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Molluscan and Pollen Assemblages from the Ochozská Cave as Climate Indicators for the Late Glacial and Holocene (Moravian Karst, Czech Republic)

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ABSTRACT. Land molluscs are competent group of invertebrate animals available for appreciation of natural conditions in karst areas. Reconstruction of the landscape and vegetation development in the southern part of the Moravian Karst was based on the investigation of molluscan thanatocoenoses and pollen assemblages. Late Glacial/Holocene boundary was assigned in the correlation with sedimentary dynamics.

KEY WORDS: molluscs, pollen, climate indicators, landscape, Late Glacial, Holocene, Moravian Karst, Czech Republic.

Introduction

This paper deals with reconstruction of the landscape and vegetation development in southern part of the Moravian Karst - the most important karst region of the Czech Republic. The reconstruction consists in the analysis of the land mollusc's thanatocoenoses and pollen assemblages extracted from slope deposits. Because land molluscs are with their relative immobility and close connection to substrate important indicators of landscape conditions, it is possible to reconstruct figure of natural landscape in the correlation with sedimentary dynamics, using their fossil remains in calcareous deposits. Molluscs appear to be an ideal faunal group for studies of landscape development.

Methods and material studied

As the representative site in the southern part of Moravian Karst was investigated area in the Říčka Valley near Ochoz Village. Studied section (Fig. 1) in slope sediments was exposed below the limestone cliff near the Ochozská Cave entrance. This section captures Late Glacial and Holocene sequence represented by nine sedimentary layers. Mollusc's thanatocoenoses selected from individual layers of the profile by means of usual method (Ložek, 1964) was studied, assorted, determined and statistically estimated.

From the same section eight samples for palynological study were taken. All samples were formed by the highly minerogenic sediment with a great content of calcium. The method of the minerogenic separation with heavy liquid (Thoulet solution - $\text{CdJ}_2 + \text{KJ}$) of the density 2g/cm^3 was used. The pollen was cumulated from the amount of 50 grams of the material per one sample. The pollen grains in the glycerin medium were observed.

From the each sample about 10 slides were counted to obtain 100 pollen grains, at least.

Results and analyses

The main results acquired from palaeontological content of individual layers are summarized in the transparent Table 1. Table also summarizes important sedimentological features and reconstruction of landscape with chronology.

The profile through the deposits below the limestone cliff involves 9 layers of slope deposits that can be divided into 4 groups with certain specific properties.

A basal series (layers 9-6) are very pure in mollusc's thanatocoenoses. Material consists of fine debris and large blocks with non-humous massive clayey silt including species with wide ecological valence that are able to sustain rough climatic conditions (e.g. *Pupilla muscorum* (L.), *Vallonia costata* (MÜLL.), *Clausilia dubia* DRAP.). The structure of species corresponds to the open landscape with climatic conditions of Glacial-Late Glacial stage.

The overlying beds (layers 5 and 4) are represented by deposits with greater portion of limestone debris. Malacofauna consists of scrubs and open landscape species, appearing species *Discus ruderratus* (FÉR.), *Semilimax kotulae* (WEST.) and *Vertigo substriata* (JEFFREYS) indicate occurrence of little damp and forestry facets still embosomed with open ground (layer 5). The following overlaying bed (layer 4) is enriched in forestry species (e.g. *Cochlodina laminata* (MTG.), *Cochlodina orthostoma* (MENKE)) or hygrophilous *Carychium tridentatum* (Risso), demanding more covered and damper facets. The culmination of *Discus ruderratus* (FÉR.) (layer 4) is characteristic for

Boreal period, appearing of *Granaria frumentum* (DRAP.) indicates its reasonable warming up.

The layer 3 is dated as Atlantic period with fully developed woodland malacocoenoses. Coarser debris is filled by slightly humous matrix formed by sandy silt containing exacting woodland species, such as *Daudebardia rufa* (DRAP.), *Discus perspectivus* (MÜHLFELDT), *Macrogastra plicatula* (DRAP.), *Ruthenica filigrana* (RSSM.), *Sphyradium doliolum* (BRUG.), *Vitrea diaphana* (STUDER) and others. Species of open habitats live in steppic areas kept up only in positions unreachable for the forest (exposed rock edges, rocky and debris slopes).

The uppermost series of beds consist of humous sandy silted matrix with sporadic coarser debris. Malacozoological content is not so different from layer 3, certain difference is in presence of epilithic snails *Chondrina clienta* (WEST.) and *Pyramidula pusilla* (VALLOT). Because it is not possible to validate these layers in detail, we have assign it to Epiatlantic-Young Holocene dating.

