

Holocene of the Bohemian Karst

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ABSTRACT. The Bohemian Karst is rich in postglacial depositional sequences containing molluscan and vertebrate faunas. These occur in cave and rockshelter fills, colluvial sediments and tufas, and show a succession which is comparable with that of vegetation stages. In most of sites, it is possible to correlate the paleozoological evidence with the development of sediments and soils, and in a number of cases also with archaeological findings. Of prime importance is the fact that the fossiliferous sites are situated over a wide range of habitats, which enables the full series of local paleohabitats to be reconstructed. The results which are based on a dense network of zoostratigraphically treated sites provide a new insight in the postglacial history of a warm-dry area where plants remains are very rare or absent.

KEY WORDS: Holocene, warm-dry karstland, Mollusca, Vertebrata, sediments, soils, prehistoric settlement.

Introduction

The Bohemian Karst is situated in central Bohemia southwest of Prague. It is built of Silurian and Devonian limestones which include complexes of shales and basic volcanics. Folded Paleozoic rocks form an undulated peneplain dissected by deep valleys at elevations 190–499 m. The local climate is warm and dry with mean annual temperatures 8–9 °C and 480–530 mm rainfall. Oak-hornbeam woodland with numerous xerothermic *Quercus pubescens*-*Cornus mas* stands on south-facing slopes is dominating. The driest places are characterized by open karst steppes whereas beech stands are confined to shady slopes with deeper soil cover. North-facing rocks bear dealpine *Sesleria* grasslands with *Saxifraga paniculata*. This mosaic of a wide variety of habitats supports the high biodiversity of the area in question. It is obvious from the foregoing that the environments of the Bohemian Karst differ considerably from those which provided the paleobotanical records on which the postglacial history was based up to the present time.

Methods and material studied

Fossil shells occur in all kinds of sediments and soils which are calcareous, vertebrate bones are concentrated in caves and rock shelters where also archaeological objects occur. The thickest Holocene sequences are represented by tufa deposits that are often more than 5 m thick (Sv. Jan pod Skalou 17 m!) whereas the fills of cave entrances or rock shelters attain only 150–200 cm, although they show well differentiated depositional sequences. Molluscan shells extracted by washing from sedimentary sequences consisting in general of 6–12 well distinguishable horizons can be treated statistically and the results represented in histograms which are comparable with current pollen diagrams (Ložek, 1964). Since molluscan assemblages well correspond to various plant communities, for instance to different types of woodland, parklands, steppes, xerothermic rocks, grasslands riverine forests, etc., it is possible to reconstruct the vegetation cover on the base of molluscan analyses (Ložek, 1982). Whereas the assemblages of fossil snails reflect environmental conditions in limited areas from which the shells were transported to the fossiliferous deposits, the vertebrate remains were concentrated in caves by the action of predators, particularly of owls, and thus represents taphocenoses that also include elements coming from wider surroundings.

Results and analyses

Quantitative analyses of molluscan assemblages from more than 40 sites dispersed over the whole Bohemian Karst (Ložek, 1992)

in correlation with sedimentological and archaeological observations provide evidence of paleoenvironmental conditions in the following developmental phases:

