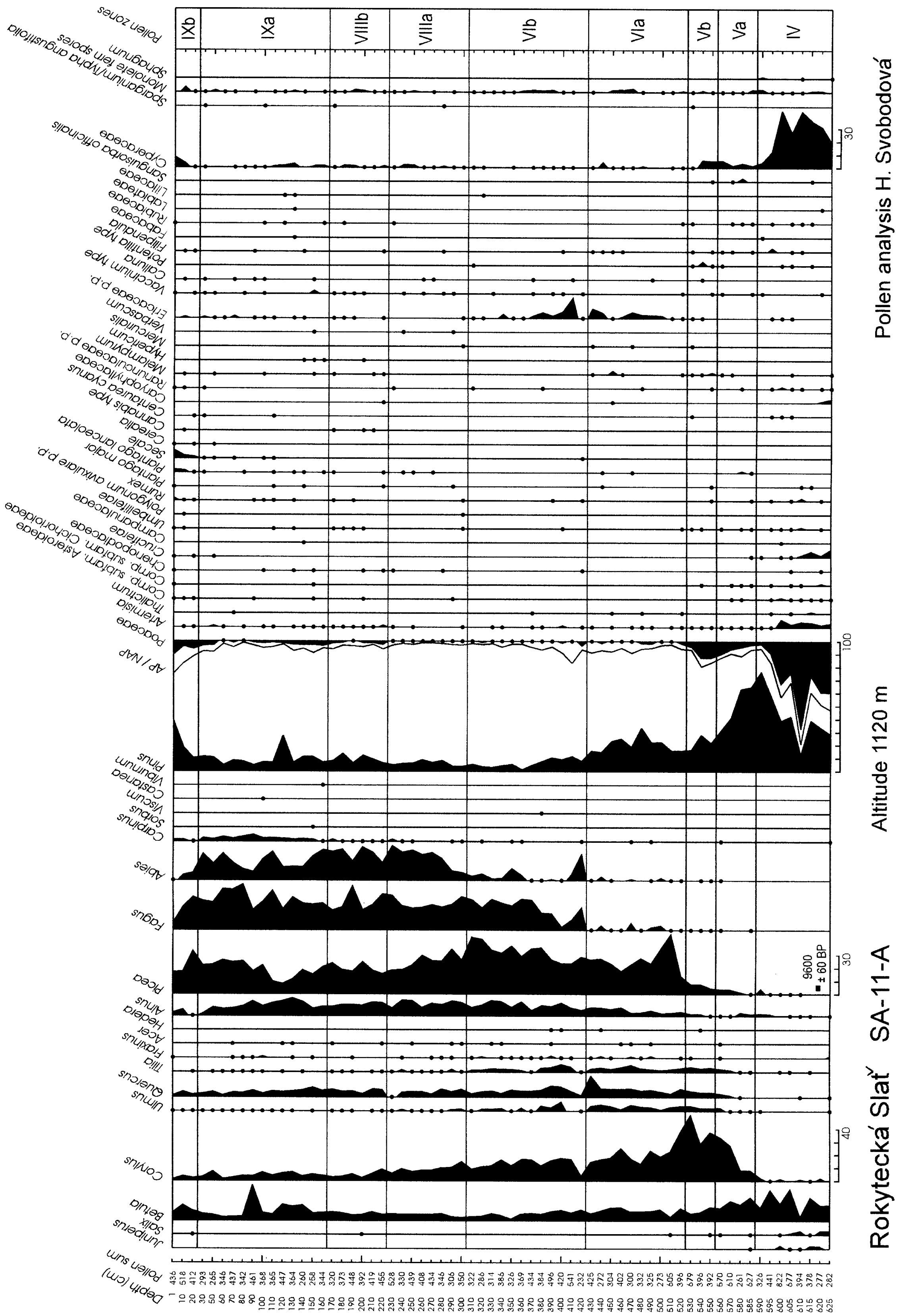

Fig. 3. Pollen percentage diagram of Rokytecká Mire.

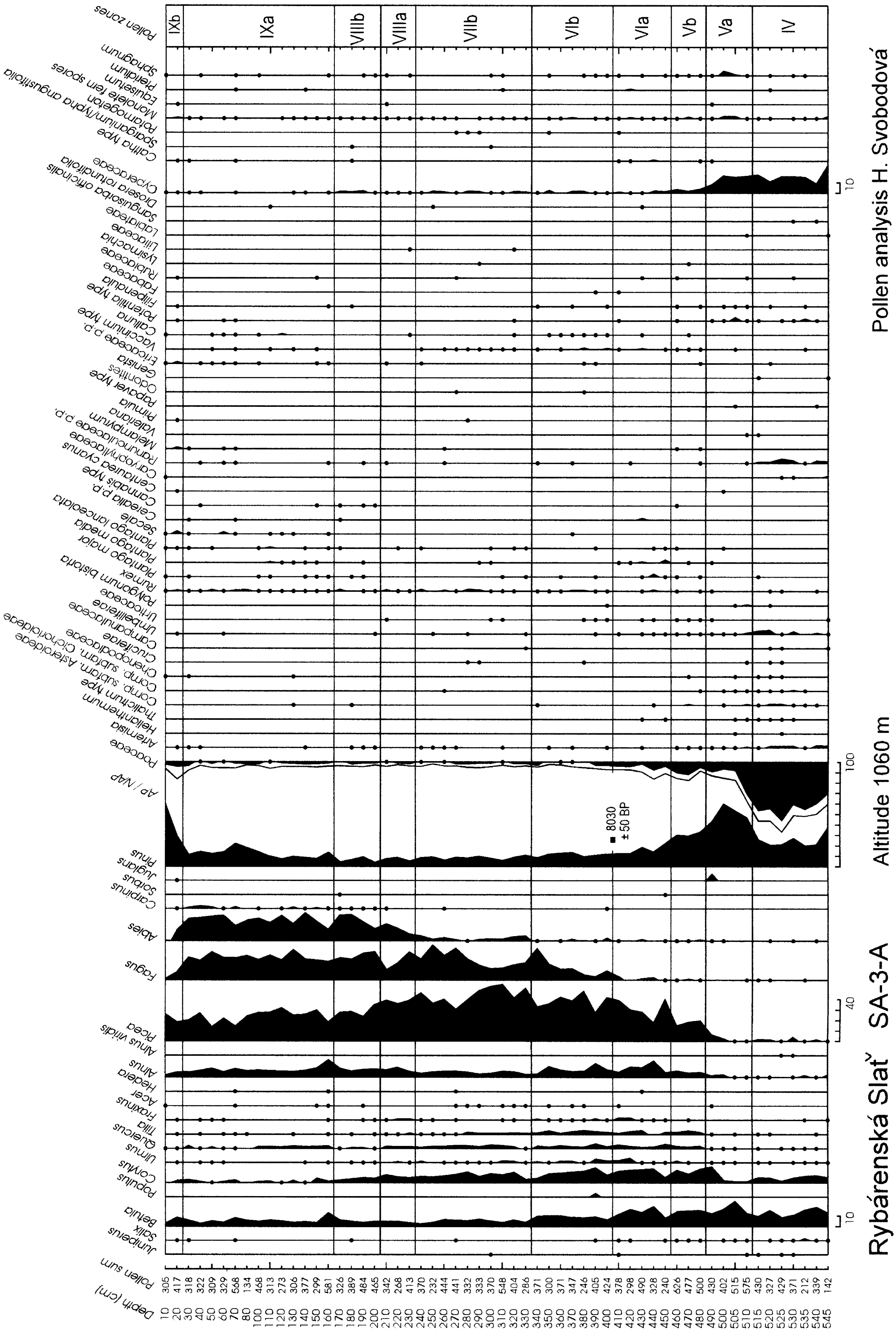

Fig. 4. Pollen percentage diagram of Rybárenská Mire.

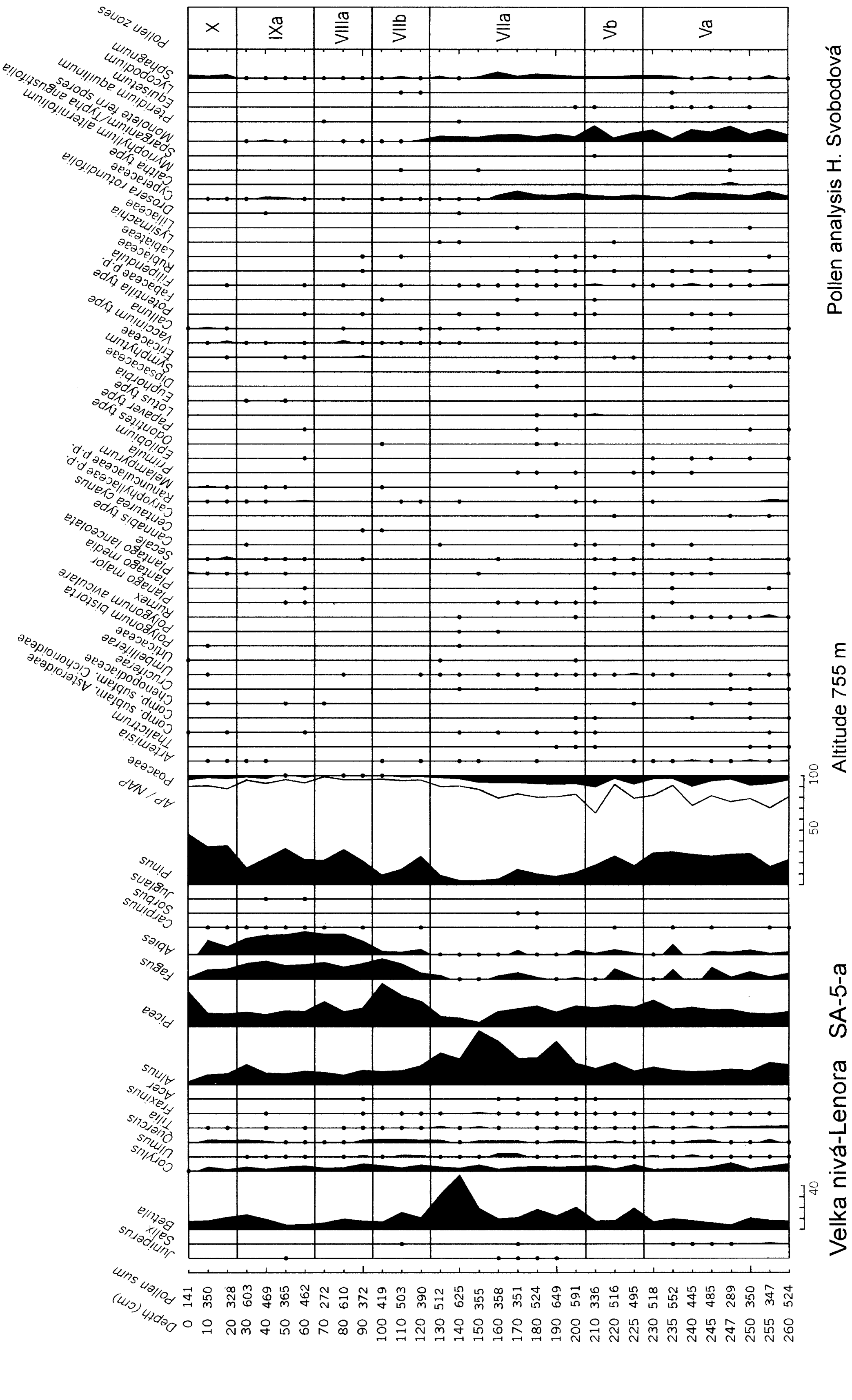

Fig. 5. Pollen percentage diagram of Velká Niva Bog (Lenora).

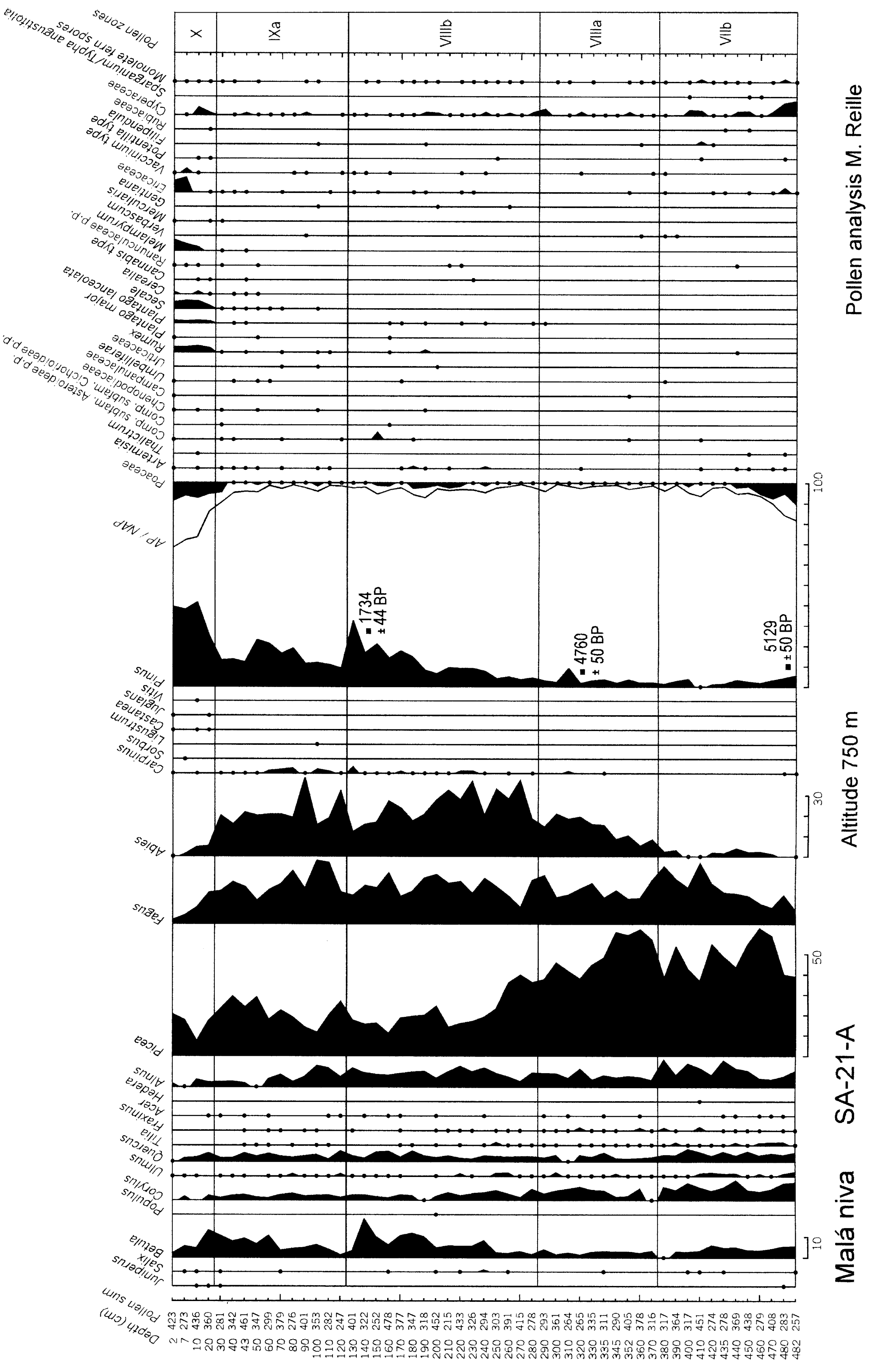

Fig. 6. Pollen percentage diagram of Malá Niva Bog.

Late Glacial and Holocene history of Plešné Lake and its surrounding landscape based on pollen and palaeoalgological analyses

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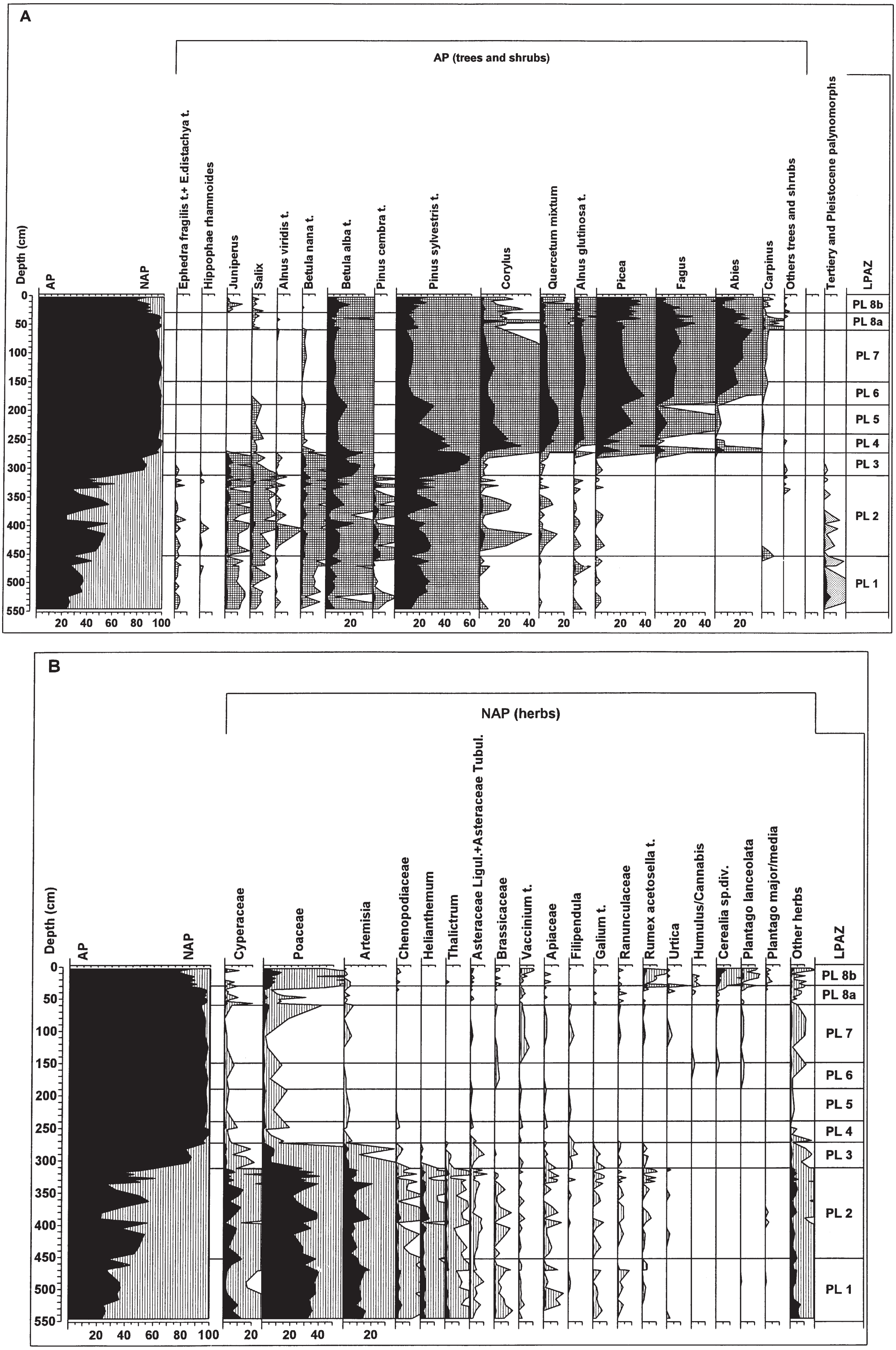
Abstract: Pollen analysis has been carried out on a 549 cm thick sediment profile from lake Plešné jezero (Plešné Lake) in the Bohemian Forest (Šumava, Czech Republic; 1090 m a.s.l.; 48°47′ N; 13°52′ E). Analyses of 67 samples characterise the development of the lake biotope and the surrounding landscape during the last ca. 14,000 years. The pollen diagram shows a very distinct transition between the Late Glacial and the Holocene biostratigraphic units at a depth of ca. 312 cm. In the surroundings of Plešné Lake the vegetation was treeless during the entire Late Glacial. The alpine tree limit, formed by *Betula* and *Pinus* with undergrowth of shrubs, might have been at ca. 500 m a.s.l. Pollen transported from long distances was significant due to the openness of the landscape, coming from southern Europe and even Africa, and including high numbers of *Artemisia*, Poaceae, Chenopodiaceae, and some other herbs and shrubs from steppe and forest-steppe areas in southern Europe or Africa (likely *Ephedra*, certainly *Lygeum spartum*). The expansion of shrubs, particularly *Juniperus,* preceded the expansion of trees near the end of the Late Glacial. Afforestation of the region by thin stands of *Betula* and *Pinus* occurred during the Preboreal. Significant warming in the Boreal resulted in the expansion of *Corylus*, Quercetum mixtum (QM) trees, and probably also *Picea* and *Alnus. Picea* as well as QM trees were further expanding during the Early Atlantic. *Picea* was the dominant tree during the Late Atlantic and *Fagus* started to spread towards its end. Abrupt expansion of *Abies* marks the Subboreal. A high degree of afforestation (*Abies, Fagus, Picea*) was characteristic for the Early Subatlantic. During Late Subatlantic, pollen of synanthropic plants appears. Phases of the lake biotope development were defined on the basis of coccal green algae and *Isoëtes.*

Key words: Palaeobotanical analyses, Late Glacial, Holocene, glacial lake, long-distance pollen transport.

Introduction

The results of palaeobotanical analyses presented in this paper form part of long-lasting multidisciplinary palaeoecological studies on the sediments of lake Plešné jezero (Plešné Lake) in the Bohemian Forest (Šumava, Böhmerwald), Czech Republic. Pollen analysis was the basic method to reconstruct the past vegetation conditions during individual time stages of the Late Glacial and the Holocene. The vegetation is visually the most distinct component in a landscape, and its composition is the result of both abiotic and biotic factors. If we know the composition of vegetation, we can make deductions concerning, e.g., fauna, climate, hydrology, pedology, and even the time of human colonisation of the studied region and the scope and quality of human activities. In Plešné Lake, pollen analysis also provided detailed information on the aquatic environment, which could be reconstructed in detail by analysing coccal green algae in the pollen slides. It would be possible to make the reconstruction of the aquatic environment substantially more precise by studying also Cladocera, Rotatoria, Rhizopoda, Chironomidae, Diatomae, etc., most of which would require separate preparations of samples in the laboratory. Presently, detailed studies of the present-day Plešné Lake biotope are being carried out on water chemistry and sedimentology and new dating methods are being developed (Pražáková et al., 2006), to the benefit of all analytical methods of this complex research. Plešné Lake is so becoming an example of a lake very well studied in a multidisciplinary way, including palaeoecology. The sediments of the former lake Švarcenberk in the Třeboňská pánev basin have been and still worked out in a similar way, and the original palaeobotanical research of the 1970s (Jankovská, 1980) were supplemented by new research methods (Pokorný & Jankovská, 2000; Pokorný, 2002). In contrast to Plešné Lake (1090 m a.s.l.), it was possible to exploit the palaeoecological research fully with respect to archaeology for lake Švarcenberk (412 m a.s.l.) (Pokorný, 2005). The periglacial landscape between the High Sudetes Mountains and the Bohemian Forest can be reconstructed by pollen analysis carried out also on other Late Glacial


A
AP (trees and shrubs)
Depth (cm)
AP
NAP
Ephedra fragilis t.+ E.distachya t.
Hippophae rhamnoides
Juniperus
Salix
Alnus viridis t.
Betula nana t.
Betula alba t.
Pinus cembra t.
Pinus sylvestris t.
Corylus
Quercetum mixtum
Alnus glutinosa t.
Picea
Fagus
Abies
Carpinus
Others trees and shrubs
Tertiery and Pleistocene palynomorphs
LPAZ
PL 8b
PL 8a
PL 7
PL 6
PL 5
PL 4
PL 3
PL 2
PL 1
B
NAP (herbs)
Depth (cm)
AP
NAP
Cyperaceae
Poaceae
Artemisia
Chenopodiaceae
Helianthemum
Thalictrum
Asteraceae Ligul.+Asteraceae Tubul.
Brassicaceae
Vaccinium t.
Apiaceae
Filipendula
Galium t.
Ranunculaceae
Rumex acetosella t.
Urtica
Humulus/Cannabis
Cerealia sp.div.
Plantago lanceolata
Plantago major/media
Other herbs
LPAZ
PL 8b
PL 8a
PL 7
PL 6
PL 5
PL 4
PL 3
PL 2
PL 1

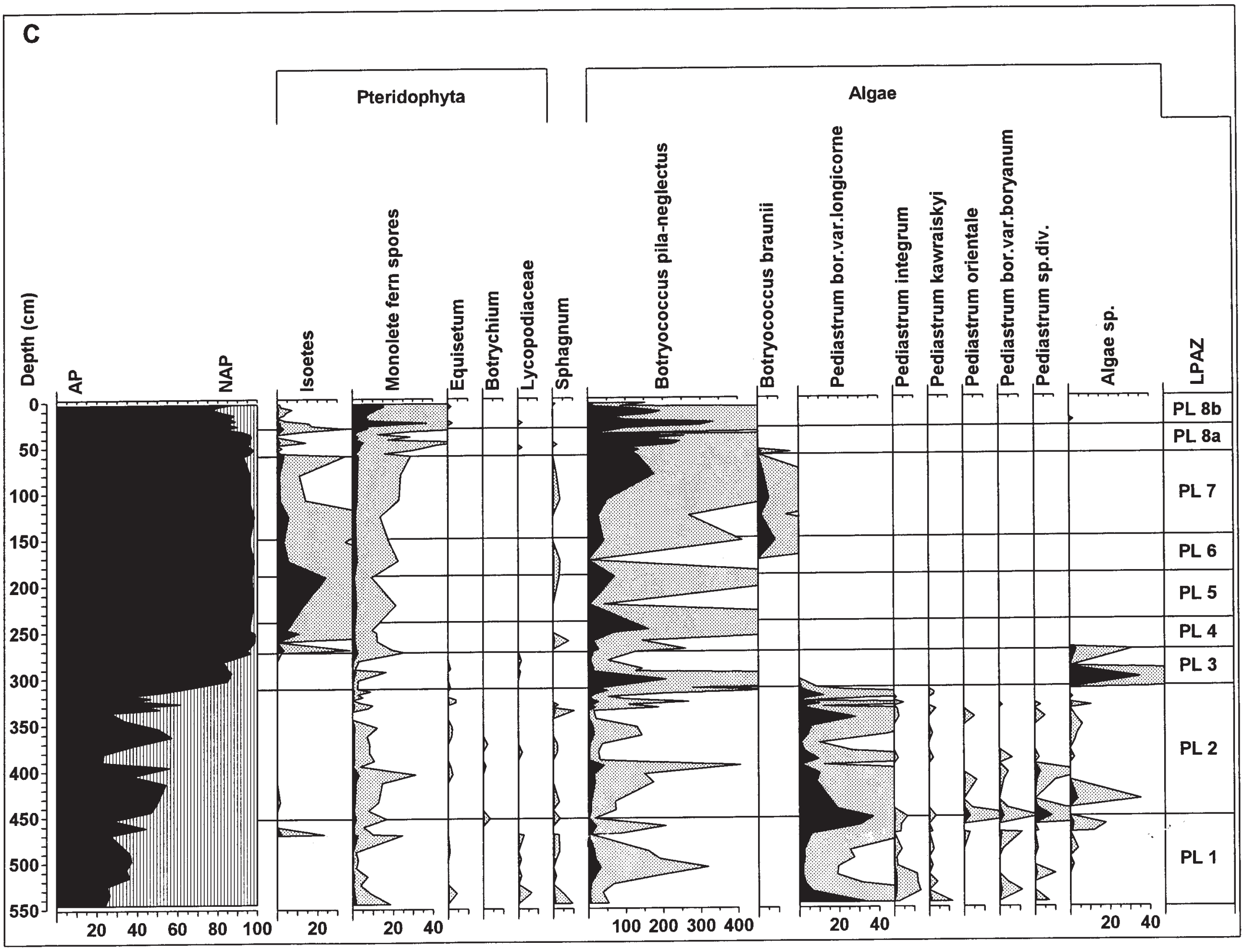


Fig. 1. Simplified pollen diagram of sediment record from Plešné Lake (the Bohemian Forest, Czech Republic, 1090 m a.s.l., 48°47′ N, 13°52′ E). A – trees and shrubs, B – herbs, C – Pteridophyta, Sphagnum, Algae. Arboreal pollen (AP, trees and shrubs) and non-arboreal pollen (NAP, herbs) diagram are shown in all parts.

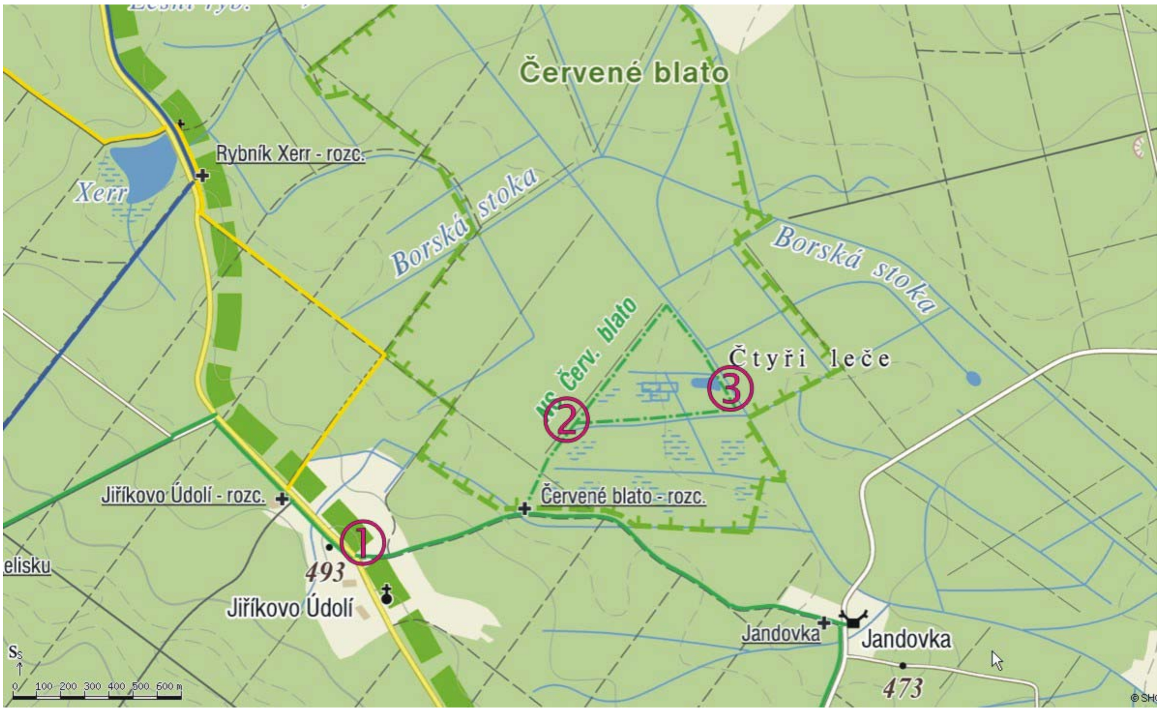
Rubiaceae, Ranunculaceae, Caryophyllaceae, *Caltha*, *Centaurea*, *Cerastium*, *Cirsium*, *Filipendula*, *Gentiana*, *Peucedanum*, *Pleurospermum austriacum*, *Saxifraga* cf. *granulata*, *Saxifraga* cf. *stellaris*, etc.). One pollen grain of *Lygeum spartum* comes from long distant transport. Pollen of aquatic macrophytes was sporadic (*Alisma plantago-aqutica* type, *Myriophyllum verticilatum/spicatum*, *Ranunculus aquatilis*). *Pediastrum boryanum* var. *longicorne* was dominant among algae, there were also present *P. orientale*, *P. kawraiskyi*, *P.integrum*, *P.boryanum* var. *boryanum*, and other *Pediastrum* species. *Botryococcus pila-neglectus* and other *Botryococcus* species were also abundant. The water of the lake was all the time very cold and oligotrophic.

Zone PL-3: Juniperus-Betula-Pinus shrubs-trees (312–273 cm)

Description. NAP is ca. 10%. All herb pollen decreases (Poaceae to 10%, *Artemisia* to 5%). Pollen of Late Glacial heliophyta, which are indicative of raw soils, meadows, wetlands, tundra, etc., gradually disappears (e.g., *Helianthemum*, Chenopodiaceae, *Thalictrum*, Cyperaceae, Ericaceae, *Saxifraga*, *Rumex acetosella* type). AP is ca. 90%. *Juniperus* (ca. 5%) and *Betula nana* type (ca. 4%) attain in this typical shrub-tree zone their highest pollen values, *Alnus viridis* type, *Ephedra*, *Hippophaë*, and *Pinus cembra* type come to an end, *Salix* decreases, and maximum pollen values attain *Betula alba* type (ca. 20%) and *Pinus sylvestris* type (ca. 50%). The upper limit of zone PL-3 is characterised by the decreasing *Betula* (*alba* type, *nana* type), *Pinus sylvestris* type, *Juniperus*, *Alnus viridis* type, and most herbs.

Aquatic environment: *Pediastrum* disappears while the *Botryococcus pila-neglectus* is spreading.

Interpretation. Zone PL-3 belongs to the Preboreal in the sense of classical chronology by Firbas (1949). A sudden vegetation change took place due to climatic amelioration at the beginning of the Holocene. Afforestation began near the lake in the originally treeless landscape. The onset of afforestation directly after the Late Glacial/Holocene transition is in many pollen diagrams characterised by a maximum of *Juniperus* followed by expansion of *Betula* and *Pinus* trees. *Pinus*



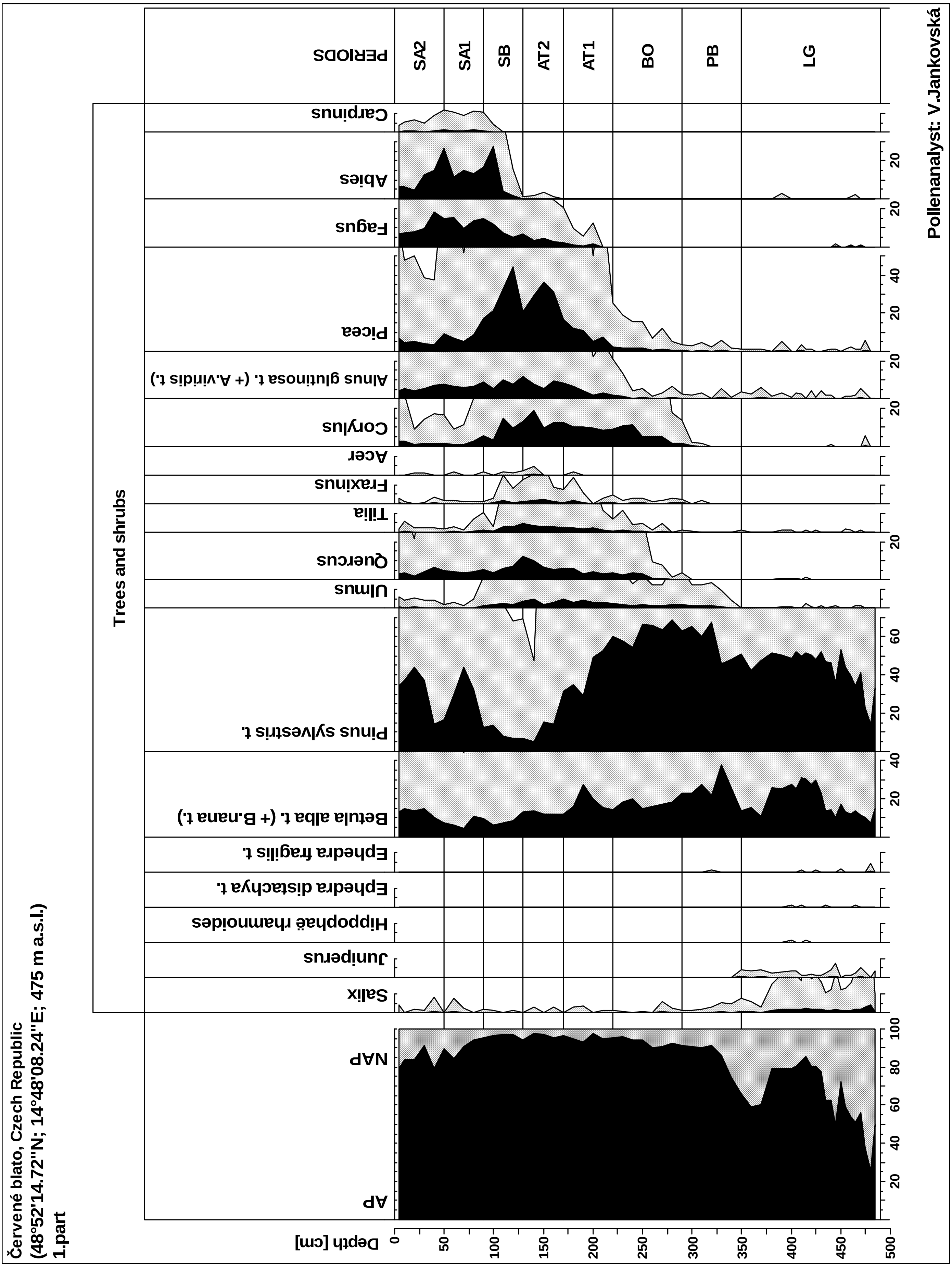
Červené blato mire is a good example of lowland transitional mire. It is forested by *Pinus sylvestris* and *Pinus rotundata* with *Ledum palustre* undergrowth. Peat extraction since 19th century (providing fuel for nearby glass manufactories) affected some parts of the mire. Today, interior of the mire is easily accessible thanks to a causeway. In 70s, Vlasta Jankovská investigated the site by means of pollen and macrofossil analyses. Recent ecology of the mire will be explained by Andrea Kučerová.

<u>Numbers on the map:</u>

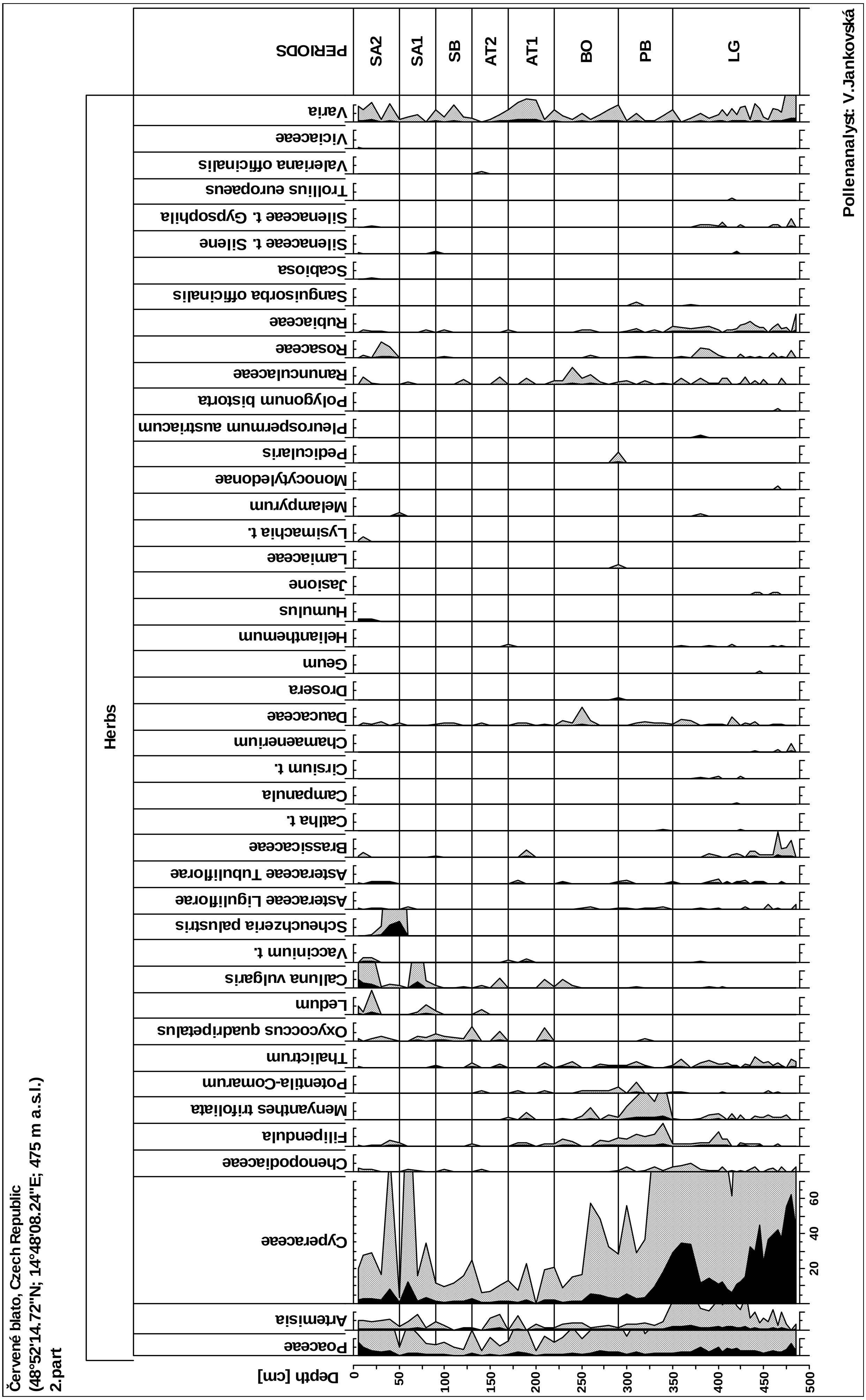
1 – Bus stop

2 – Discussion on the actuo-ecology of the mire.

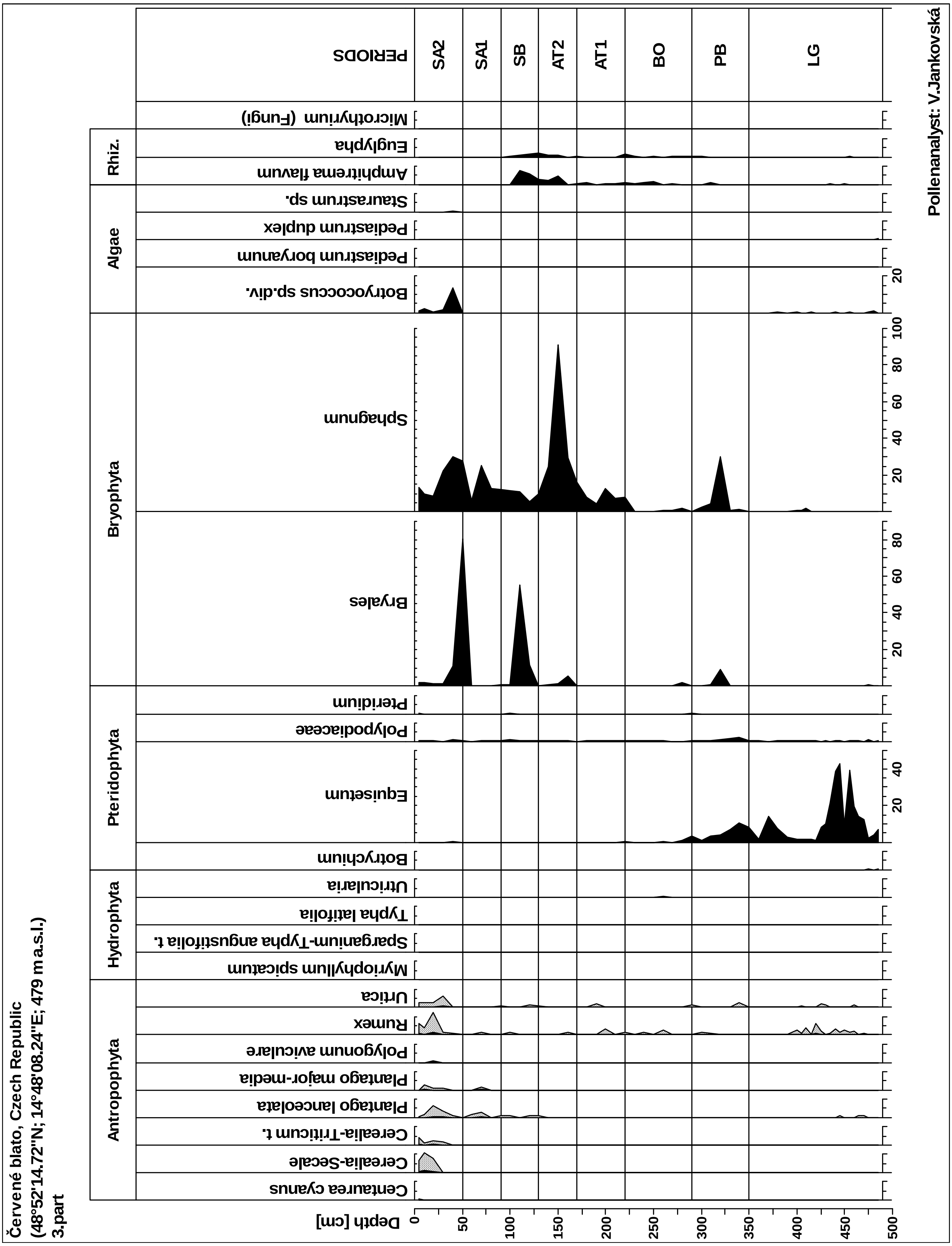
3 – Discussion on the local Holocene vegetation development.



