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A charcoal record of Holocene woodland succession from sandstone rock shelters of North Bohemia (Czech Republic)

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ABSTRACT

Archaeological excavations at North-Bohemian sandstone rock shelters have uncovered complex evidence of intermittent human presence since the Late Palaeolithic to recent times. In this paper, we investigate the history of Holocene woodlands based on charcoal assemblages from stratified sandy accumulations under archaeologically investigated rock shelters. In total, we carried out anthracological analyses of eight profiles excavated under rock shelters.

Our study shows that the number of charcoal taxa correlated with local environmental diversity around the rock shelters. Charcoals of *Pinus sylvestris* were abundant in all the profiles analysed. Profiles in bottom parts of valleys recorded a higher abundance of broadleaf tree charcoal. The abundance of oak gradually decreased from the Bronze Age onwards, as oak got replaced by pine, and locally beech, fir and spruce. Today, several of the recorded woody species are rare or even absent in the sandstone region under study.

We focused on comparing anthracological results with results of pollen analyses carried out in the same areas. Our results demonstrate that when results from different types of archives are compared, it is possible to gain a more differentiated insight into local vegetation composition. This may carry wide methodological implications.

1. Introduction

Late Quaternary vegetation and palaeoenvironmental studies have traditionally been based on interpreting pollen data. This can, however, lead to distorted results due to the complexity of the pollen-vegetation relationship. Pollen profiles are usually situated in wetlands, although the matrix of surrounding vegetation is composed of terrestrial habitats. A more realistic view of past vegetation changes can be obtained by combining data resulting from analyses of pollen, macrofossils (seeds and fruits) and charcoal (e.g. Ritchie, 1995; Birks and Birks, 2004; Nelle et al., 2010). Macrofossil and charcoal analyses provide information about local vegetation, which may not necessarily correspond to pollen records, as already pointed out by Couvert (1968). Past vegetation and tree species composition at terrestrial sites over centuries and millennia can more reliably be reconstructed based on soil charcoal, that is, by performing pedoanthracological analyses (e.g. Clark et al., 1998; Blackford, 2000; Robin et al., 2012; Nelle et al., 2013).

Vegetation reconstructions from charcoal data obtained from archaeological layers are usually based on the assumption that these data are not seriously biased by intentional selection during wood collection or by post-depositional transformation processes. The first serious attempts to perform such reconstructions were made in the 1940s (Salisbury and Jane, 1940). Criticisms of the basic assumptions of such reconstructions followed soon (Godwin and Transley, 1941), and discussions have been ongoing ever since. Whereas collecting firewood is generally considered to be mostly non-selective, collecting and felling wood for specialized production (e.g. metallurgy or carpentry), funerary customs or house building is obviously highly selective (Marston, 2009; Théry-Parisot et al., 2010; Rubiales et al., 2011 and others). Samples containing selectively collected wood are generally assumed to be characterized by reduced species composition (e.g. Novák et al., 2012a). On the other hand, people probably obtained firewood from woody

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species growing near archaeological sites (Shackleton and Prins, 1992; Jansen et al., 2013).

Continual or long-term charcoal records from European archaeological sites are still infrequent, and each new locality provides new perspectives. Some of the best examples of sites with a potential for such investigations are caves and rock shelters with long-term or repeated human presence (e.g. Badal et al., 1994; Heinz and Barbaza, 1998; Henry et al., 2012). In this regard, North-Bohemian Cretaceous sandstone areas seem to be quite unique in the Central European context. Rock shelters are a characteristic geomorphological formation of sandstone regions (Fig. 7). In many cases, the stratigraphy of deep sandy sediments has been preserved intact under rock shelters. Sandy accumulations under rock shelters are generally formed in a specific way. Most of the sandy sediment comes from the sandstone rocks above. Biological (e.g., earth worm bioturbation; e.g. Jégou et al., 1998; Preston and Schmidt, 2006) and physical factors (e.g., uprooting; Samonil et al., 2010) are frequently discussed as influences which significantly affect the deposition of charcoals in soil. However, the dry and acidic sandy sediments under rock shelters are usually less strongly affected by biological factors than common soil horizons. Nevertheless, charcoal records in accumulations of sediment probably result from a very complex process of charcoal formation, recording and preservation (Forbes et al., 2006; Fréjaville et al., 2013).

Archaeological investigations show that rock shelters of the study region (North Bohemia) were widely used as temporary retreats by hunters and gatherers since the Late Palaeolithic until recently (e.g. Svoboda, 2003; Svoboda et al., 2007; Šída and Prostředník, 2007; Svoboda, 2014). Repeated visits of rock shelters over decades, centuries and even millennia are an important aspect of hunter-gatherer land use (e.g. Smith and McNees, 2011). Former fireplaces are one of the visible traces of their repeated visits. Plant macroremains, bones, chipped tools and ceramics have been found besides charcoal pieces in sediment layers (e.g. Svoboda et al., 2013).

The first systematic archaeological investigation of Bohemian sandstone rock shelters was carried out approximately 20 years ago (Svoboda, 2003). Some anthracological and macrofossil research of sandstone rock shelters has been carried out (e.g. Opravil, 2003; Svoboda et al., 2007), but few samples of charcoal or plant macroremains have been systematically collected and examined.