- The Late Weichselian Pleniglacial is represented by a number of loess malacofaunas that are usually composed of a small number of tolerant open-ground species (less than 10), but a few may occur abundantly (*Pupilla* sp., *Succinella oblonga*, *Trichia hispida*, *Helicopsis striata*). They reflect steppe environments under severe continental climatic conditions. Scree formation and pedogenic processes were strongly reduced, at elevations exceeding 350 m the loess graded into accumulations of fine angular debris with loess-like matrix.
- The Weichselian Late Glacial is characterized by light brown colluvial deposits that include snail communities with increasing numbers of more hygrophilous catholic species (*Cochlicopa lubrica*, *Perpolita hammonis*, *Petronella*, *Punctum*, *Arianta*, etc.) which gradually replace the above loess species and thus reflect more diversified environments, i.e. parklands with climatically tolerant woods. Of prime importance is the appearance of the taiga communities with the index species *Discus ruderatus*. Reliable traces of the Late Glacial climatic oscillations in the sedimentary sequences are hardly observable, but some records of first demanding species (*Aegopinella minor*, *Fruticicola fruticum*) in Late Glacial context may probably reflect the climate amelioration in the Alleröd oscillation (Martina Cave).
- The Early Holocene, i.e. the Preboreal and Boreal, are characterized by the gradual increase in thermophilous elements, such as *Chondrula tridens*, *Cochlicopa lubricella* and the surviving *Helicopsis striata*, which reflects the expansion of continental steppe patches characterized by chernozem soils. The *D. ruderatus*-fauna (*Perpolita petronella*, *Clausilia cruciata*, *Vertigo substriata*) is confined to moister wooded habitats whereas in mesic to xeromesic areas *Helix pomatia*, *Aegopinella minor*, *Vertigo pusilla* and other mesophilous elements appear. *Fruticicola fruticum* and *Euomphalia strigella* occur in high numbers. This combination of species reflects a patchwork of open and woodland habitats under different moisture conditions, i.e. a landscape very rich in ecotones. In general, open patches and open woodland are dominating except for the final Boreal which is characterized by a rapid increase in moisture reflected by intensive tufa accumulation and soil decalcification (Ložek and Čilek, 1995).
- The Atlantic period is characterized by a dramatic expansion of elements confined to rather moist closed woodland as well as by intensive tufa formation and precipitation of loess sinter

Section	Sedimentation, soil formation	Zoofossils	Environments	Chr.
	dark loams rich in humus	slightly depauperized woodland fauna of present-day type	coppiced woodland	ATLANTIC
	scattered medium to small-sized fragments		oak-hornbeam forest of present-day type	SUB
	coarse breakdown with compact humic matrix	<i>Isognomostoma</i> <i>Cepaea hortensis</i> <i>Heligona lapicida</i>	deterioration of climate increase in scree formation middle bronze age occupation	SUBBOREAL
	calcareous loams with medium humus content medium scree	predominance of woodland fauna	closed forest	EPIATLANTIC
	rather coarse break down	appearance of <i>Heliocodonta</i> rereat of <i>Granaria</i> and <i>Cochlicopa lubricella</i>	woodland optimum last patches of warm karst steppe	
	dark reddish-brown loam with humic infiltrations charcoal lenses in basalt part	appearance of <i>Bulgarica nitidosa</i>	expansion of woodland	ATLANTIC
	dark red clayey loam with decalcified fine earth maximum decalcification	<i>Rana</i> <i>Acanthinula</i> <i>Sphyradium</i> <i>Urticicola</i>	neolithic occupation maximum humidity	
	light slightly humic loams with whitish CaCO ₃ efflorescences	<i>Cochlodina</i> , <i>Alinda</i> <i>Pitimys</i> , <i>Lacerta vivipara</i> expansion of woodland fauna appearance of <i>Granaria</i>	increase in humidity parkland with warm steppe patches major increase in temperature and moisture	BOREAL
	light loam Very rich in CaCO ₃ efflorescences	open-ground species remain dominant <i>Pupilla triplicata</i> <i>Semilimax kotulae</i> <i>Discus rotundatus</i>	parkland (forest steppe) gradual increase in temperature and moisture	PREBOREAL
	decrease in humus content	predominance of steppe snails: <i>Chondrula</i> , <i>Helicopsis</i> , <i>Pupilla</i> , <i>Vallonia</i> , <i>Truncatellina</i> <i>Discus ruderatus</i> – Fauna: <i>Perpolita petronella</i> appearance of: <i>Fruiticola fruticum</i> , <i>Euonphalia strigella</i> , <i>Aegopinella minor</i> , <i>Anguis</i> , <i>Lacerata</i> cf. <i>Agilis</i>	minor deterioration of climate moderate warming and increase in humidity (?alleröd)	LATE GLACIAL
	dark humic loams (rendsina sediments) high in CaCO ₃ crumb structure		parkland with patches of cold steppe and mesic grassland	
	charcoals medium scree	<i>Semilimax kotulae</i> sicista. <i>Microtus oeconomus</i> increase in biodiversity	moderate climatic amelioration	
	humic infiltration	<i>Pupilla loessica</i> very poor <i>Pupilla steri</i> in bones <i>Arianta</i> <i>Clausilia dubia</i>	glacial steppe	PLENIGLACIAL
	medium to small-sized scree with light ochreous loess-like matrix		climate dry cold-continental	