Červené blato, Czech Republic
(48°52'14.72"N; 14°48'08.24"E; 475 m a.s.l.)
1.part
Depth [cm]
AP
NAP
Trees and shrubs
Salix
Juniperus
Hippophaë rhamnoides
Ephedra distachya t.
Ephedra fragilis t.
Betula alba t. (+ B.nana t.)
Pinus sylvestris t.
Ulmus
Quercus
Tilia
Fraxinus
Acer
Corylus
Alnus glutinosa t. (+ A.viridis t.)
Picea
Fagus
Abies
Carpinus
PERIODS
SA2
SA1
SB
AT2
AT1
BO
PB
LG
Pollenanalyst: V.Jankovská



Červené blato, Czech Republic
(48°52'14.72"N; 14°48'08.24"E; 475 m a.s.l.)
2.part
Pollenanalyst: V.Jankovská
Depth [cm]
0
50
100
150
200
250
300
350
400
450
500
Herbs
Poaceae
Artemisia
Cyperaceae
20
40
60
Chenopodiaceae
Filipendula
Menyanthes trifoliata
Potentila-Comarum
Thalictrum
Oxycoccus quadripetalus
Ledum
Calluna vulgaris
Vaccinium t.
Scheuchzeria palustris
Asteraceae Liguliflorae
Asteraceae Tubuliflorae
Brassicaceae
Caltha t.
Campanula
Cirsium t.
Chamaenerium
Daucaceae
Drosera
Geum
Helianthemum
Humulus
Jasione
Lamiaceae
Lysimachia t.
Melampyrum
Monocytyledonae
Pedicularis
Pleurospermum austriacum
Polygonum bistorta
Ranunculaceae
Rosaceae
Rubiaceae
Sanguisorba officinalis
Scabiosa
Silenaceae t. Silene
Silenaceae t. Gypsophila
Trollius europaeus
Valeriana officinalis
Viciaceae
Varia
PERIODS
SA2
SA1
SB
AT2
AT1
BO
PB
LG

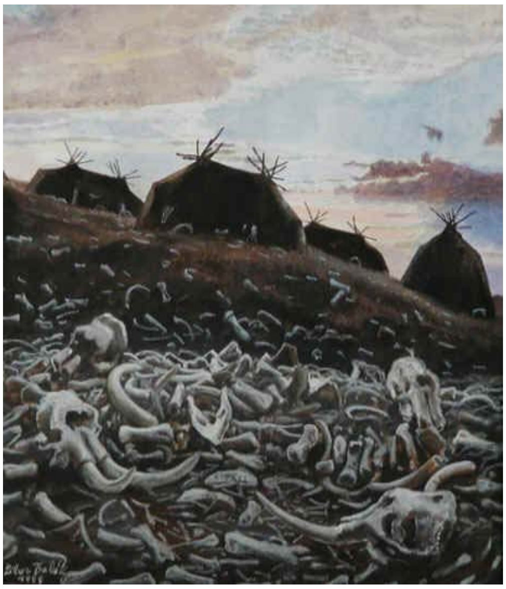


Červené blato, Czech Republic
(48°52'14.72"N; 14°48'08.24"E; 479 m a.s.l.)
3.part
Depth [cm]
Antropophyta
Hydrophyta
Pteridophyta
Bryophyta
Algae
Rhiz.
Centaurea cyanus
Cerealia-Secale
Cerealia-Triticum t.
Plantago lanceolata
Plantago major-media
Polygonum aviculare
Rumex
Urtica
Myriophyllum spicatum
Sparganium-Typha angustifolia t.
Typha latifolia
Utricularia
Botrychium
Equisetum
Polypodiaceae
Pteridium
Bryales
Sphagnum
Botryococcus sp.div.
Pediastrum boryanum
Pediastrum duplex
Staurastrum sp.
Amphitrema flavum
Euglypha
Microthyrium (Fungi)
PERIODS
SA2
SA1
SB
AT2
AT1
BO
PB
LG
Pollenanalyst: V.Jankovská

Tuesday, 9. 9. 2008
Mammoth hunters of southern Moravia

Dolní Věstonice (by *J.A. Svoboda* and *E. Rybníčková*)
Mammoth hunters of southern Moravia and their environment. Excursion to xerothermic vegetation of Pálava hills.

Accommodation at Mikulov. Local wines tasting in the castle.



Dolní Věstonice and **Pavlov** are world-famous archaeological sites dated to Younger Palaeolithic (Gravettian) period. Remains of the settlement are preserved within loess deposits and are dated to around 25 ka BP. These will be expained by head of local archaeological investigations, Prof. Jiří Svoboda. Eliška Rybníčková will explain results of her pollen-analytical research to the full-glacial period. Adjacent Pálava Hills is a good terrain to observe xerothermic vegetation of Pannonian area that grows on loess and limestone rocks.

Numbers on the map:

1 – Bus stop and inspection of a small museum of mammoth hunters.

2 – Inspection of an archaeological site.

3 – Small excursion to local vegetation.

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THE GRAVETTIAN ON THE MIDDLE DANUBE

Jiří A. Svoboda (1)

Abstract : This paper resumes actual results and current viewpoints on the Gravettian in the Middle Danubian part of Europe. The origin of Gravettian is seen as a more complex process than was thought before, involving an impact of industries with backed blades and bladelets from the eastern Mediterranean (Ahmarian, Lagaman, Dabba, beginning before 40 ky BP). After its establishment in Europe, the Danubian Gravettian is ordered into earlier Pavlovian stage (30-25 ky BP), concentrated in the Austrian-Moravian-South Polish corridor, and later Willendorf-Kostenkian stage (25-20 ky BP), widely dispersed over central and eastern Europe. The Epigravettian, termed Kasovian (after 20 ky BP), should be clearly separated from the earlier Gravettian stock (the radiocarbon datings used through this paper are uncalibrated). Finally, this paper gives examples of complex analyses of a typical large settlement (Pavlov I – Southeast) and of a burial site (Predmostí).

Key words: Gravettian, Ahmarian, Pavlovian, Willendorf-Kostenkian, Kasovian, settlement analysis, burial site analysis

Résumé : Le Gravettien du cours moyen du Danube. Cet article résume les résultats récents et les points de vue actuels sur le Gravettien du cours moyen du Danube. L’origine du Gravettien semble plus complexe que ce qui était admis jusqu’ici, impliquant notamment une influence des industries à lames et lamelles à dos abattu du Proche-Orient (Ahmarien, Lagaman, Dabba) apparues avant – 40 ka BP. A la suite de son arrivée en Europe, le Gravettien danubien comporte d’abord un stade Pavlovien (30-25 ka BP, toutes dates non calibrées), limité au couloir constitué par l’Autriche, la Moravie et le sud de la Pologne. Vient ensuite un stade Willendorf-Kostienkien (25-20 ka BP) largement répandu sur l’Europe centrale et orientale. L’Epigravettien, appelé Kasovien (postérieur à 20 ka BP) doit être clairement distingué du Gravettien. Cet article présente également quelques résultats des analyses d’un grand habitat (Pavlov 1 – sud-est) et d’un site funéraire (Predmostí).

Mots-clés : Gravettien, Ahmarien, Pavlovien, Willendorf-Kostienkien, Kasovien, habitat, site funéraire

INTRODUCTION

The Gravettian, as the most complex Upper Paleolithic cultural entity in the Danubian Europe, presents a constant focal point in regional prehistoric studies and subject of regularly organized international meetings, as at Pavlov in 1995 (Roebroeks *et al*., eds. 2000), at Mikulov in 2002 (Svoboda & Sedlácková, eds., 2004), and currently in Vienna in 2005. Several overview papers on the Middle Danube Gravettian were presented in the edited volumes that resulted from these conferences (Svoboda *et al*. 2000; Oliva 2000; Dobosi 2000; Otte & Noiret 2004; Haesaerts *et al*. 2004; Jöris & Weninger 2004; Svoboda 2004). Given this amount of previous synthetic literature, including lists with earlier references, this paper focuses on the actual results, current viewpoints, and more recent literary references.

In the present moment, excavations are in course at the Gravettian sites in Lower Austria, on the Danube (Krems Wachtberg and Hundsteig; Einwögerer 2004; Fladerer & Salcher 2004) and Lower March (Grub/Kranawetberg, Antl, Fladerer 2004; Nigst 2004). In Moravia, excavations are running at Dolní Vestonice and Predmostí (excavation project by J. Svoboda and M. Jones in 2005-2006) and Middle Moravia Basin (Spytihnev, Jarosov and Borsice; Skrdla, ed. 2005). A new site, named Pavlov VI, has been discovered in 2007. At the same time, earlier excavated sites are being revised and prepared for new publications, as in Bohemia (Jenerálka, Revnice, Lubná; project by P. Sída), Moravia (Pavlov I; Svoboda, ed. 2005; Milovice, project by M.Oliva), Silesia (Petrkovice; project by J. Svoboda), Slovakia (Cejkov; Kaminská & Tomásková 2004; Kasov; Novák 2004; Trencianské Bohuslavice, project by O. Zaar) and Hungary (Bodrogkeresztúr-Henye; Dobosi, ed. 2000).
Specifically, sites of the Danubian Gravettian provided a relatively large series of modern human fossil remains. From this viewpoint, the most important new discoveries of 2005 and 2006 are the spectacular finds of newborn babies, ritually buried at Krems-Wachtberg (Einwögerer *et al.* 2006). At the same time, several research and publication projects aim to complex evaluation of the previously collected anthropological evidence from the classical sites of Dolní Vestonice – Pavlov (Trinkaus & Svoboda, eds. 2006) and Predmostí (Velemínská *et al*. 2004; Svoboda 2005).

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From the viewpoint of paleoclimate and environment, the Mid-Upper Paleolithic, or later Interpleniglacial (terminal oxygen isotope stage 3 and early stage 2), was a period of global climatic instability leading towards the Last Glacial Maximum (Klíma *et al*. 1962). Wherever complex stratigraphies are present, as at Willendorf II with multiple Gravettian occupations, the loess/paleosol sequences suggest a dynamic climatic evolution in a "staccato" rhythm (Haesaerts *et al*. 1996; 2004; this volume). At Predmostí I, the old excavation records supported by the new 2006 excavation results document a superposition of two main Gravettian stages. Elsewhere, in the absence of well structured vertical sequences, chronological studies are based on the spatial analysis of the large sites (Pavlov I, Dolní Vestonice II, Petrkovice I), on radiocarbon dating, and wherever possible, on microstratigraphic analysis of the thick cultural layers (Svoboda 2003a).

Origin and formation of the Gravettian

One of the hotly debated questions in paleoanthropology, molecular genetics, and archaeology is wheather modern human penetration from Africa and the Near East to the northern latitudes was a single or multiple event. In terms of archaeology, the distributions of dates and sites in time and space for the individual entities of the Upper Paleolithic suggest a variety of answers in the individual cases. In case of the Bohunician, for example, we do not know who were the producers anatomically – all we know is that they appeared at the right time at the right places. The Aurignacian was an entity created by the invading modern humans (Teschler-Nicola, ed. 2006), but the related techno/typology and symbolic behavior was most probably formed at place, after the occupation of the Danubian Europe. The Gravettian question seems to be more complex one, where both local developmental trends and outside impulses should be combined (Svoboda 2007). The Gravettian modern humans, even if inhabiting glacial Europe, conserved a more tropically adapted body form which suggests an elevated, and perphaps repeated gene flows from more temperate regions (Holliday 1997; Pearson 2000; Churchill *et al*. 2000).

Until now, central European researchers – including myself - expected a local origin of the Gravettian, but the new typological and chronological studies make the search for a direct ancestry more and more difficult. A link to the Aurignacian is unlikely due not only to the lack of typological connection, but also to partial chronological overlapping between the two entities. Another option, a relationship to the Szeletian, is being rejected ever since the absence of foliate leafpoints was attested for the Early Gravettian (and proved, inversely, in the Late Gravettian). The Bohunician certainly accelerated the trends towards blade technology in general, but a direct link to the Gravettian cannot be traced. Therefore, somehow shadowy formulation resulted from this uncertainity, suggesting that the Gravettian appears in Danubian Europe as a "*Deus ex machina*" - in a complex situation composed by a variety of the preceding Early Upper Paleolithic entities.

In this paper I suggest that, in terms of the techno/typological relationships of the lithic industries, the Gravettian of Europe may well be compared to blade industries with pointed blades, bladelets, and backed elements (the Ahmarian, Lagaman and Dabban), starting about 10 ky earlier in the eastern Mediterranean (fig. 1). Early Ahmarian knapping methods aimed for production of series of pointed blades and microblades from unipolar narrow-fronted cores may be compared to a variety of blade and microblade knapping techniques as recorded at Pavlov by Skrdla (1997), for example, even if the importance of the bipolar technique increased markedly in the Gravettian. Some of the el-Wad points in the Near East are at least partly backed, as are the La Gravette points in Europe (an observation made already by Garrod), whereas the finer el-Wad points recall the Font Yves or Krems points of central Europe. The rest, i.e. the variable representations of endscrapers and burins on blades and their specific morphology is analogous in the Ahmarian, Lagaman, Dabba, and the Gravettian.

Recent research by the French and Bulgarian teams in the Balkans has possibly overbridged the important gap of the 10 ky between the appearance of Ahmarian in the Near East and the dispersal of Gravettian in the Danubian Europe by inserting in an early Gravettian (Kozarnikian) industry from Kozarnika cave (layer VII). This industry, including microblades, backed blades and points recalling the el-Wad type, is dated as early as 39 ky – 36 ky BP (Tsanova 2006). Another comparable industry appeared in the western Caucasus (Golovanova et al. 2006). On the other hand, more care would be advisable in arguing about the date of 35,5 ky for the "Proto-Aurignacien" of Krems-Hundsteig in Austria, an industry which, in fact, may result from mixing the Aurignacian and Gravettian layers during the excavations more than 100 years ago. Intensive research is carried out at Krems actually, both at the sites of Hundsteig and Wachtberg, and new data may be expected in the near future.

However, even if we propose - on the basis of lithics - that the Gravettian may be more or less directly related to the earlier backed-blade industries of eastern Mediterranean, it should also be stressed that formation of the complex Gravettian culture including the large open-air settlements, with industries of organic materials, art, symbolism, and ritual burials, was a local Danubian adaptation.

Early Gravettian - The Pavlovian

As the most important component of the Early Gravettian in Danubian Europe, the Pavlovian (30 – 25 ky) occupies a central location within the Lower Austrian – Moravian – South Polish geomorphological corridor (fig. 2a). Both the Pavlovian settlement archaeology and the resource analysis suggest a discontinuity compared to the previous Early Upper Paleolithic settlement strategies: the typical formation of the large open-air settlements in an axial manner, in lower altitudes and along the rivers; the long-distance transport of lithic raw materials; the intensive exploitation of mammoths supplemented by a variety of small animals; and, finally, aspects of ritual and style.

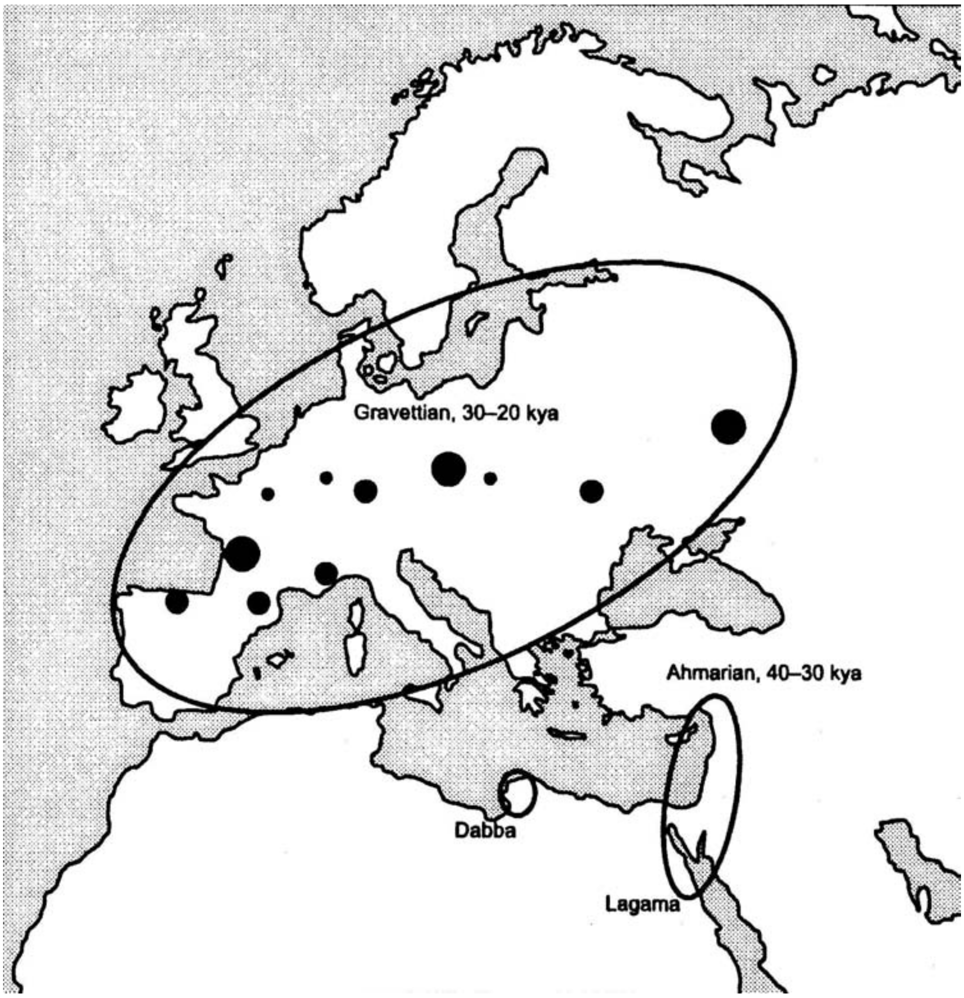

Figure 1 - Schematic map of the Mediterranean backed industries (Ahmarian, Lagaman, Dabba) of the Near East and the Gravettian of Europe.

Figure 1 – Carte schématique des industries méditerranéennes à dos abattu (Ahmarien, Lagaman, Dabba) du Proche-Orient et du Gravettien européen.

In addition, the lithic industries are accompanied by a rich and varied industries of organic materials. In case of the bone/ivory/antler industry, the morphological variability suggests a multiplicity of functions (Klíma 1997; Zelinkova 2007), but the interpretation, including the archeological nomenclature of certain implements, is still poorly understood. Recently, Brühl (2005) suggested that some of the "shovel-shaped" tools may in fact be blunt bone projectiles aimed for hunting fur animals without damaging the skins, whereas Steguweit (2005) interpreted some of the ivory "cylinders" ar soft hammers. The discovery of textile imprints on surface of certain ceramic fragments may, logically, imply a variety of textile-producing functions for the bone industry (Soffer & Adovasio 2004). However, we still lack a systematic description and nomenclature of the bone industry in general.

The art production at this stage of the Gravettian is remarkably complex, and includes carvings and engravings, soft stone carvings, and especially the ceramic plastic production. This phenomenon, typical of the Pavlovian, is worth special attention that lies beyond the scope of this summary paper.

Finally, majority of the human skeletal remains are equally dated to this period (Predmostí, Dolní Vestonice – Pavlov, Krems). Some of the ritual burials are covered by ochre, and some are covered by mammoth shoulderblades. It should be underlined, however, that they are poorly equipped by additive artifacts (if any, so just a few pierced decorative objects; Trinkaus et Svoboda, eds., 2006; Einwögerer *et al.* 2006).

The earliest Pavlovian occupation is best documented at Willendorf II, layer 5 (around and after 30 ky BP), Krems, and Dolní Vestonice II (a complex occupation horizons dated to 27 ky). The industry is dominated by burins, backed implements, and endscrapers, where burins are about the twice as numerous as endscrapers. The number of microliths, and especially geometric microliths, is usually low. A variety of pointed blades (including the

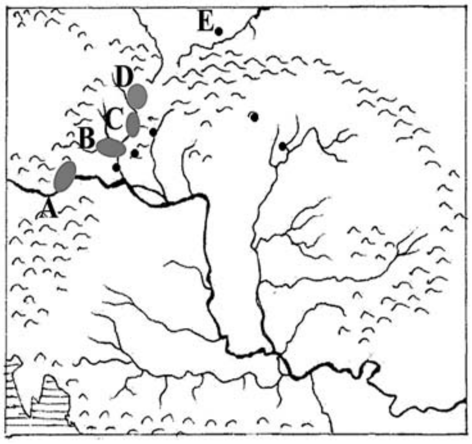

Figure 2a - Map of the Early Gravettian (Pavlovian) sites in the Middle Danube region.
A: sites of the Wachau Gate,
B: Dolní Vestonice – Pavlov,
C: Middle Morava Basin,
D: Predmostí,
E – Cracovie.

Figure 2a – Carte des sites du Gravettien ancien (Pavlovien) du Danube moyen.

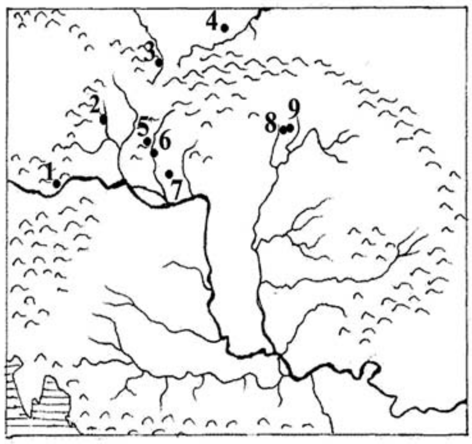

Figure 2b - Map of the Upper Gravettian (Willendorf-Kostenki) sites in the Middle Danube region.
1: Willendorf (layer 9),
2: Brno II,
3: Petrkovice,
4: Cracovie,
5: Trencianské Bohuslavice,
6: Moravany,
7: Nitra-Cermán,
8: Cejkov,
9: Kasov (lower layer).

Figure 2b – Carte des sites du Gravettien supérieur (Willendorf-Kostienkien) du Danube moyen.

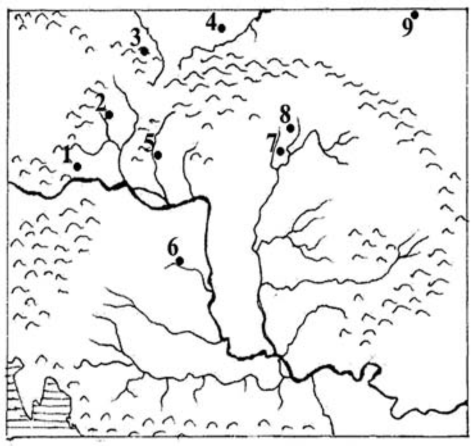

Figure 2c - Map of the Epigravettien (Kasovian) sites in the Middle Danube region.
1: Grubgraben,
2: Stránská skála IV,
3: Opava,
4: Cracovie,
5: Banka,
6: Szágvár,
7: Arka,
8: Kasov (upper layer),
9: Lipa.

Figure 2c – Carte des sites Epigravettiens (Kasovien) du Danube moyen

Jerzmanowice-type points) and pointed microblades (including the Krems or Font Yves points) occur as well.
A remarkable cluster of Pavlovian radiocarbon dates is recorded during the following two millenia, between 27 – 25 ky (Jöris & Weninger 2004). These dates were received from Willendorf II (layers 6-8), Aggsbach, Krems, Grub/Kranawetberg, Dolní Vestonice – Pavlov, Milovice (settlement), Borsice, Jarosov (settlement), Spytihnev, and Predmostí (the main occupation layer). An increase of microliths, including the geometric microliths (lunates, triangles, trapezes), is typical at this stage, especially within the Dolní Vestonice – Pavlov area (fig. 3). A variety of pointed blades and microblades continue to occur, but the typical leaf-points are absent at this stage. A few of the C14 datings from sites like Dolní Vestonice, Milovice and Jarosov are later than 25 ky; so, for example, the mammoth bone deposits at Milovice and Jarosov are dated later than the related settlements. If these dates are correct, they would suggest a prolongation of occupation at these sites after the Pavlovian.

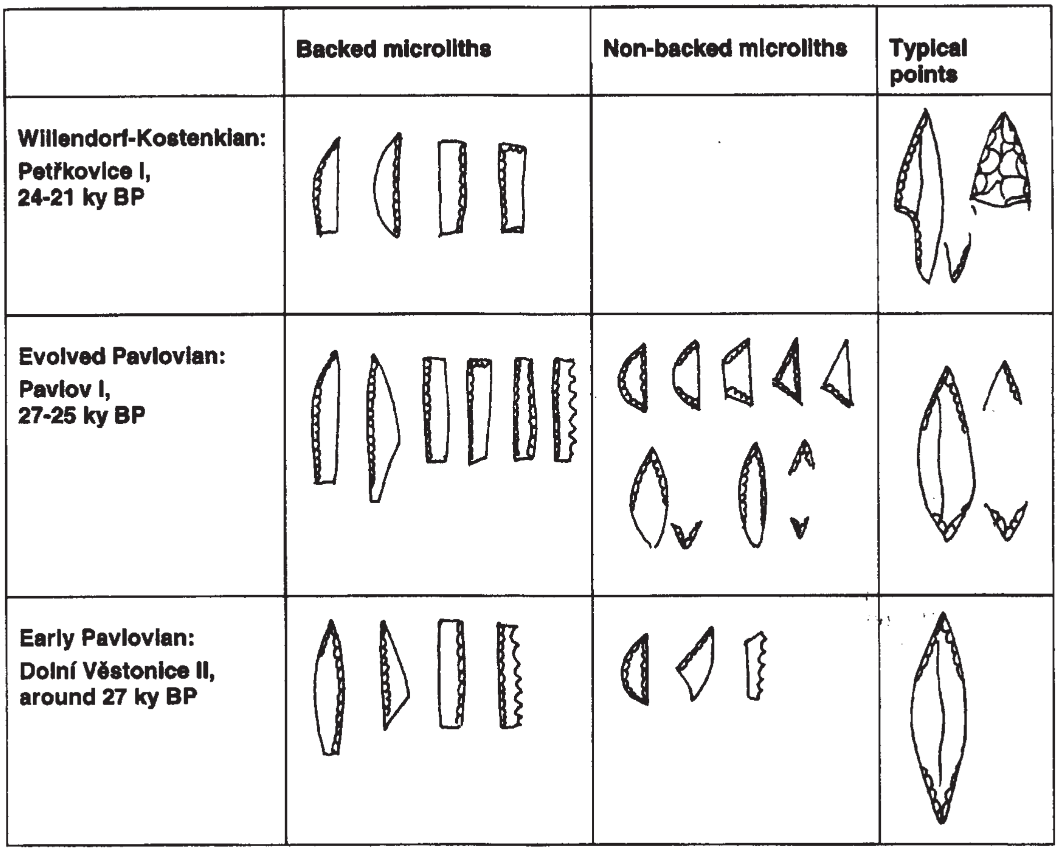

Figure 3 - Comparison of the Pavlovian and Willendorf-Kostenkian stages in Moravia and Silesia: aspects of typology, with emphasis on microliths and points.

Figure 3 - Comparaison typologique et plus particulièrement desmicrolithes et pointes entre le Pavlovien et le Willendorf-Kostienkien de Moravie et de Silésie.

The most typical example of another type of Early Gravettian, non-Pavlovian site, is Bodrogkeresztúr-Henye in eastern Hungary (Dobosi, ed. 2000). The site provided two dates, 28.7 ± 3 ky and 26.3 ± 0.4 ky that place it chronologically to the Early Gravettian. Contrary to the Pavlovian sites, however, the fauna is dominated by horse and elk, and the lithic industry, dominated by burins, retouched blades, endscrapers and sidescrapers, lacks the typical microliths.
In addition, there are differences of rather functional nature. Nem_ová, a workshop site with an Early Gravettian date in western Slovakia, is located near an important raw material source: the radiolarite. Two smaller cave sites, Slaninova Cave and Dzeravá skala Cave, yielded early Gravettian dates in association with fragments of the typical ivory points with circular section. This may be an evidence for periodical visits of Gravettian hunters in the karstic regions.

Upper Gravettian - the Willendorf-Kostenkian

After 25 ky, approximatively, the Middle Danubian region becomes covered by a network of Upper Gravettian sites (fig. 2b). Compared to the Pavlovian, however, we observe larger and less regular distances among the sites, with more emphasis on the "gates" (Wachau Gate, Moravian Gate), but also dispersal into new regions, especially in the Carpathian Basin. The art assemblages are less complex: instead of the large and varied assemblages of the Pavlovian art, we mostly have remarkable female images only, such as the aolithic figurine of Willendorf II, the hematite figurine of Petrkovice and the ivory figurine of Moravany (therefore, we sometimes speak of "horizon of lonely Venuses"). There is only one burial, Brno II, with a date of 23,7 ky (Pettitt & Trinkaus 2000; Oliva 2001). It differs from the Pavlovian burials by the richess of associated objects such as the male figurine of ivory, marlstone discs, and smaller items of body decoration.

The most typical site is the uppermost layer 9 of the classical stratigraphic sequence at Willendorf II in Austria, providing a typical industry with shouldered points, the "fossil directeur" of the period with a series of ^{14}C dates ranging from 25 to 23 ky (Haesaerts *et al.* 1996; Neugebauer-Maresch 1999). Moravia, compared to the previous period, received scarce evidence of occupation at this time-period, as at Predmostí, upper layer, dated 24,3 ky. A typical site of this period is Petrkovice in Silesia, with five dates between 21-23 ky, and a network of Upper Gravettian sites of a similar age in Slovakia, as at Trencianské Bohuslavice, Moravany, Nitra-Cermán, Cejkov and Kasov (lower layer).

In addition to the typical shouldered points, certain sites of this time-period also provided leaf-points (Petrkovice, Trencianské Bohuslavice, and Predmostí – the upper layer). Genetic relationships to the Szeletian, formerly anticipated by certain authors, are unlikely given the long time-span separating the two periods. Rather, we expect an independent wave of leaf-production at 20 ky BP, which, by the time of the Last Glacial Maximum, seems to be an element of evercontinental significance (cf. the Solutrean of western Europe).

Epigravettian – the Kasovian

Industries from Middle Danube region dated after the Last Glacial Maximum (20-15 ka BP) were hitherto presented as a „mosaic" of derived Gravettian and Aurignacian features (Grubgraben, Stránská skála, Szágvár, Arka, Kasov - upper layer, Lipa; Svoboda *et al*. 1996; Valoch 1996, etc.). Actually, following a preliminary revision of the sites and redating of some of them (Moravany-Zakovská as the Upper Gravettian, Verpoorte 2002; Hranice as the Magdalenian), the techno/typological structure becomes more homogenous and we propose to unite the remaining industries into a distinct techno/typological unit (Svoboda & Novák 2004).

These sites form a network of scarcely distributed sites over the Middle Danubian region (fig. 2c). In terms of raw material exploitation and economy, there is more emphasis on local sources, and the sites located directly in vicinity of the outcrops display the character of primary workshops (Arka, Lipa). Contrary to the Gravettian based predominantly on lithic imports and producing long blades from the classical crested and prismatic cores, the Epigravettian blanks (flakes, shorter blades, microblades) are produced from short and cubical cores as well as from elongated blade cores. Typically, some of the microblades were made by pressure technique from wedge-shaped cores strongly recalling the North Asian parallels. Typologically, the groups of short endscrapers and burins predominate, but their quantitative relationship may be flexible at the individual sites. Both types are usually made on short blanks. Some of them are thick and some are polyhedric, thus recalling «Aurignacian» forms, but the quantity of these types is low. The backed implements, previously used as the key argument for continuity of the Gravettian tradition, are also present (cf. Arka, Lipa) but are in fact less frequent than was expected. In addition, the bone-and-antler industry, whenever preserved, shows parallels to the Magdalenian ("*batons de commandament"* at Grubgraben and Ságvár, needles at Grubgraben) rather than to the rich bone industry of the preceding Gravettian. Symbolic art is absent.

These techno/typological changes copy with radical changes in settlement strategy (preference for slopes and protected valleys), hunting techniques and strategies (termination of the mammoth exploitation and orientation on horse and reindeer herd hunting, West 1996). Thus, we argue that in the Middle Danube region, the Gravettian/Epigravettian continuity has been interrupted, most probably as a result of the Last Glacial Maximum.

As the terms "Epigravettian", "Epiaurignacian", or even "Protomagdalenian" are missleading by the nature of their meaning, we may either look for parallels in the contemporary development elsewhere (e.g., the Badegoulian of Western Europe, Terberger & Street 2002) or coin a new name valid for eastern Central Europe. The earlier suggested names such as the Lipa culture or the Ságvárian were used in a more local sense and never refered to the whole geographic entity as is observed over the whole Middle Danube region. The site of Grubgraben, recently proposed by Terberger (2003) has the advantage of a solid dating framework associated to a wealth of archaeological evidence, but the typological structure seems more versatile compared to the other sites; therefore, it is difficult to characterize the site typologically before the publication of the complete material.
A candidate could be the site of Kasov - upper layer (Bánesz *et al.* 1992). Even if we only have one ^{14}C date (18,6 ky BP), this site documents a simple but clear stratigraphy, and a rich but typologically standard and characteristic archaeological content. Hence, we proposed the term "Kasovian" for further discussion (Svoboda & Novák 2004). The term "Epigravettian", sensu stricto, should be reserved for Mediterranean Europe, where the Gravettian typological tradition is clearly conserved and further developed (backed implements and microliths). In contrast, the typological characteristic of the Kasovian lies closer to the Badegoulian of the west of Europe, or to the other entities further to the east of the North Eurasia.

Gravettian Landscape: the Moravian Corridor

Danube, given the west-east orientation accross the Central and Southeast Central Europe, unifies the mosaic of plains separated by highlands and mountaneous chains. This river emerges from the west in the narrow Wachau Gate in Austria, and, after accepting two affluents from the north, Morava and Váh (both linked with the Gravettian sites), it turns suddenly towards the south to cross the Hungarian Plain. Two other affluents are important on this journey, Tisza, connecting Gravettian sites of eastern Hungary and Slovakia in the northeast, and Sava in the southwest.
The regional literature rightfully emphasizes the role of the Moravian Gate as one of the most important European passages, both for animals and their hunters. The bottleneck of the gate itself, and the adjacent Moravian corridor composed of narrow plains between the Bohemian Massif and the western Carpathians, provides the easiest passage from the Danube valley towards the plains of Northern and Eastern Europe. Spatial patterning of the Upper Paleolithic sites shows that no other entity adapted its site-location strategy to the Moravian geomorphology as precisely as the Gravettian. The largest and most complex sites are located along this corridor axially, in almost regular distances, starting with the Willendorf, Aggsbach and Krems cluster at the end of the Wachau Gate in the southwest, towards the Dolní Vestonice-Pavlov cluster and further through the Middle Morava Basin towards the Predmostí sites at the southern end of the Moravian Gate and Petrkovice at the northern end.
Theoretically, there are several levels of spatial analysis of the Danubian Gravettian (Svoboda 2003b):

- the Gravettian landscape is related to the riverine network of Moravia, where sites and site-clusters are localized on the valley slopes and elevations, in relatively lower altitudes (200 – 300 m a.s.l.), with almost regular distances between one another. The Dolní Vestonice-Pavlov area is a typical example (fig. 4-5). In constrast, the "Aurignacian landscape" favours higher locations, and was less dependent on the Moravian rivers;

- the individual sites demonstrate a distinguished hierarchy with regards to their size and complexity. Another factor is the function of sites, their universality or specialization, so that the nature of the difference is both quantitative and qualitative. Finally, occupation of a site has a rhythm and dynamics of its own, in terms of seasonality, microchronology (relationships between units and features within the sites, microstratigraphies) and of the overall Gravettian chronology. Therefore, the sites represent units composed by elements and factors of incomparable nature, requiring various analytical approaches;

- the settlement units. Large sites are sectioned into individual units (central hearths with related features, objects, and patterns of artifact distribution); the spatial/temporal relationships among them are the object of a site analysis. Dwelling structures are, in fact, ideal architectural reconstructions of the settlement units.

Large Gravettian settlements: the Pavlov case

Formation of the large hunter's settlements is a characteristic phenomenon of the Pavlovian (Kozlowski 1986; Valoch 1996; Svoboda *et al.* 1996, 2000; Neugebauer-Maresch 1999; Verpoorte 2001, etc.). The first characteristic of these "mega-sites" is simply their size (minimal diameter of 100 m). In addition, the evidence of a high artifact density, thickness of cultural layers and charcoal deposits, the complexity of activities, including rituals and symbolism has been recorded. While interpreting the records, two extreme models are usually applied: the first model proposes a large, relatively sedentary, «camp»; the second model suggests an accumulation of successive short-term occupations. Or, in another words, two site-formation factors are involved: the intensity of occupation on one hand, and its duration on the other.
The large and complex sites, with extended and intensive occupations and complexity of art and other symbolic production, are Dolní Vestonice I and Pavlov I, as well as Predmostí I. Dolní Vestonice II is large in size, but the occupation was less intensive and more structured in time and space than the above sites. Other important sites are at Krems (Wachtberg and Hundsteig), Grub, and others. Willendorf II, on the other hand, is important stratigraphically, as a repeatedly but only shortly visited landmark (with the exception of a more extended layer 9). Preliminary

Figure 4 - Aerial view of the Dolní Vestonice – Pavlov sites.

Figure 4 - Vue aérienne des sites de Dolni Vestonice et de Pavlov.

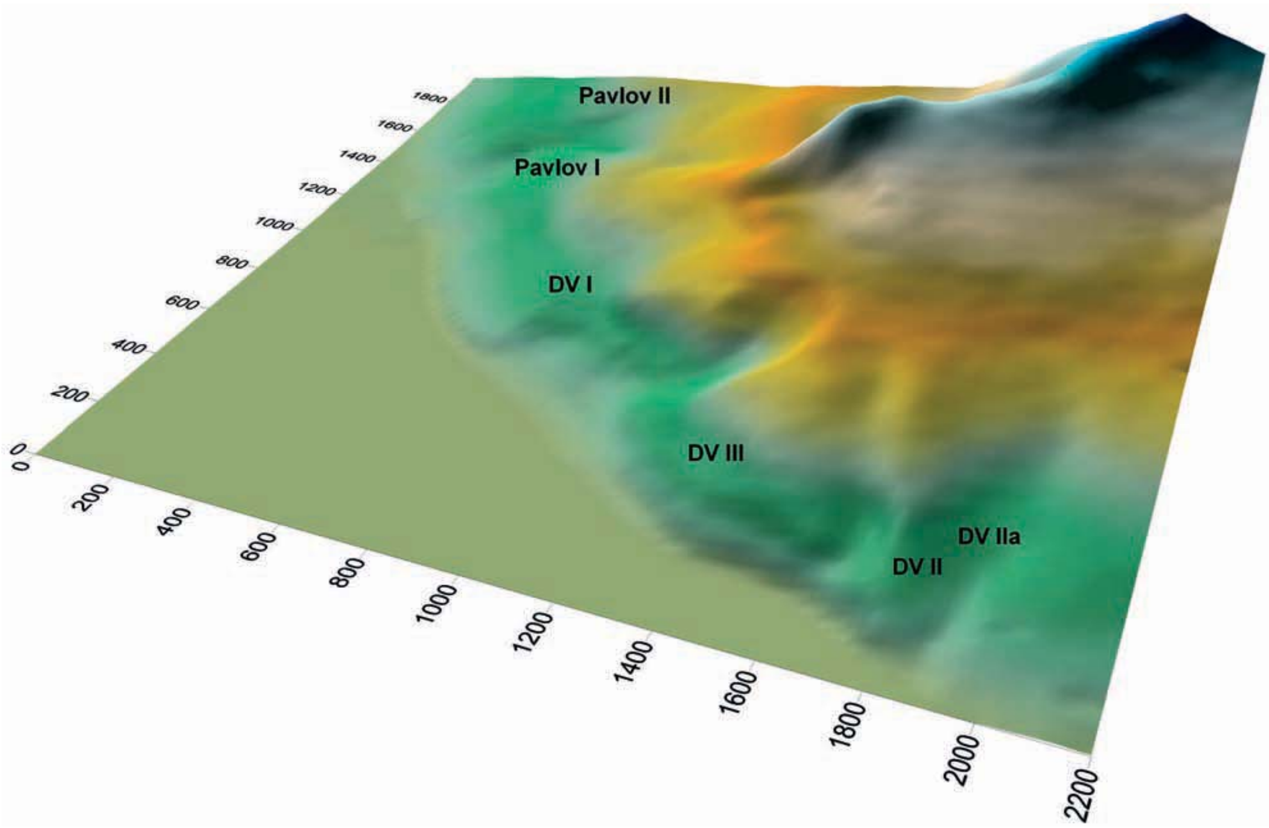

Figure 5 - Surfer reconstruction of the site location within the Dolní Vestonice – Pavlov area.

Figure 5 – Reconstitution 3D des sites des zones de Dolni Vestonice et Pavlov.

results obtained on seasonality by Nyvltova Fijakova (2007), based on animal dental microstructures, suggest that the large sites were settled all the year round, whereas some of the smaller sites in the region functioned seasonally (spring-autumn).

The advantage of Pavlov I is that it was excavated by one person, Bohuslav Klíma, on a large scale, and using a single research strategy (Klíma 2005). In the early 90s, we initiated a long-term, multidisciplinary, international process of description and evaluation of the site and its inventories. We started with a pilot area in the Southeastern part (Svoboda, ed. 1994), and continued in the Northwestern part (Svoboda, ed. 1997), so that the results gave us the opportunity to compare the situations in the two opposite areas. With the first comparative results at hand, the consecutive step was to approach the densely settled parts excavated in 1954 and 1956, with the richest and the most complex evidence, and thus to complete the picture of Pavlov – Southeast (Svoboda, ed. 2005).

The data-set based on 1m or 2m square grid recording systems, and on incomplete provenience data about the microstratigraphies, certainly represents a rough scale compared to modern excavation standards. Therefore, more detailed insights into artifact clustering were not possible, but we are able to operate on another scale, within a considerably larger area, and with larger features such as hearths, depressions, and artifact clusters.

While identifying the 13 features, or "huts", B. Klíma (2005) combined several viewpoints of a different character and value: hearths, pits, large bones along the edges, the spatial extent of the cultural layer, and artifact concentrations. Our approach was to analyze each of these components separately. The depressions were reconstructed newly, using a Surfer approximation of the data derived directly from the stratigraphic sections (fig. 6; Svoboda, ed. 2005). The distribution patterns were analysed subsequently, separately for each type of artifacts (Novák 2005), and than plotted over the surface reconstruction. The aim was to distinguish more clearly the levels of empirical observation ("settlement units") from interpretation ("dwellings").