In the layer 9 the pollen of *Pinus*, *Betula*, *Salix* and *Juniperus* were indicated. Very abundant spectrum of herbs (*Helianthemum*, *Thalictrum*, *Rosaceae*, *Jasione*, *Asteraceae Liguliflorae*, *A. Tubiflorae*) accompany the light forest. This sample could be compared with warmer oscillation of the Late Glacial Bölling or Alleröd. The sample from layer 7 is similar to the previous one and belongs also probably to Dryas III or Dryas II. The sample from layer 6 is very important in the chronostratigraphy. From the palynological point of view the scarce traces of arboreal pollen and pollen of herbs reflects cold tundra-steppe character of the vegetation, which could be synchronous with some cold interval of the Late Glacial (Dryas III). The pollen assemblage in layer 5 documents the change of climatic conditions and appearance of colder vegetation with *Pinus* forest. The scarce traces of other arboreal trees are mentioned the pollen of *Corylus*, *Juniperus* and *Salix*. The herbal pollen spectrum is rich of represents of the Late Glacial species as *Polemonium*. This pollen sample indicates the Preboreal or Boreal periods. The sample from layer 4 reflects the Middle Holocene vegetation cover. Under the *Picea-Alnus* forest the cover of ferns are reconstructed. The layer 3 is very similar in pollen spectra with the previous one. However, the herbal pollen spectra is more abundant suggested the lawns around the brooks. *Polyodiaceae* were also abundant covering the hillsides. The sample from layer 2 corresponds to the Subatlantic period with the arboreal pollen of *Picea*, *Alnus*, *Tilia*, *Corylus* and *Juglans*. Among the herbs *Poaceae* are prevailing. Lot of species of ferns (*Polypodiaceae*) completes the vegetation cover.

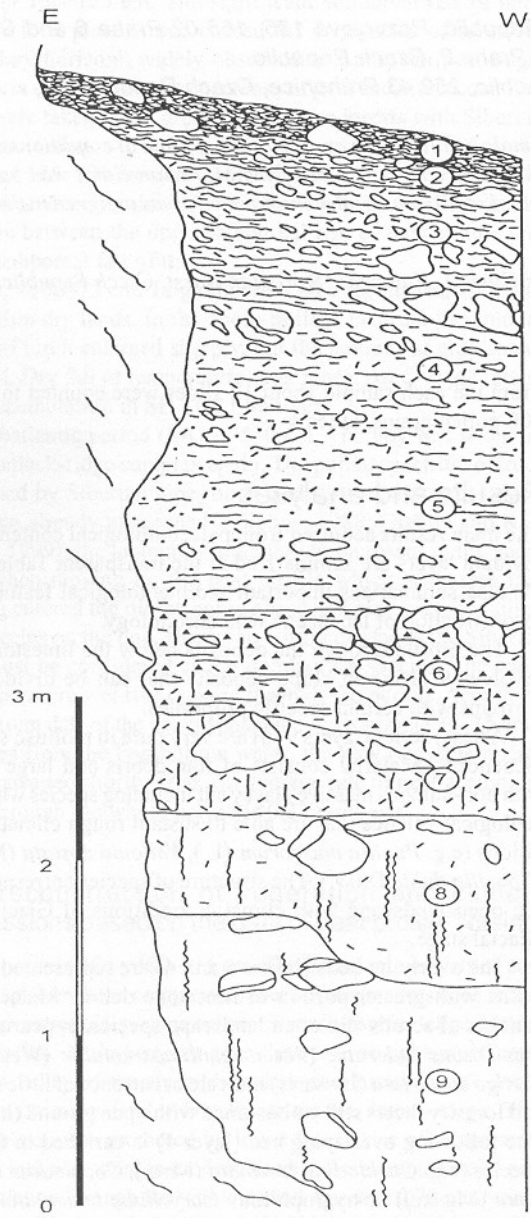


Fig. 1. Profile near the Ochozská Cave entrance.

Layer	Sedimentology	Enviroment	Development of molluscan fauna	Chronology
1	Formation of humus-carbonate soil Dark matrix with sporadic clastic material	Deciduous forests with coniferous admixture	Molluscan fauna similar to the recent one, expansion of epilithic species <i>Chondrina clienta</i> and <i>Pyramidula pusilla</i> slight reexpansion of species of open habitats	Epiatlantic - Young Holocene
2		Open habitats on the xerothermic places and rocky edges		
3	Stony and blocky debris with sandy silted matrix, very poor in humus	Strong retreat of open habitats, mix deciduous forests prevail	Expansion of exact woodland fauna, <i>Discus ruderatus</i> still survives, strong retreat of species of open habitats (<i>Truncatellina cylindrica</i> , <i>Vallonia costata</i>)	Atlantic
4	Clayish silt, slightly sandy with numerous stones, matrix with white greyish coting	Parkland with occurrences of open xerothermic habitats	<i>Semilimax kotulae</i> extincts, kulmination of <i>Discus ruderatus</i> , <i>Granaria frumentum</i> appears	Boreal
5	Like in 4, increase of clastic material	Open woodland of the taiga character, many open areas	Coming <i>Discus ruderatus</i> , <i>Semilimax kotulae</i> , <i>Vertigo substriata</i> , <i>Fruticicola fruticum</i>	Preboreal
6	In the upper part fine debris and large blocks, clayish silted matrix	Steppe grassland with patches of scrubs	Ecologically indifferent species appear such as <i>Vitrina pellucida</i> or <i>Euconulus fulvus</i>	Glacial - Late Glacial
7	Clayish and silted massive matrix with sporadic debris and blocks			
8	Matrix like in 7, in the direction of lower beds stony debris decreases			
9		Open cold glacial landscape, rocky slope with poor vegetation	<i>Pupilla muscorum</i> , <i>Succinella oblonga</i> , <i>Trichia hispida</i> and <i>Clausilia dubia</i>	