Fig. 5. Sediment sequence in the entrance of the Martina Cave near Tetin.

horizons (foam sinter) in cave entrances. The *D. ruderatus*-fauna gradually declines and the continental steppe elements are replaced by thermophilous southern species, particularly by *Granaria frumentum* which dominates the karst steppes and sunny rocks. The foam sinter formation abruptly declines in the middle Atlantic, immediately before the Neolithic occupation. Since that time, the Bohemian Karst was continuously colonized and its plateaus with loess covers transformed into cultural landscape. The expansion of closed forest was hindered by grazing, which enabled a secondary expansion of open-country species and probably supported the immigration of *Capaea vindobonensis*, from the southeast.

- The later phase of the Climatic Optimum-the Epiatlantic is characterized by the culmination of demanding woodland malacocoenoses, as well as by the appearance of some thermophiles coming from the south, particularly *Truncatellina claustralis*. Nevertheless, karst steppes persist at many places, obviously due to pasture. Some anthropophobic forest snails, for instance *Bulgarica cana* occur throughout the Bohemian Karst. During the Climatic Optimum also the neoendemic microspecies *Bulgarica nitidosa* (of Balcan origin) appears.
- The Subboreal (sensu Jäger, 1969; 1400–700 BC): This predominantly dry phase is characterized by the expansion of the Knovíz Culture at the decline of the Bronze Age. The climate is unbalanced, which is reflected by the formation of coarse breakdown in cave entrances and formation of coarse screes poor in matrix. The tufa formation declines and rendsina soils develop on the deposits.
- The Subatlantic and historical times: sensitive forest species, such as *Bulgarica cana* decline, while *Alinda biplicata*, *Discus rotundatus* and *Helicodonta obvoluta* culminate. Later, re-expansion of open-ground species and appearance of moder immigrants (*Cecilioides*, *Xerolenta* and even *Oxychilus cellarius*) take place.

Discussion and conclusions

The above developmental pattern is comparable with the results of pollen analyses (Firbas, 1949, 1952), but differs in a number of important details. This is due to environmental conditions in the area in question which are very different from those in regions where the Holocene paleoenvironmental history is based on pollen analyses. These are located in humid mountains or in marshy basins which are very poor in traces of pre-

historic humans and are covered by mesic to marshy closed forests whereas the Bohemian Karst is a warm-dry area dominated by thermophilous, often semi-open woodland with numerous open patches affected by long-term human activities. The survival of xerothermic biocoenoses in the Bohemian Karst from the early Holocene was continuously supported by a dense prehistoric settlement that hindered the forest expansion during the moist phases of the Climatic Optimum. It should be also stressed that the reconstruction of Holocene paleoenvironments in the warm-dry areas of Czechlands is based not only on the succession of molluscan or vertebrate assemblages but also on the changes in sedimentation, soil formation and CaCO₃ metabolism in correlation with archaeological records, which provide a much broader evidence of particular events (standstill phases, erosion, scree accumulation, drying-up of tufa deposits, etc.) than the pollen analyses.

These results that coincide with observations from other xerothermic areas of Czechlands (e.g. Pálava, České Středohoří Mts.) suggest that the Postglacial in warm-dry lowlands and hill countries shows a development different from that in colder humid areas and thus represent a distinct facies characterized by specific faunal succession, soil and sediment development, which is in agreement with the proposal of K.-D. Jäger (1969) presented to the VII INQUA Congress.

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Glacial Cycles and Mammalian Biodiversity of Central Europe: Large Scale Migrations or Vicariance Dynamics?

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ABSTRACT The extensive fossil record was examined to reveal the geographic variation in patterns of the Pleistocene-Holocene faunal turnover. The considerable differences were found between the Mediterranean region (Balkans including) and central Europe. The response of individual species to the climatic fluctuations was not concerned, the central European interglacial communities did nowhere survived. The metapopulation dynamics, an essential factor of the response, has mostly operated rather on small than large geographic and time scales.

KEY WORDS: faunal turnover, Holocene, biogeography, mammals.