One of the results of our analysis address the difference between the central and the peripheral parts of the settlement from the viewpoints of microstratigraphies, features, and of the spatial distribution of the artifacts. Generally, the palimpsest area ranges over the central and the western parts of the area, with irregular, multiplied features 7-11, whereas the settlement record seems plainer, and easily readable along the peripheries (features 3, 5, 6). Other contributors, while discussing the individual types of artifacts in detail, analysed this problem from their specific viewpoints. For Verpoorte (2005), the central part of the site is just a palimpsest of various occupation episodes. Bartosíková (2005) located, at the periphery of the site, the "production areas" and the

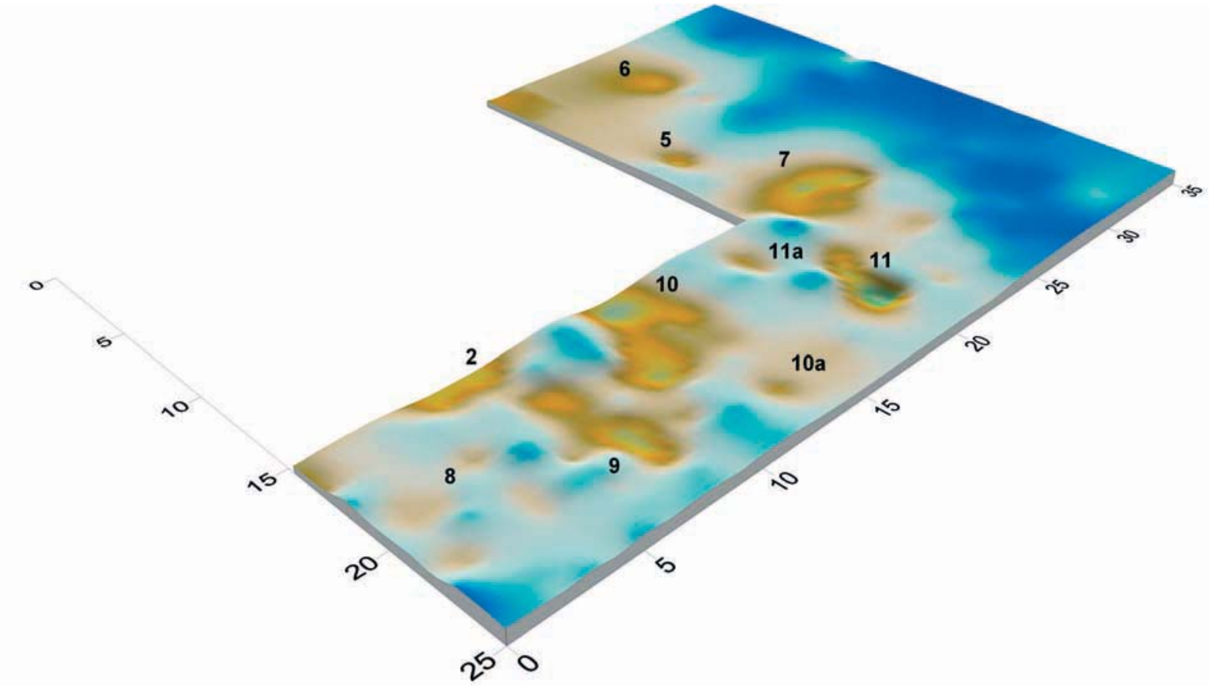

Figure 6. Approximative Surfer reconstruction of the numbered depression features (huts?) at Pavlov I – Southeast (1954-1956 excavation seasons), based on data from the stratigraphic sections. The feature numbers (2, 5-11) follow and complete the numeration system by the excavator.

Figure 6 - Reconstitution approximative des structures en creux (huttes ?) enregistrées à Pavlov sud-est (fouilles 1954-1956) à partir des coupes stratigraphiques. La numérotation des structures (2,5 – 11) suit et complète le système de numérotation du fouilleur.

"working places" (the later using already finished products); however, it is suggested that the two types of activities spatially overlapped. _ajnerová (2005) recorded a higher percentage of used pieces in the center and, in addition, traces of working hard materials in these areas. Musil (2005) defined several activity areas on the basis of the faunal remains, together with their relationships to the individual settlement units, and, on a larger scale, to the settlement areas.

Another question touches upon the settlement dynamics and seasonality. Musil, based on the faunal analysis, and Verpoorte, on the basis of the lithics, argue for a permanent or semi-permanent occupation of this site, with emphasis on winter seasons. Even if the settlement would be rather permanent and related to a limited hunting territory, the spring migrations along Moravian drainage system are expected. This scenario would accord with the records of a large volume of lithic material imported from the northeast and east.

While discussing the faunal remains, several points should be considered. Firstly, the records may not be complete because of the limitation of the excavated area, or because of erosions in the adjacent valley of an active brook (this could explain why we at Pavlov I lack mammoth bone deposits which are typical features of Dolní Vestonice I, II, Predmostí I, and Milovice I sites). Secondly, the faunal structure we have received from Pavlov I resulted from a deliberate human selection. However, an animal not only served as a source of meat and fat for nutrition, but also of furs for clothing and building, and of bones for tools, buildings, and fuel. Certain carnivores may have appeared on the faunal list simply as animals being killed when attacking the site and the food stored there.

After Musil (2005), the dominant animal species were reindeer, hares, wolves, foxes, mammoths, and horses, respectively. As Wojtal *et al*. (2005) remark, reindeer and hare bones also bear the majority of the visible cut marks, which is in an agreement with their importance on the faunal records. However, as emphasized by Nyvltová Fisáková (2005), Brühl (2005), and García Diez (2005a), mammoth remains, especially the precious ivory, formed more than a half of the materials selected for the production of tools and decorations (followed by reindeer and fox remains).

Faunal analysis is closely related to study of possible hunting weapons. The composite projectiles made of backed and/or geometric microliths were never recovered "in situ", nor confirmed by the use-wear analysis, but their existence is usually admitted. Brühl (2005), based on analogies with ethnology, turned his attention to the blunt "foliates" made of organic material, which could have been intended for killing smaller animals in order not to damage the furs. In addition, using nets was probably another hunting technique, especially with the smaller fur animals, as suggested by the knot imprints in ceramics (Adovasio *et al*. 2005; Kovacic *et al.* 2005).

Since the publication by Mason *et al.* (1994) of ground plant tissue in a hearth at Dolní Vestonice II, there is no further evidence confirming plant consumption, a supplementary activity that should be presumed at these sites. Thus, based on the number of grindstones documented at Pavlov I, this problem is raised again (Svoboda, ed. 2005). However, the available evidence shows that the majority of the grindstones were evidently used for colorants, while other possible usage remains unacknowledged. New excavation project at the same site, now oriented towards the paleobotanical analysis and bases on extensive floating of the sediments, has been initiated in 2005 in collaboration with the University of Cambridge (M. Jones).

Pavlov I witnessed a broad variety of techniques and objects of self-adornment. Namely, the collection and simple usage (or perforation) of naturfacts such as carnivore teeth and the Tertiary molluscs (Hladilová 2005), supplemented by ivory beads and other more sophisticated, and perhaps more "symbolic", items of decoration (García Diez 2005a). In additon to items of decoration, there are also symbols of their own such as the ivory carvings depicting a lion and a mammoth. Soffer and Vandiver (2005) wonder about the two-dimensional aspect of these images. I believe that this may be due to the fact that both were, in fact, attached to clothings as were the other items of decoration. The morphology of these "contours découpées", and especially the notches, would support this interpretation.
The most typical phenomenon of the Pavlovian art is the production of clay plastics – the earliest ceramics. Even though this production is also recorded elsewhere in Moravia (Predmostí and sites of the Morava river valley), lower Austria (Krems), Silesia (Petrkovice) and Slovakia (Moravany, Cejkov, and Kasov), the South Moravian sites of Pavlov I and Dolní Vestonice I represent the true centers of these activities. Similarly to the decorative objects of organic materials, the ceramics was also found clustered in three concentrations in the western part of Pavlov-Southeast (features 9, 10, 11), and inside of a one concentration in Pavlov-Northwest (feature 13). Logically, these concentrations were likely to be protected by a construction – early architecture. And, presumably, production and destruction of symbols in clay around certain hearths may, since the first discovery of such a place be interpreted as a ritual activity (Absolon 1938; Soffer *et al*. 1993).

Additional evidence is conserved as imprints on surface of the ceramic pieces. Microscopic examinations confirmed the existence of regular structures that are interpreted as simple textile imprints (Adovasio *et al.* 2005; Kovacic *et al*. 2005) and animal hair. Dematoglypic studies suggest that young people and children were present – and active – around the ceramic production processes (Králík & Novotny 2005). This coincides well with some of the Western European data from painted caves, where the presence of children has also been documented. I do not wish to suggest that children were the producers of this art, neither of the "big" parietal art of the West nor of the miniatures of Moravia, but it should be taken into an account that the symbolic art production was a complex process assisted by the whole community. And - as today - children were probably anxious to touch everything directly.

If placed in context with the other symbolic activities performed at Pavlov I and Dolní Vestonice I-II, such as traces of colorants, carvings in ivory and stone, and human burials, the ceramic production suggests that these sites were the centers of activities related to rituals, information storage and transmission by the means of symbols, decoration of bodies, and their ritual deposition in graves. The traces of symbolism, concentrated especially at Dolní Vestonice I and Pavlov I, place these sites on the top of the site-hierarchy not only quantitatively – as a result of the size and volume of the excavated material, but also qualitatively – as the places of special activities. In the light of the above, the two sites are considered not only as palimpsests of accumulated subsequent occupations, but as centers of human aggregation, information exchange, and social rituals.

Of equal interest are the isolated settlement units composed just of a central hearth and encircled by pits, large bones, and artifact scatters. Most recently, a unique example of this "elementary" type of situation was discovered in 2007 about 1 km from Pavlov I, at the site VI (fig. 7).

Site	Individual	Position	Orientation	Ochre	Items of decoration
DV I	DV 3	strongly flexed	NW	head, upper part of the body	10 fox canines
DV II	DV 13	supine, torded	SSE	head	20 pierced carnivore teeth, ivory pendants
DV II	DV 14	on belly	S	head	3 wolf canines, ivory pendants
DV II	DV 15	supine	S	head, pelvis	4 pierced fox canines
DV II	DV 16	flexed	E	head, pelvis	4 pierced fox canines
Pavlov I	Pavlov 1	flexed ? (disturbed)	SE	—	—

Table 1 - The Dolní Vestonice (DV) and Pavlov ritual burials and their archeological contexts (solitary finds are not recorded).

Tableau 1 – Les sites funéraires de Dolní Vestonice (DV) et Pavlov et leurs contextes archéologiques (les découvertes isolées ne sont pas mentionnées).

Human burials: the Predmostí case

Burials are an integral component of the large Gravettian settlements. Human fossils appear as well-preserved ritual burials, sometimes covered by mammoth shoulderblades or other means of protection, or as disturbed situations and scattered fragments. Only a few pierced beads and teeths are associated, but parts of the bodies are usually covered by ochre. First zooarchaeological analysis of the faunal remains in the vicinity of Dolni Vestonice 16 suggest that complete animal bodies were laid next to buried man, perhaps intentionnally (Nyvltova Fisakova, pers. com.). In the chronological framework, the majority of human burials from Dolní Vestonice I, II and Pavlov I, plus Predmostí I, fall into the Evolved Pavlovian stage (27 – 25 ky BP; Vlcek 1991; Klíma 1995; Trinkaus & Svoboda, eds. 2006). An earlier Pavlovian horizon, identified at Dolní Vestonice II and dated to around 27,000 years BP, is related only to the isolated human fragments Dolní Vestonice 33, 36, 39, 47 and 49. This, at least, is the chronological picture given by standard laboratories such as Groningen.

One later burial, corresponding with the Willendorf-Kostenkian stage of the Gravettian, is Brno 2 (23,7 ky BP; Pettitt & Trinkaus 2000). It is unique in two aspects; its location is outside of the typical Pavlovian regions and settlements, and it is unusually rich in grave goods. Another later date obtained directly from the Dolní Vestonice 35 femur from the site of Dolní Vestonice I (22,8 ky B.P.) may possibly be contaminated, since the majority of the other dates from the Dolní Vestonice I settlement correspond with the Evolved Pavlovian stage (Trinkaus *et al.* 2000).

In Austria, the 2005 and 2006 discoveries of newborn childern´s burials at Krems-Wachtberg fall chronologically to the Evolved Pavlovian stage as well. The first two bodies were lain together in crouched position in a shallow pit, richly covered by ochre, and protected by a mammoth shoulderblade. The associated ivory beads are of the same type as at Dolní Vestonice. Additional infant burial was located about one meter north (Einwögerer *et al.* 2006). The only other human remains from the same region and time period are the isolated pieces from Willendorf I and II, which date to the Willendorf-Kostenkian (Teschler-Nicola & Trinkaus 2001), and two human teeth recently discovered in Grub/Kranawetberg (Antl & Fladerer 2004). Some other human fossil finds from the Middle Danube region were deleted from the list on basis of direct ^{14}C dating (Svoboda *et al*. 2002).

In this contest, Predmostí I still represents the largest accumulation of Gravettian human remains at one place (e.g., Klíma 1991; Valoch 1996; Oliva 2001). These materials were recovered by J. Wankel in 1884, K.J. Maska in 1894, M. Kríz in 1895 and K. Absolon in 1928 (and probably 1930). The majority of the Gravettian anthropological materials from Predmostí were destroyed in 1945; today, the Moravian Museum at Brno only houses cranial fragments including teeth of unclear origin and parts of the postcranial remains. However during the last few years, the first mandible found at this site by Wankel was redis-

Figure 7 - Pavlov VI, excavation 2007. View of an isolated settlement unit, with central hearth encircled by small boiling pits, and accumulation of mammoth bones (two individuals) aside.

Figure 7 - Pavlov VI, fouilles 2007. Vue d´une unité isolée, avec un foyer au centre entouré par des petites fosses et une accumulation des ossements du mammouth (deux individus) à côté.

covered in the Olomouc museum, and the original photo-documentation by Matiegka was found at the Department of Anthropology of Charles University. Therefore, a recent anthropological-archaeological project has been focused on description and a new interpretation of this discovery (Velemínská *et al*. 2004; Svoboda 2005).

Basing on the original field diaries by Maska, supplemented by the published literary references, we created a list of the paleoanthropological finds from Predmostí according their discovery dates and placed them into the spatial context of the site I (fig. 8) and the burial area (fig. 9a,b). One of the main tasks of this study was reconstruction of

N° of find	Discovered by	Date of discovery	More precise location	Characteristics
1.	J. Wankel	1884	Chromecek´s loam pit	mandible
2.	K.J. Maska	18.5.1894	North	fg. of mandible humerus
3.	K.J. Maska	7.8.-10.9. 1894	Burial area	skeletons
4.	K.J. Maska	18.8. 1894	NW, uncertain	ulna
5.	K.J. Maska	23.8. 1894	South	pierced pelvis
6.	K.J. Maska	24.-28.8. 1894	SE	mandible, fg. of skull, ulna, radius, humerus, ribs
7.	K.J. Maska	24.8. 1894	South	fg. of skull, humerus
8.	K.J. Maska	30.8.	South	rib
9.	K.J. Maska	4.8./10.9.	NE	falang, ulna, humerus
10.	M. Kríz	25.6. 1895 and later	Chromecek-trench VIII	skull, mandible
11.	M. Kríz	1895	Chromecek-trench IV	mandible
12.	M. Kríz	1895	Chromecek-trench II	two femurs
13.	M. Kríz	1895	Dokoupil-trench VII	fg. of skull, two humeri, 2 ulnae, fg. of radius
14.	K. Absolon	August 1928, 1930		54 bones of extremities, 2 teeth, mandible

Table 2 - Review of paleoanthropological discoveries at Predmostí, site Ia (for spatial reconstruction, see fig. 8).

Tableau 2 – Inventaire des découvertes paléoanthroloplgiques à Predmostí, site Ia (pour la répartition spatiale, voir fig. 8).

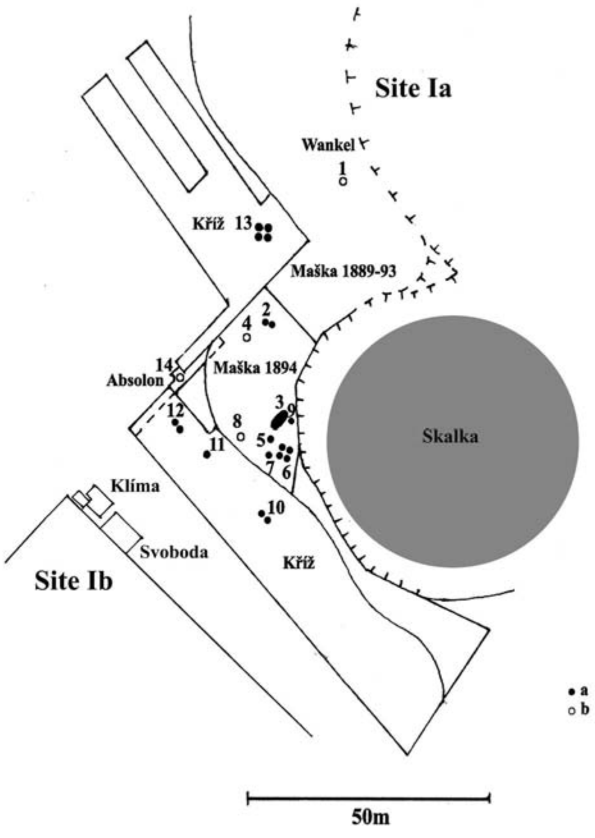

Figure 8 - Spatial distribution of human finds at Predmostí I made by Wankel, Maska, Kríz and Absolon between 1884-1930. Full oval – the central burial area of 1894; full point – solitary find with a relatively certain location; empty point – solitary find with generally estimated location.

Figure 8 - Répartition spatiale des restes humains à Predmosti 1 établi par Wankel, Maska, Kríz et Absolon entre 1884 et 1930 : Ovale, zone de sépulture centrale de 1894 ; Point, restes isolés relativement bien localisés ; Cercles, restes isolés avec une localisation estimée.

the movements of Maska within the 1894 area and, in more detail, within the burial area, which adds a spatial dimension to the daily records.
Seen from the viewpoint of the center – periphery relationships inside the large hunter´s settlements, we do not consider the burial area at Predmostí, nor the Skalka rock above it, as a real settlement center. Rather, the area seems peripheral, with a lower representation of lithic industry (compared to previously and later excavated parts of the same site), with scattered accumulations of mammoth bones and other faunal remains.
Majority of the skeletons found at this place are only partially preserved, but some, such as Predmostí 3, are remarkably complete, given Matiegka's descriptions. The differential preservation of the individual bones does not prove a pattern of intentional human selection. Therefore, after discussing of a series of aspects and explanations that could have contributed to the formation of such a funeral situation (ethnological parallels, patterns of formation and protection of burials, absence of ochre, additional artifacts, effects of cannibalism or secondary burials), we focused in more detail on three of them.
All researchers at Predmostí have underlined the role of carnivores in the site formation processes and in disturbance of human skeletal remains. In the photodocumentation, the effect of carnivore gnawing of human bones is not directly observable. However, there is a high ratio of carnivores in the associated faunal record, especially whole groups of wolves and foxes. In 1996, we observed fox activites on guanaco carcasses at Tierra del Fuego where at each carcass, foxes created a separate nest to profit from the meat in longer-term, and, as an effect, removing the remains slightly each day. It is possible that the accumulation of fox remains, found at one spot by Maska (on Aug. 7) at the southern margin of the burial area, and elsewhere in the vicinity, could be explained using this analogy.
Maska´s records demonstrate the thickness of the deposits in the burial area, composed of loess, humus and charcoal layers, and partly by limestone debris. Because the complexity of these deposits increases towards the former Skalka limestone rock, located a few meters eastwards, I believe that the geological context is influenced by slope removals and accumulation of deposits which one should logically expect at the foot of a larger rock formation.
The mention by Maska that „no skull was found complete, all were fragmented (along the suturas)" may be explained (as at Dolní Vestonice – Pavlov) by pressure of the overlying loess which had accumulated relatively rapidly after the abandonment of the settlement (and, by the same time, after decompositon of the interior soft tissues).
Since the moment of discovery, two competing hypotheses were raised about Predmostí: a contemporary burial as an effect of a catastrophic event, versus gradual accumulation of human bodies. The second alternative offers an additional explanation for the body disturbances because each addition of a new body would affect the previous depositions. So, as an example, the best preserved male skeleton 3 found on Aug. 10 most probably overlay more disturbed bodies below. In addition, some bones display special human activities, as the perforated human pelvis found separately south of the burial.
Most of the bodies were oriented towards the norths, parallel to the original rock wall. Longitudinal axis of the oval-shaped bone deposit concurs with animal bone redepositions as recorded during the 2006 excavation nearby, and with the declination of the original slope.
The burial area yielded only a few artifacts and no ochre. Some of the published mentions of associated decorative objects are due to a later confusion. The only remarkable artifact from the vicinity of the burial area is a half (now completed) of a large, perforated marlstone disc, a type that also accompanied the male burial of Brno 2. In this case, a symbolic interpretation seems plausible.
Mammoth shoulder blades (one with irregular scratches) covered three or more skeletons in the marginal parts of the burial area, but there was no regular nor complete coverage of the whole space. Two more covering shoulder blades were recorded south of this area. Some mammoth bones, erected in the upright position in the vicinity, may also be related to burials (cf. a few human remains below a mammoth mandible, found on Aug. 4). Deposition of the limestone debris layers over the area was natural, however, the limestone blocks were there, and thus also available as coverage of the bodies.
In conclusion, we suspect that the noticeable Skalka rock played a certain role in selecting a burial place at Predmostí. A long-term tendency to deposit dead bodies outside the settlement centers, „below the rock", could result in this accumulation of human remains at one place, with a pattern of free dispersal around, where they were opened to various postdepositional processes such as carnivore activity and the deposition of slope sediments.
In 2006, the remaining part of the Predmostí I site, with mammoth bone deposits and artifact scatters, has been excavated and the situation is now preserved under an exhibition pavillon.

Conclusions: notes on the Gravettian settlement dynamics

By suggesting the possibility of eastern Mediterranean origin for the Gravettian, this paper is certainly far from Europocentric. However, it should be stressed that Europe, as the westernmost Eurasian peninsula, played not only a passive role of recipient of the invading populations, but functioned also as a cradle of new behavioral patterns, technologies, and cultural entities. In this area, the anatomically modern humans created the typical Upper Paleolithic entities such as the Aurignacian and the Gravettian in their complexity. The related archaeological record of the both archeological entities suggests advancement in behavior and lifestyles, be it in selection of a variety of unorganic and organic raw materials, artifact production, hunting, settlement structure, and especially in symbolism and art.
It is evident that the mosaic of Gravettian occupations, after its establishment in Europe, was not a static one, but it displays a dynamic pattern of changes. Moravia, where the settlement density and complexity culminates during the earlier Gravettian (Pavlovian, 30-25 ky), provides a reverse picture to that of eastern Central Europe, Eastern Europe and Siberia, where the majority of dates ranges between 25-20 ky (Willendorfian/Kostenkian, Siberian Upper Paleolithic). Given the strong formal resemblances

in form and style among art objects found in long distances, it has been argued that this dynamics reflects certain population shifts from Central to Eastern Europe, and possibly further east. The impuls for these changes is most probably the expansion of Fennoscandinavian glacier and the related climatic deterioration around 20 ky (Last glacial maximum). This climatical boundary terminated the Gravettian occupation on the Middle Danube, where new systems of landscape use and technology were established between 20-15 ky (Kasovian); evidently, it had less effect on settlement and cultural continuity further east.

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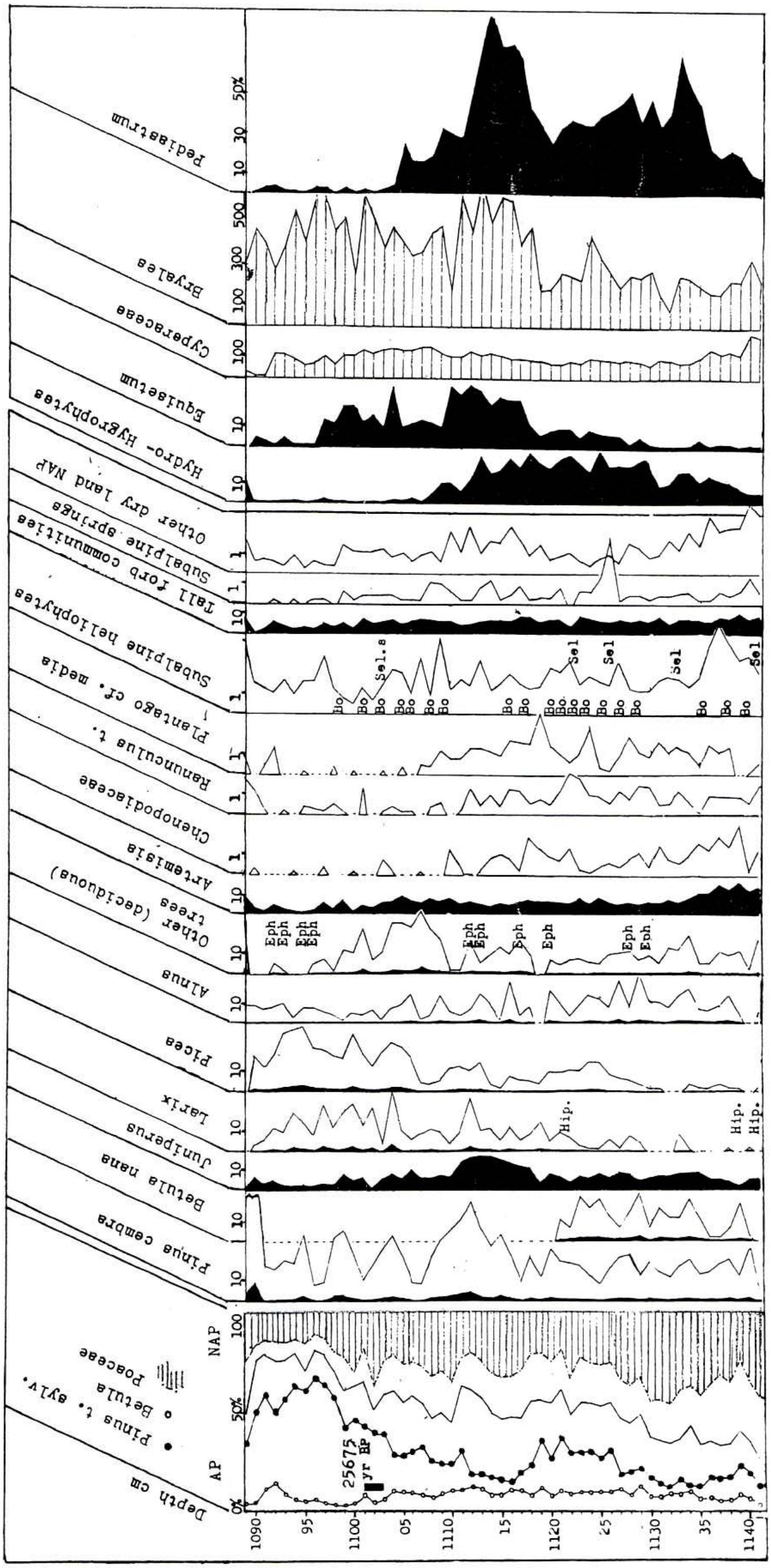


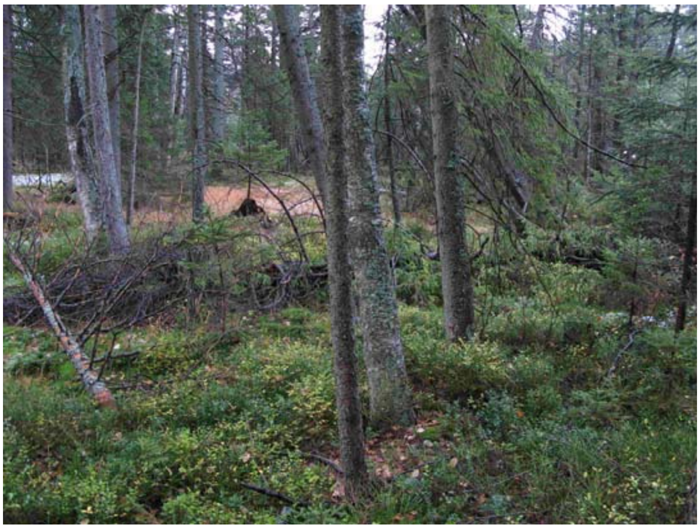
Simplified pollen diagram from the Bulhary core

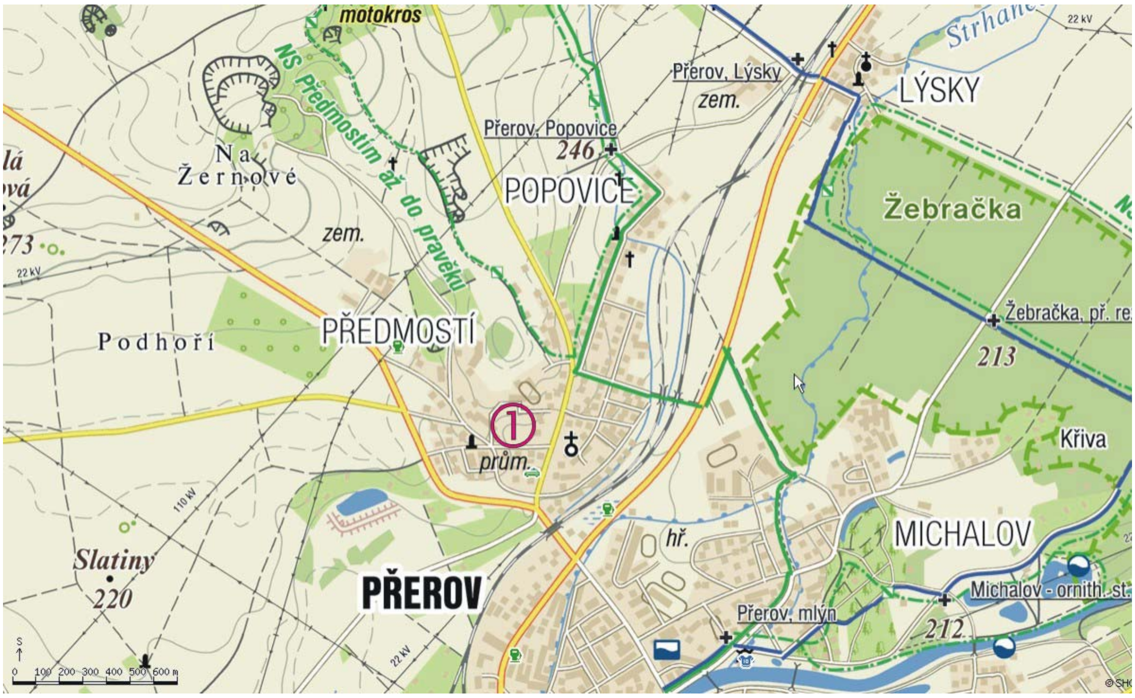
Wednesday, 10. 9. 2008
Run over northern Moravia

Předmostí u Přerova – mammoth hunter's museum.

Rejvíz (by *L. Navrátilová*)
Ombrotrophic mountain peatbog and its palaeoecology.

Accommodation at Rejvíz.





In situ archaeological situation dated to Gravettian period of Younger Palaeolithic is easy to look-over in local museum at **Předmostí** (no. 1 on the map). Vlasta Jankovská will explain her palaeoecological investigations to the last full-glacial period being conducted recently in Slovakia and Moravia.

Preslia, 80/3, 2008.

Forest vegetation of the Pleni-Weichselian Period (ca 50 – 16 ka 14C BP) in West Carpathians, Slovak and Czech Republics.

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Abstract: The paper presents both pollen and plant macrofossil data concerning history of Pleni-Weichselian vegetation in NW Carpathians and central Bohemia. The main goal is to discuss hypotheses about local development of forest vegetation and existence of glacial refugia of selected tree taxa in the studied area. Palaeobotanical data from last full-glacial period of eastern–central Europe repeatedly confirm the existence of parkland landscapes with coniferous trees at relatively northern latitudes. However, up to now, the absence of fossil finds has prevented the study of the full-glacial vegetation in the mountain areas of the West Carpathians – a region crucial to answering the question to the existence of Last Glacial refugia of present European forest biota. This paper provides new pollen and macrofossil evidence from this key region, dated to a critical period of the Weichselian full-glacial (between 50 and 16 ka 14C BP). Our data from two study sites in the West Carpathians (part of today's Slovakia and easternmost Czech Republic - Moravia region) confirm the hypothesis that well-protected and relatively humid valleys of this mountain range were, as far as climate is concerned, favourable for forest vegetation during the last full-glacial period. These forests had character analogous to present Siberian coniferous taiga. In the lowlands and highlands that surround the West Carpathians, there occurred a diverse parkland landscapes: mosaic of steppe communities and tundra patches. However, we use the example of one site in central Bohemia, near what is the present city of Prague, to show that trees may also have occurred here at sites with a suitable local climatic setting.

KEY WORDS: palaeoecology, Weichselian Pleniglacial, coniferous taiga, West Carpathians, pollen analysis

Introduction

Earlier concepts on the environments that existed in central Europe during the last full-glacial period saw the periglacial landscapes of as inhospitable steppe, bush- and forest tundra. New evidence that came from different kinds of data sources has gradually changed this view. This is especially true for already results published from the lowlands to the north, west and south of the Carpathian Range's extension into central Europe. Charcoal from a number of Upper Palaeolithic archaeological sites in central and southern Moravia and the Pannonian Basin (in both Austria and Hungary) had shown evidence of collected and sometimes *in-situ* wood material already since the 1950s (Slavíková-Veselá 1950, Kneblová 1954, Klíma 1963, Opravil in Valoch et al. 1969). Although most of the finds represented rather cold- or drought- tolerant coniferous taxa (*Pinus sylvestris, Pinus cembra, Larix, Picea, Juniperus*), there were also more demanding tree taxa regularly present, including *Abies,* *Corylus, Quercus, Fagus, Fraxinus, Ulmus, Taxus* and *Carpinus*. The available charcoal evidence for the last full-glacial from archaeological contexts and loess profiles has been listed and comprehensively summarized in Musil (2003), Rudner & Sümegi (2001), Willis & van Andel (2004), and Hajnalová & Hajnalová (2005). For a long time, these finds were interpreted in the light of the traditionally-held concept of an inhospitable, cold, full-glacial mammoth steppe, and where considered ambiguous. Serious damage has been inflicted on the hypothesis of "mammoth steppe" environment of Gravettian mammoth-hunters by an incidental discovery of buried peat dated to 25,675 ±2750 14C yr BP at the site of Bulhary (Rybníčková and Rybníček 1991), not far from the famous Gravettian site of Dolní Věstonice (Czech Republic), where occupation has been dated to the same period. The Bulhary pollen diagram indicated not only a coniferous forest vegetation containing *Pinus sylvestris, P. cembra, Picea, Larix, Juniperus* but also included sporadic pollen of some temperate deciduous trees like *Ulmus, Corylus, Quercus, Tilia* and *Acer*. If these trees were locally present, which is by far not certain, this would be a rather surprising find for the full-glacial period at a latitude of 48°50′ N. Nevertheless we must state, that Bulhary site is situated in the foothills of warm Pálavské vrchy Hills with complicated relief, high insolation at S-oriented slopes, and favorable calcareous rocks. Already in 60's of the 20th century, Frenzel (1964a,b) proposed possibility of local occurrence of demanding tree taxa in this region. Nevertheless, the possibility of long distance pollen transport still must be taken into account.

An abundance of tree taxa is seen also in pollen diagrams from Hungary, dated to the transition from the Pleniglacial to the Late Glacial (around 17 ka BP in the case of the Bátorliget site; Willis et al. 2000). Here, relatively early presence of pollen of broadleaf trees may show the proximity of their full-glacial refugia. North of the Carpathians, at the transition to the Polish plain, several pollen profiles have provided evidence of coniferous forests domined by *Pinus cembra* and *Larix* during interstadial periods of the Weichselian Pleniglacial (Ralska-Jasiewiczowa 1980, Mamakowa 2003). Valuable information on vegetation development, climatic conditions and biostratigraphy of the Last Glacial period in NW Europe were given by Behre & Lade (1986) and Behre (1989). From the territory of Eastern Europe (Russian Plane), important information about the character of environmental conditions during 33-24 ka BP interval is given by Markova et al. (2002).

Willis & van Andel (2004) have argued, on the basis of the above-mentioned data, that in the lowlands surrounding the western extension of the Carpathian range we must look for full-glacial refugia for many tree species such as *Picea, Pinus, Larix, Juniperus, Salix, Betula, Fagus, Ulmus, Quercus, Corylus, Sorbus, Carpinus, Rhamnus* and *Populus*. However, they found it difficult to establish from the fossil evidence whether these trees grew in isolated patches within an otherwise open steppe-tundra landscape or formed an opened-canopy forest. Recent palaeoclimatic simulations of the "Stage 3 Project" (Barron & Pollard 2002, Barron et al. 2003, Pollard & Barron 2003) suggest that full-glacial conditions in eastern-central Europe were not nearly as severe as previously anticipated. Related biome model simulations for the last full-glacial indicate that the central and eastern-central European landscape could have supported true taiga forest (Huntley & Allen 2003). This interpretation was taken up by Willis & van Andel (2004) and has led them to suggest that "*during the last full-glacial interval the central and eastern European landscape was covered by taiga/montane woodland, which in some regions also contained isolated pockets of temperate trees.*" The climatic downturn to the Last Glacial Maximum changed atmospheric circulation patterns in Western Europe and around the Alps. Florineth & Schlüchter (1998) argue that the winds bringing moisture from the Atlantic Ocean moved to the south of the Pyrenees and the Alps as the result of the southward shifting of the northern polar front. Germany, located on the northern side of the Alps, became much dryer as the result. The southern winds were bringing moisture to the southern flanks of the Alps and further to the east into the Carpathians, Pannonian Basin, eastern regions of Austria, and Moravia. These regions might have received sufficient moisture from the Mediterranean and Adriatic Sea for trees to survive through the Last Glacial Maximum.

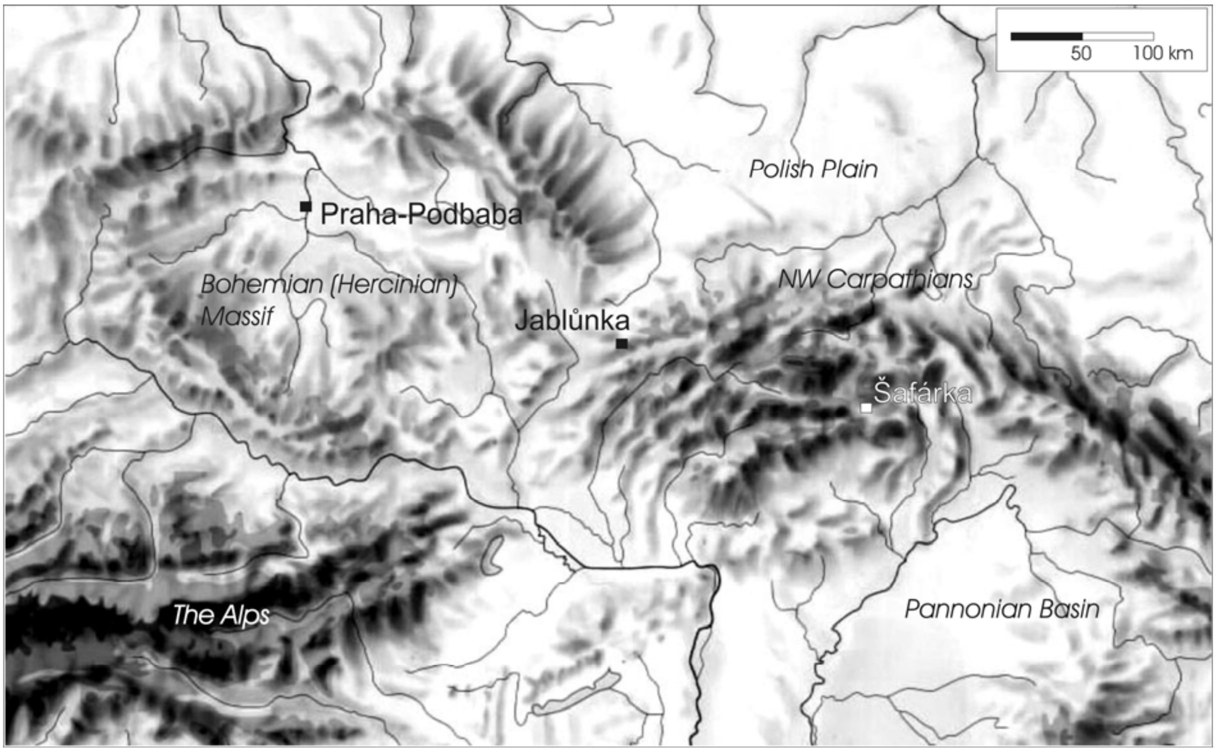

Fig. 1 - Orographic map of eastern central Europe giving location of investigated sites. The map covers the territories of the Czech Republic, Slovakia, Hungary, Austria, Poland and Germany.

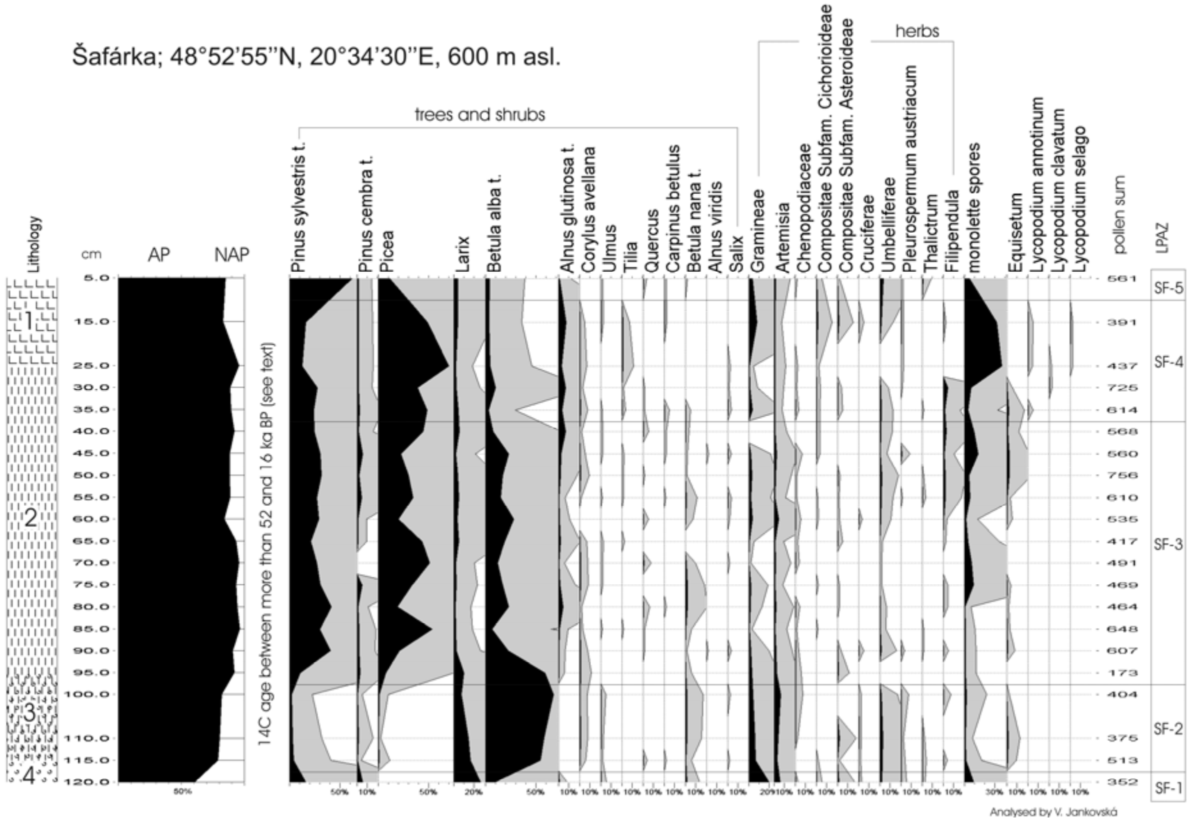

Fig. 2 - Pollen percentage diagram from Šafárka site. Lithology description: 1- clay with plant detritus; 2- peat with remains of herbs and wood; 3- peat with large pieces of wood; 4- peat with wood and sand.