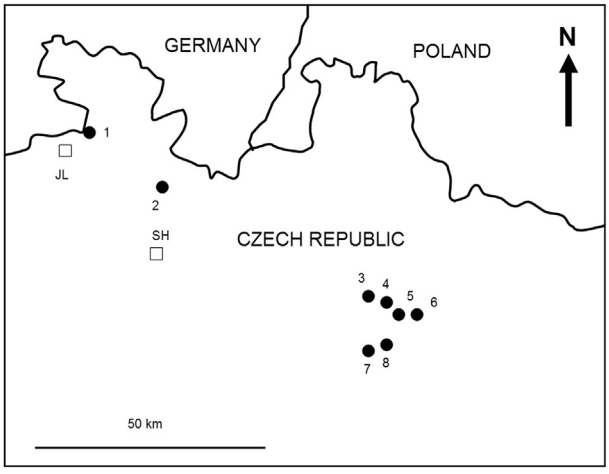

Fig. 1. Location of the study area and sites of anthracological profiles: 1 – Janova zátoka, 2 – Údolí samoty, 3 – Dvojitá brána, 4 – Konejlova cave, 5 – Velbloud, 6 – Kristova cave, 7 – Věžák, 8 – Hlavatá skála; and pollen profiles: JL – Jelení louže, SH – Skřítkův hrnec.

Palaeoecological studies from sandstone areas in Central Europe have so far been mainly based on pollen analyses (e.g. Jankovská, 1992; Kuneš and Jankovská, 2000; Pokorný and Kuneš, 2005; Kuneš et al., 2007). Here we present the results of the first systematic anthracological survey of eight rock shelter profiles coupled with pollen-analytical investigations. The main goals of this paper are to: (1) determine the history of local forests, (2) draw attention to the relationship between the dynamics of local vegetation and adjacent environmental conditions, (3) compare anthracological results with results of pollen analyses carried out in the same areas, and (4) investigate the human impact on local vegetation.

2. Study areas

The North-Bohemian Cretaceous sandstone area is one of the largest sandstone landscapes in Europe (Härtel et al., 2007). It comprises several neighbouring sandstone sub-regions. For our study, we selected three (Bohemian Switzerland, Lužické hory and the Bohemian Paradise; Fig. 1) because these are the only ones where data-bearing systematic archaeological investigations took place in the last decade or so. Our set of study areas is characterized by the presence of rocky sandstone hummocks and rock shelters, flat or gently sloped tablelands, sunken valleys, and sporadic volcanic hills (Demek, 1987). Valleys with steep rocky slopes and humid gorges represent only a small part of the landscape. There are only a few watercourses within the sandstone areas, so the lack of water always significantly influenced human presence and activities. Humans often visited rock shelters located near water sources, though settlements have also been discovered under rock shelters situated in upper parts of valleys (Svoboda et al., 2013). Most of the investigated territory is situated 200–400 m above sea level, but several volcanic hills rise above 500 m.a.s.l.

According to soil maps of the Czech Republic (Němeček et al., 2008; soil taxonomical units according to; Michéli et al., 2007), arenosols, lithosols, podzols, cambisols, luvisols and fluvisols are the most common soils on the sandstone bedrock in the area, which is now predominantly forested. Bottoms of slopes and valleys are characterized by the presence of luvisols, cambisols and fluvisols. Arenosols, lithosols and podzols are typical for upper parts of slopes and places near rocks.

The recent forests in the area are mostly composed of *Pinus sylvestris* and *Picea abies*. Also common are *Fagus sylvatica*, *Betula pendula*, *Quercus petraea* and *Quercus robur*. Xerophilous pine forests (un. *Dicrano-Pinion*, with e.g. *Avenella flexuosa*, *Calluna vulgaris*, *Festuca ovina*, *Rumex acetosella* and *Cladonia* sp.) are typical habitats in upper parts of slopes. Today's presence of *Fagus* is often connected with bottoms of slopes or valleys. *Picea* is also more frequent at valley bottoms, but it mostly occurs there due to coniferous plantations. *Quercus* sp. and *Corylus avellana* is admixed in all types of habitats, but their abundance is slightly higher at bottoms of valleys and slopes. *Carpinus betulus* and demanding broadleaf trees (*Tilia* sp., *Acer* sp., *Fraxinus excelsior* and *Ulmus* sp.) occur infrequently at bottoms of slopes and valleys. The rare presence of *Alnus* sp. and *Salix* sp. is restricted to watercourses and springs. Microclimatically inverse stands are characterized by oreophytic indicators (e.g. *Blechnum spicant*, *Homogyne alpina*, *Huperzia selago*, *Petasites albus*, *Viola biflora*).

According to the Archaeological Database of Bohemia (Kuna, 2002), the study area borders with an agricultural landscape dotted with sites of ancient settlement from the Late Palaeolithic (14,000–11,500 cal BP), Mesolithic (11,500–7500 cal BP), Neolithic (7500–6000 cal BP), Late Neolithic (6000–4000 cal BP), Bronze Age (4000–2800 cal BP), Hallstatt (2800–2400 cal BP), La-Tène (2400–2000 cal BP) and Roman periods (2000–1650 cal BP).