Tab. 1. Landscape analysis of the profile discussed.

Discussion and conclusions

It is possible to use mollusc's thanatocoenoses as indicator for Late Glacial/Holocene boundary. In the lower beds down from this boundary is developed pure malacofauna consisting of species with wide ecologic valence, that are able to sustain cold climatic conditions. Holocene period is typical in appearance more exigent species demanding for more moist and warmer climate. Late Glacial/Holocene boundary is situated in the profile between layers 6 and 5 and its main feature is presence of fine debris and large blocks indicating accession of damper stage. The pollen analyse has yielded results consistent with mollusc analyse.

Studied section expresses development of the southern part of the Moravian Karst since the Last Glacial stage until

the Young Holocene. When obtained results are compared with the ones detected in profiles at northern part of the Moravian Karst (Ložek and Vašátko, 1991), it is evident, that the karst landscape developed during the Late Glacial and Postglacial stages was similar in both parts of the karst area.

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Quaternary-Malacological Analyses for Modelling of the Upper Weichselian Palaeoenvironmental Changes in the Carpathian Basin

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ABSTRACT: Most species of the Quaternary mollusc fauna exist nowadays and the ecological demands of living species are known and their extrapolation for the Quaternary is worked out. The species composition of land snail assemblages is largely depended on microclimate and local habitat, especially vegetation cover. The Quaternary malacological analysis of loess area in the Carpathian Basin is promising, because species of various palaeoecological indicators appeared and migrated quickly from different palaeobiogeographical parts of Europe, firstly from the lower Danube region. We collected fine-stratigraphical samples from 20 Late Pleistocene loess sequences for sedimentological, quaternary malacological analysis and radiocarbon dating. Chronology was obtained from 60 radiocarbon age determinations. According to these radiocarbon-dated palaeoecological records we reconstructed the palaeoclimatological, palaeoecological, palaeobiogeographical changes during the Late Weichselian. The Mollusc fauna changes indicate nine short-time (1000–3000 years), cyclically palaeoclimatological changes which repeatedly transformed the palaeoecological condition and vegetation in the Carpathian Basin between 32–12 ka.

KEY WORDS: mollusc analysis, loess sequences, Carpathian Basin, Late Weichselian.

Introduction

Most species of the Quaternary molluscan fauna exist nowadays, the ecological demands of living species are known and their extrapolation for the Quaternary is worked out. Quaternary malacological studies therefore provide the most detailed data for palaeoenvironmental and palaeoclimatological conditions of the Quaternary periods, especially during the intervals of loess deposition because molluscan shells are well preserved in loess accumulations, characterized by high concentrations of calcium carbonate. Species compositions of terrestrial snail assemblages largely depend on microclimate and local habitat, especially the vegetation cover. Quaternary malacological analysis of the loess area in the Carpathian Basin is promising, because species of various palaeoecological indicators appeared and migrated quickly from different palaeobiogeographical parts of Europe, particularly from the lower Danube region. The Late Pleistocene environmental history of the Carpathian Basin can be regarded as one of the missing links in our understanding of the last glacial development of Europe. In terms of its location

and geology the Carpathian Basin provides an important area of low relief among main mountain ranges of Central Europe (Carpathians, Alps, Dinaric Alps).

We collected fine-stratigraphical samples from 20 Late Pleistocene loess sequences for sedimentological and Quaternary-malacological analyses and for radiocarbon dating. Chronology was obtained from 60 radiocarbon age determinations. Based on this radiocarbon-dated palaeoecological record, it was possible to reconstruct the palaeoclimatological, palaeoecological and palaeobiogeographical changes during the Upper Weichselian.

Upper Weichselian molluscan fauna changes in space and time

As suggested by Quaternary-malacological data and radiocarbon dating of 21 Late Weichselian loess profiles, the climate (temperature, rainfall, humidity) and vegetation cover oscillated cyclically (Table 1) in the Carpathian Basin (Krolopp and