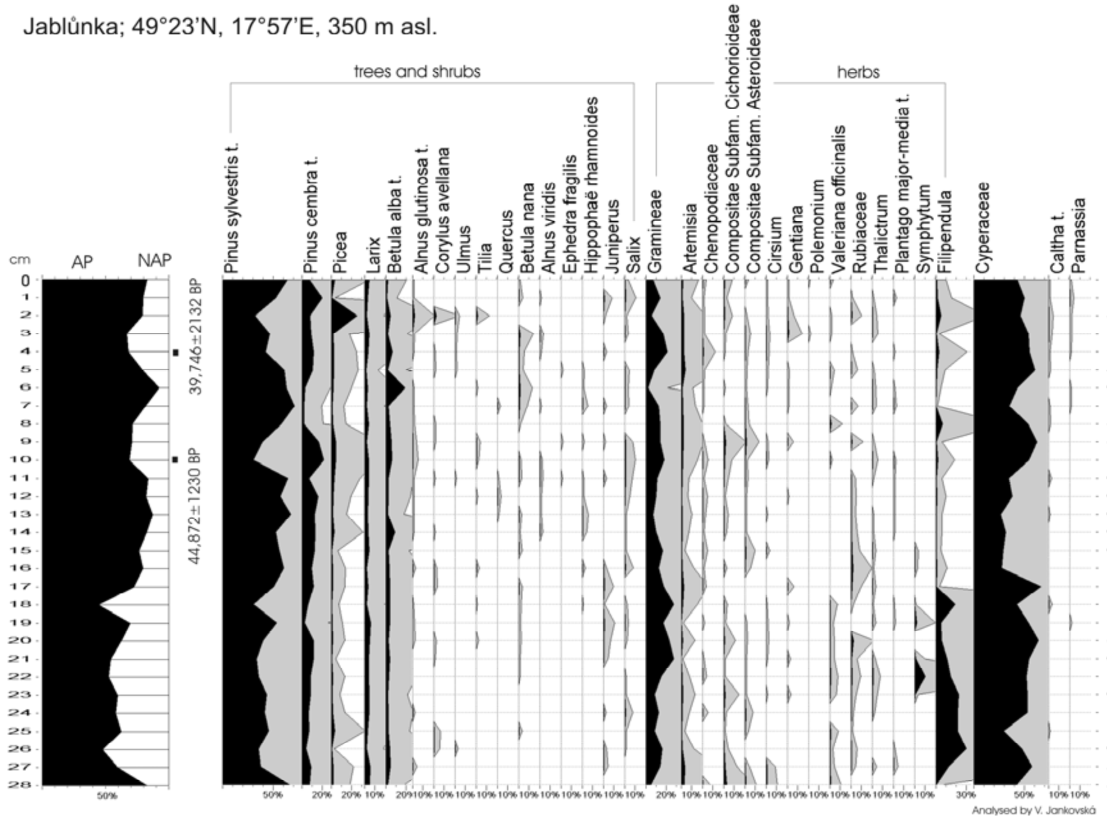

Fig. 3 - Pollen percentage diagram from Jablůnka site. Lithology: From the bottom to the top a highly compressed and strongly decomposed peat.

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ORIGINAL ARTICLE

Interpretation of the last-glacial vegetation of eastern-central Europe using modern analogues from southern Siberia

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ABSTRACT

Aim Interpretation of fossil pollen assemblages may benefit greatly from comparisons with modern palynological and vegetation analogues. To interpret the full- and late-glacial vegetation in eastern-central Europe we compared fossil pollen assemblages from this region with modern pollen assemblages from various vegetation types in southern Siberia, which presumably include the closest modern analogues of the last-glacial vegetation of central Europe.

Location Czech and Slovak Republics (fossil pollen assemblages); Western Sayan Mountains, southern Siberia (modern pollen assemblages).

Methods Eighty-eight modern pollen spectra were sampled in 14 vegetation types of Siberian forest, tundra and steppe, and compared with the last-glacial pollen spectra from seven central European localities using principal components analysis.

Results Both full- and late-glacial pollen spectra from the valleys of the Western Carpathians (altitudes 350–610 m) are similar to modern pollen spectra from southern Siberian taiga, hemiboreal forest and dwarf-birch tundra. The full-glacial and early late-glacial pollen spectra from lowland river valleys in the Bohemian Massif (altitudes 185–190 m) also indicate the presence of patches of hemiboreal forest or taiga. Other late-glacial pollen spectra from the Bohemian Massif suggest an open landscape with steppe or tundra or a mosaic of both, possibly with small patches of hemiboreal forest.

Main conclusions Our results are consistent with the hypothesis that during the full glacial and late glacial, the mountain valleys of the north-western Carpathians supported taiga or hemiboreal forest dominated by *Larix*, *Pinus cembra*, *Pinus sylvestris* and *Picea*, along with some steppic or tundra formations. Forests tended to be increasingly open or patchy towards the west (Moravian lowlands), gradually passing into the generally treeless landscape of Bohemia, with possible woodland patches in locally favourable sites.

Keywords

Central Europe, forest, fossil pollen spectra, full glacial, late glacial, steppe, surface pollen, tundra, Weichselian.

INTRODUCTION

Earlier authors described the periglacial landscapes of central Europe during the last full-glacial as an inhospitable steppe, tundra or forest-tundra (Frenzel & Troll, 1952; Lang, 1994). However, recent records of various proxy data are changing this view. These include pollen data from the lowlands adjacent to the northern, western and southern fringes of the Western Carpathians (Rybníček & Rybníčková, 1996; Willis *et al.*, 2000; Jankovská *et al.*, 2002) and charcoal from Upper Palaeolithic sites in central and southern Moravia, north-eastern Austria and the Pannonian Basin, which contained collected – and in

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MATERIALS AND METHODS

Modern pollen assemblages

Study area

The study area is situated in southern Siberia (Russia) between the towns of Abakan and Minusinsk in the north and the Russian–Mongolian border in the south (50°43′–53°33′ N, 91°06′–93°28′ E; Fig. 1). It includes the Western Sayan Mountains and adjacent areas of the Minusinskaya Basin, Central Tuvinian Basin and the Tannu-Ola range. The mountains range in altitude from 350 to 2860 m a.s.l. and have a predominantly rugged topography. The basins lie at altitudes of 300–600 m a.s.l. (Minusinskaya) and 550–1100 m a.s.l. (Central Tuvinian).

The macroclimate of the study area is continental, though the northern front ranges of the Western Sayan are relatively warmer and more humid than elsewhere in Siberia (Polikarpov *et al.*, 1986). In contrast, the southern part of the Western Sayan, Central Tuvinian Basin and the Tannu-Ola Range are in the area of rain shadow. Their climate is arid and continental. Central parts of both basins are covered by steppe, with trees only surviving in narrow galleries along rivers. The Minusinskaya Basin is dominated by meadow steppe and dry steppe with many Euro-Siberian species (see Appendix S1 in Supplementary Material, types N5 and N6). The mesic sites are occupied by patches of *Betula pendula* or *Populus tremula* woodlands or *Caragana–Spiraea* steppic scrub (N4). The drier and cooler Central Tuvinian Basin is covered with a dry steppe containing mainly central Asian (Mongolian) species (N7). Small woodland patches are mainly dominated by *Larix sibirica* (F2). *Caragana–Spiraea* scrub (N4) is scattered on relatively humid sites.

Forest steppe forms a transitional zone between the continuous forests covering the humid mountain ranges and the steppe in the basins. Here, steppe regularly occurs on south-facing slopes and forest on north-facing slopes. Forests in the forest-steppe zone of the northern part of the study area are usually dominated by *B. pendula* and/or *Pinus sylvestris* (F1, F3), while those in the southern part are usually dominated by *L. sibirica* (F2; Chytrý *et al.*, 2008). The forest zone occupies humid areas at middle and higher altitudes, especially on the northern side of the Western Sayan. Forests are divided into hemiboreal forests on drier and summer-warm sites (often in the forest-steppe zone, rich in herbaceous species and poor in bryophytes), and taiga on wetter, summer-cool sites (poor in herbaceous species and rich in bryophytes; see Appendix S1 & Chytrý *et al.*, 2008, for details). Alpine tundra (Appendix S1, types N1–N3) is developed above the timber line, i.e. above 1600 and 2000 m on humid northern and drier southern ranges, respectively (Zhitlukhina, 1988).

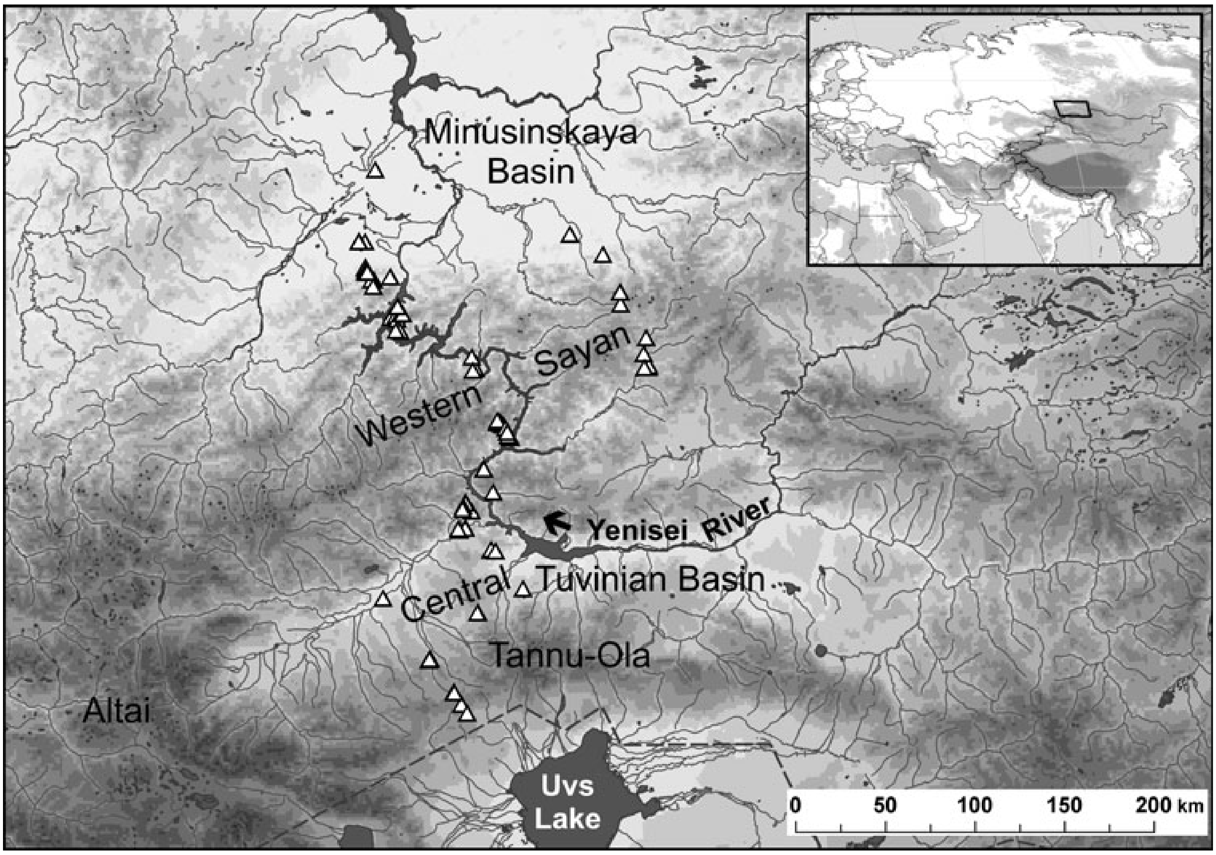


Figure 1 Location of 81 sampling plots where the modern pollen samples were collected, projected on a hypsometric map of southern Siberia, in the area of the Western Sayan Mountains north of the Mongolian–Russian border. Points displaying closely adjacent sites are over-plotted.

The human population is concentrated in scattered villages in the basins and on the mountain foothills, where steppe or forest steppe is used for livestock grazing. In contrast, the mountain areas of the Western Sayan are almost completely devoid of any permanent settlements. Thus the area harbours primeval vegetation, although forest fires occur frequently and various stages of post-fire succession are common.

Sampling and laboratory preparations

Surface pollen samples were collected in 307 plots of 10 × 10 m in the Western Sayan Mountains. The plots were further used for a parallel vegetation survey (Chytrý *et al.*, 2007, 2008). In each vegetation plot, a pollen sample was collected as five subsamples, which were merged into one. The area of a subsample was *c.* 10 × 10 cm. We collected either up to 3 cm of humus and topsoil (in dry steppe and xeric scrub) or polsters of ground-dwelling bryophytes (in forests, tundra, alpine scrub and meadow steppe). In order to cover all main vegetation types, we refrained from sampling only in places having moss polsters available (Gaillard *et al.*, 1994; Brayshay *et al.*, 2000), even though sampling in two different trapping media (soil surface and moss) may slightly reduce the comparability among the samples.

Vegetation survey plots were classified, based on their species composition, using TWINSPAN (Hill, 1979). Separate analyses of forest and treeless plots resulted in six vegetation types of the former (described in Chytrý *et al.*, 2008) and eight types of the latter (Appendix S1). Using this vegetation classification, we selected 88 surface pollen samples for analysis in order to cover the 14 major vegetation types (Appendix S1). The relationship between these vegetation types and their surface pollen spectra is described in detail by Pelánková *et al.* (2008).

All samples were dried at room temperature and prepared by acetolysis (Erdtman, 1960). Besides a reference pollen collection, the following keys and atlases were used for pollen identification: Moore *et al.* (1991), Punt (1976–1996), Reille (1992, 1995, 1998) and Beug (2004). The total sum of arboreal pollen (AP) and non-arboreal pollen (NAP) was used to calculate percentages. Local pollen (including aquatic and mire taxa, Pteridophyta and Cyperaceae) was excluded from the total pollen sum. The percentages of taxa excluded from the total pollen sum were calculated for each pollen type count relative to the total pollen sum.

Fossil pollen assemblages

Seven fossil pollen assemblages were selected from eastern-central Europe for the comparison with the modern Siberian pollen spectra. All of them are from the Czech Republic (CZ) or Slovakia (Fig. 2) and have a reliable chronological dating to

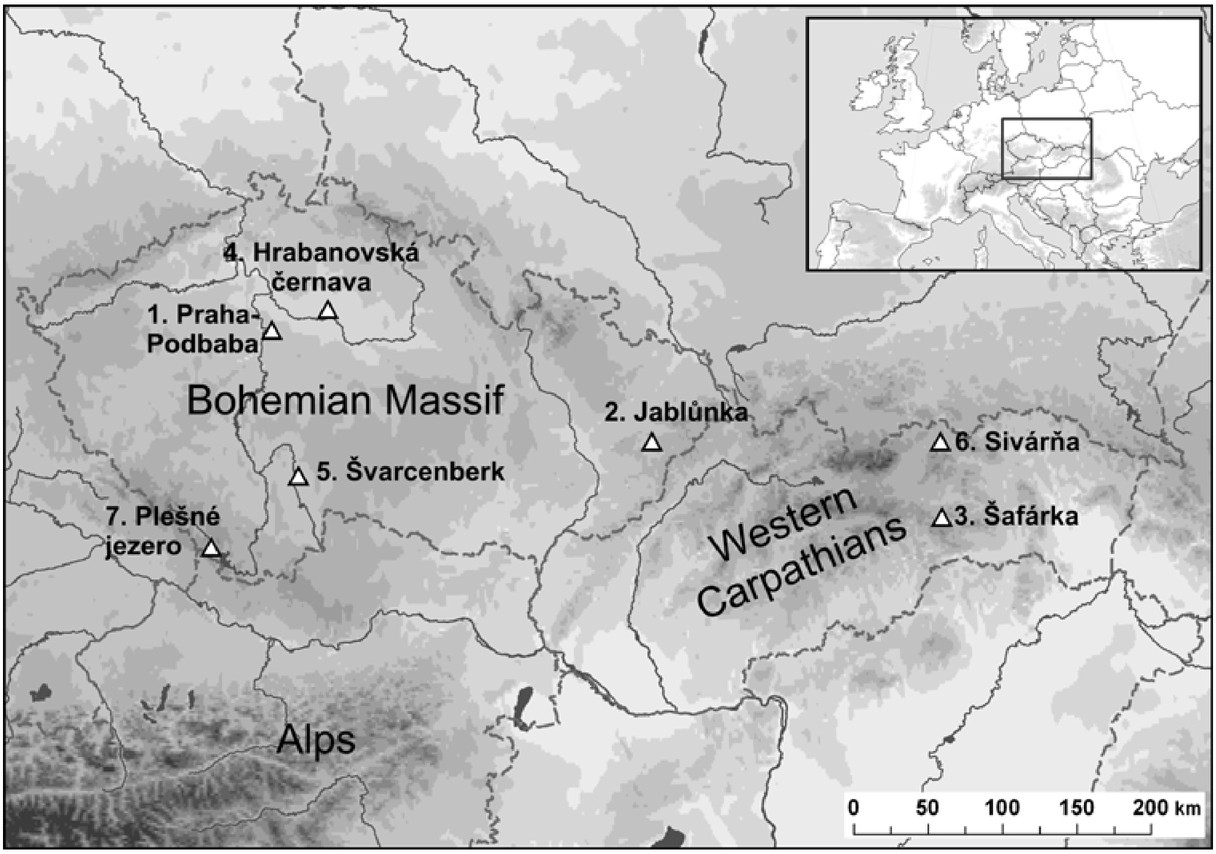


Figure 2 Fossil pollen sites from the Czech Republic and Slovakia used in this study, projected on a hypsometric map of eastern-central Europe.

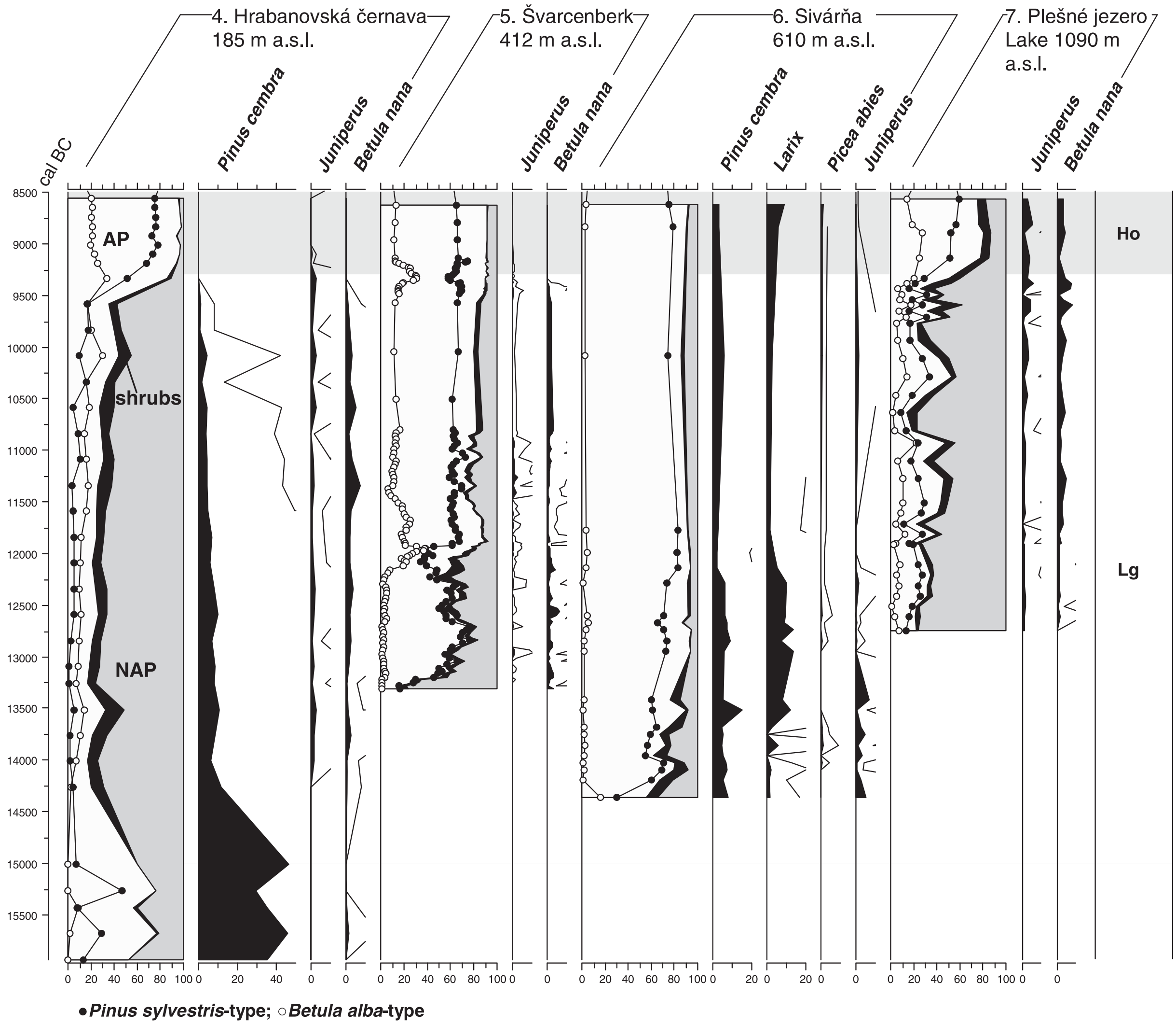


Figure 4 Percentage pollen diagrams of selected pollen taxa in the late-glacial profiles from eastern-central Europe drawn on a joint time axis. Lg, late glacial; Ho, Holocene (dates are calibrated BC); AP, arboreal pollen; NAP, non-arboreal pollen.

Plešné Jezero Lake. These represent extreme situations. Hrabanovská Černava is situated in a lowland area with a supposedly dry climate, which may have suppressed tree growth during the younger phases of the late glacial. Plešné Jezero Lake is a montane locality (above 1000 m a.s.l.) with a cool climate, which probably did not support trees as well. Moreover, there are many AP/NAP fluctuations in the pollen record of Plešné Jezero Lake, which can reflect timber line fluctuations due to strong climatic changes during the late glacial. Open areas could host *Juniperus* and *Betula nana* in both localities.

At Švarcenberk, even though the AP/NAP ratio was fluctuating, the AP content stayed above 60% for most of the late glacial. This included considerably high percentages of *Pinus sylvestris* pollen and some *Betula*, which could indicate an occurrence of patchy or open woodlands, similar to the mesic hemiboreal forests of *Betula pendula* and *Pinus sylvestris* in southern Siberia (F1 in Appendix S1). Pollen curves of *Juniperus* and *Betula nana* attained lower values.

The Sivárňa locality, situated in an intermountain basin within the Western Carpathians, had the highest proportions of AP pollen among the late-glacial localities (up to 90%). Compared with the other localities, this can mean the occurrence of closed forest with *Pinus sylvestris*, *P. cembra* and/or *Larix decidua* and an admixture of *Picea abies*. The occurrence of some *Juniperus* pollen can be linked to patchy forest openings on drier sites.

Comparison of fossil and modern pollen spectra

Principal components analysis of all (fossil and modern) pollen spectra (Fig. 6) reveals the difference between the forest (upper left) and treeless (lower right) samples. The taiga samples (F4–F6) are situated in the upper left part of the ordination diagram, whereas the samples from drier hemiboreal forests (F1–F3) lie in the central part. The tundra samples (N2 and N3) overlap with the forest samples (both taiga and hemiboreal forests), as well as samples from meadow steppes

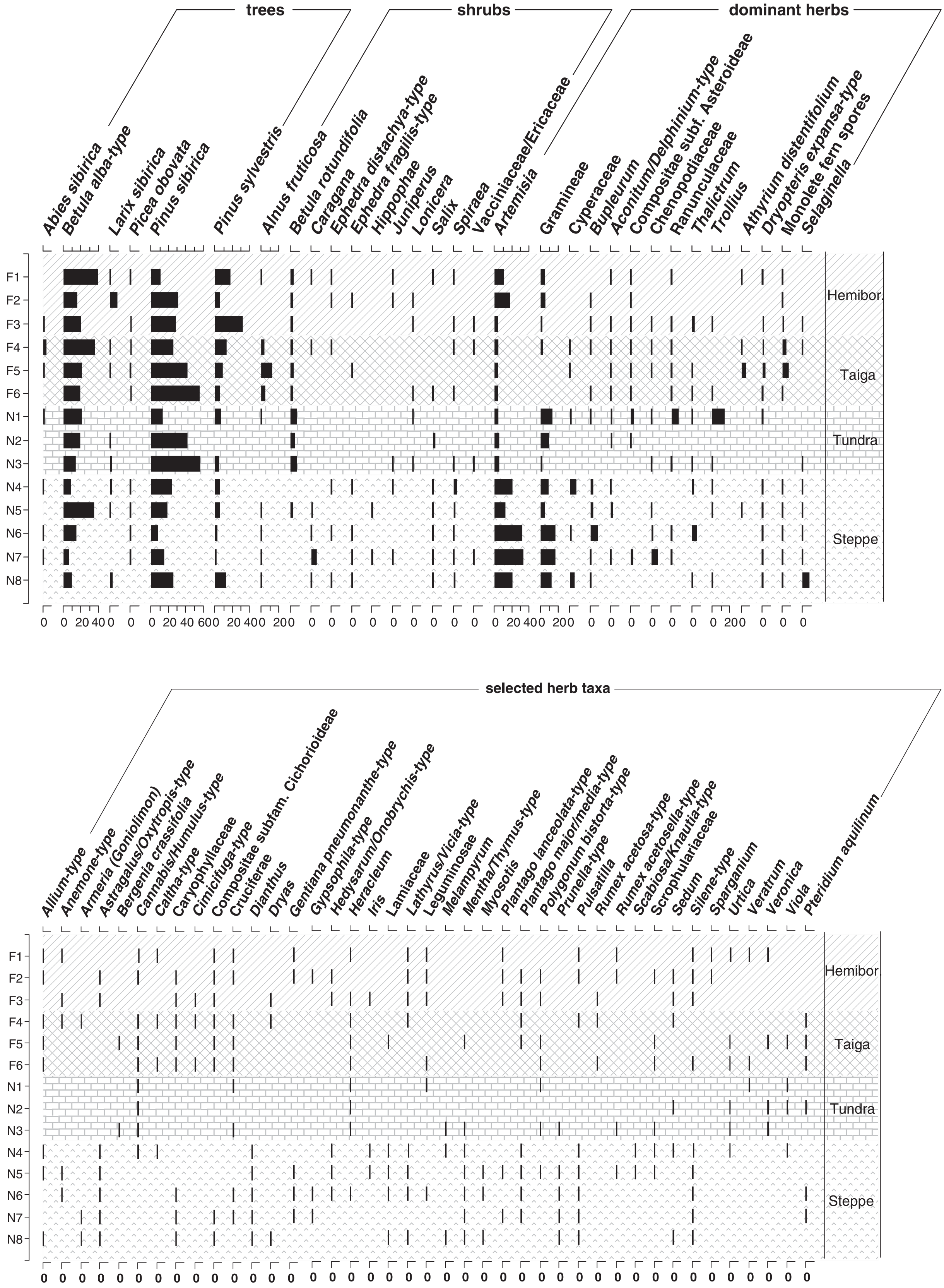


Figure 5 Modern pollen spectra from the main vegetation types of southern Siberia.

Table 1 Full-glacial pollen spectrum from Praha-Podbaba locality (selected pollen taxa).

Pollen taxon	Total count	Percentage
Arboreal pollen (AP)		
Abies	2	0.3
Alnus glutinosa-type	5	0.7
Betula alba-type	21	2.8
Corylus avellana	1	0.1
Larix	6	0.8
Picea	23	3.1
Pinus cembra-type	8	1.1
Pinus sylvestris-type	365	49.5
Betula nana-type	1	0.1
Juniperus	3	0.4
Non-arboreal pollen (NAP)		
Anthemis-type	3	0.4
Artemisia	14	1.9
Compositae subfam. Cichorioideae	7	0.9
Calluna vulgaris	2	0.3
Cruciferae	3	0.4
Filipendula	8	1.1
Gramineae	181	24.5
Chenopodiaceae	2	0.3
Phyteuma-type	4	0.5
Potentilla-type	5	0.7
Rubiaceae	30	4.1

Percentages were calculated from the total pollen sum of arboreal and non-arboreal pollen (AP + NAP).

(N5) with those of hemiboreal forests. The samples from more arid and more continental steppes (N4, N6–N8) lie in the lower right part of the diagram.

Late-glacial profiles are found in the bottom part of the diagram. The samples from Plešné Jezero Lake form a distinct group, close to modern Siberian samples of treeless vegetation, especially to dry steppic or shrubby communities (N6, N7 and N8). The upper samples of the Hrabanovská Černava profile are also very similar to dry xeric scrub (N4) or dry steppes (N6–N8). In contrast, its older samples are similar to the modern pollen assemblages of cool taiga (F6) or mesic hemiboreal forest (F1). Samples from Sivárňa are situated mainly on the left-hand side of the diagram, where the closest modern samples are those of drier forest types, such as continental taiga or dry hemiboreal forest (F6 and F3). Samples of the last late-glacial locality, Švarcenberk, are placed on the transition between the modern samples of mesic hemiboreal forest (F1) and tundra on one side, and of steppe vegetation (more continental to the right) on the other.

Generally, the full-glacial profiles are similar to the modern pollen samples from forests, tundra and forest tundra. According to their position, the pollen spectra from Jablůnka should mainly correspond to hemiboreal forests, most probably occurring in a mosaic with shrubby tundra of *Betula nana*. The similarity of the Praha-Podbaba pollen spectrum to Jablůnka is confirmed by its position among the Jablůnka samples. In contrast, the samples from Šafárka are situated at the top of the ordination diagram, close to the modern samples of taiga vegetation, especially its mesic and wet types (F4 and F5). Only a few of the lowest Šafárka samples are closer to the samples of dry *Larix*-dominated hemiboreal forest (F2).

The ordination biplot with both samples and species (Fig. 7) illustrates the main differences in the pollen assemblages of the full-glacial sites: *Picea*, *Larix* and *Abies* most abundant at Šafárka, whereas Jablůnka and Sivárňa were dominated by *Pinus cembra* and *P. sylvestris*.

DISCUSSION

Our analysis has demonstrated similarities between modern pollen spectra from southern Siberia and fossil pollen spectra from central Europe. There was even some overlap of the fossil and modern samples in the ordination diagram (Fig. 6), although in general each group of samples occupied a different part of the diagram. This is not surprising, given that: (1) some pollen types are poorly preserved in fossil records (Sayer *et al.*, 1999), (2) in spite of the considerable similarity, the modern flora of southern Siberia is not exactly the same as the glacial flora of central Europe, and (3) both the Western Sayan sites and each of the sites with fossil pollen samples are influenced by local idiosyncrasies, which are responsible for differences in pollen spectra (this is reflected by the fact that samples from each of the fossil profiles are clustered in the ordination diagram, with the exception of the Hrabanovská Černava samples). However, the proximity in the ordination space of the fossil pollen samples to the modern ones from certain vegetation types can be used for interpretation of palaeovegetation.

Interpretation of full-glacial vegetation

Our results are consistent with the hypothesis that during the full glacial much of the Western Carpathians were covered with forests, forest steppe or forest tundra, and even some favourable areas in the Bohemian Massif may have supported some forest patches. However, there are differences between the full-glacial sites. Jablůnka contains variable samples corresponding to taiga, hemiboreal forest and tundra, some of them being similar to samples from the upper section of the late-glacial Švarcenberk profile (Fig. 6). The single sample from Praha-Podbaba lies close to samples representing a mosaic of treeless and forest vegetation, similar to those from Švarcenberk and the older part of Jablůnka profile. Their pollen spectra may represent a landscape with patchy woodland vegetation, growing in wind-protected sites with favourable moisture. However, there probably still existed enough open areas, indicated by the presence of light-demanding taxa, such as *Betula nana*, *Hippophaë* and *Juniperus*, and a low representation of *Pinus cembra.* The occurrence of moisture-demanding taxa (*Corylus*, *Alnus glutinosa* and *Abies*) at the Praha-Podbaba site could result from long-distance pollen transport, when we take into account the considerable landscape openness at this site. Samples from Šafárka show

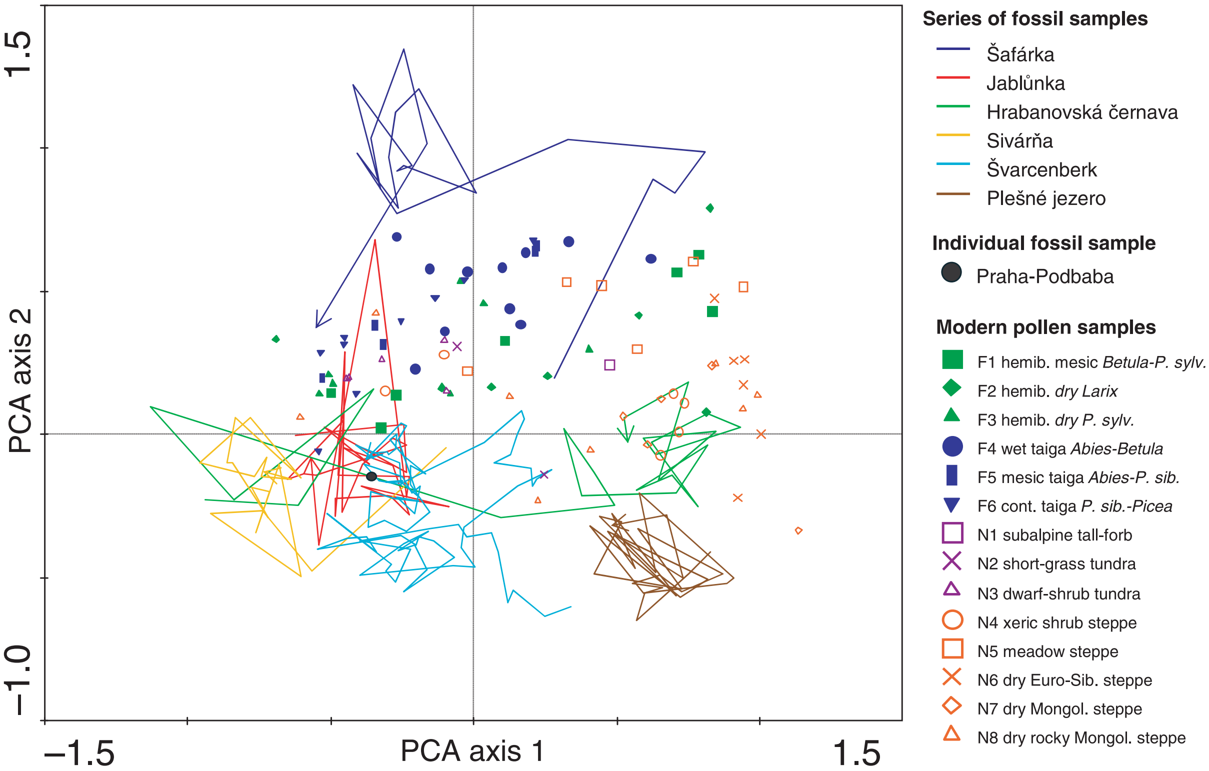


Figure 6 Principal components analysis (PCA) ordination scatterplot of modern and fossil pollen samples analysed together. Full and empty symbols represent the modern forest and treeless vegetation types of southern Siberia, respectively. Fossil pollen spectra from eastern-central Europe are represented by lines connecting samples of each profile in their stratigraphical order, with arrows pointing from the chronologically oldest to the youngest sample. Axes 1 and 2 explain 25.1% and 16.1% of the total variance, respectively.

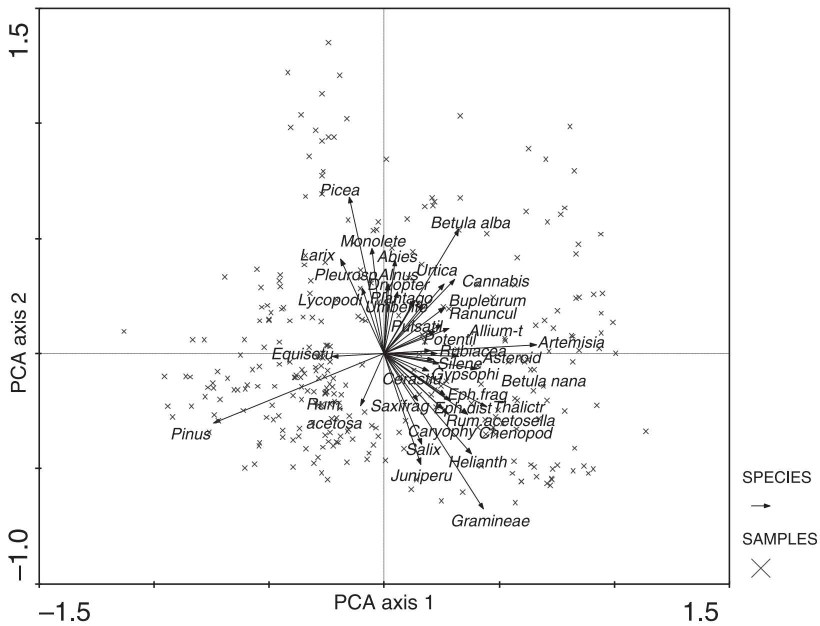


Figure 7 Principal components analysis (PCA) biplot from the same ordination as presented in Fig. 6, showing pollen taxa and positions of pollen samples. See Fig. 6 for legend of samples.

an affinity to the modern pollen spectra of taiga. However, the species composition and dominants are slightly different. The upper part of the profile corresponds to taiga dominated by *Picea*, *Betula*, *Larix*, *Pinus cembra* and *P. sylvestris* (Fig. 6). Two samples from Jablůnka can also be assigned to this category. The bottommost samples from Šafárka depict a drier forest

Appendix S1. Overview of major vegetation types (codes with F – forest types, codes with N – non-forest types) with examples of stand structure of main vegetation types (Photos N5, N6 and N7 by Zdenka Otýpková). See Chytrý *et al.* (2008), ***Plant Ecology*, 196**, 61–83, for the detailed description of forest types.

Code	No. of pollen samples	Vegetation type
F1	7	***Betula pendula-Pinus sylvestris* mesic hemiboreal forest** occurs in relatively warm, mesic to dry sites. In places, *Larix sibirica* and *Populus tremula* are admixed, the latter in the formerly disturbed sites. This forest is very rich in herbaceous species.
F2	7	***Larix sibirica* dry hemiboreal forest** occurs in very dry and winter-cool areas. In places, *Pinus sibirica* is co-dominating with *Larix*.
F3	8	***Pinus sylvestris* dry hemiboreal forest** is found in the same areas as F1, with relatively warm climate, but it is confined to steeper slopes with well-drained soils.
F4	11	***Abies sibirica-Betula pendula* wet taiga** occurs in relatively warm and precipitation-rich areas, where it occupies lower slopes and valley bottoms. Admixed woody species include *Alnus fruticosa, Picea obovata, Pinus sibirica* and *Sorbus sibirica*. Its richness in herbaceous species is higher than in the other taiga types, and is comparable with the hemiboreal forests.
F5	5	***Abies sibirica-Pinus sibirica* mesic taiga** is typical of north-facing slopes in the summer-cool and precipitation-rich areas. *Picea obovata* often occurs besides the two dominant tree species. This forest type is poor in herbaceous species but rich in bryophytes.
F6	9	***Pinus sibirica-Picea obovata* continental taiga** occurs in areas which are relatively cool in both winter and summer but receive higher precipitation than F2. *Larix sibirica* can co-occur in the tree layer. Herb layer is species-poor but there are abundant bryophytes and lichens.
N1	1	**Subalpine tall-forb vegetation** occurs in stream valleys and on the bottoms of glacial cirques above the timberline, especially in the precipitation-rich areas with a distinctive snow accumulation. It forms dense stands dominated by tall broadleaf forbs.
N2	2	**Short-grass mountain tundra** occurs at drier, often wind-swept sites with shallow soils above the timberline in the precipitation-

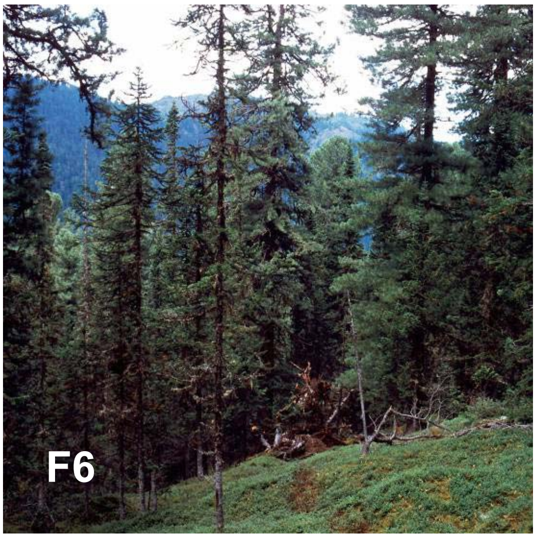
		rich areas. It is a patchy mosaic of short grassland and dwarf heathland of *Vaccinium myrtillus*, with frequent bryophytes and lichens.
N3	5	***Betula rotundifolia-Vaccinium myrtillus-Vaccinium vitis-idaea* dwarf-shrub moutain tundra** occurs above the timberline in topographically wetter places than N2. It contains frequent bryophytes and lichens.
N4	6	***Spiraea media-Caragana pygmaea* xeric scrub** occurs in slightly humid places in the steppe and forest-steppe zone, which are ecologically transitional between steppe and hemiboreal forest. Other common species of this type include shrubs *Cotoneaster melanocarpus* and *Rhododendron dauricum*, grasses such as *Poa* sect. *Stenopoa*, and sedge *Carex pediformis* s. lat.
N5	6	**Species-rich meadow steppe** occurs in relatively warm, mesic to dry sites, often in contact with hemiboreal forests of F1. It forms dense stands of grasses, sedges and dicot herbs. Shrubs typical of N4 also occur locally with low cover. Most species of this steppe have Euro-Siberian distributions.
N6	6	**Dry Euro-Siberian steppe** is short grassland occurring in dry and summer-warm areas, dominated by tussocky grasses such as *Stipa, Festuca* and *Koeleria*, tussocky sedge *Carex pediformis* s. lat., sages (*Artemisia* spp.) and other herbs. Most species have Euro-Siberian distributions, but vegetation is species-poorer than the meadow steppe of N5.
N7	5	**Dry Mongolian steppe** is species-poor, open and short grassland occurring in dry, summer-warm and winter-cool areas, both on slopes and flatlands. It is dominated by short tussocky grasses and low-growing herbs, including *Artemisia* spp., Chenopodiaceae and *Ephedra dahurica*. It is species-poorer than the other steppe types and consists mainly of species with central Asian distribution.
N8	8	**Dry rocky Mongolian steppe** is found on rock outcrops or steep slopes in the same areas as N7. It also has a similar structure and species composition as N7, but is richer in the rock-outcrop species (e.g. *Selaginella sanguinolenta*) which increase the overall species richness.


F1

F2

F3

F4

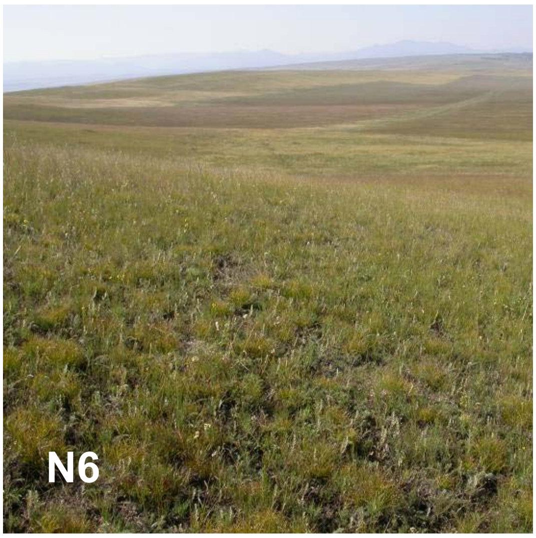
F5

F6

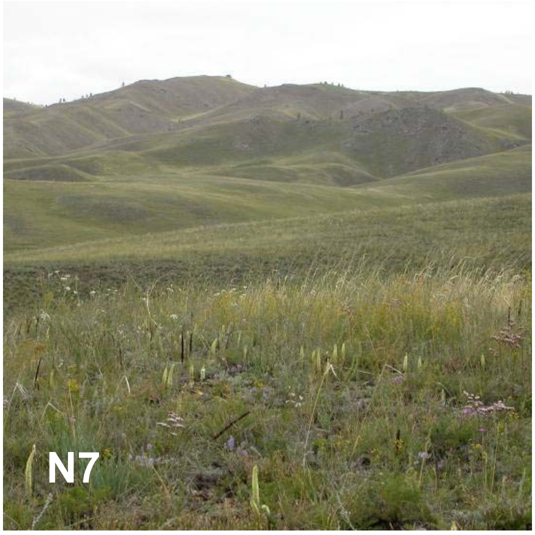

N1

N2

N3

N4

N5

N6


N7


N8

Rejvíz is a nice example of mountain raised bog situated at Jeseníky Mountains of Silesia. Lydie Navrátilová, now PhD. student of Kamil Rybníček, will explain her pollen-analytical investigations to the mire history. Evening at Rejvíz will be quite opened as we will be accommodated in a nice wooden hut just nearby the site of interest.

<u>Numbers on the map:</u>

1 – Bus stop and place of accommodation.

2 – Excursion site in the middle of the mire.

Palaeoecology of Rejvíz mire at Hrubý jeseník Mts.

(Short summary from a Master thesis).

Lydie Navrátilová

Introduction

The Rejvíz mire is one of the best preserved pine bogs in the Czech Republic. The locality is situated at northern Hrubý Jeseník Mts., the very east High Sudetes. The bog situated southwards from the Rejvíz village (altitude 778 m) is a national nature reserve. It belongs to the Jeseníky PLA (protected landscape area).

The climate of the area is quite cold and wet. Annual mean air temperature is 5,3 ºC (compare Prague 10,4 ºC), annual mean total precipitation is 1029 mm (cp. Prague 456 mm) (LEDNICKÝ 1971).

The bedrocks of the Rejvíz territory is built mostly of metagranitoids, somewhere we can find younger devonian rocks (hornblende schist, quartzite, phyllite and gneiss). The ground of the bog itself is built of Pleistocene-Holocene deluvial impermeable deposits eroded from rocks mentioned above.

Water from west part of the basin continues to the Černá Opava River, water from the east part goes to the Vrchovištní Brook. Both rivers belong to the Odra river-basin. There are two small lakes in the peat bog area. Big Peat Lake (Big PL) lies in the western part, Small Peat Lake (Small PL) is in the eastern part of the bog (Fig. 1). Lakes as well as organic sediments were studied by KŘÍŽ in 1971 (Tab. 1).

Peat deposit covers aprox. 195 ha and its volume is 2 480 000 m^3. The maximum depth 660 cm was found near the Small PL. There is only 300 cm depth in the neighbourhood of Big PL.

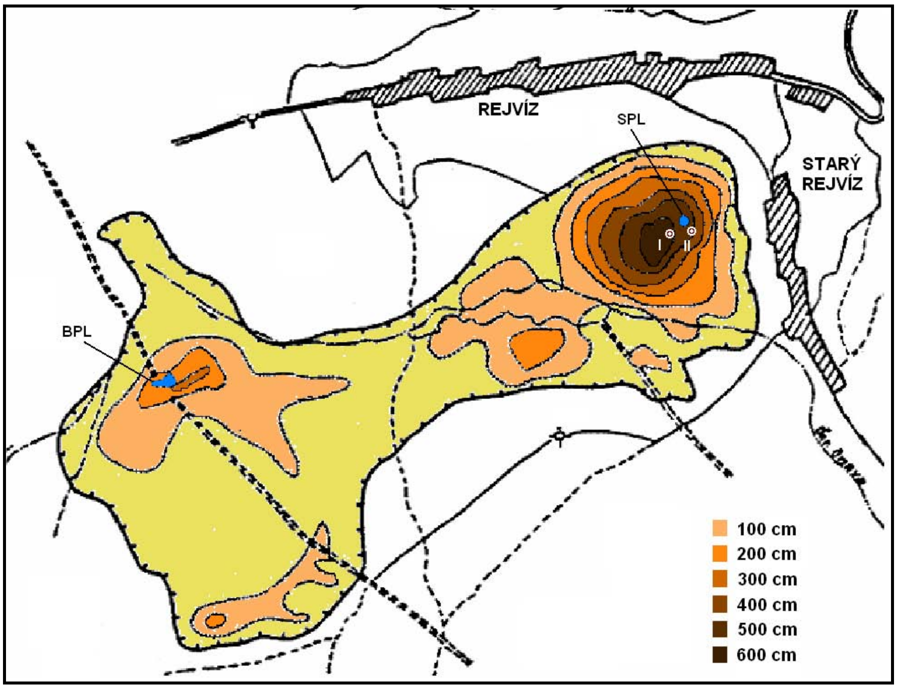


Figure 1: Map of the Rejvíz peatbog sediment depth (Kříž 1971). BPL – Big peat lake, SML – Small peat lake, I – the first sampling place, II – the second sampling place.

Table 1: Rejvíz peat lakes characteristics (according to KŘÍŽ 1971).

	Big Peat Lake	Small Peat Lake
maximum depth	295 cm	more than 500 cm
water level surface	1696 m^2	920 m^2
volume	4050 m^3	not found out

We can find almost all types of mire vegetation in the Rejvíz site. The most valuable middle part is covered with bog pine forest (*Pinus uncinata* subsp. *uliginosa* sensu BUSINSKY et KIRSCHNER 2006) with *Ledum palustre* shrub, *Eriophorum vaginatum*, *Oxycoccus pustris* and *Vaccinium* dwarf shrubs. There is bog hollow vegetation with *Drosera rotundifolia*, *Carex canescens* and *Scheuchzeria palustris* on the lakeside of peat lakes situated in the middle of the pine woods. Open raised bog vegetation with *Eriophorum vaginatum*, *E. angustifolium* and moss *Sphagnum* and *Polytrichum* is widespread in lagg which is too wet for tree growth. There is transitional mire vegetation and wet meadow vegetation with sedge and grass species between pine forest and Rejvíz village. It is possible to find some rare species there, such as *Carex lasiocarpa*, *C. rostrata*, *Gladiolus imbricatus*, *Lilium bulbiferum* or *Lysimachia thyrsiflora*.

History of the Rejvíz territory

The site has been known since the 14th century as the Reihwiesen (that means "meadows in row"). The area along the Black Opava River was used only for mowing that time. In 1768 first building, a tavern, was built in place of today‘s Starý Rejvíz. In 1793 more than 40 houses were built by German settlers. In 1938 Rejvíz had 390 inhabitants and 90 buildings. In 2000 only 20 houses have stable inhabitants (JOANIDIS 2004).

North-eastern territory of the Hrubý Jeseník Mts. has been known as gold mining area since 14th century. Mining needs huge timber harvesting. In 17th century a part of gold mining was changed into pyrite and iron ore mining. In the 17th century in the Rejvíz vicinity were timber harvesting started as well, beside for mining also for glassworks built nearby. Since the 16th century special laws have been issued to protect woods against exploitation. Tree percentages of forest composition in the middle of the 19th century: spruce 63 %, fir 30 %, broadleaf trees 7 %, in the beginning of 20th century: spruce 84 %, fir 8 %, pine 2 %, larch 1%, beech 4 %, others 4 % (JOANIDIS 2004).

Parts of the Rejvíz peatbog have been protected since 1866. In 1970s the first wooden path leading to Big Peat Lake was built. But at the same time there was still an effort to exploit the site. In 1883 drainage channel 80 cm deep was ditched along the whole bog. Since that time adjacent wet meadows have been intensively mowed. Other drainage channels near Big PL ditched at the end of the 19th century are still visible. The Rejvíz bog became very popular place in the beginning of the 20th century.

History of paleoecological research

The first paleoecological research on the Rejvíz bog was done in 1926 as a doctoral thesis by Robert Fahl (FAHL 1926). He explored the sediment by means of 26 test holes. He carried out pollen analysis as well as macrofossil analysis. Fahl distinguished two bogs in the Rejvíz site: one lies around Small PL, next lies around Big PL.

His conclusions are:

1. Both peat bogs are of Post-glacial age.
2. Bogs are not of the same age, the Small PL bog is older.
3. Small PL bog originated in the pine-hazel period (i.e. Boreal), Big PL bog originated during the spruce period (i. e. Atlantic).
4. Bogs still continue to grow.
5. Rejvíz bogs, Krkonoše Mts. bogs and Seefeld bogs developed under the same conditions.

In 1947 Marie Puchmajerová explored the Rejvíz sediment by “Swedish” sampler. She confirmed the maximum depth around Big PL. Unfortunately she did not finish her research. Since that time no investigation has been done there.

Material and methods

The first field work was carried out 10 m southeastwardly Small PL in October 2005. 220 cm deep open face excavation was dug out and samples of peat were taken. Deeper layers of peat were got by Intorf sampler (core diameter 5 cm). Approximately in 300 cm depth there were a lot of trunks and branches deposited in the peat sediment and it was not possible to get trough this layer. Because of that the deepest samples were taken away with thinner Hiller sampler (core diameter 3 cm). We managed to get samples of 0-520 cm depth (Fig. 2). Unfortunately we did not reach the lowest layers of organic sediment.

The second sampling took place 10 m southwest of Small PL in December 2006. Samples were taken away by special geological sampler (core diameter 5 cm). This time we reached the bottom of the peat sediment and clay basis as well. We obtained organic sediment of 610-643 depth and mineral sediment from 643-800 cm (Fig. 2). However it was not possible to get samples above 610 cm because of very wet and soft peat layers.

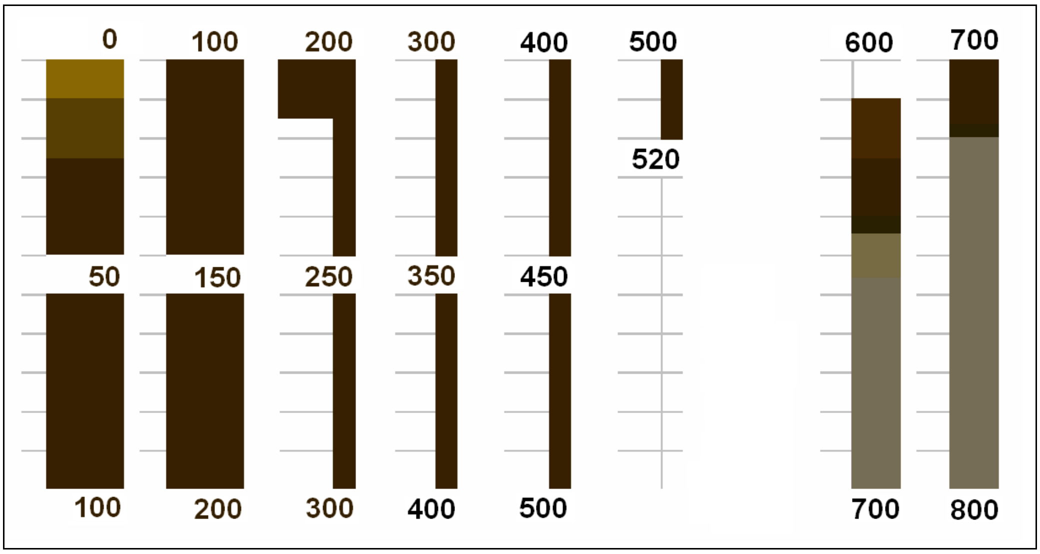


Figure 2: Sediment from 0-520 cm and 610-800 cm was obtained (brown *peat*, grey *clay*). There is a hiatus in 520-610 cm depth.

Conventional radiocarbon dating of four samples was carried out by Gadam centre laboratory in Gliwice, Poland.

The core was analysed in 10 cm distances. Peat samples were prepared by the standard acetolysis method (FAEGRI et IVERSEN 1989). Those samples with mineral admixture were pre-treated with concentrated hydrofluoric acid. All samples were analysed on microscopic slides. Pollen was determined by means of BEUG 2004. Spores and non-pollen objects names follow MOOR et al. (1991) and VAN GEEL et al. (1980/1981, 1989). At least 500 arboreal pollen were counted per sample.

Pollen analysis results are presented in percentage pollen diagram (AP + NAP = 100 %). Pollen diagram is constructed in PolPal software (NALEPKA et WALANUSZ 1999). Zonation of the diagram is based on changes in the AP/NAP ratio and trends in the percentages of dominant arboreal taxa.

Results

Major part of the Rejvíz profile consists of peat sediment. Light olive brown layer of not decayed bog moss take place in 0-10 cm depth. Dark reddish brown peat layers occur in 10-625 cm depth. The lowest peat layer of 625-640 cm depth is almost black. There is a peat layer mixed up with clay in 640-643 cm depth. Thereunder (olive) grey clayey mineral is found.

A peat layer situated in 700-720 cm depth is most likely caused by contamination during field work. Any transitional peat-clay layer was not found there.

There are at least two levels in the sediment where plenty of trunks and brunches are deposited. The first woody layer is situated around 300 cm depth, the second one occurs approximately in 520 cm depth. The second sampling was successful in getting through both woody layers.

Radiocarbon dating results are presented in Table 3. Two samples (120 cm and 180 cm) were analysed twice by mistake. Different dating results of the same sample warn us of limits of this method. Dating analysis of the lowest peat layer is in progress now.

No.	Sample name	Age ^{14}C (BP), uncalibrated
1	**120 cm/A**	**1210 ± 120**
2	**120 cm/B**	**1660 ± 95**
3	**180 cm/A**	**1730 ± 130**
4	**180 cm/B**	**1800 ± 90**
5	**350-355 cm**	**3930 ± 290**
6	**515-520 cm**	**7040 ± 190**

Table 3: Radiocarbon dating results.

Pollen analysis results are presented in pollen diagram (Fig. 3). Both profiles cored are figured in one diagram. The sediment from 610-625 cm obviously contaminated with upper peat (*Vitis* pollen found) is excluded from the diagram. Five chronozones were differentiated in the profile. The lowest layers of 625-643 cm depth are dissimilar comparing to the lowest layers of the first core. That is why we consider this part as originated in the Boreal period.

***Boreal* (625 - 643 cm)**

The oldest sediment layers record probably the Boreal period as we assume of pollen spectra. There is pine (*Pinus*), hazel (*Corylus avellana*) and spruce (*Picea abies*) pollen found in very high amount, while other trees are almost absent. The presence of elm (*Ulmus*) pollen may signify final stage of Boreal period.

This time is distinguished by gradual reforestation of landscape. Mountain altitudes were largely covered with forest, in Rejvíz surroundings composed by spruce, hazel and birch (*Betula*). High amount of fern and *Equisetum* spores and wet meadow herbs pollen bear evidence of wet local environment. Most likely there was hydrophilous tall herb vegetation of *Cyperaceae*, *Scheuchzeria palustris* and *Filipendula ulmaria* with willows (*Salix*) scrub in site of today's peatbog.

***Atlantic* (420 - 520 cm)**

The transition between the Boreal and this warm and humid period is not recorded in obtained sediment, while the end is located in 420 cm depth (estimated age 5200 years BP).

Mixed deciduous forest of elm, lime (*Tilia*), ash (*Fraxinus excelsior*) and maple (*Acer*) is widespread in mountain elevation, probably in Rejvíz vicinity as well. The Silesian lowland was covered by mixed forest of oak (*Quercus*), lime and elm. All mentioned trees have their maximum occurrence in this part of pollen diagram. Very high amount of hazel pollen was also found. This phenomenon is characteristic of Hrubý Jeseník Mts. as we know from previous studies (RYBNÍČEK et RYBNÍČKOVÁ 2004). Hazel tree most probably occurred in higher elevation together with spruce or even above this vegetation belt.

Herb pollen indicates wetter conditions directly in the Rejvíz site. A quantity of *Cyperaceae* and *Poaceae* pollen and *Sphagnum* spores found in sediment reflect large area of open mire vegetation.

During the final stage of the Atlantic period and on the beginning of next period bog hollow species (*Utricularia*, *Scheuchzeria* and *Drosera*) and mire species (*Menyanthes trifoliata*, *Sparganium*, *Typha*, *Equisetum*) were recorded. Therefore larger Small peat lake area or another one small lake is supposed in this site formerly.

***Subboreal* (270 – 420 cm)**

This period is delimited by spruce maximum occurrence in the pollen diagram. Spruce largest expansion in landscape is caused by climatic deterioration. High amount of hazel pollen occurs also in Subboreal period, which is not common elsewhere. Hazel could range lowlands as well as uplands this time, including the highest elevation. There is a theory of timber-line formed by hazel, spruce and lime in Hrubý Jeseník ridge (RYBNÍČEK et RYBNÍČKOVÁ 2004).

Mixed forest trees decline is obvious in the second half of the period. Hazel, oak, elm, lime and ash as well as maple pollen amount decrease for the benefit of hornbeam (*Carpinus betulus*), beech (*Fagus sylvatica*) and fir (*Abies alba*). Hornbeam coming as the first of this trio is not ussual. That seems to be a specific feature of the east High Sudetes, considering studies by MADEYSKA (1989), RYBNÍČEK et RYBNÍČKOVÁ (2004) and RALSKA-JASIEWICZOWA et at. (2004).

General NAP decline speaks for open area reduction for progressive forest invasion. Present area was probably slightly dried in the final stage of period, becuase of pine and dwarf shrubs pollen increase.

***Older Subatlantic* (90 – 270 cm)**

The biggest part of the sediment had been formed during the Older Subatlantic period, which is characterised by expansion of hornbeam, beech and fir. Hornbeam expanded in lowlands and formed mixed forest with oak forcing out lime, elm and hazel. Beech and fir became dominants in mountains together with spruce, previous prevailing tree of higher elevation. The Rejvíz site was surrounded with beech-fir-spruce forest just as well.

There is only small amount of non-arboreous pollen found in this part of sediment. Nevertheless human indicators as *Plantago lanceolata*, *Rumex acetosa*, *Urtica* or *Centaurea cyanus* became a stable component of pollen assemblages. Those herbs indicating ruderal sites and pastures and even crops (*Secale*, *Triticum*) pollen found were probably brought by long-distance transport.

Younger Subatlantic (0 - 90 cm)

This period generally delimited by significance human activity in landscape is divided into two stages. In the beginning woody species composition is the same as in previous period. Herb pollen rate is still quite low, which means the Rejvíz surrounding is still untouched by human. Nevertheless stable human indicators rate indicates settlement and agricultural exploitation of lowlands.

In the second part of Younger Subatlantic total arboreous pollen rapidly retreated. All woody species have declined except of azonal pine and birch as well as spruce remaining at higher elevations. Azonal alder (*Alnus*) is retreated consequent on transformation of alluvia into meadows. *Pinus* pollen increase was probably caused not only by other trees percentage decline but also by pine spreading directly on the bog. Timber harvesting as well as farmers activity is evident in the pollen spectra. Both human indicators and crops pollen culminate in this time.

Conclusion

1. Five Holocene climatic periods are recorded by analysing the organic sediment obtained.
2. The oldest layers were formed during the Boreal period, upper layers record Atlantic, Subboreal, Older Subatlantic and Younger Subatlantic period.
3. Robert Fahl's estimation of the Rejvíz bog boreal origin has been confirmed.

This paper represents the first modern paleoecological study of the mountain elevation site in the Hrubý Jeseník Mts.

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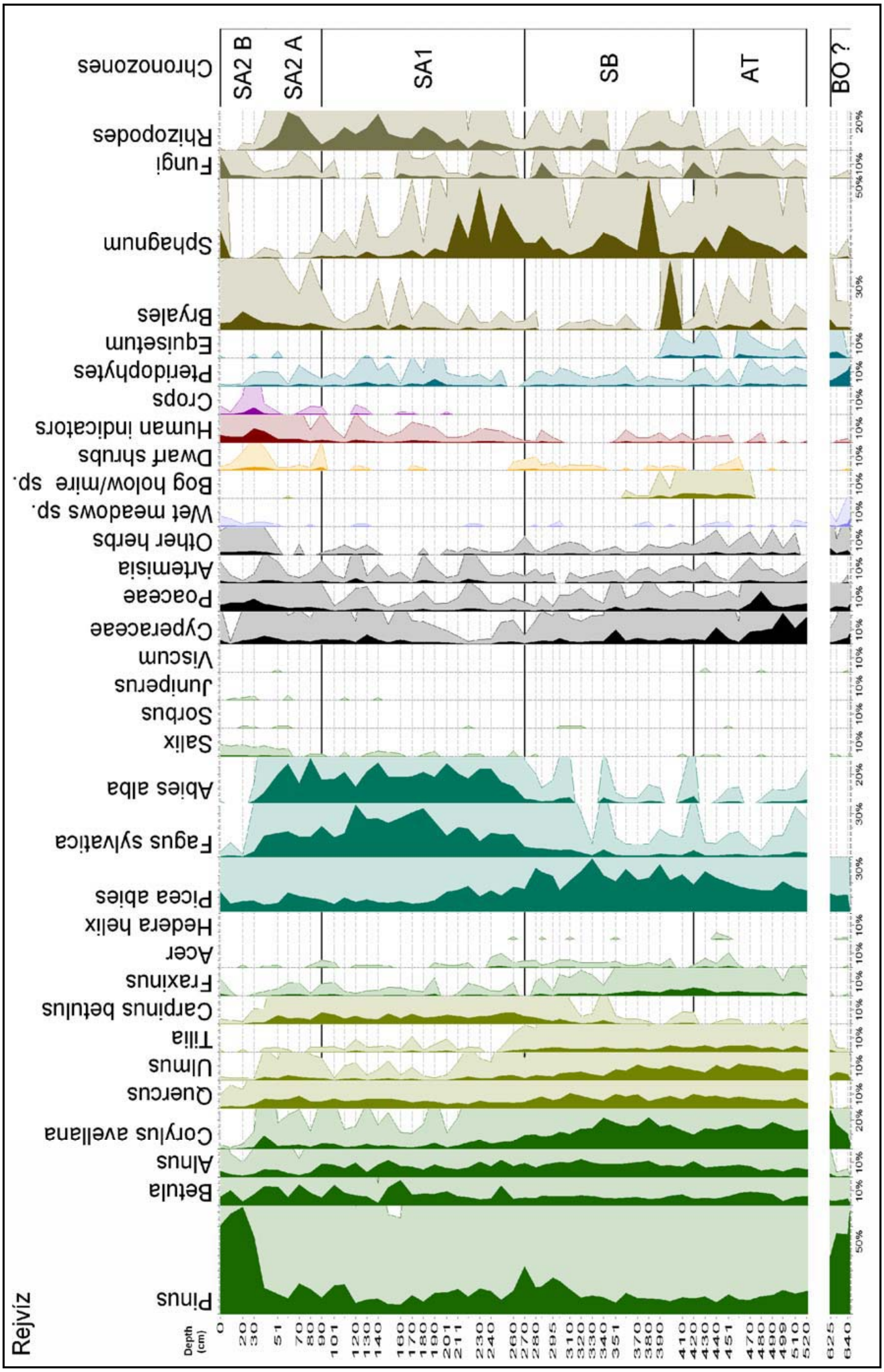
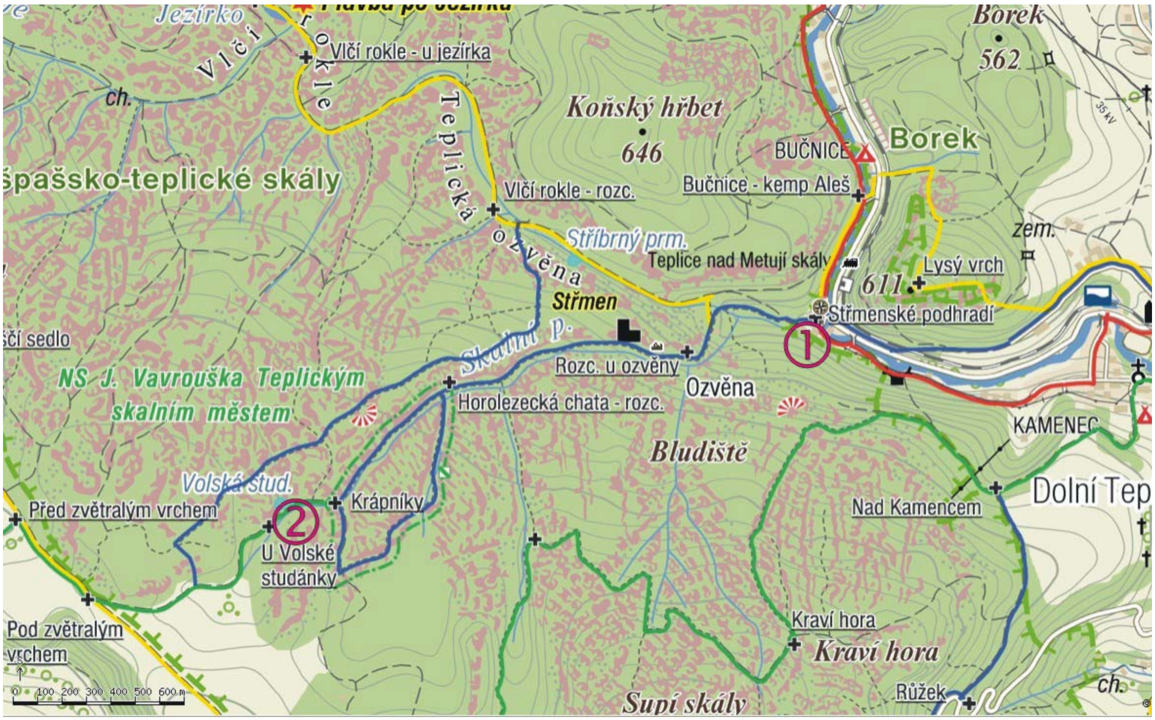


Figure 3: Simplified percentage pollen diagram. Chronozones: BO – Boreal period, At - Atlantic period, SB – Subboreal period, SA1 – Older Subboreal period, SA2 – Younger Subboreal period.

Thursday, 11. 9. 2008
Ecology and palaeoecology of sandstone landscapes

Adršpach (by *P. Kuneš* and *V. Jankovská*)
Sandstone "town" and its palaeoecology.

Accommodation in the castle of Liblice.



Sandstone "rock towns" are distinctive feature of some Czech landscapes that are situated in areas with horizontally deposited Cretaceous sandstone deposits (marine and deltaic). They were formed by combination of uplifts and falls along tectonic faults and erosion processes during Quaternary. Periglacial processes played an important role in this. One superb example is **Adršpašsko – Teplické skály** at NE Bohemia. Such landscape with steep geomorphological (and ecological) gradients displays enormous habitat diversity in limited space. This is why local vegetation development strongly differs from adjacent "ordinary" areas. This will be explained by Petr Kuneš and Vlasta Jankovská who investigated vegetation history from several local valley-bottom mires.

Numbers on the map:

1 – Bus stop and the restaurant.

2 – Turning point on the excursion journey through the "rock town". As the trip will be some 10 km long, those who are afraid of it may leave off the main group and wait it in a terrace of a restaurant where bus will wait.

KUNEŠ, P.; POKORNÝ, P.; JANKOVSKÁ, V. **Post-glacial vegetation development in sandstone areas of the Czech Republic**. In HÄRTEL, H.; CÍLEK, V.; HERBEN, T.; JACKSON, A.; WILLIAMS, R. (eds.). *Sandstone Landscapes*. Praha: Academia, 2007, s. 244-257. ISBN 978-80-200-1577-8.

Post–glacial vegetation development in sandstone areas of the Czech Republic

Petr Kuneš[1], Petr Pokorný[2] and Vlasta Jankovská[3]

Keywords: sandstones, Holocene, Late-Glacial, vegetation development, palaeoecology, pollen analysis, human impact

Introduction

In the Bohemian territory of the Czech Republic, sandstone areas have always been generally described as small-scale islands with well-defined montane vegetation, situated within landscapes with a mesic or thermic character. These small-scale islands are caused mainly by climatic inversions at the bottom of sandstone gorges, very low irradiation and a very low nutrient content. This is supported by typical sandstone geomorphology, which often forms a very complicated network of narrow valleys and gorges together with small, top plateaus, their margins and steep walls (Figure 1). The present poor nutrient content in soils and in the sandstone bedrock itself is reflected by a relatively poor vegetation cover (low alpha-diversity *sensu* Whittaker 1972) of sandstone areas (Sýkora and Hadač 1984), mainly characterized by species of poor pine-oak forests (*Avenella flexuosa*, *Calluna vulgaris*, *Vaccinium myrtillus*, *Vaccinium vitis-idaea*), fragments of degraded beech forests (*Calamagrostis villosa*, *Trientalis europaea*), and microclimatically inverse stands with oreophytic indicators (*Athyrium distentifolium*, *Cicerbita alpina*, *Rumex alpestris*, *Viola biflora*). From the point of

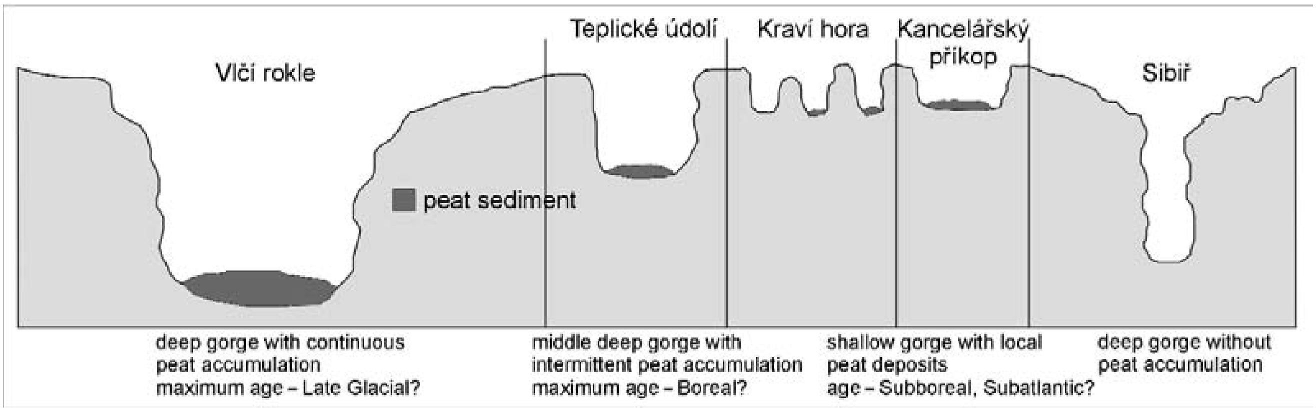


Figure 1. Geomorphological profile of the Teplické skály Cliffs (schematic view)

Figure 2. An idealized chart of various habitat types with their typical vegetation during the Late Glacial and Holocene (an example from the Adršpašsko-teplické skály Cliffs. >

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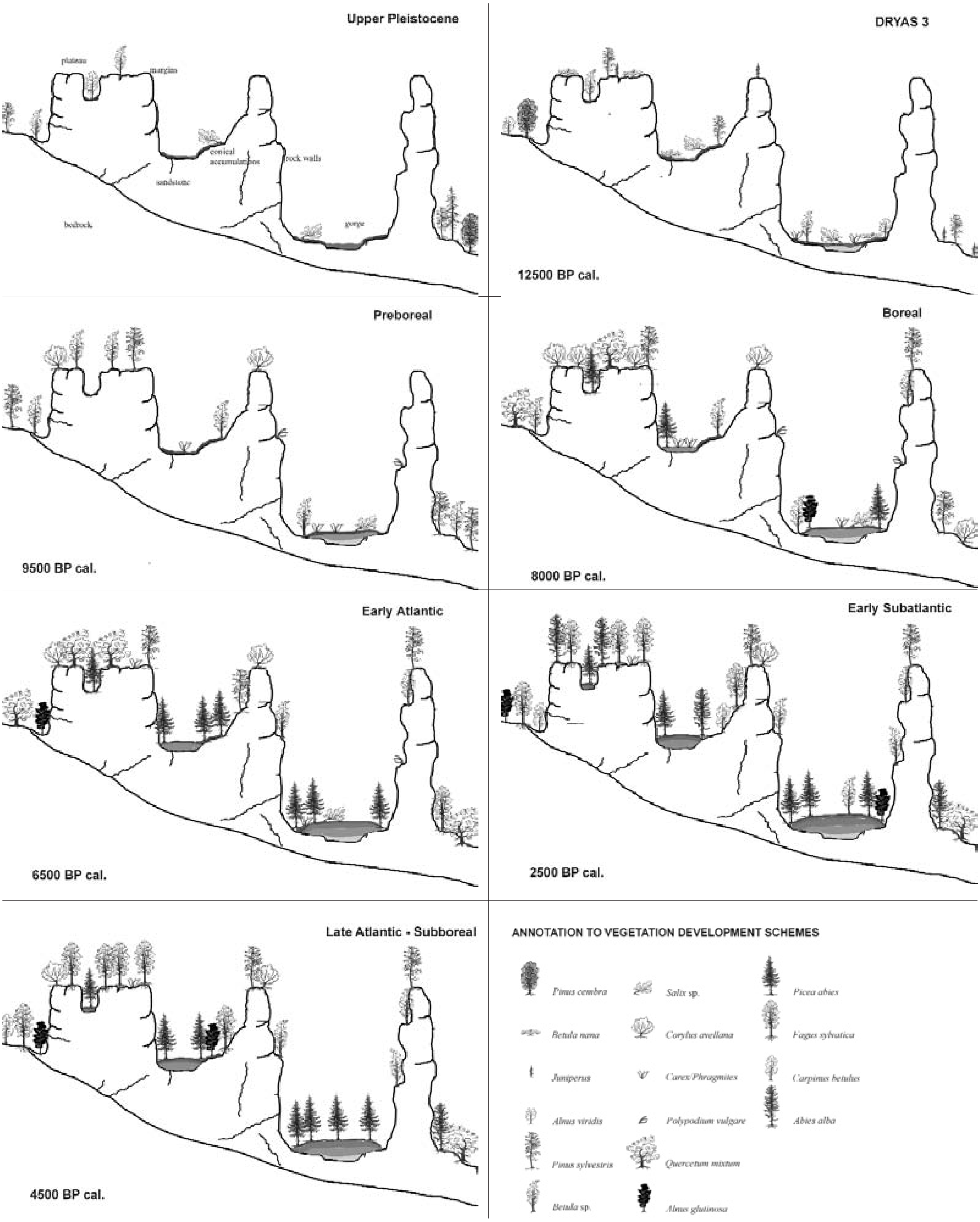

Upper Pleistocene
plateau
margins
conical accumulations
rock walls
sandstone
bedrock
gorge
DRYAS 3
12500 BP cal.
Preboreal
9500 BP cal.
Boreal
8000 BP cal.
Early Atlantic
6500 BP cal.
Early Subatlantic
2500 BP cal.
Late Atlantic - Subboreal
4500 BP cal.
ANNOTATION TO VEGETATION DEVELOPMENT SCHEMES
Pinus cembra
Salix sp.
Picea abies
Betula nana
Corylus avellana
Fagus sylvatica
Juniperus
Carex/Phragmites
Carpinus betulus
Alnus viridis
Polypodium vulgare
Abies alba
Pinus sylvestris
Quercetum mixtum
Betula sp.
Alnus glutinosa

Table 1. A list of individual sites with palaeoecological records that represent the source data for interpretation in this paper.

Locality	Sandstone area	sediment type	data collected	reference
Vlčí rokle	Adršpašsko-teplické skály Cliffs	peat profile	pollen, macrorem.	Figure11; (Kuneš and Jankovská 2000)
Adršpašsko-teplické údolí	Adršpašsko-teplické skály Cliffs	peat profile	pollen	(Kuneš 2001)
Anenské údolí	Adršpašsko-teplické skály Cliffs	peat profile	pollen	Figure 13
Kancelářský příkop	Adršpašsko-teplické skály Cliffs	peat profile	pollen, macrorem.	(Nováková 2000)
Kraví hora	Adršpašsko-teplické skály Cliffs	peat profile	pollen, macrorem.	(Nováková 2000)
Vernéřovice	Broumovská kotlina Basin close to Adršpašsko-teplické skály Cliffs	peat profile	pollen	(Peichlová 1979)
Heřmánky	Kokořínsko	rock-shelter	pollen	(Svobodová 1986)
Zátyní	Kokořínsko	rock-shelter	molluscs	(Prošek and Ložek 1952)
Jestřebské blato	Jestřebská kotlina Basin close to Kokořínsko	peat profile	pollen	(Jankovská 1992)
Tišice	Middle Elbe River valley close to Kokořínsko	lake sediments	pollen	(Pokorný 2004)
Jezevčí převis	Bohemian Switzerland	rock-shelter	macroremains	(Pokorný 2003)
Pryskyřičný důl	Bohemian Switzerland	peat profile	pollen	Figure 12; Pokorný, unpublished results

of individual profiles (Chaloupková 1995, Nováková 2000, Kuneš and Jankovská 2000). From the rest of the sandstone areas there exists only sparse palaeoecological data, represented mostly by malacological analyses from rock shelter sediments (Cílek et al. 1996) and by one single profile from Jestřebská kotlina Basin (Jankovská 1992). Most recent pollen-analytical investigations focus on the Bohemian Switzerland region (one profile now available) and on the region of acidic terraces of the middle Elbe River valley, adjacent to the southeastern segment of the Kokořínsko area (Pokorný 2005).

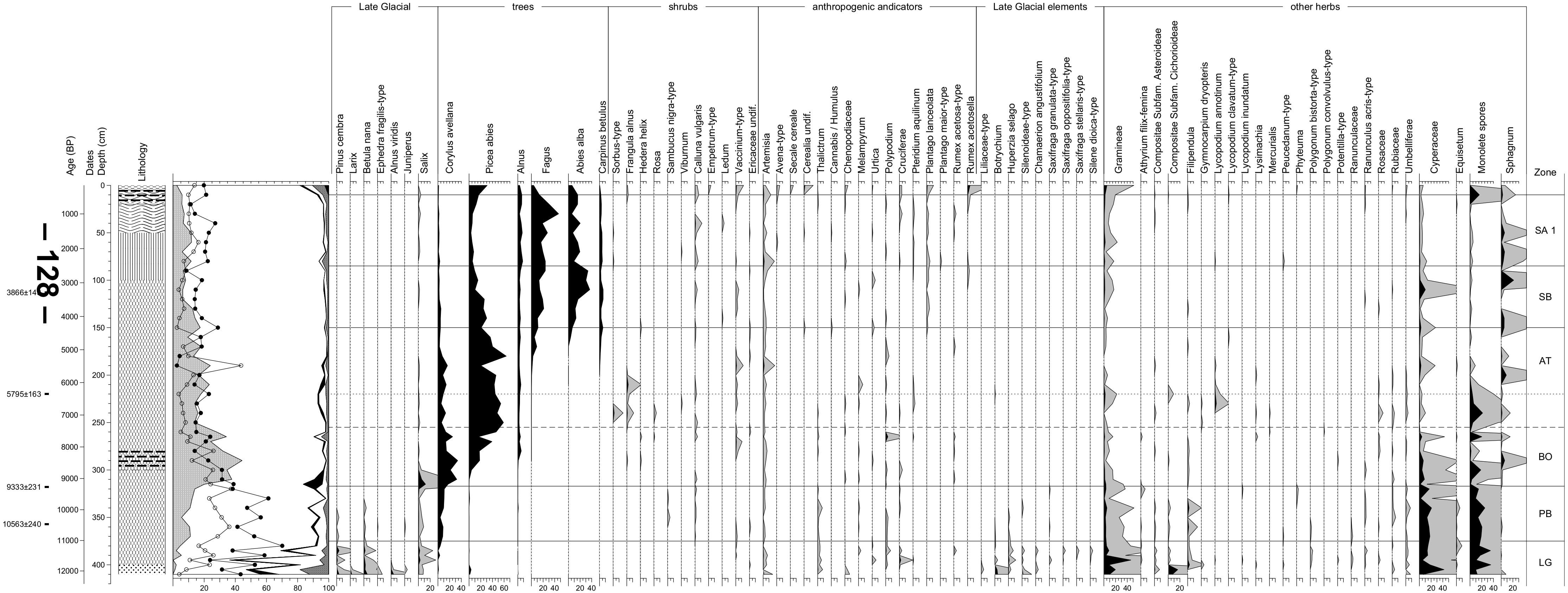
Palaeoecological record from sandstone areas

When discussing the reconstruction of past vegetation, it is important to take into account exactly where the data was collected. This is why some remarks on sedimentology will be useful for the following text. There is a great variety of post-glacial sediments inside sandstone gorges, but only a few of them are useful for the task of obtaining an appropriate palaeoecological record. Most important for the reconstruction of past vegetation is data obtained from continuous peat profiles. But not all peat accumulations bear information of the same quality. An idealized chart of various types of gorges with accumulated material and supposed age is shown in an example from the Adršpašsko-teplické skály Cliffs (Figure 1). In periods with wetter and colder climates, specific hydrological and microclimatic conditions caused the sedimentation of organic material in shallow water reservoirs. The conditions inside gorges might have been differentially influenced by the global climate at various places and to varying degrees. The deepest parts of each sandstone area ought to preserve a better record of local conditions than the shallower parts, in which the sediment could be easily eroded due to a more prominent cycle of desiccation, subsequent weathering, and washing out. The initial phases of peat growth were usually characterized by very wet conditions derived from a rich water supply of rainfall and percolation through the sandstone. In existence were localised water reservoirs, overgrown by mosses and peat-producing vascular plants. The oldest layers from the bottom of the Vlčí rokle Gorge profile, dating to the Late Glacial (Figure 11), are formed by greyish-white clay, and probably accumulated in a local pond with oligotrophic, cool water. The sedimentation of both organic and inorganic material is also likely to have taken place in other gorges and during the earlier period of the Late Pleistocene. Nevertheless, the deposited material could have been washed away during major flood events connected with snow melts, strong downpours, etc. Thus, the microfossils identified in the deepest parts of profiles in clayey or sandy sediment are only residua from originally thicker deposits. Records from other profiles in the Adršpašsko-teplické skály Cliffs support the theory of existing small water reservoirs during the initial phases of organic sedimentation. Basal layers of these sites are formed by organic material, possibly redeposited and mixed together with sand. Continuous peat accumulation began only around 8000–7500, BP i.e. during the Boreal period. These deposits originated from *Sphagnum* and *Polytrichum*

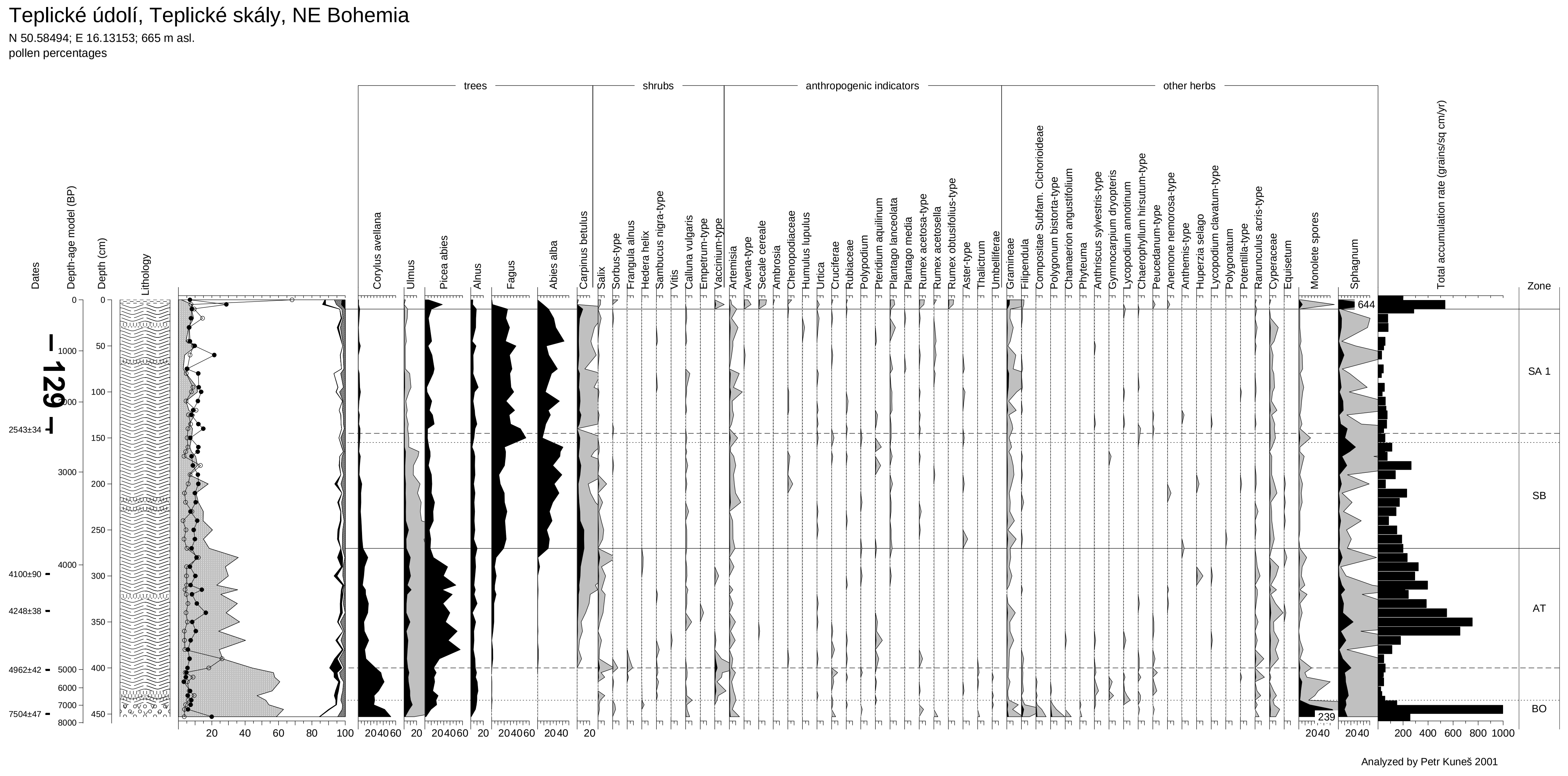
Vlčí rokle, Teplické skály, NE Bohemia

N 50.6045; E 16.12841; 520 m asl.

pollen percentage diagram



Analyzed by Vlasta Jankovská


Teplické údolí, Teplické skály, NE Bohemia
N 50.58494; E 16.13153; 665 m asl.
pollen percentages
trees
shrubs
anthropogenic indicators
other herbs
Dates
Depth-age model (BP)
Depth (cm)
Lithology
Corylus avellana
Ulmus
Picea abies
Alnus
Fagus
Abies alba
Carpinus betulus
Salix
Sorbus-type
Frangula alnus
Hedera helix
Sambucus nigra-type
Vitis
Calluna vulgaris
Empetrum-type
Vaccinium-type
Artemisia
Avena-type
Secale cereale
Ambrosia
Chenopodiaceae
Humulus lupulus
Urtica
Cruciferae
Rubiaceae
Polypodium
Pteridium aquilinum
Plantago lanceolata
Plantago media
Rumex acetosa-type
Rumex acetosella
Rumex obtusifolius-type
Aster-type
Thalictrum
Umbelliferae
Gramineae
Filipendula
Compositae Subfam. Cichorioideae
Polygonum bistorta-type
Chamaerion angustifolium
Phyteuma
Anthriscus sylvestris-type
Gymnocarpium dryopteris
Lycopodium annotinum
Chaerophyllum hirsutum-type
Peucedanum-type
Anemone nemorosa-type
Anthemis-type
Huperzia selago
Lycopodium clavatum-type
Polygonatum
Potentilla-type
Ranunculus acris-type
Cyperaceae
Equisetum
Monolete spores
Sphagnum
Total accumulation rate (grains/sq cm/yr)
Zone
SA 1
SB
AT
BO
2543±34
4100±90
4248±38
4962±42
7504±47
644
239
Analyzed by Petr Kuneš 2001

Holocene acidification process recorded in three pollen profiles from Czech sandstone and river terrace environments

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Introduction

Late Quaternary climatic changes had dramatic effect on the terrestrial biosphere. In temperate mid-latitude regions of the Northern Hemisphere, vegetation belts migrated over several thousands of kilometers. These macroscale vegetational changes were accompanied (and were partly in response to) changes in soil properties. The ways in which soil-vegetation relationships have evolved, and particularly the response of vegetational and pedogenetic processes to climatic change, are of fundamental importance in understanding the dynamics of contemporary ecosystems. Viewed in this light, acidification is a long-term natural process that occurs especially during warm phases of Quaternary climatic cycle (Iversen 1958; Birks 1986). It is characterized by loss of cations (namely bivalent bases - Ca^{2+} and Mg^{2+}) that are normally bound to clay minerals in the soils. Under wet and warm conditions, bases are leached from these complexes, being dissolved in percolating water and transported out of the ecosystem (and finally through the rivers to the sea). This process results in change in species composition and productivity of the ecosystems. The dynamics of acidification is seriously modified by climatic changes, biotic influences, and, during the Holocene, also by human intervention (Bell & Walker 1992). Antropogenic activities contribute to the acidification through removal of biomass (grazing, mowing, woodcutting, harvesting without subsequent manuring) and through triggering the soil erosion. Positive backbound mechanisms may play an important role in case of biological control of acidification. To give a simple example from Central Europe: At the first stage of acidification, coniferous trees (namely *Pinus sylvestris*, *Picea abies*, and *Abies alba*) spread within broadleaf forests. During the decomposition of coniferous falloff, humic acids are produced in great quantities. Organic compounds in soils change from mull to mor humus. This efficiently speeds up further acidification and soils structure is changed in the process called podzolisation. Usually also upper layer of underlying bedrock is being leached and decalcified.

Due to its long long-term nature, acidification processes can be best studied in secular to millennial time scale. Pollen analysis is appropriate tool for this as it enables to record time scales long enough and because vegetation corresponds directly to local geochemical changes.

The pollen and sediment chemistry evidence

Soils developed on relatively acidic bedrock are often more sensitive to loss of nutrients than those on calcareous substrata. This is why best evidence for Holocene acidification in the Czech Republic comes from sandstone regions and from river environment with extensive cover of acidic sands and gravel. In the following, we will give three examples of profiles, where acidification process can be studied (location of profiles indicated in Fig. 1).

Anenské údolí, Broumovsko sandstone region

The site, a topogenic mire in the bottom of a valley at 645 m a.s.l. altitude, is surrounded by dramatic

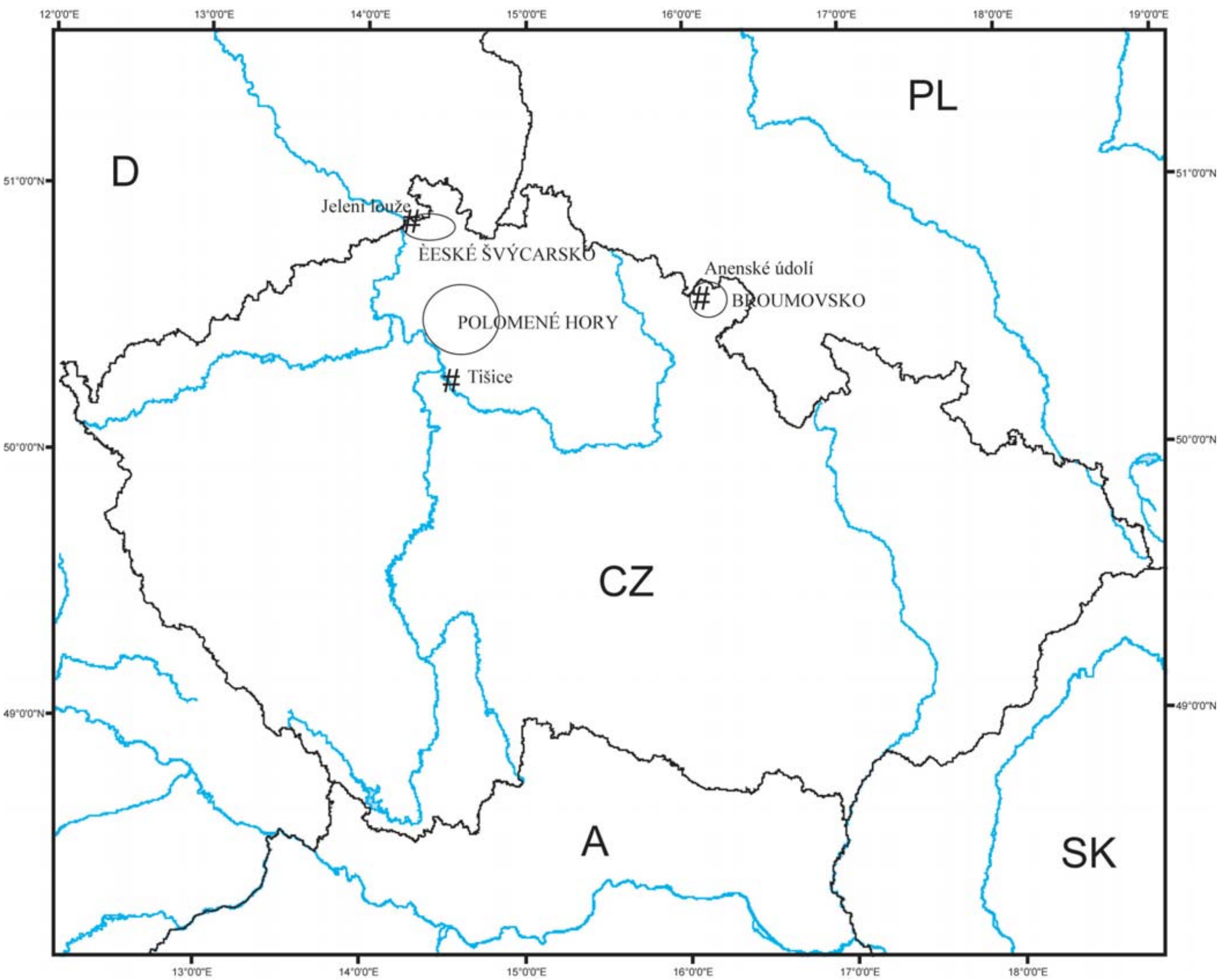

Fig. 1: Territory of the Czech Republic and the location of sites and regions mentioned in the text.

relief with sandstone rocks and gorges. Present vegetation is dominated by acidic pine woodland in relatively dryer situations and by spruce plantations in the bottoms of the valleys. Climate of the region is oceanic and relatively cold (mean annual temperature around 7°C and rainfall around 800 mm).

In the pollen diagram (Fig. 2) we see gradual vegetation change from mixed oak woodlands to communities dominated by spruce (*Picea abies*), beech (*Fagus sylvatica*), and silver fir (*Abies alba*). This change can be observed between 150 and 85 cm – i.e. between ca 4 100 and 3 400 B.P. according to radiocarbon chronology. While the decrease in demanding tree species is gradual, expansion of constituents of oligotrophic woodland communities is stepwise: In the first step this is the expansion of *Picea abies*, followed by strong increase in *Fagus sylvatica* and *Abies alba*. Also hornbeam (*Carpinus betulus*) appears in this stage. As human impact indicators virtually lacking in the pollen record we may assume that above-described process of acidification was controlled entirely by natural influences in this case.

To get more insight to process of acidification, samples for chemical analysis of Ca^{2+} and Mg^{2+} cations (Fig. 5) were taken directly from above-described peat profile. At first, concentration of both elements steadily rises (from about 190 to 95 cm). This must be the result of increased leaching from the soils in the catchment after invasion of beech (*Fagus sylvatica*). Leached cations were than bound into peat organic matter (Digerfeldt 1972). Maximum concentrations are found at the level of 95 cm – this is probably the result of silver fir invasion (see *Abies alba* curve in pollen diagram). As already described above, the decomposition of coniferous falloff may speed up acidification process. Spread of coniferous forest in the catchment caused more Ca^{2+} and Mg^{2+} to be released from the soils. After the maximum at 95 cm, the concentrations of both Ca^{2+} and Mg^{2+} started to decline as their availability slowly decreased in the catchment. At this time finally, acidification process was completed.

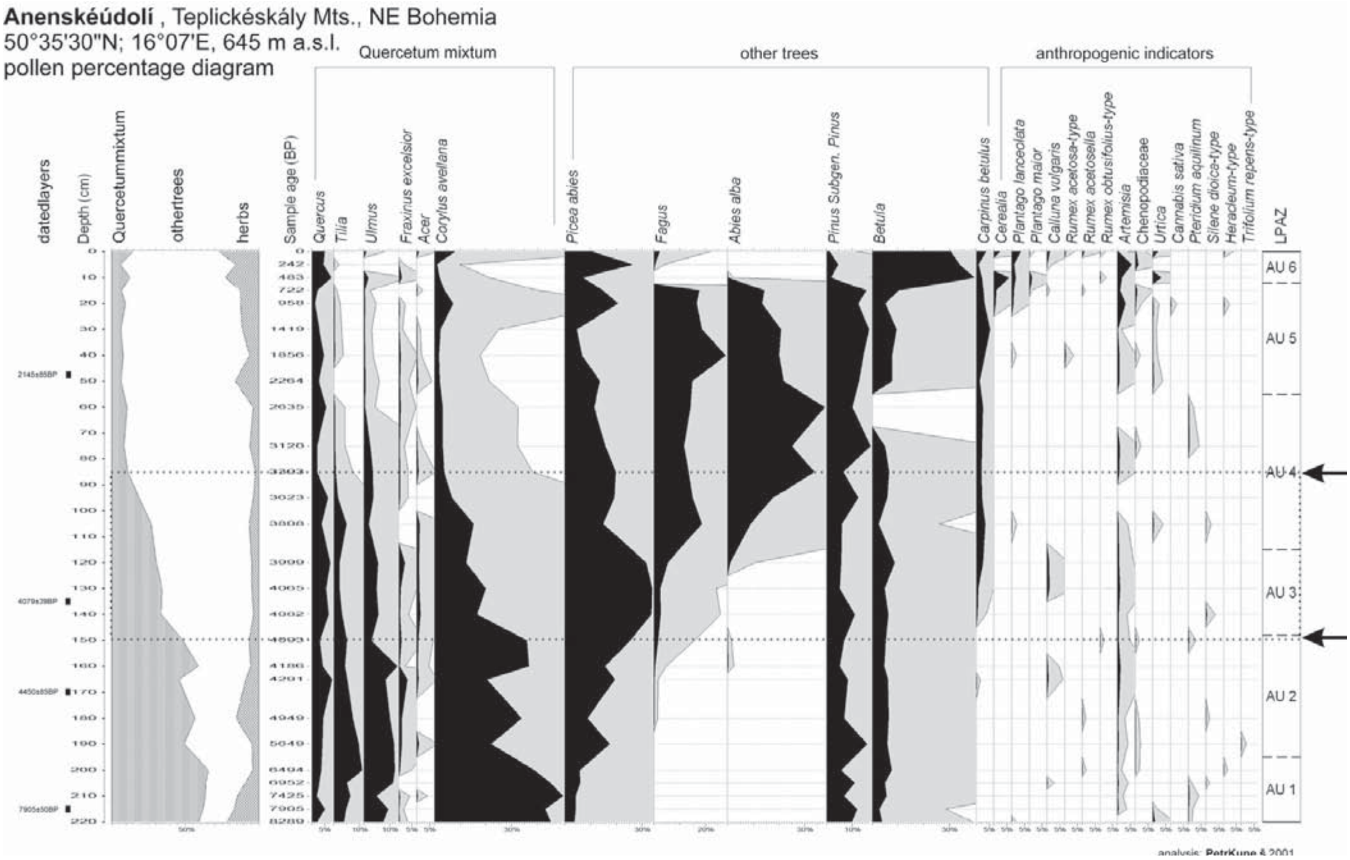

Fig. 2: Simplified percentage pollen diagram from Anenské údolí site. The period of acidification indicated at right.

Jelení louže, České Švýcarsko sandstone region

This pollen profile comes from a topogenic mire that is situated in relatively shallow sandstone gorge, about 400 m a.s.l. The site is surrounded by large sandstone plateau bordered by well-developed rock formations. Today, this area is extremely acidic with species-poor vegetation dominated by pine and birch. Surface pollen spectrum (0 cm in the pollen profile) reflects the present vegetation conditions. Local climate is rather oceanic with relatively high annual rainfall (nearby station at Chřipská: 934 mm).

Acidification process is seen in the pollen diagram between the depth of 210 and 120 cm (Fig. 3). This corresponds to the time period between about 4700 B.P. and 2900 B.P. according to radiocarbon dating. As in the case of Anenské údolí site, although final consequences of acidifications are very deep, the process itself is rather gradual. Vegetation response to acidification has a stepwise character. The starting point is the vegetation of rich mixed oak woodlands with significant admixture of hazel (*Corylus avelana*). In the first step, the curves of demanding trees (*Quercus*, *Tilia*, *Ulmus*, *Acer*, *Fraxinus*, and *Corylus*) decline in favor to expanding beech (*Fagus sylvatica*). During the second step we may observe another decrease in demanding broadleaf trees, but also the decline in *Fagus* that is replaced by silver fir (*Abies alba*). In the same period, anthropogenic indicators are very low in the pollen diagram, excluding again the possibility of anthropogenic control of acidification process.

Tišice, middle Labe region

Unlike the previous two cases, this site is situated at low elevation (165 m a.s.l.) and in very different geomorphologic situation - in a flat landscape within a broad valley of Labe River, adjacent to Polomené hory sandstone area. The valley is filed with sandy and gravel substrata of Pleistocene river terraces. We may trace the history of human impact in the region deep into Neolithic period from the pollen-analytical investigations and according to archaeological excavations (Dreslerová & Pokorný 2004). Today, this is an agricultural landscape with some little remains of acidic pine woodlands. Local climate is warm, dry, and relatively continental (mean annual climatic characteristics of nearby city of Mělník: 8.7 °C, 527 mm).

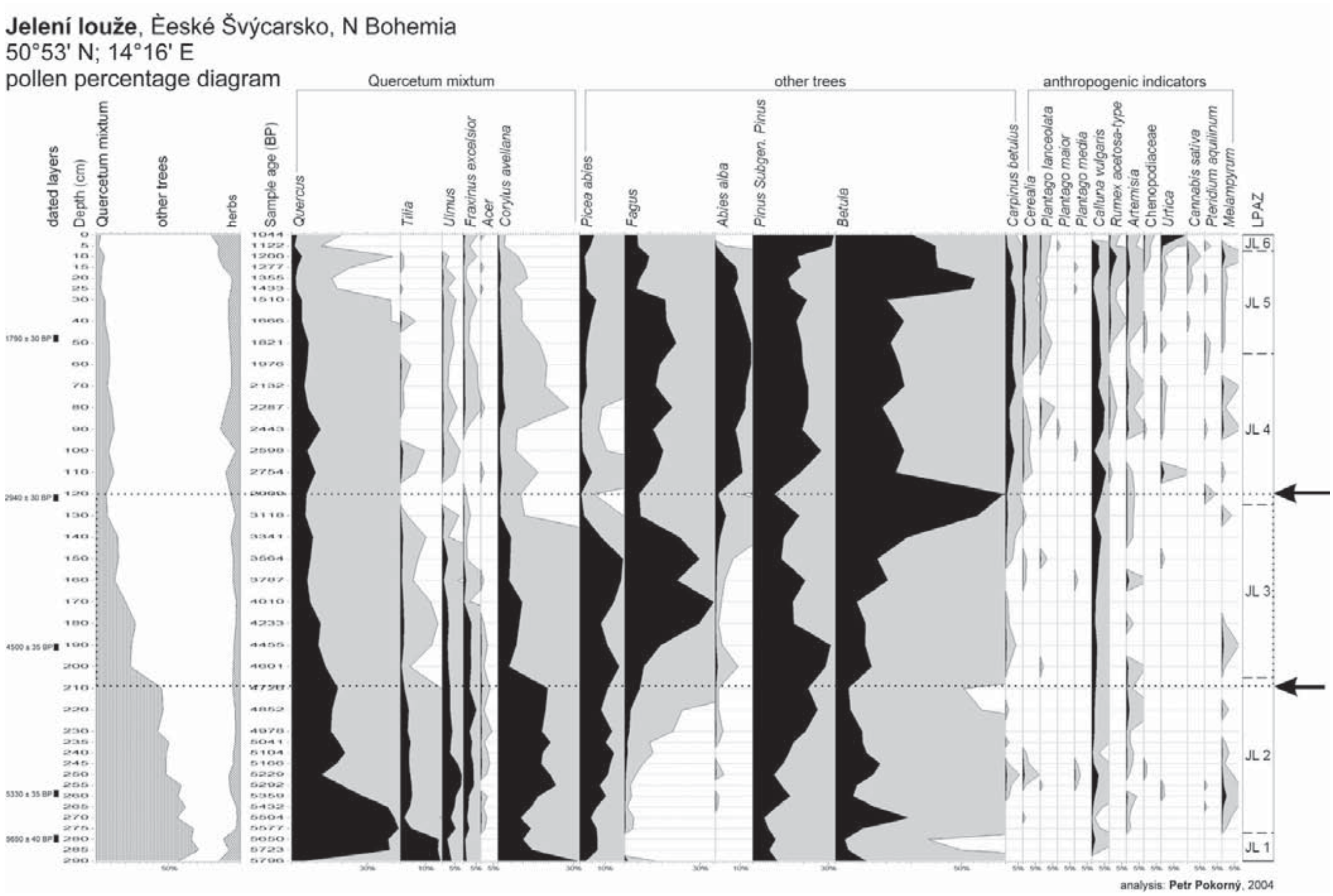

Fig. 3: Simplified percentage pollen diagram from the Jelení louže site. The period of acidification is indicated on the right side.

Older part of the pollen diagram (Fig. 4) is characterized by high pollen curves of *Quercus*, *Tilia*, *Ulmus*, *Fraxinus*, and *Corylus*. Acidification is much more dramatic process than in previous two examples. It is seen in pollen diagram as sudden vegetation change between 185 and 175 cm depth. This period corresponds roughly to 3 000 B.P. according to radiocarbon chronology. Demanding trees of mixed oak woodlands decline in this point and curves of *Pinus* and *Abies alba* increase significantly. This event is synchronous with sudden rise in antropogenic indicators – both arable and grazing indicators. Close correlation of both phenomena suggests an anthropogenic control of acidification process. This was probably the reason why vegetation change is so sharp in this case.

Discussion and conclusions

Sandstone and river terrace landscapes in the Czech Republic experienced considerable changes in their productivity, species richness and composition during the Late Holocene. These areas, today extremely acidic and oligotrophic, were much more nutrient rich during most of their Holocene history. In the example of three pollen profiles we could see how process of acidification may differ in the timing and in its dynamics. These differences are due to different local climatic setting and, more important, due to different human impact histories.

First evidence for Late Holocene acidification of Czech sandstone landscapes was given by V. Ložek (1998). His arguments are based on palaeomalacological finds from sedimentary fills of rock shelters at Polomené hory sandstone area. Middle Holocene snail communities were surprisingly rich in species, whereas at present the areas in question are characterized by only very poor communities consisting of few most resistant species. Strong decrease in snail species richness – from 41 species to only 6 in case of a single site - coincides with the Final Bronze Age period (about 3 000 B.P.). This suggests a dramatic transformation of ecosystem during respective time. For the explanation of this phenomenon, Ložek proposes model of environmental collapse induced by climatic change associated with human activity - woodland clearance and grazing. This model corresponds very well to our present

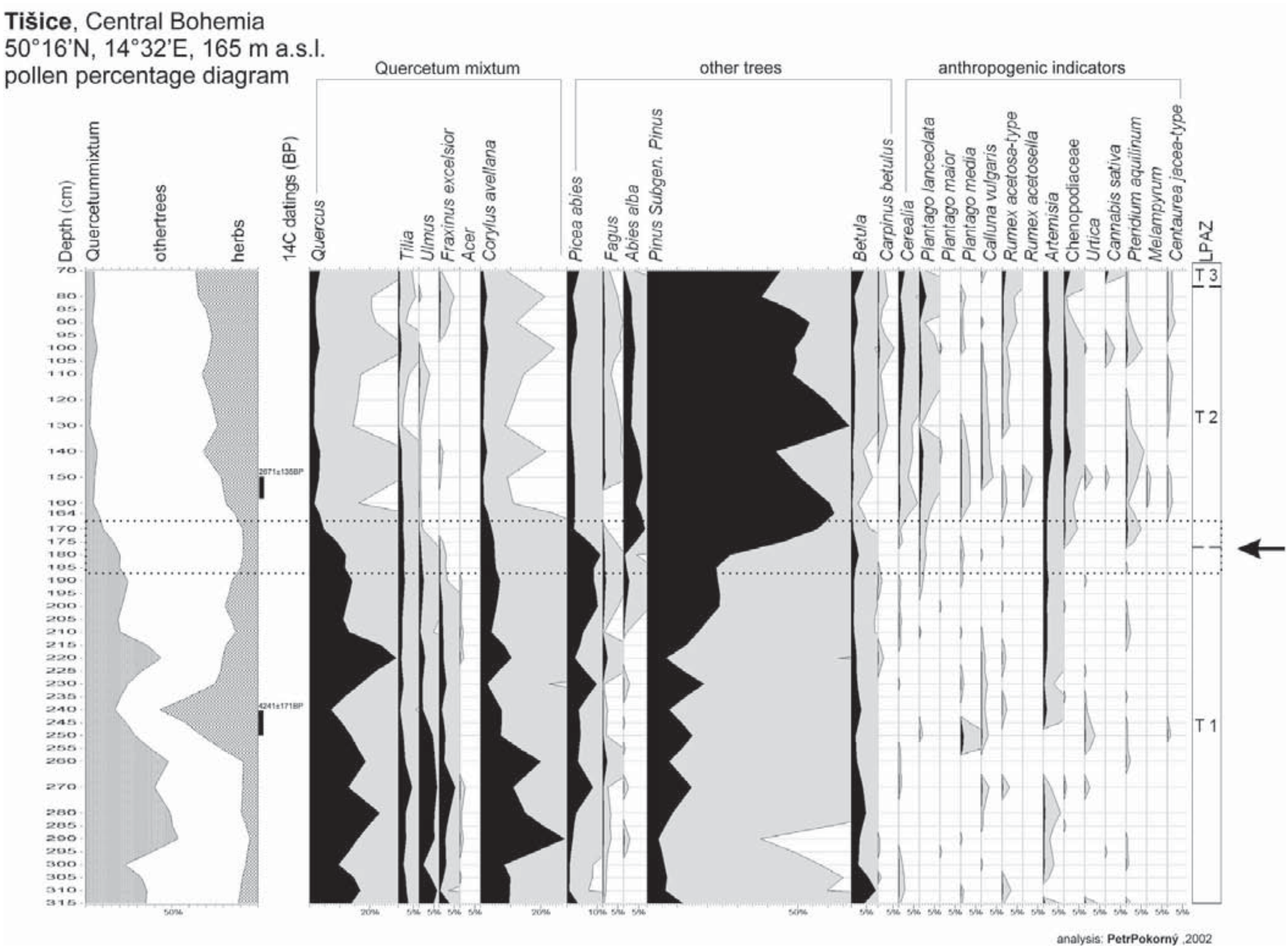

Fig. 4: Simplified percentage pollen diagram from the Tišice site. The moment of acidification is indicated on the right side.

data from Tišice site, where vegetation change to more acidic conditions is synchronous with significant increase in human impact. Also the timing of both acidification events is about the same (Late to Final Bronze Age). In contrast to this, pollen evidence from Broumovsko and České Švýcarsko sandstone regions suggests more gradual acidification that took place between ca 4 700 and 3 000 B.P. (Late Neolithic to Final Bronze Age according to archaeological chronology). This difference is probably due to the lack of prehistoric human influence which was negligible in two later mentioned regions.

According to arguments presented in this paper, soil acidification and ecosystem depauperization is a process that is natural under climatic conditions of Central Europe. Sandstone substrata are especially sensitive to loss of basic nutrients. Around 3 000 B.P., natural process of acidification culminated in both sandstone regions under study. This happened obviously without influence of man. Nevertheless, human impact may have been an important factor that speeded up this process. This happened during Late and Final

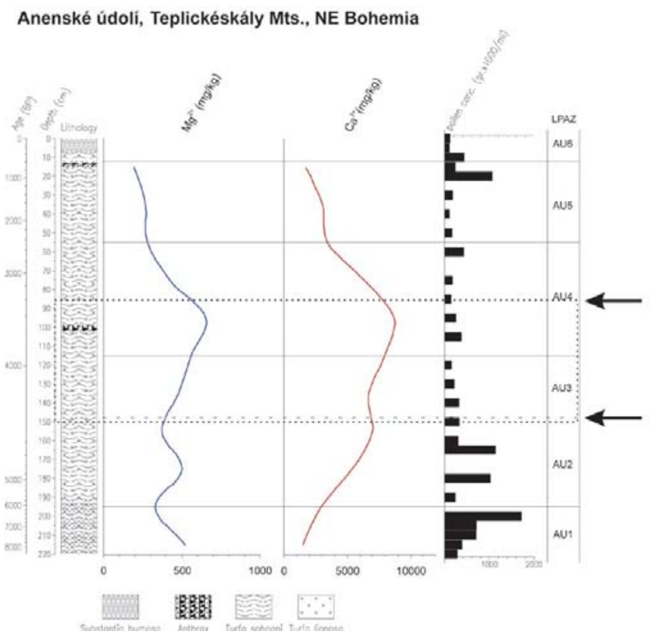

Fig. 5: Ca^{2+} and Mg^{2+} total concentrations diagram from Anenské the údolí site. The period of acidification (derived from pollen diagram; Fig. 2) is indicated on the right side.

Bronze Age (i.e. at about 3 000 B.P. again) in case of Polomené hory sandstone area and in nearby-situated terraces of Middle Labe River. Woodland clearance, grazing and subsequent soil erosion were probably most important control mechanisms that played a role.

Acknowledgements

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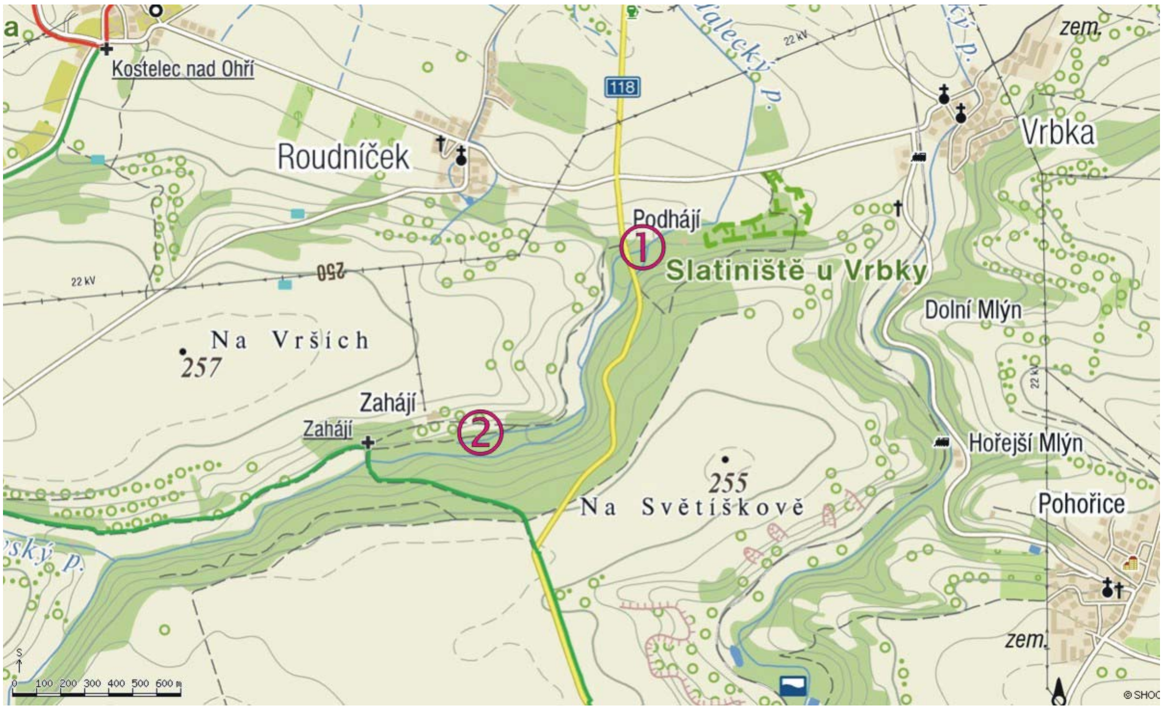
Friday, 12. 9. 2008
Cultural landscape development of the Bohemian Basin

Zahájí (by *P. Pokorný* and *J. Novák*)
Palaeoecology and settlement history of the Czech lowland.

Accommodation and a closing dinner at Loket.



Lowland of Central Bohemia is a large basin formed by upper and middle course of Elbe (Labe) River. Cultural landscape of this relatively warm and dry area has formed over millennia of continuous settlement history. Valleys of some small creeks, tributaries of the main river, are filled in with thick organic fen deposits and loamy sediments eroded from prehistoric to Modern Age fields. **Zahájí** is one good example of this. Petr Pokorný will explain his palaeoecological investigations of these archives that are conducted in close correlation with archaeologists.

Numbers on the map:

1 – Bus stop

2 – The site. Possibility for examination of local eutrophic fen vegetation.

Role of man in the development of Holocene vegetation in Central Bohemia

Vliv činnosti člověka na lokální vývoj vegetace holocénu středních Čech

Petr P o k o r n ý

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Pokorný P. (2005): Role of man in the development of Holocene vegetation in Central Bohemia. – Preslia, Praha, 77: 113–128.

In the subcontinental, semiarid lowland region of Central Bohemia (Czech Republic), continuous human impact acting together with diverse natural environmental conditions resulted in the present extraordinarily complex pattern of vegetation. Three radiocarbon-dated pollen diagrams for the area indicate that this complexity results from past vegetation development. During prehistory, places suitable for settlement (with respect to climate, geology, hydrology, etc.) were colonized and transformed first. This resulted in a diachrony in vegetation development due to human activity starting in the first half of the Holocene. This caused an increase in diversity in the region as plant species persisting from previous periods, along with those associated with different agricultural practices, increased. Local abiotic factors affected not only the chronology of human impact but also its specific effects on the ecosystem. Anthropogenic pressure may have had different effects under different conditions. Human population pressure was the mediator between the abiotic diversity and selectively transformed vegetation suitable for the respective habitats. Differences in the chronology of human impact, mixed oak woodland degradation, and the chronology of beech, silver fir and hornbeam expansion are documented for the different ecological zones of the study area. These differences shed light on the mechanisms resulting in some of the important changes in Holocene vegetation. In the absence of man, the decline in mixed oak woodlands, typical of the Middle Holocene in Central Bohemia, would have been probably much slower and less extensive. Unlike in the uplands and mountains, the expansion in the area of beech, silver fir and hornbeam would have been insignificant. The present vegetation resulted to a large extent from management during High Middle Ages. There is almost no continuity in vegetation from the late prehistory to the present.

K e y w o r d s : Central Europe, the Holocene, deforestation, forest composition changes, human impact, pollen analysis

Introduction

Central Bohemia is the lowland part of the Czech Republic, with the capital Prague at its southern edge. This region is specific in terms of Central European environment. Diverse geology and soil conditions, a long history of human impact and its geographical position at the transition between continental and oceanic Europe have resulted in a characteristic pattern of contrasting biotopes and high biological diversity. This is without doubt a result of complicated developments during the Holocene. Unfortunately, due to the absence of an adequate fossil record in the form of peat deposits (the region is too dry for peat formation), our knowledge of the history of the regional vegetation is very incomplete and, as a consequence our understanding of the development of present day vegetation and landscape diversity is poor.

The first palaeobotanical data for Central Bohemia is that of Losert (1940a,b) who described the development of Late-Glacial and Early Holocene vegetation at two adjacent sites in the middle course of the Labe (Elbe) river. Later research of Pacltová & Hubená (1994) and Břízová (1995, 1999a) concentrated on the middle Labe valley, a specific ecological zone, and resulted in a relatively complete picture of the vegetational history of the floodplain during Early and Late Holocene. In N Bohemia, a large lowland lake Komořanské jezero was studied using pollen analyses (Rudolph 1926, Losert 1940c, Jankovská 1983, 1984, 1998, 2000). Břízová (1999b) investigated the Late-Glacial and Early Holocene sediments in the peat deposit at Rynholec, a site that is also covered by the present paper. Rybníčková & Rybníček (1999) analysed two sequences from several kilometers W of Rynholec. Earlier investigations done in the same area were published by Puchmajerová (1948). Only a short, rather preliminary study by Buttler (1993) of the loess plateau exists for the central part of the area. Although much more is known about the vegetation history of other parts of Central Bohemia, most of its loess plateau remained almost unknown to palaeobotanists. On the other hand, quaternary geological, geomorphological, malacostratigraphical and archaeological data for the same area are plentiful. This information, although scattered in regional literature, is in many cases relevant to discussions about the development of vegetation in the past.

In recent field investigations, several peat deposits situated at key locations were found, which were appropriate for further pollen-analyses. In the present paper, results for three contrasting sites are used to illustrate the surprising differences in the development of local vegetation and draw conclusions about what determined them. It must be stressed that this information is too fragmentary to determine the development of vegetation in Central Bohemia, an area of high environmental complexity, now and also in the past.

The aim of the present paper is to compare past developmental trends and evaluate how a combination of environmental and human-impact factors affected changes in vegetation composition.

Study area and description of the sites

Due to its position between important European biogeographical units, Central Bohemia may be regarded as an area where various phytogeographic elements present in Central Europe occur together: Boreo-continental (represented by e.g. *Astragalus arenarius*, *Pulsatilla patens*, *Hierochloë odorata*, *Carex humilis*, *Lilium martagon*, *Veratrum nigrum*, *Ligularia sibirica*, *Geum rivale*), Submediterannean (*Quercus pubescens*, *Festuca valesiaca*, *Ranunculus illyricus*, *Stipa pennata*, *S. capillata*, *Alyssum saxatile*), Alpine-Carpathian (*Soldanella montana*, *Polygala chamaebuxus*, *Phyteuma nigrum*, *Melica uniflora*, *Euphorbia amygdaloides*, *Carex davaliana*) and Central-European (*Euphorbia dulcis*, *Potentilla neumanniana*, *Galium sylvaticum*, *Corydalis cava*, *Lysimachia nemorum*, *Asarum europaeum*, *Lunaria rediviva*). Central Bohemia also harbours some endemic species, such as *Dianthus bohemicus, Pinguicula bohemica, Melampyrum bohemicum* and several other endemic infraspecific taxa (Slavík 1980). The presence of species from very different climates and habitats (most of them at the limit of their geographic distribution) results from a high microhabitat diversity, caused mainly by the many contrasting geological substrates present within a relatively small area. They vary from ultramafic serpentinite to acidic sandstone and from erosion-resistant quartzite to easily eroded calcareous marl. This not only makes soil chemistry and structure diverse but also determines the

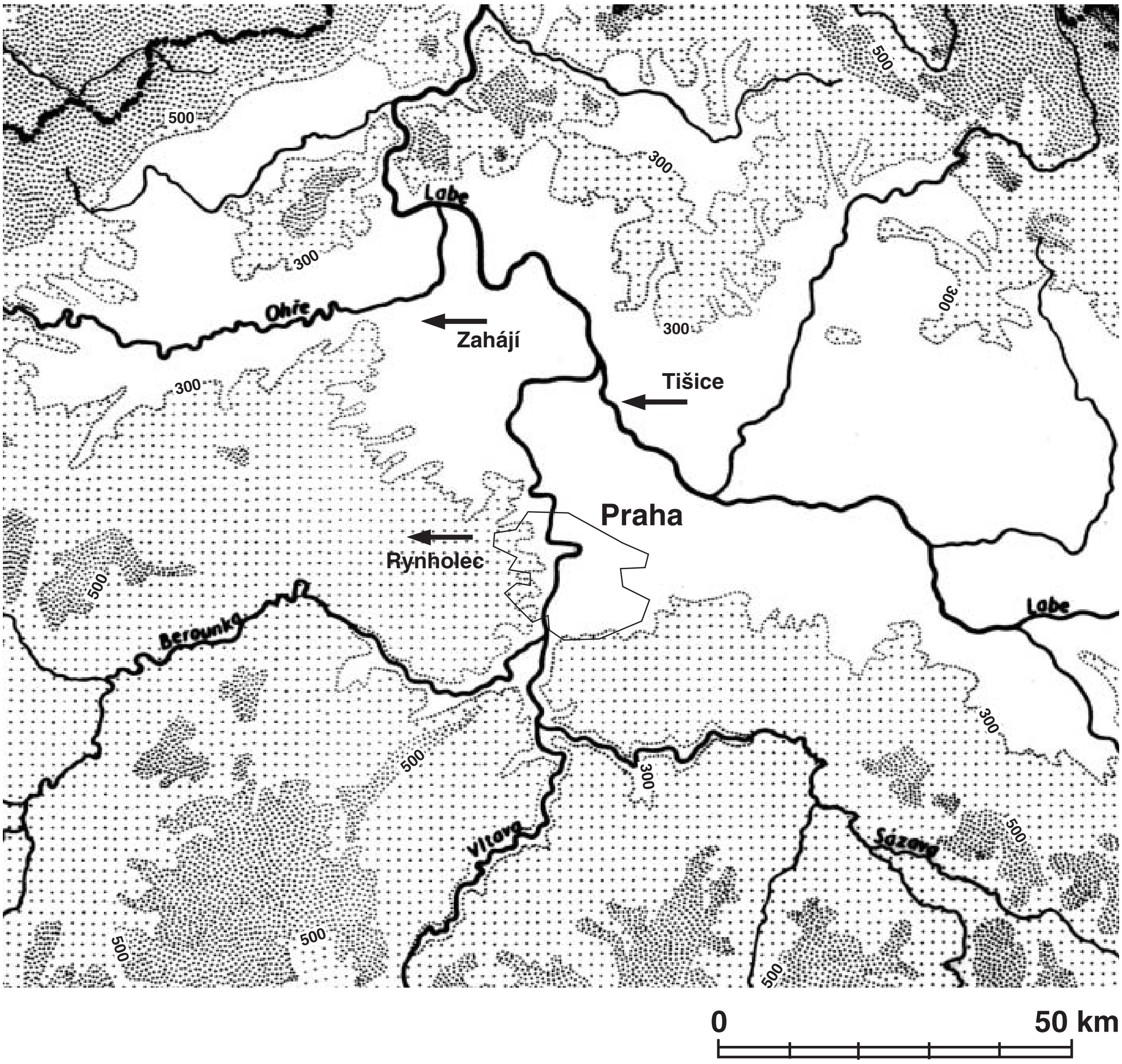

Fig 1. – Study area and position of the sample sites.

nature of micro- and mesorelief, and predisposes individual sites to different kinds of human management. The effects of bedrock quality are usually complicated by superposition of unconsolidated Quaternary sediments, most important of which are gravelly river terraces and extensive loess deposits of variable thickness (Ložek 1980, Kunský 1968). In mountainous regions, e.g. the Alps, extreme diversity is caused mainly by altitude and exposure. The Central-Bohemian landscape is a slightly undulating plain, sculptured by geomorphic processes during the Quaternary. The explanation of regional diversity is thus complicated and historical factors must be taken into account.

The overall climate of the study area is relatively hot, semiarid and subcontinental, with average July temperature 18–19°C, January temperature from –2 to –4°C, and average annual rainfall 450–600 mm. The effect of macroclimate is rather uniform, and local anomalies, like slope exposure, position on plateau or valley bottom, or in valley with respect to prevailing wind, are more important.

As for human occupation, the study area (especially its central part) is one of the principal old settlement areas of Central Europe. Human influence in Central-Bohemian land-

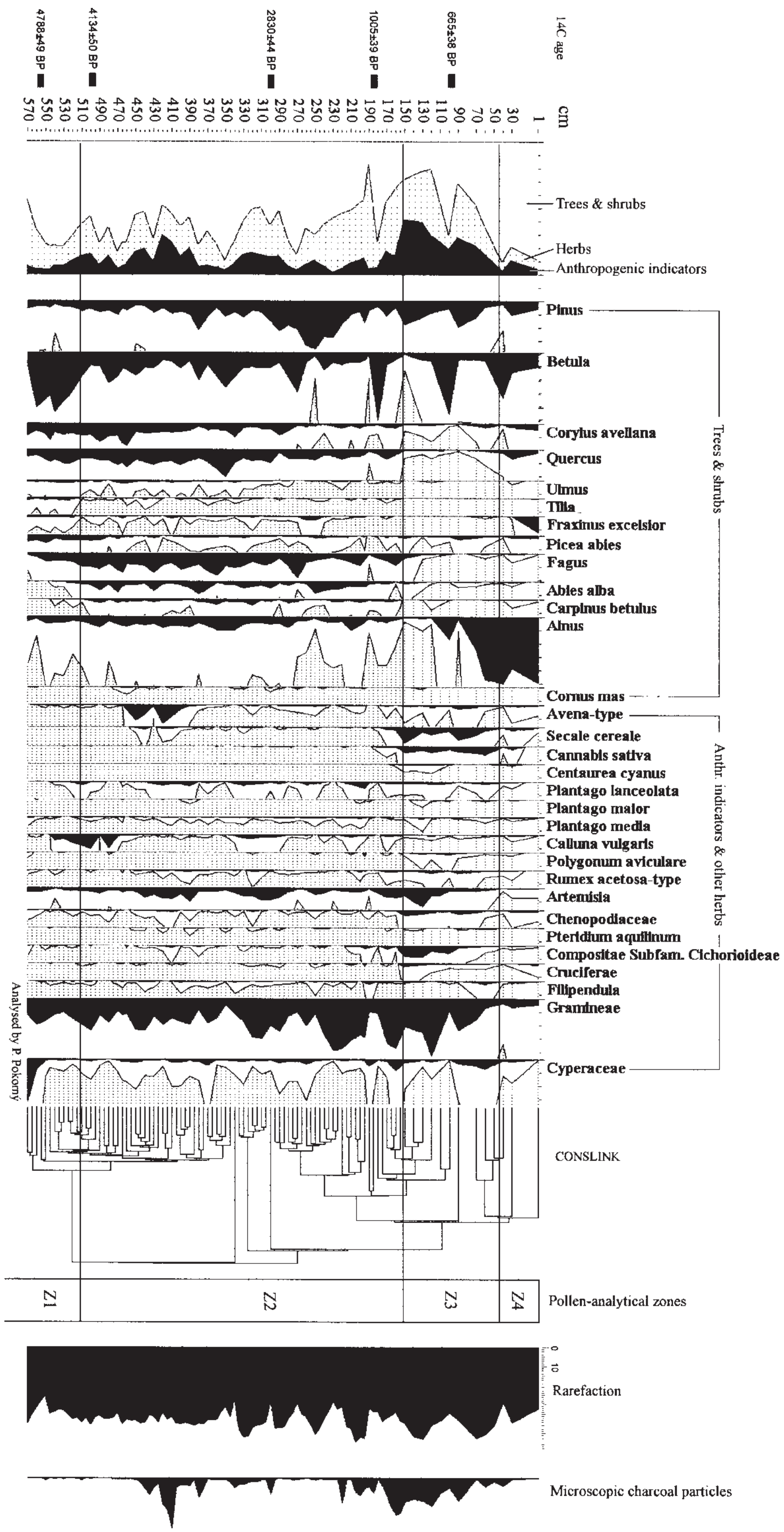

Fig 2. – Pollen diagram for the Zahájí site. 50°22'N, 14°08'E, 190 m a.s.l.

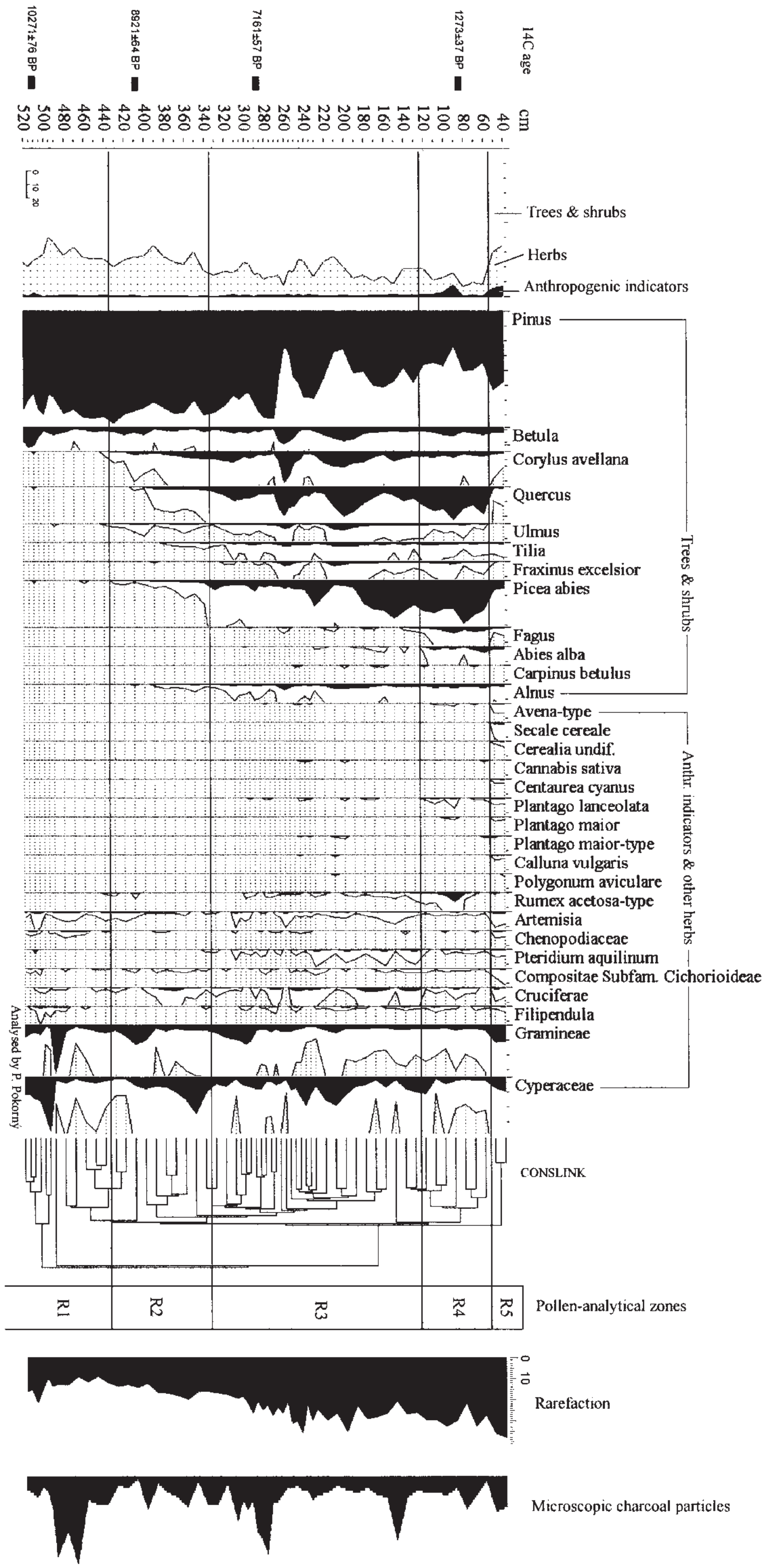

Fig 4. – Pollen diagram for the Rynholec site. 50°08'N, 13°58'E, 407 m a.s.l.

Veget Hist Archaeobot (2005) 14:295–302
DOI 10.1007/s00334-005-0076-9

ORIGINAL ARTICLE

Aldona Bieniek · Petr Pokorný

A new find of macrofossils of feather grass (*Stipa*) in an Early Bronze Age storage pit at Vliněves, Czech Republic: local implications and possible interpretation in a Central European context

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Abstract The abundance of *Stipa* remains in material dated to the Middle Neolithic (ca. 4400–4000 B.C.) from Kujawy (central Poland) and their presence in a storage pit at Vliněves (Czech Republic) dated to the Early Bronze Age (ca. 2300–1600 B.C.) are most probably connected with gathering of the plant. *Stipa* grains are edible and the whole plant could have been used as insulation, for making mattresses and for a range of similar purposes. Nowadays spikelets of *Stipa* are used for decoration. They are dangerous to herbivores because of the sharpness of the basal part of the spikelet and the tendency of the awns to unroll in wet conditions. Already in the first half of the 20th century the plant was regarded as a weed of meadows. The gathering and use of *Stipa*, as suggested by the abundance of its archaeological macroremains, was most probably prompted by changes in the local environment. These latter arose from intensive human activity, mostly deforestation and grazing by domestic animals, leading to the formation of steppe-like vegetation. This process is documented by a pollen diagram from a peat section located near the Vliněves site.

Keywords Stipa · Gathering · Neolithic and Bronze Age · Czech Republic and Poland

Introduction

The main aim of this research is an interpretation of archaeological finds of *Stipa* macrofossil remains against a background of past environment and economy. Several finds of carbonised grains and awns of feather grass (*Stipa pennata* or *Stipa* sp.) suggest it had an important role in the life of prehistoric settlers. Its abundance at the epi-Palaeolithic Near Eastern site of Abu Hureyra (Hillman 2000) was explained in terms of its use as a gathered edible plant. The gathering of feather grass in Europe during the Neolithic has been suggested by several authors (e.g. Kreuz 1990; Bakels 1992), but primarily for decorative purposes. Bieniek (2002) postulated the use of its grains for food in the Kujawy region during the Middle Neolithic Lengyel culture (ca. 4400–4000 B.C.). The new find of *Stipa* grains and awns preserved in a storage pit dated to the Únětice culture (the Early Bronze Age, ca. 2300–1600 B.C.) at Vliněves in the Czech Republic is important for further interpretations of their possible use. It demonstrates the major role of *Stipa* in the environment and the economy of prehistoric settlers occupying dry territories of Europe, where the precipitation was probably not higher than 500 mm per year.

Both the aggregate species *Stipa pennata* s.l. and *Stipa capillata* grow in steppe-like communities. They prefer sunny, dry places on oligotrophic, non-acid soils. Their distribution is associated with a continental climate (Pontic-Pannonian region). Most probably they have an Irano-Turanian origin (Pawłowska 1972, pp 194–195). According to Ceynowa-Giełdon (1976 and cited literature), during the Pleistocene several species of *Stipa* migrated across Europe via several routes. Probably before the last glaciation, they reached Polish territory from the south, through the Moravian Gate. At the end of the last glacial period, *Stipa* species and other steppe elements again migrated from the south in the same way, also arriving from southeastern territories via the Podole route. After the retreat of the ice, a new route opened up from the west through the Toruń-Eberswald proglacial stream valley allowing immigration of some of the *Stipa* species and subspecies growing nowadays in northern Poland. The southern and western migration routes crossed in the Kujawy region (Ceynowa-Giełdon 1976, pp 68–73).

On the basis of the discontinuous range of *Stipa pennata* s.l. in northern Poland (Zarzycki and Kaźmiercza-

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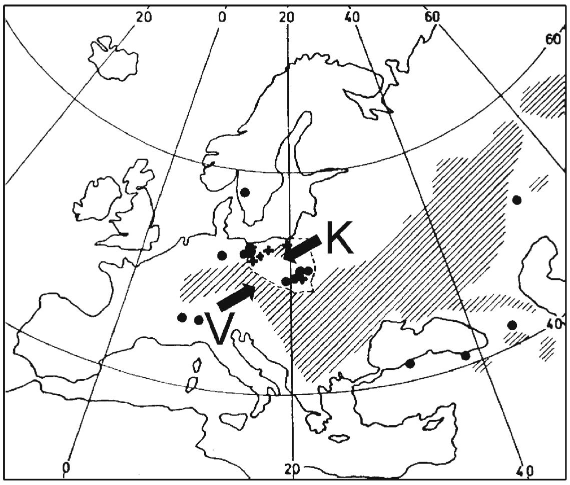

Fig. 1 Location of sites mentioned in the text against the background of the modern distribution of *Stipa joannis* (after Zarzycki and Kaźmierczakowa 1993), K—Kujawy region, V—Central Bohemia, Vliněves

kowa 1993), it could be supposed that the Holocene migration of the grass was caused or aided by prehistoric man (Bieniek 2002; Ceynowa-Giełdon 1976 and pers. comm.). The activities of early Neolithic farmers caused deforestation and this was most probably a very important factor in the development of a steppe-like vegetation outside its continuous range and remote from its refuges. It has been pointed out that open-habitat communities like heaths and arid grasslands appeared in Europe as the result of human activity (Behre 2000). Nevertheless the possibility of natural Holocene migration of *Stipa* species should also be taken into account because the plants can be easily spread by animals (zoochory) or can be transported along slopes of river valleys where open communities must have existed.

The study areas

Two study areas with finds of *Stipa* macroremains were selected for this research: The Central Bohemian lowland within the Czech republic and the Kujawy region within Poland. As described below, both areas have close parallels in terms of climate, soils and vegetation. Their position is shown in Fig. 1.

Central Bohemia (the lowland part of the Czech Republic with the capital Prague at its centre) is a region of high environmental diversity. Diverse geological and soil conditions and a long history of human impact have resulted in a specific pattern of contrasting biotopes and high regional biological richness. Due to its position between important centres of biogeographical distribution (Slavík 1980), the study area can be regarded as lying at the crossroads of the Central European biota. Plant diversity is also promoted by the existence of several different geological substrates within a relatively small area. They vary from serpentinite to acidic sandstone and from erosion-resistant quartzite to easily eroded marl. The effects of bedrock quality are sometimes negated by the superposition of unconsolidated Quaternary sediments, the most important of which are gravel river terraces and extensive loess deposits of variable thickness (Ložek 1980; Kunský 1968). The climate of the region is warm to moderately warm, moderately dry with a mean annual temperature of 8.0–8.8°C and a mean annual precipitation of about 460 mm (Rybníčková and Rybníček 1996, p 475).

As for human occupation, the study area represents one of the principal Central European settlement areas. According to the results of landscape archaeological investigations, settlement has been dense and continuous at many sites for at least the past 7000 years, i.e. since the Early Neolithic (Kuna 1998). Human influence on the Central Bohemian landscape was thus long and intensive, so that separation of "the natural" and "the secondary" in present and past ecosystems is highly problematic, or even impossible. Nevertheless, it is supposed that the virgin vegetation would have included mainly subxerophilous, thermophilous and xerothermic oak forests, oak/hornbeam forests and floodplain forests (Rybníčková and Rybníček 1996, pp 475–476).

The first palynological data in the area arose from the investigations of Losert (1940a, b), who described in detail the Late-Glacial and Early Holocene vegetation development from two sites adjacent to the middle course of the Labe River. The later research of Pacltová and Hubená (1994) and Břízová (1995, 1997, 1999) concentrated on the middle Labe River alluvium and resulted in a relatively comprehensive picture of the floodplain vegetation history for most of the Holocene. However, the landscape outside large river floodplains remains virtually unstudied by these methods. There is a short and regrettably only preliminary study by Butler (1993) from the loess plateau where xerothermic habitats occur.

The Kujawy region is located in central Poland (Fig. 1). It is the driest part of the country, with an annual precipitation of less than 500 mm (Kondracki 2000, p 138; Szafer 1972, p 47), and has some patches of steppe-like vegetation and halophytes (Szafer 1972, pp 44–50, 68–71). The mean annual temperature is 7.6–8.1 °C and the natural vegetation is mainly comprised of mixed deciduous woodlands (Ralska-Jasiewiczowa and Latałowa 1996, p 445). The region was under ice during the last glacial period. In the 6th millennium B.C. it was probably warmer and relatively drier in Central and Eastern Europe than today (Ralska-Jasiewiczowa and Starkel 1999, p 177; Starkel 1995, p 38). The study area is covered mainly with black earth and brown or grey-brown podzolic soils (Dobrzański et al. 1972). It was occupied by early Danubian farmers from the beginning of the Neolithic, meaning in this part of Poland from about 6670±70 B.P., 5650–5480 B.C. (Nalepka 2002/2003, p 17). In the Atlantic period the area was covered by mesophilous deciduous mixed forests comprised of *Quercus*, *Tilia*, *Ulmus*, *Fraxinus* and *Corylus*. Pollen diagrams covering this period show the appearance of pollen grains of cereals

Saturday, 13. 9. 2008
Iron Age hillfort in western Bohemia

Special exhibition about Vladař site in the Loket castle (by *P. Zahradníček*).

Vladař (by *P. Pokorný*)
Environmental archaeology of an Iron Age hill-fort.

Accommodation in Prague.

Vladař is an exciting example of a large Iron Age hillfort that is recently studied by archaeologists. As waterlogged sites are present in the area of this prehistoric monument, detailed palaeoecological investigations were possible (by Petr Pokorný and colleagues). Especially an Early La-Téne cistern for water storage, situated in the middle of acropolis, appeared a good source of information.

Numbers on the map:

1 – Bus stop and examination of prehistoric defense systems.

2 – Preserved wooden construction from Early Iron Age.

3 – Acropolis of the hillfort with studied water cistern. Panoramic views to the surroundings.

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ORIGINAL ARTICLE

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Insight into the environment of a pre-Roman Iron Age hillfort at Vladař, Czech Republic, using a multi-proxy approach

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Abstract The large fortified hilltop site of Vladař, northwest Bohemia, Czech Republic (50°05′N, 13°13′E), has recently been studied intensively by way of environmental archaeology, in which palaeoecological methods have played a crucial role. The latter include the analyses of pollen, green algae, Cladocera, other microfossils, plant macro-remains (including charcoal and wood) and chemical composition, carried out on the wet sediments from an artificial cistern/pond situated in the middle of the large citadel, supplemented by charcoal and wood analysis on material from dry situations. The continuous palaeoecological record consists of well-preserved biological remains and covers the period from ca. 400 B.C. to recent times. The chronology is primarily based on radiocarbon dating, supplemented by archaeological finds. The main focus is on the La Tène period of the Iron Age. During the early to middle La Tène the hillfort had a considerable number of permanent inhabitants and woodland was almost completely replaced by an agricultural landscape. The site became partly abandoned by the end of the 3rd century B.C. and completely abandoned around the birth of Christ, after which it reverted to natural woodland communities.

Keywords Pollen analysis · Plant macro-remains · Cladocera · Land-use history · La Tène · Bohemia

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Introduction

In central Europe, a number of fortified hilltop sites dating to the late Hallstatt/early La Tène period have been found. The hillfort at Vladař, situated in the northwest Czech Republic (Fig. 1), represents an impressive example (Fig. 2). Archaeological investigations of the fortifications and of dry cultural layers on its citadel have only recently been undertaken. The results show that this extensive fortified site of 115 ha has had a long and complex history. The oldest fortification is dated to the middle Bronze Age (Table 1). During the 6th and 5th centuries B.C. the fortifications significantly expanded, most probably to a total length of 18 km – this is what is seen today as the remnants of the walls. The finding of a bronze fragment of a *pyxis* of Mediterranean origin, a luxury artefact, indicates that the hillfort was an important link for inter-regional trade during this period. At that time, a network of nobility centres had developed over most of Europe (Herrmann 2002; Krause 2002; Stöllner 2002; Tomedi 2002), some of them in the Czech Republic (Chytráček 2002; Chytráček and Metlička 2004). The importance of the Vladař hillfort in this network probably resided in the fact that rich gold-extracting areas existed in the vicinity.

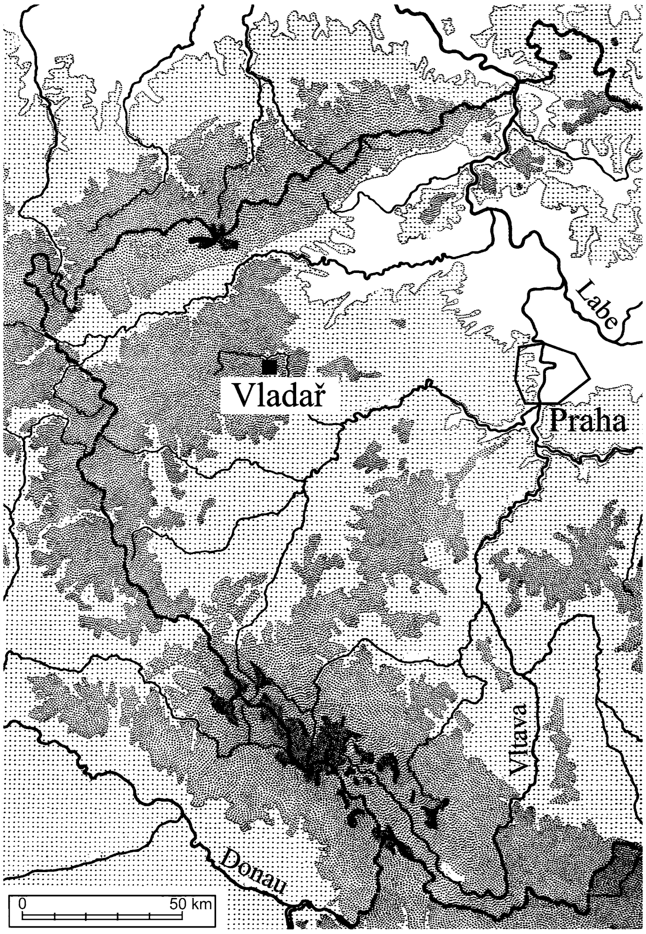


Fig. 1 The location of the Vladař hillfort in the northern rim of the western Bohemian Basin in the western Czech Republic. Thick lines are country boundaries. The basin has been densely inhabited during the Hallstatt and early La Tène periods, and several hilltops were fortified. Vladař, one of the most spectacular hill-forts of that time, had a strategic position at the transition to an important settlement area in the lowlands of northern Bohemia

There can be no doubt that the settlement area of such an extensive hillfort contained all the essential units of a prehistoric cultural landscape: a central settlement, associated villages in the vicinity (proven by surface artefact studies), agricultural land (fields, fallow, pastures, and meadows), transitional zones of woodlands which were managed for grazing, bedding, and coppicing, and probably forest of a more or less natural composition and structure, and areas for production, burial, ritual, and assembly. The exact geographical locations of these units would certainly have followed certain rules, but unfortunately this cannot be reconstructed with palaeoecological methods, which only provide information on the presence of some of them within a certain landscape (different types of woods, pastures, fields, and settlements).

The hillfort at Vladař offers ideal conditions for modern palaeoenvironmental research, thanks to a rather exceptional combination of archaeological and palaeoecological evidence. In addition to the usual ecofacts such as carbonized wood or plant diaspores found in dry situations, a cistern, ca. $50 \times 30\ m^2$, which had been dug out for use as a water reservoir, and in which peat sediments had been deposited, lay in the middle of the large citadel plateau (Fig. 2). This site has been studied intensively using a multi-proxy approach, in order to increase the probability of a correct interpretation by cross-checking different data sources. The goal of this study is to answer the following questions:

a. What was the settlement chronology? A key to this is radiocarbon dating combined with archaeological chronology. All the palaeoecological methods used have contributed to the results. The environmental data from the cistern deposits have the major advantage above the purely archaeological findings in that they cover more aspects of the environment and all historical periods, including those with only little or no occupation.
b. What was the character of human activities at the hillfort? Did the use of the site differ with time? Here, pollen and wood analyses are the most important. The comparison of charred woods from dry situations and waterlogged woods from wet situations enables a more detailed reconstruction of the use of timber and firewood than is usually possible. The changes in the pollen assemblages reflect changes in human impact on the site and its surroundings with respect to secondary woodland composition, use of crops, intensity of pasture, and the appearance of settlement areas such as the presence of intensively trampled sites or organic waste deposits. The analysis of plant macrofossils also sheds light on the vegetation around the cistern and in its direct vicinity. The settlement activities must have had an effect on the quality of water in the reservoir. Combined analyses of chemical elements, algal remains, and Cladocera enable us to follow the changes in water contamination, while trace elements are used to detect ore smelting within the site or the transport of volatile metals through the atmosphere during smelting (Veselý 2000a).
c. What happened at the site after it was abandoned? The collected material offers insights into the events connected with the abandonment and destruction of the prehistoric settlement, and the biological succession which should eventually lead to climax communities consisting of natural biological communities in equilibrium with the site conditions. The latter is important not only for theoretical archaeology, but also for general ecology, as it offers a view on natural succession processes that last too long to be studied by direct observation.

Material and methods

The cistern at Vladař is today almost fully terrestrialised and has deposits up to three metres deep. First, sediment cores were taken in two vertical transects. They show a fine and visually differentiated stratigraphy, which made correlations between individual profiles possible. Next, a trench was dug down to the bottom at 2.75 m below the present surface in the central part of the cistern. A complete

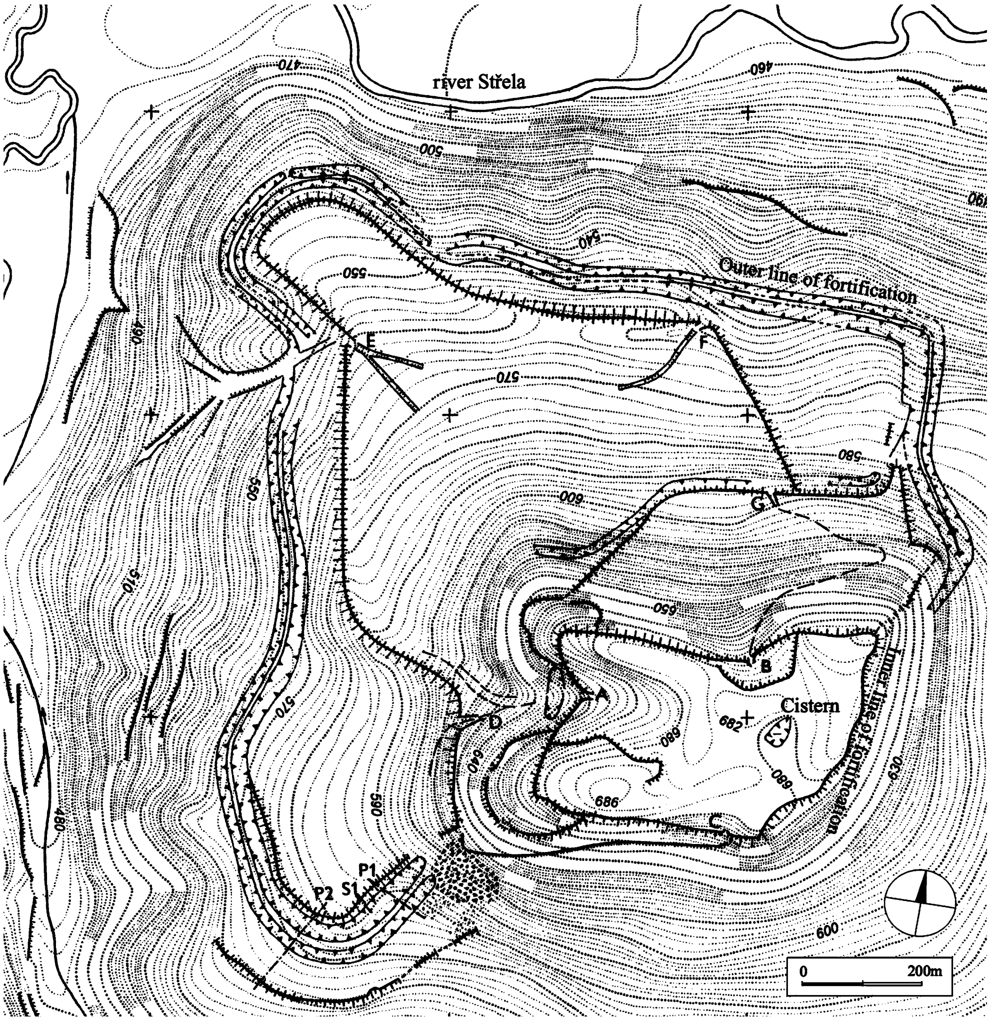


Fig. 2 Vladař hillfort situation plan. It lies 50°05′N 13°13′E, 680 m a.s.l. Letters A–G refer to individual gates. Outer line of fortification is composed of ramparts and walls, while the inner line of walls only

Table 1 AMS radiocarbon dates at the hillfort Vladař; C: cistern; No. 21.9: second latest construction phase of the fortification; No. ZA60: earliest construction phase of the fortification

Sample	Dated material	Lab. code	^{14}C age (B.P.)	Cal age (1σ range) and probability (%)
102 cm (C)	*Carex* fruits	Poz-2321	1195 ± 25	A.D. 805–885 (60.9)
145 cm (C)	*Picea abies* needles	Poz-2323	1630 ± 30	A.D. 380–440 (51.3)
176 cm (C)	*Carex* fruits	Poz-2324	1920 ± 25	A.D. 95–130 (34.5)
				A.D. 60–90 (33.7)
210 cm (C)	*Carex* fruits	Poz-2325	2225 ± 30	320–200 B.C. (61.1)
240 cm (C)	*Carex* fruits	Poz-2327	2175 ± 30	360–290 B.C. (37.1)
				240–170 B.C. (31.1)
265 cm (C)	*Pinus* twig	Poz-2328	2245 ± 35	300–230 B.C. (38.2)
				390–350 B.C. (25.7)
No. 21.9	Charcoal (burnt construction wood)	Poz-9841	2375 ± 35	520–390 B.C. (68.2)
ZA 60	Charcoal (burnt construction wood)	Poz-6180	3355 ± 35	1690–1600 B.C. (59.2)
				1560–1530 B.C. (9.0)

profile was taken from this spot, and sub-sampled later for the various analyses. Due to the wet conditions this yielded a wide range of well-preserved organic remains. Only bones were in a poor state due to the acid environment. Pottery fragments and stones were present in significant quantities.

The sub-samples for pollen analysis were treated by acetolysis after pre-treatment by cold, concentrated HF for 10 h. Usually more than 900 pollen grains were counted per sub-sample. The pollen diagrams are based on a total terrestrial pollen sum (AP + NAP = 100%) (Figs. 3–6). The percentages of aquatic taxa and all non-pollen objects are related to this sum. Pollen nomenclature follows the list of the Alpine Palynological Database (ALPADABA; housed at the Institute of Plant Sciences, Bern), slightly

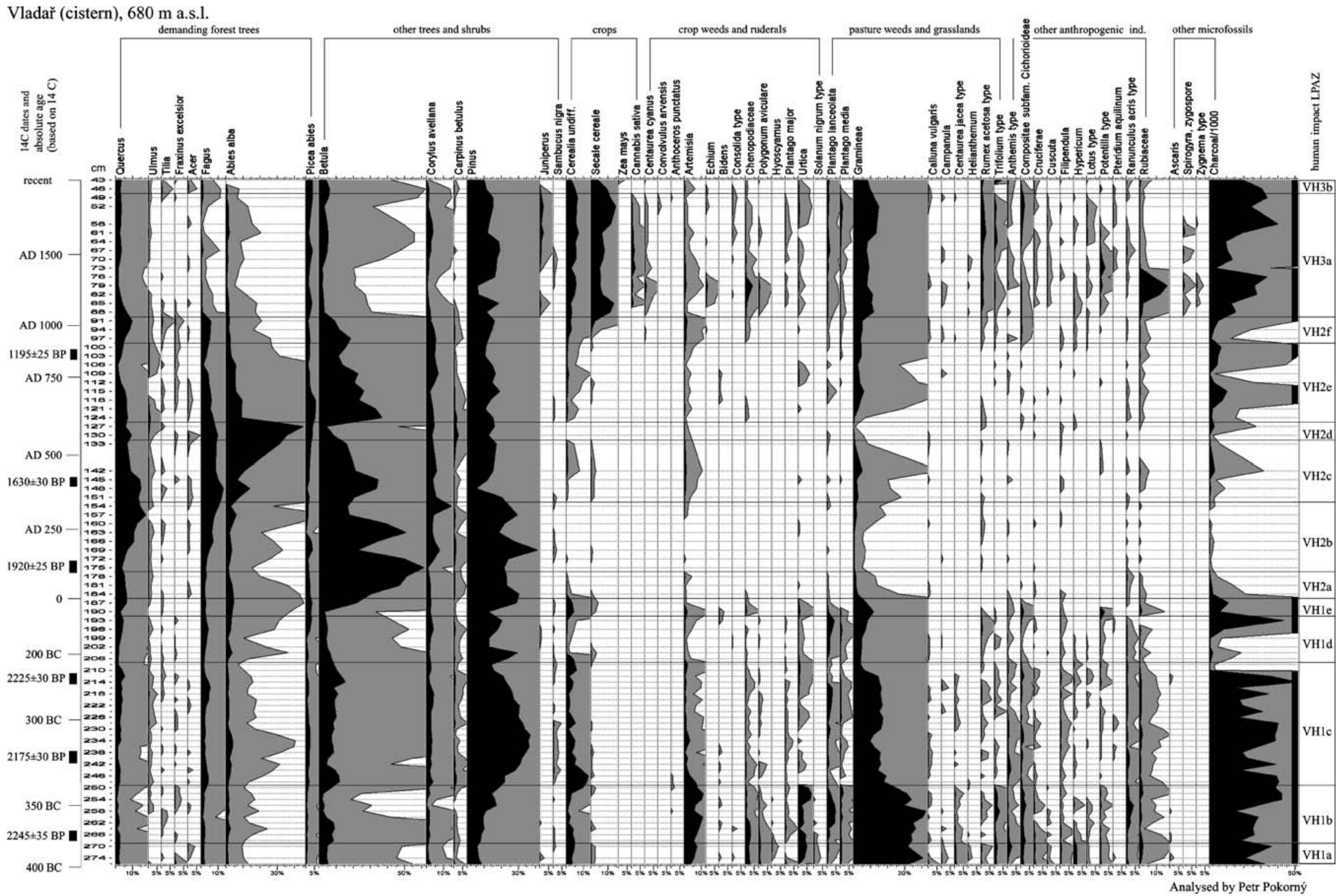


Fig. 3 Percentage human impact pollen diagram from the cistern deposits at Vladař containing selected upland pollen taxa, classified into ecological groups. Percentages are shown in black; a 10 × exaggerated scale is in grey

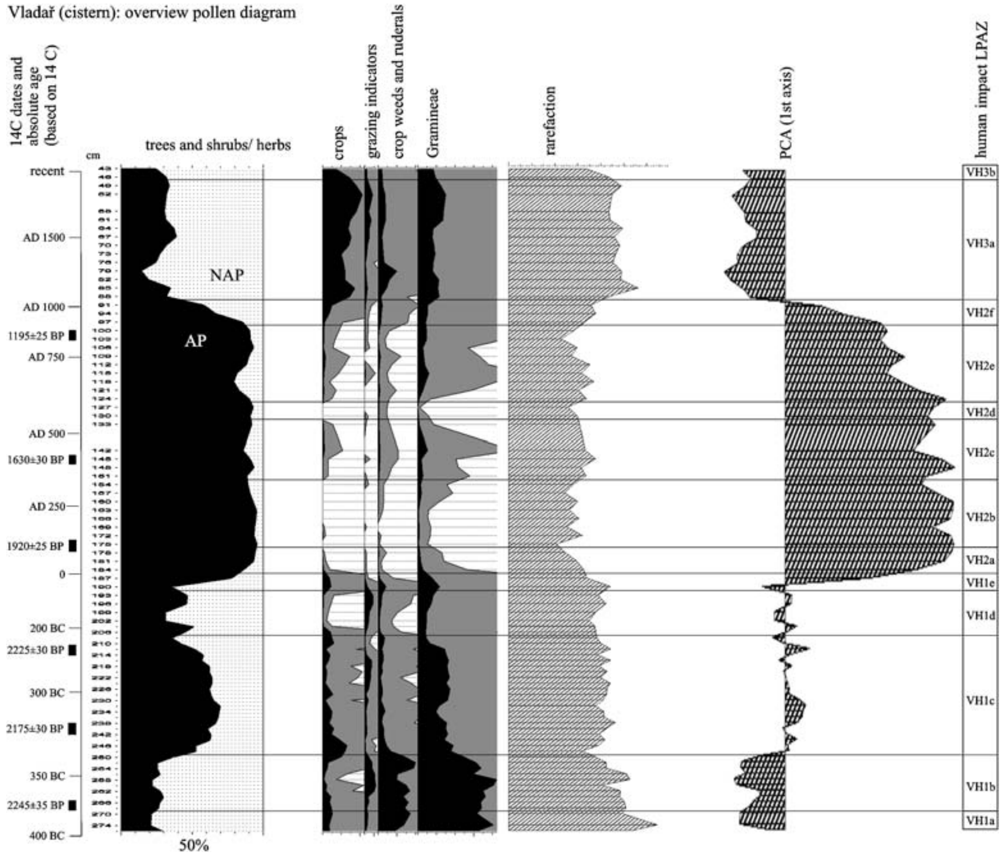


Fig. 4 Summary percentage pollen diagram of the cistern deposits at Vladař with the results of numerical analyses

adapted to the local flora. The key of Beug (2004) was the main source for pollen identification. *Plantago media* and *Plantago major* were separated by consulting pollen reference slides; problematic pollen grains were classified as *Plantago major* type. For calculating the data and drawing the pollen diagrams the POLPAL program (Walanusz and Nalepka 1999) was used. The pollen data were statistically tested using Constrained Single-Link Cluster Analysis, Rarefaction Analysis (Birks et al. 1988), and multivariate statistics PCA. The results were used as the basis for the pollen diagram zonation. Individual local pollen analytical zones (LPAZ) reflect the main features of local human impact history.

Analysis of Cladocera was performed according to the standard technique given by Frey (1986). The diagram shows numbers per cm^3 subsample (total count; Fig. 7). Samples from telmatic phases of the cistern deposits contained no material (see gaps in the diagram).

The total content of the major inorganic compounds and selected trace metals were determined by flame atomic absorption spectroscopy (FAAS) after digestion with HNO_3, $HClO_4$, and HF; results are in Fig. 8. Analyses were performed at the Institute of Geology, Czech Academy of Sciences, Prague.

The cistern deposits yielded abundant plant macroremains. In addition, archaeobotanical samples from dry excavations were taken from 2004 onwards. All wet and dry samples were wet sieved over 1, 0.7, and 0.2 mm meshes. Plant diaspores and vegetative parts (except wood–see below) were then picked out under a dissecting microscope. The results are presented as numbers per 250 ml of sediment (Fig. 9).

Wood remains from the cistern deposits were collected and treated as follows. First, one half of the trench was dug down to the bottom. Only worked wood, for example with cutting marks, was kept. The second half of the trench was then excavated in layers of 5 cm thickness (called "layer samples" in Table 2 and Fig. 10), and every piece of wood, twig, and branch was collected. All wood was studied in the layers from the time of digging out of the cistern in the 4th century B.C. (bottom) to approximately 200 B.C. (208 cm), when the first intensive occupation of the Iron Age hill fort came to an end. A total of 828 pieces of wood has been described, measured, and identified, according to Schweingruber (1990) and Grosser (1977).

The wood material from the dry excavation site on the hillfort plateau, 120 m northwest of the cistern, included only carbonized remains. Twenty two samples (between 0.65 and 14.5 l) were taken from different archaeological features dated to the late Hallstatt/early La Tène Periods such as postholes, pits, and fireplaces. In addition, all charcoal was collected during the excavation (230 samples). Although these samples are not of quantitative value to determine the consumption of firewood and timber, they can show which taxa were selected and for what purpose. For this study we use the preliminary results of 88 charcoal samples (525 pieces, up to the size of ca. 0.05 cm^3).

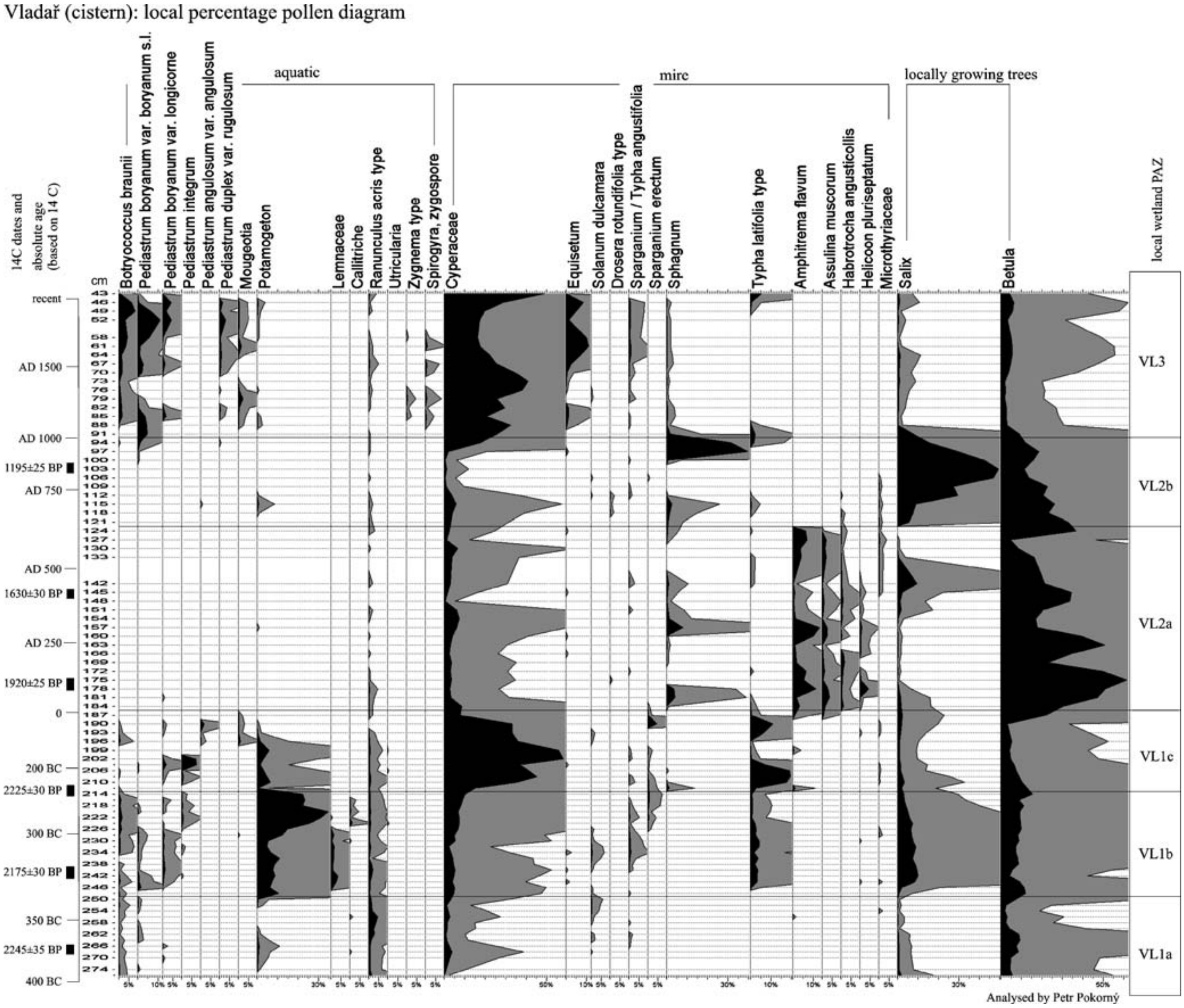


Fig. 5 Local percentage pollen diagram of the cistern deposits at Vladař containing selected wetland taxa and non-pollen micro-remains of aquatic organisms

Six AMS radiocarbon dates were obtained from the cistern deposits, and two from a section through the fortification. All measurements were performed in the Radiocarbon Laboratory at Poznań, Poland. The radiocarbon dates were calibrated using OxCal 3.5 (Table 1). The ages of the sediment layers were determined by linear interpolation between horizons with calibrated radiocarbon dates.

Results and discussion

Stratigraphy and chronology of the cistern deposits

The cistern was without doubt man-made in order to collect rainwater. It is tub-shaped with steep sides and a flat bottom sunk into the basalt bedrock. The sediment stratigraphy is best observed in the collected profile (Fig. 11). Just above the base of the profile there was a layer of broken basaltic stones from bedrock and rounded silica pebbles most probably brought in from the nearby river. In this layer and directly above it were fragments of pottery and pieces of worked wood. A thin but well-defined layer of carbonized plant macro-remains (mainly chaff) 11 cm above the base included burnt husks of grain and weed seeds. This may suggest some sort of initiation ceremony, but further evidence is lacking. A distinct layer of greyish clay lies at 208–210 cm between the lake sediment and the peat deposits. The layer of tree trunks and branches between ca. 205 and 115 cm had no artefacts or any other indirect traces of human activity (such as eroded clay material or thrown-in stones present in other layers). Above it was peat with a substantial amount of clay and stones, which upwards graded into sedge peat.

The pottery fragments in the cistern profile include two main groups, dated to the early La Tène (LTA2) in the deepest part and the later La Tène (LTB2/C1–D) in contact with the clay layer at 208–210 cm. The archaeologically

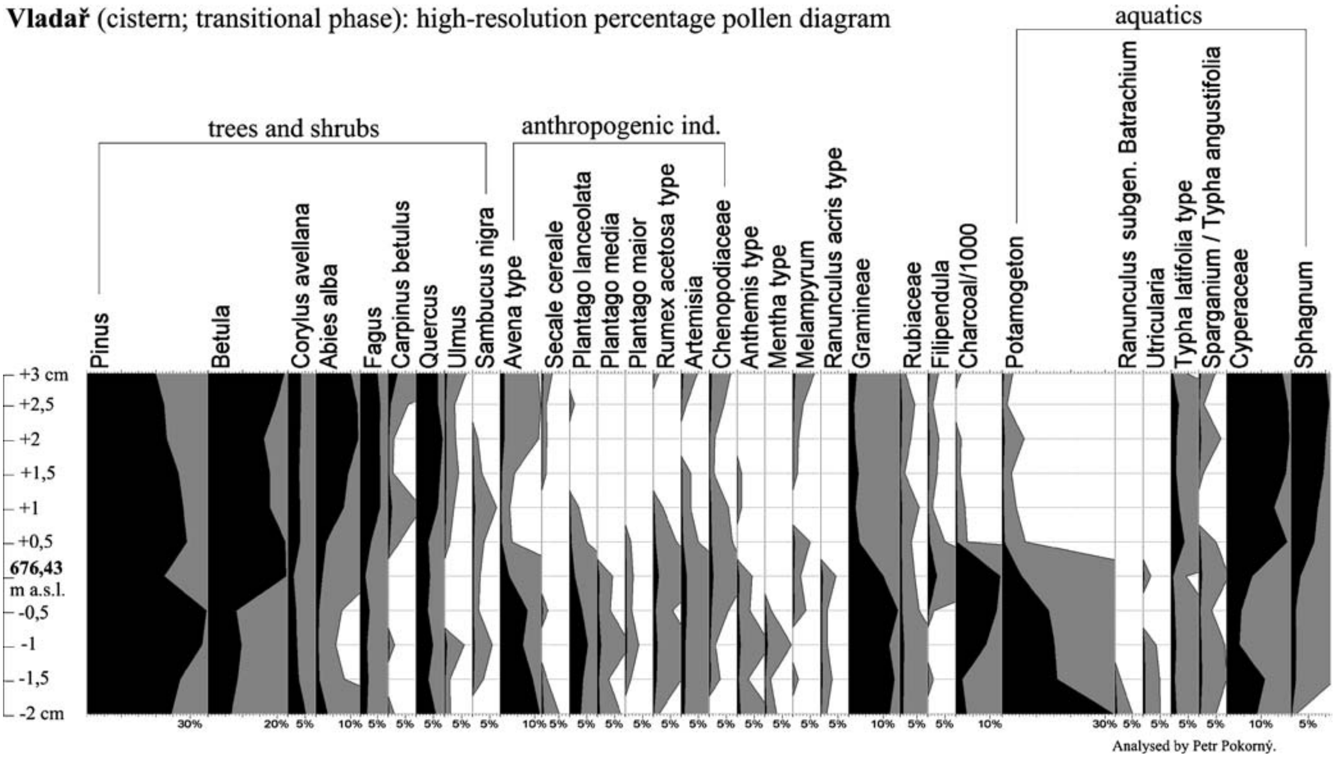
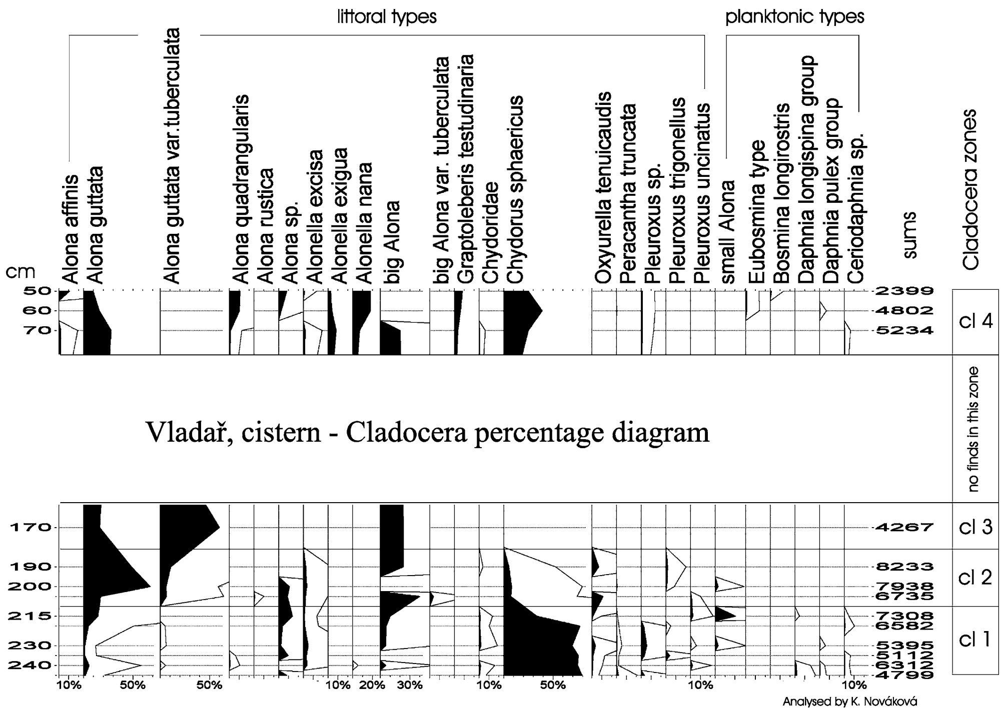


Fig. 6 High resolution pollen diagram from the cistern deposits at Vladař of a transitional period associated with a clay layer (208 cm). On the vertical sample axis, distances from the clay layer are indicated

Fig. 7 Percentage diagram of Cladocera species found in sediments from the cistern at Vladař. Between 80 and 160 cm and between 255 and 275 cm no Cladocera were found. Analyst: K. Nováková



derived ages of the two pottery layers are in agreement with the sediment ages determined by radiocarbon, taking into account the statistical and methodological errors. The radiocarbon dates, which are older at 210 cm than at 240 cm, are not necessarily erroneous, but may be the result of a radiocarbon plateau (Bradley 1999). This is supported by the calibrated ages of the two dates, which are in correct stratigraphic order if we accept the later calibrated interval for the date at 240 cm.

Human impact is classified in five distinct periods on the basis of fluctuations in anthropogenic pollen indicators (Figs. 3 and 4), which correlate well with the development

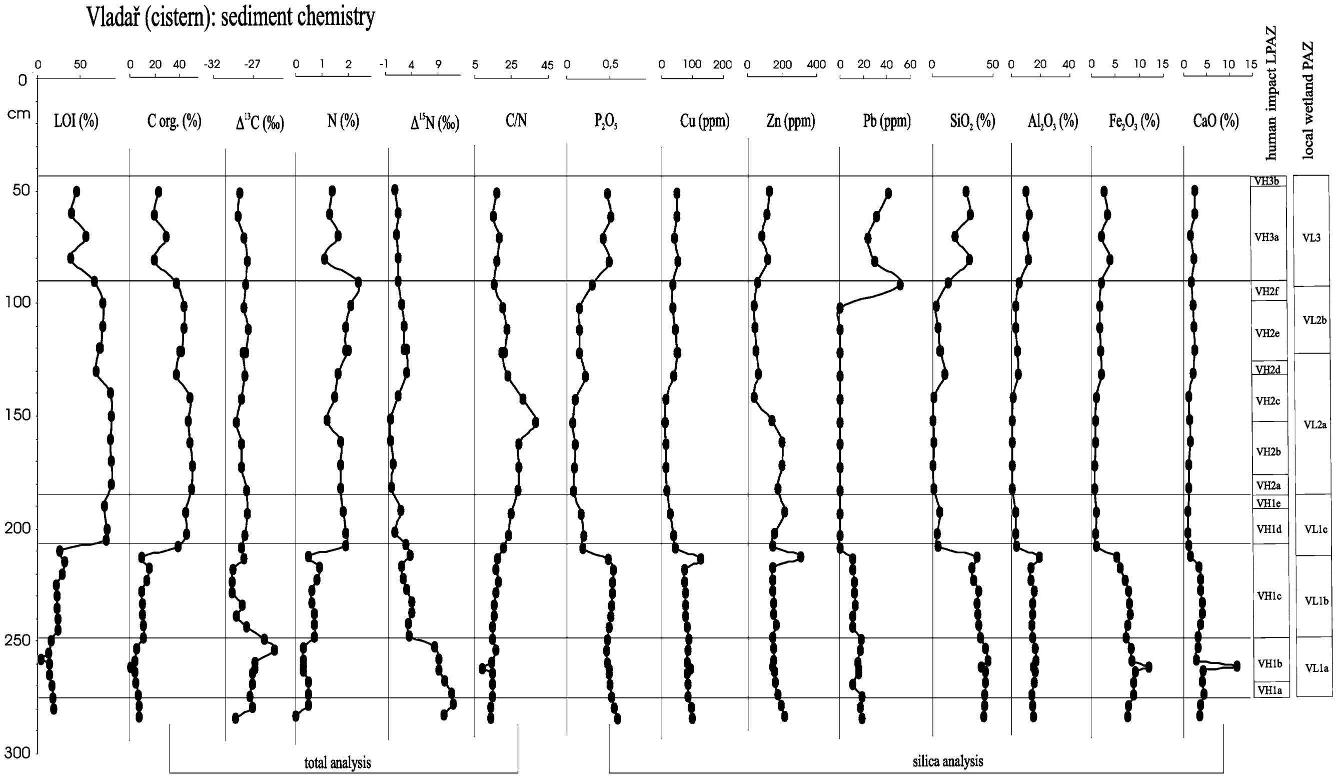


Fig. 8 Selected results of chemical analyses from the cistern deposits at Vladař. The pollen zonation is displayed on the right side. Analyst: J. Veselý

of local wetland vegetation (Figs. 5 and 6), fluctuations in Cladocera (Fig. 7), and the chemical composition of the sediments (Fig. 8). The periods are as follows:

1. Ca. 400 to 1 B.C. (human-impact pollen zones VH1a–VH1e), characterized by initially considerable human impact and its gradual decline, ending in the sudden abandonment of the hillfort. This is the La Tène period, discussed in detail in the following section.
2. Ca. A.D. 1 to 570 (human-impact pollen zones VH2a–VH2d). After the sudden abandonment of the hillfort at the start of the Christian era, it may be expected that the surrounding landscape also became uninhabited. All anthropogenic indicators decrease dramatically together with ecologically less indicative herb species, with a corresponding increase in tree pollen and tree macrofossils. The hillfort plateau obviously became overgrown by woodland, first *Pinus sylvestris* (pine) and *Betula pendula* agg. (birch) which are fast growing trees colonizing abandoned settlements, pastures, and fields, then *Corylus avellana* (hazel), and finally *Fagus sylvatica* (beech), *Quercus* (oak), *Abies alba* (fir), and *Picea abies* (spruce). The final phase of this period is characterized by a climax community with mainly fir, beech, and oak. Altogether, this succession took about 500 years. The development of dense forest had an impact on the hydrological regime, as the soil became drier because of increased evapo-transpiration. The reforestation thus resulted in lowering of the water level in the reservoir, which slowly turned into fen with sedges and later *Salix* cf. *cinerea*/*aurita* (willow) and birch trees. Conifer branches, needles, and cones (fir, spruce, and pine) from trees growing in the mire's vicinity became buried in the deposits. The peat is completely devoid of Cladocera and algae, which excludes the likelihood of even small patches of open water.
3. Ca. A.D. 570–1050 (human-impact pollen zones VH2e and VH2f). During the 6th century, humans slowly started reversing the natural forest development. This is shown by a slight decline in the pollen of most trees and increased presence of anthropogenic pollen indicators (mainly cereals) and some ecologically indifferent, light-demanding herbs such as Gramineae. Increased microscopic charcoal at the beginning of this period reflects the renewed human activities. Compared to the previous La Tène period, human impact is however very low. The decreasing trend of *Abies alba* pollen indicates some selective tree felling on the hilltop and its slopes, and *Betula* probably invaded the clearings. We infer that there were settlements only in the surrounding areas whereas the former hillfort served for off-site agricultural activities such as tree felling. At the end of this period, the sediments show slightly increased levels of lead, which may be best ascribed to the expansion of silver smelting in the Czech lands or in Germany (Veselý 2000b).
4. Ca. A.D. 1050 to sub-recent (human-impact pollen zone VH3a). Intense changes in the appearance of the Vladař hill, and doubtless also of the surrounding landscape, date back to the 11th century. Extensive woodland clear-

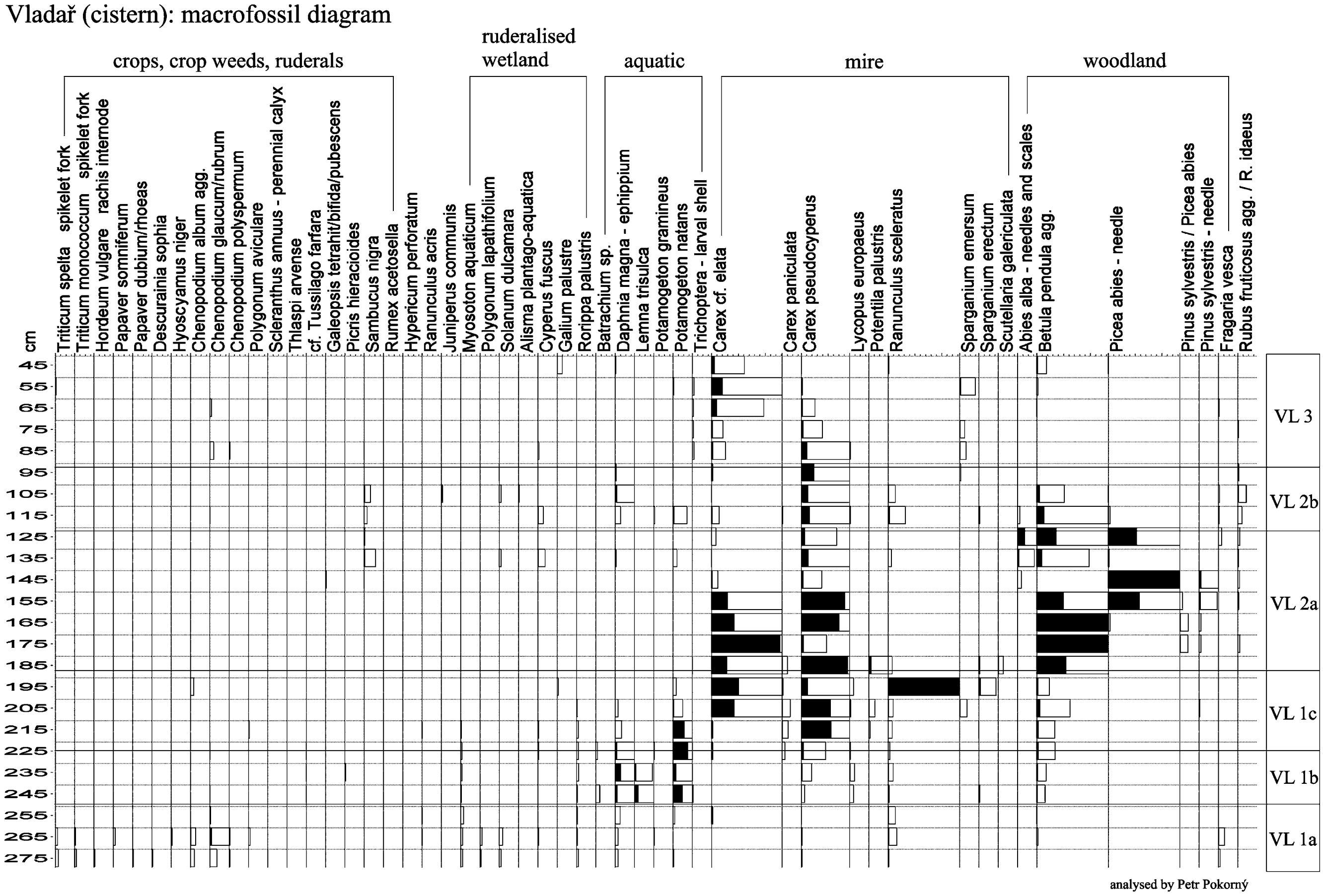


Fig. 9 Results of plant macrofossil analyses from the cistern deposits at Vladař (selected taxa only). Absolute counts are given. If not stated differently, individual finds represent diaspores (seeds and fruits). A 10 times exaggerated scale is drawn as empty histograms

ance took place and the landscape was changed into a mosaic of fields, fallow land, pastures, and meadows. This process is the typical development during the onset of the high medieval period for most of the territory of the Czech Republic. As a result of deforestation of the Vladař hilltop, the hydrology changed and permanent open water re-appeared in the cistern. *Cannabis sativa* (hemp) and *Secale cereale* (rye) pollen dominated for the first time amongst the field crops; previously, in the pre-Roman period rye appeared probably only as a weed among other cereals (Behre 1992). Also, *Centaurea cyanus* (cornflower) appeared for the first time, a segetal weed typical of the high medieval period. The high intensity of farming on the Vladař plateau can also be demonstrated by the water quality in the cistern. Indicative of polluted water are the algae *Spirogyra* and *Zygnema* type and the Cladocera *Bosmina coregoni*, *Bosmina longirostris*, and *Alonella exigua*, the latter three characteristic of waters with increased nutrient input (Szeroczynska 2002). During the high medieval period the water became much more polluted than in the La Tène period. This may partly be due to the smaller volume of water in the reservoir during the Middle Ages.

5. The latest period (human-impact pollen zone VH3b; the surface pollen sample) witnessed a decline in human activities at the hillfort. The abundance of many indicators of anthropogenic activities (including cereal pollen) is reduced, whilst *Zea mays* (maize) pollen appears, a crop of modern times. The changes in the composition of forest trees are also noticeable, corresponding with the present-day spread of woodland over the hill top and slopes as a result of discontinued management.

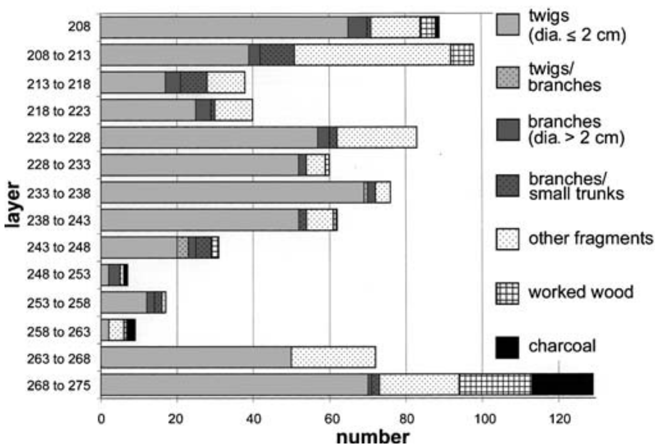


Fig. 10 Different types of wooden objects from the 5 cm thick layers of the cistern deposits at Vladař. Analyst: N. Boenke

Table 2 Species composition and number of wood finds from the 5 cm thick layers of the cistern deposits at Vladař (757 pieces of wood in 14 samples)

Layer/samples (cm)	208	208–213	213–218	218–223	223–228	228–233	233–238	238–243	243–248	248–253	253–258	258–263	263–268	268–275
Abies alba	6	1		1										4
Pinus sylvestris/mugo	5	7	2				1	2	1	2	4		2	1
cf. *Pinus sylvestris/mugo*	3		1				1							1
Picea/Larix	1													
Larix/Picea														1
Coniferous wood	2	3									1	1	1	5
Salix sp.	27	11	1	5	3	26	42	66	55	69	25	19	20	23
cf. *Salix* sp.													4	
Salix/Populus	1		1				12			4	2			
Alnus sp.	4	5							1		1			
Corylus avellana	9	4						2		1		10	1	
Betula pendula/pubescens	15	4		10		1				6	1	1	40	27
cf. *Betula pendula/pubescens*				1										
Fagus sylvatica		1						2						
Fraxinus excelsior												1	6	
Pomoideae	2					1					2			
Quercus sp.	1	7												
Rosa sp.													5	
Viscum album	1										2			
cf. *Viscum album*		1							1				1	4
Leafwood	14	24	1		3		5	4	1	1	2	6	12	13
Indet.	3	4				1								5
Total number	94	72	6	17	6	29	61	76	59	83	40	38	92	84

Activities at the hillfort connected with settlement and agriculture during the La Tène period

The development of settlement during the La Tène period (recorded between ca. 400 and 1 B.C.) was far from sustainable. The earliest phase until about 340 B.C. is characterized by a strong human influence due to a large number of permanent dwellers at the hillfort and extensive reduction in woodland. The next phase begins with a sudden decrease in anthropogenic indicators, despite the probably still intensive character of occupation shown by still rather significant anthropogenic pollen indicators. The fortification at Vladař ceased to exist, most probably due to a big fire, as shown by basaltic stones melted to a glassy mass and blocks of slagged gravel at the base of the destroyed fortification. The clay layer in the cistern deposits at 208–210 cm might be connected to the increased erosion following this fire. It is dated to the period just before 200 B.C. and has markedly elevated contents of mercury (prior to the fire probably bound in organic matter) and zinc with copper bound in mineral matter. High-resolution pollen analysis around the level of the clay layer (Fig. 6) shows very clearly a temporary period of abandonment and the recovery of the natural communities shortly after the event. The declining occupation of the hillfort is also recorded in the chemical composition of the cistern deposits as an increase of autochthonous organic or organically bound matter and a decrease of elements connected with erosion as well as reduced sedimentation rates. All this supports the possibility of a destructive fire.

Anthropogenic pollen indicators in the early and middle La Tène period (pollen zones VH1a, VH1b) indicate a similar or even higher human impact than in the high medieval period (zone VH3a) or modern times (zone VH3b). This strong impact can be explained by a sizeable number of permanent inhabitants on the hillfort who were involved in intensive agriculture directly around the study site. The pollen and macrofossil indicators of ruderal plants such as *Polygonum aviculare* and *Plantago major* show the close proximity of human dwellings and trampled areas. Weeds such as Chenopodiaceae, *Chenopodium* spp., *Urtica, Artemisia*, and *Hyoscyamus niger* indicate waste deposits causing soil eutrophication. The quality of the water in the reservoir decreased due to the input of waste, resulting in a nutrient-rich wetland vegetation (Fig. 9: "ruderalised wetland"). The eutrophication of the water by animal and human excrements, for example, is shown by a higher P_2O_5/C ratio and the anomalously high concentration of the nitrogen isotope N^{15} (Fig. 8). In pollen analyses of similar sediments elsewhere, eggs of human and animal parasites such as *Trichuris trichiura* and *Ascaris* are rather abundant, which were found by Břízová (1997) and Pokorný (2005) in palaeochannels of the middle river Labe where Iron Age and early medieval settlements were present in the vicinity. In the La Tène layers of the investigated cistern, no more than three eggs of *Ascaris* (thread-worm) have been found so far. Considering the close proximity of the source of the parasites, these low numbers suggest that the cistern was deliberately kept

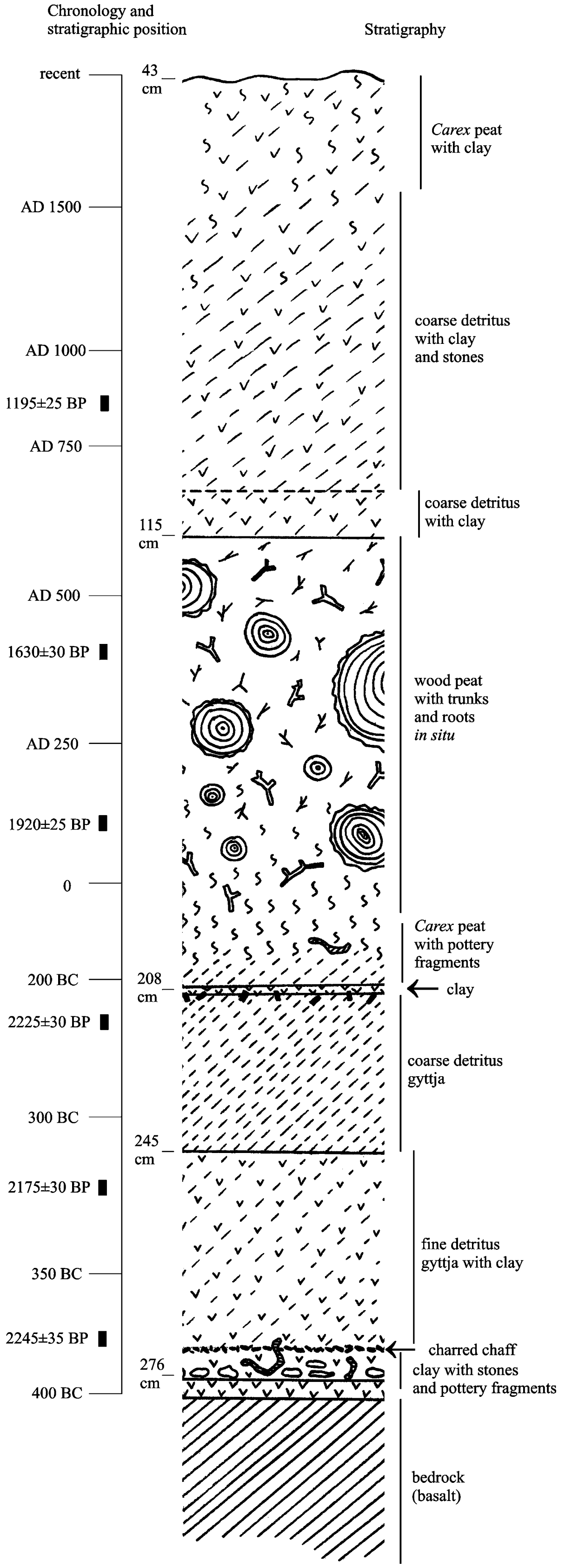


Fig. 11 Stratigraphy of the studied profile in the centre of the cistern at Vladař. Depths are measured from the actual water level. Drawn lines between sediment layers indicate abrupt transitions, dashed lines indicate more gradual transitions

clean and free of a massive input of faecal matter. This evidence of clean water is supported by the Cladocera (Fig. 7), as species of highly polluted waters are absent.

Macro-remains of cultivated plants were found mainly in the layer of carbonized material at 265 cm, including *Triticum spelta*, *T. monococcum*, *Hordeum vulgare*, and *Papaver somniferum*, the latter among the oldest records from within the Czech Republic. It is, however, questionable whether these crops were cultivated at the hillfort itself; transport from fields further away is more likely. The great abundance of cleistogamous cereal pollen proves that the harvest was threshed locally.

The abundance of pollen indicators of meadows and pastures (Figs. 3 and 4) indicates with high probability that large numbers of livestock were grazing at the hillfort and in its closest vicinity. The simplified pollen diagram (Fig. 12) shows the remarkable phenomenon that the trend for arable crops (sum of Cerealia pollen types) is to a great extent the inverse of the main pasture indicators. This suggests an alternation of different farming strategies, with periods with predominant grazing and periods of higher proportions of arable crops. From about 400 B.C. to A.D. 1, four periods with mainly crop indicators and three with more grazing indicators have been distinguished, each lasting about 50 years. Possible explanations are changes in climate, a soil exhaustion/regeneration cycle, alternating arable and pasture land in order to reduce specific weeds, and changes in society customs and needs (which are however hard to detect).

A rather untraditional view of some landscape details, shortly after 400 B.C., is offered by the pollen analysis of a piece of animal excrement (probably from horse) found at the base of the cistern deposits (at 270 cm; shown in Table 3). The pollen was mainly from grasses and herbs. Notable are pollen of *Centaurea jacea* type, Rubiaceae, and *Hypericum perforatum* type. This most likely represents *C. jacea*, *Galium album/verum*, and *H. perforatum/maculatum*, which thrive on meadows with low management intensity and on grassy fallow land where intensive but short-term disturbance (grazing, mowing, trampling, or burning) alternates with long periods of no intervention, characterized by slow overgrowing by tall herbs. Similar but wetter conditions are favoured by *Lychnis flos-cuculi* on meadows and the tall herbs *Cuscuta europaea*, Cyperaceae, *Filipendula*, and *Valeriana* growing in unmanaged woodland margins and close to rivers. Contrasting ecologically are *Plantago lanceolata*, *P. media*, *Melampyrum*, and *Rhinanthus*, taxa of lower-growing and drier grasslands exposed to grazing, mowing, or trampling, whereas *Calluna vulgaris* grows in similar but more oligotrophic conditions. The *Artemisia* pollen can indicate either dry pastures (*A. campestris*) or grazing on fallow land and along the ruderalised margins of paths (*A. vulgaris* and *A. absinthium*). No indications were found for grazing within woods, as the occurrence of pollen of woodland plants was very sporadic with alder being the most abundant. The fodder probably originated from a wide variety of biotopes, structural types of vegetation stands, and management practices. July/August seems the most likely period of dung deposition.

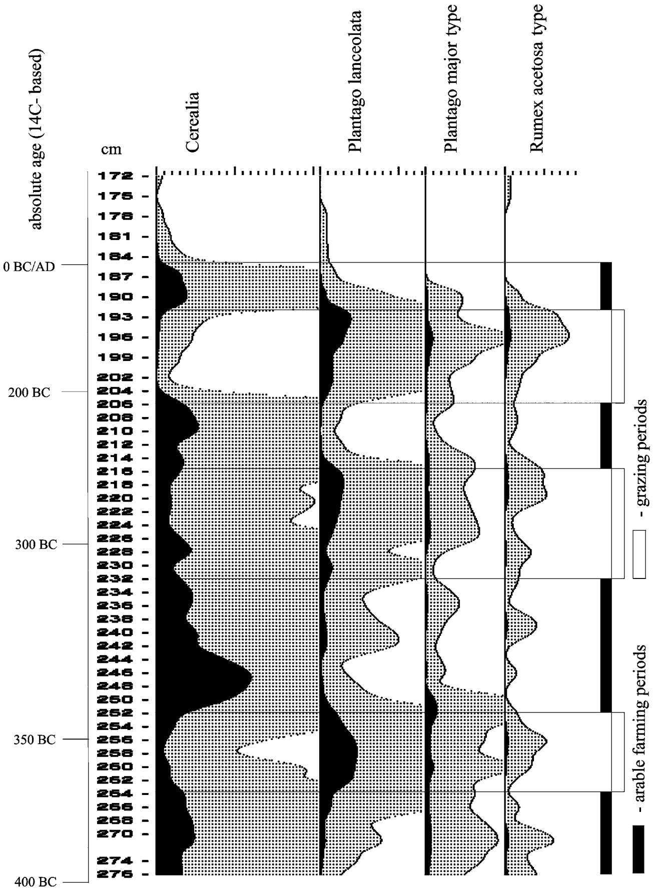


Fig. 12 Interpretation percentage pollen diagram from the cistern deposits at Vladař showing opposed trends between cereals and grazing indicators

Based on the results from pollen analyses of the dung, one can conclude that the grassland vegetation in the middle La Tène period did not differ substantially from the present one, especially with regard to grassland biotopes at stages close to being replaced by shrubs and trees. In contrast to the 19th and beginning of the 20th centuries when there was intensive land-use with all meadows regularly mown and pastures systematically used, in the Middle Ages and early modern times there were typically extensive pastures, which at the hillfort at Vladař led to the common occurrence of *Juniperus communis*. The scarcity of juniper pollen during the La Tène period could have been due to frequent cutting of juniper for medicinal or ritual purposes. The large area of extensively used pasture during the La Tène period may be explained from an economic viewpoint. Whilst from the high medieval period onward land became a scarce commodity and was thus intensively exploited, prehistoric people faced the problem that land was in abundance but it was necessary to keep it open with a minimum of effort. The clearing of trees and shrubs took much energy, and yet it might have been a question of strategy and prestige to keep the area around the hillfort open. Grazing might have been one of most efficient ways of doing this.

Table 3 Results of pollen analysis of animal excrement found in the cistern (position 270 cm)

Taxon	%
Abies alba	0.39
Alnus	2.06
Betula	0.51
Corylus avellana	1.16
Pinus	1.93
Aethusa type	0.26
Anthemis type	2.70
Artemisia	0.13
Calluna vulgaris	0.13
Campanula	0.64
Caryophyllaceae, Silenoideae type	0.26
Centaurea jacea type	18.12
Compositae, Cichorioideae	1.16
Cuscuta europaea type	1.41
Cyperaceae	1.03
Filipendula	2.83
Gramineae	52.57
Hordeum type	0.39
Hypericum perforatum type	0.39
Labiatae	0.77
Lychnis flos-cuculi	1.29
Melampyrum	1.03
Mentha type	0.90
Pimpinella major type	0.77
Plantago lanceolata	0.13
Plantago media	0.13
Ranunculus acris type	0.77
Rhinanthus	0.90
Rubiaceae	2.44
Rumex acetosa type	0.26
Trifolium pratense type	0.13
Valeriana officinalis type	0.51
Veronica	0.39
Vicia type	0.13
Undetermined	1.41

The total pollen count is 775 grains; AP + NAP = 100%

Intensive grazing and human activities resulted in an almost complete removal of woodland from the Vladař hill and large surrounding areas. This is shown by the very low tree/herb pollen ratio with an AP/NAP around 4:6 (Fig. 4). The extent of loss of woodland during the La Tène period is comparable with that in the high medieval period, as well as with that of modern times as illustrated by pollen analytical results. The dominant tree was *Pinus*, which became established on poor soils disturbed by grazing, in pastures, and grazed woods. Also important in the woodland remnants were *Quercus*, *Abies* and *Fagus*. Timber from all trees was used for the construction of the fortifications, which however started much earlier, in the middle Bronze Age according to the radiocarbon dating of the oldest parts of the fortifications (ca. 1600 B.C.; Table 1). The carbonized beams found in the cross-section through

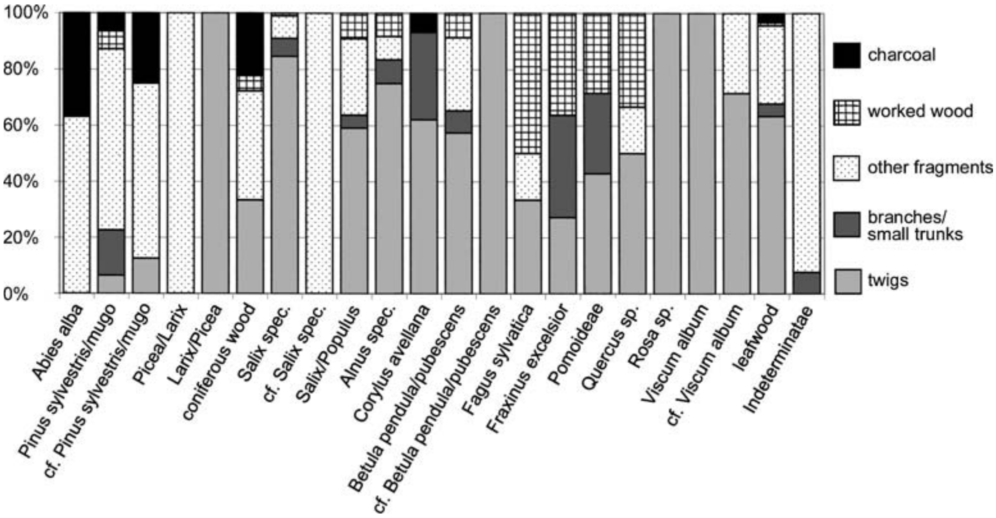


Fig. 13 Percentage of the different taxa found as wood fragments in the 5 cm thick layers from the cistern deposits at Vladař. Analyst: N. Boenke

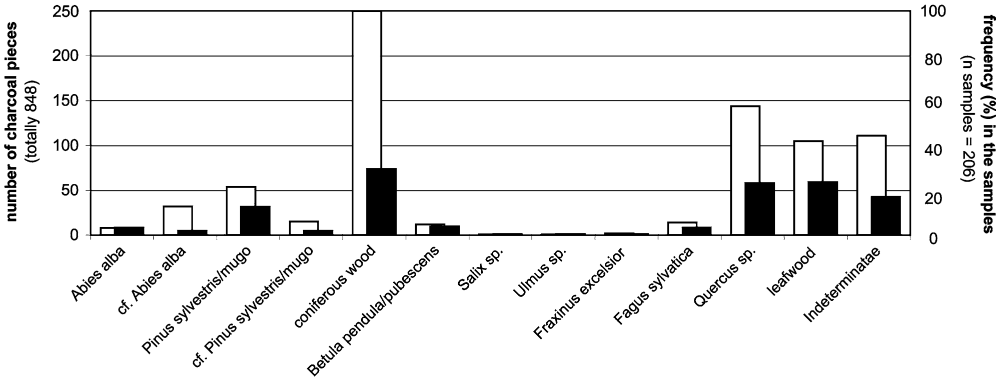


Fig. 14 Charcoal from the dry settlement layers dated to the early La Tène period. Analyst: N. Boenke

the fortifications are *Quercus* (31 cases), *Abies* (10), *Pinus* (7), and *Fagus* (1). Similar results were obtained for the fortifications of the hillforts of Svržno and Štítary in western Bohemia (Pokorný 2004). For the Hallstatt period (between ca. 800 and 500 B.C.) they yielded oak (Svržno 68%; Štítary 63%), fir (Svržno 25%; Štítary 4%), and pine (Svržno 2%; Štítary 18%).

The comprehensive analysis of wood from the cistern and the dry settlement layers of the hillfort plateau show a good correspondence with the pollen results. Many trees from the natural woodlands of the region, like *Pinus sylvestris/mugo* from drier sites, *Abies alba*, *Fagus sylvatica*, and *Fraxinus excelsior* (ash) from richer soils, and *Quercus* sp. are represented in the cistern (Table 2; Pokorný 2002, 2004). Wet areas are represented by *Alnus* sp. (alder). The dominant and therefore locally growing taxa were *Salix* spp. and *Betula pendula/pubescens*, which also today indicate local woodland in the process of recovery. Other taxa found as wood in the cistern are *Picea/Larix* (spruce/larch), *Viscum album* (mistletoe), Pomoideae (crab-apple etc.), *Corylus avellana* and *Rosa* spp. (rose). The last three were only sporadic. As their nuts and fruits are common foodstuffs, it is likely that they were allowed to grow in the settled area as small trees, bushes, or in hedges.

Viscum album macrofossils are rather frequent in the bottom layers of the cistern (Table 2). Mistletoe may have therefore grown on locally present trees, for the presence of isolated trees within the settlement and near the cistern cannot be excluded on the basis of the available palaeoecological data. Alternatively, mistletoe might have been collected as winter fodder for domestic cattle, a practice for which there is some evidence from Neolithic times (K.-E. Behre, personal communication). Otherwise, its occurrence in the cistern could be the result of some ritual practice; for the Iron Age Celts, for example, mistletoe was sacred and of ritual use, according to Pliny. This importance is also shown by several decorations in Celtic art (Frey 1996; Herrmann 1997). In our opinion, the origin of *Viscum album* wood is most likely to be local.

The majority of the wood finds in the cistern were small twigs, tiny branches, and other fresh and small pieces (Fig. 10). In addition, some charcoal and worked wooden objects occurred. But even inconspicuous objects like these can tell us something about the human activities in the surroundings of the cistern. The minor representation of larger wooden pieces, whether they be rubbish or of natural origin, show us that the people tried to keep the cistern clean. Only small pieces easily spread by the wind reached the cistern, among which *Salix* twigs were absolutely dominant. Willow found favourable conditions for growing at the damp edges of the basin, especially during periods of settlement decline. Worked *Salix* wood fragments indicate that the willows had been cut from time to time (Fig. 13). Several reasons could be given for this: to avoid the overgrowth of the cistern by tall shrubs or trees, and/or to use the willow for basketry or wickerwork. The twigs could have been used for leaf fodder as well. It is interesting that in the oldest sediments willow wood and even twigs occur in the sediments, while at the same time *Salix* pollen is relatively scarce. An intensive use of the willow trees in this period might have reduced their ability to flower (the twigs are normally cut every year).

Looking at Table 2 and Figs. 10 and 13, we observe a correspondence between the occurrence of worked wood and the diversity of the wood spectrum. The reason is the selection of special trees for different uses in the settlement. Fig. 13 shows that only certain of the trees dominate in worked wood. *Quercus*, as an excellent building timber, was used for the construction of the walls of the hillfort. In Iron Age times the straight-growing coniferous trees were also used for timber (Lobisser 2005). *Fraxinus* and *Fagus* are good for tool handles, for example (Schweingruber 1976; Boenke 2005). *Fagus* is also one of the best firewoods. But not only do the good properties of a timber contribute towards its use, its availability also does. At Vladař, for example, coniferous wood of *Abies alba* and *Pinus sylvestris/mugo* dominates the charred material from the cistern as well as from the dry settlement layers (Figs. 13 and 14). Another possible explanation for the large amount of charred coniferous wood could be burned timber, either unintentionally by a destructive fire, or by secondary use of timber and waste wood as fuel.

Large amounts of wood are necessary for such activities as charcoal production, ore smelting, and metalworking. Chemical analysis of the water reservoir sediments did not indicate ore smelting at the Vladař hillfort, which should have been accompanied by increased levels of trace elements, especially lead, but they were not found. A low background pollution caused by atmospheric transport, as was for example found in the Šumava (Bohemian Forest) lakes in the same period (Veselý 2000a), was not observed either. This might be the result of a higher background variability (derived from the bedrock) in the sedimentary record at the Vladař site.

Conclusions

1. The results of the palaeoecological analyses depict the Vladař hillfort as an important regional population centre during the early and middle La Tène period (from ca. 400 to 340 B.C.). The hillfort must have been settled by a substantial number of permanent inhabitants.
2. The hillfort was in this period surrounded by a varied landscape, characterized by a mosaic of pasture and arable land. Grazing played an important role in the economy and in keeping the settlement area mainly free of woodland.
3. We assume that from around 200 B.C. the hill of Vladař was only scarcely inhabited. Shortly after the beginning of the Christian era the site was abandoned completely, being beyond the edge of the settled region of that time. After the abandonment, the succession to natural woodland communities took about 500 years.
4. In the 11th century a new phase of colonisation reached the region. Although the former hillfort must have been recognized as such in the Middle Ages because of the considerable remnants of the fortifications, it was not settled again and was only used for grazing and fields.

More palaeoenvironmental research at the Vladař site will be undertaken during the coming years, with among other things more attention to the archaeobotany of the dry settlement layers.

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