QUATERNARY DEPOSITS IN ORLOVA CHUKA CAVE, NE BULGARIA

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INTRODUCTION

Caves are specific environment where continental deposition produces sediments different from surface ones. Although many facial types cave deposits have their surface analogues they show specific features due to formation in limited space and in more constant microclimate. Genesis of separate units in a cave sediment sequence assists ascertainment of Quaternary climatic changes. Knowledge about climatic variations during the Quaternary is very important for the recognition of modern climatic conditions as a continuation of the oscillating tendency imposed during the period. In addition caves are ones of the most suitable continental sites for preserving climatic variation records.

This study attempts the palaeoclimatic reconstruction of the environment in which the sediments in Orlova Chuka Cave (NE Bulgaria) originated, based on some physical parameters of lithologic units and on their paleontological content. Used physical parameters of subaerial lithologic units depend on local climatic conditions during deposition. Their complex origins and postsedimentologic processes complicate the proximate paleoclimatic interpretation. Stratigraphic sequence in Orlova Chuka Cave could be informative for studying long and continuous palaeoclimatic record because it reaches a thickness up to 12 m.

CAVE MORPHOLOGY AND GENESIS

Orlova Chuka Cave is a network maze cave builds up from subhorizontal passages with total length of the mapped sections more than 13 km. Morphological features of the cave galleries suggest a phreatic origin. The cave system lies just bellow an old river terrace at elevation about 60 m above present floodplain of Cherny Lom River, tributary of Danube River. Terrace at 60 m corresponds to an erosion surface formed in southern margin of so called Dacian Basin during the Pliocene and Early Pleistocene. Erosional surface is cut 2.59 Ma BP, and the alluvium deposits over it extend to the beginning of loess formation in NE Bulgaria during MIS 20 (Evlogiev, 2000) or MIS 22. Therefore main phreatic stage of cave formation should assign to the same time span. Brunhes/Matuyama geomagnetic boundary (0.78 Ma BP) has been found at 1.20 m below the top of sedimentary sequence in an excavation in the cave (Evlogiev, et al., 1997).

The average height of cave passages is 10-20 m, approximately two-thirds of which are filled in with clastic deposits intercalated rarely by speleothem. Although large volume of passages furthers equalization in sedimentary conditions lithologic units show lateral discontinuity.

METHODS

Facial types sediments have been defined on the base of structure, texture, and color. Lithologic features, magnetic susceptibility, organic carbon content and fossil fauna of individual sedimentary units from a sequence in a pit situated 20 m away from the cave entrance are applied for the purposes of palaeoclimatic reconstruction. The location of the pit was chosen next to the entrance to provide for requirement of the presence of animal remnants. The closeness to the entrance supposes more active influence of outer climatic conditions during origination of the cave deposits. In the studied cross-section there are no speleothem. Relationship between different speleothem generations and clastic sediments has been observed in other excavations.

Variations of grain size, carbonate content and magnetic susceptibility along the profile studied show clear distinctions among different layers (Figure 1), which means that the chosen physical parameters can be used as dependable criteria. Organic carbon content along the profile is less variable than the other parameters. Sedimentologic agents are all complex, but usually only some of them dominate during formation of an individual layer. Grain size content and other lithological features (e.g. color, structure) are used as tools for establishing the relative proportions of mechanical and chemical weathering of the bedrock, and the aeolian transport factor. Large grains coming from bedrock are very important as paleoclimate indicators because they have thermoclastic origin, and their large amount in layers suggests a severe cold climate. Magnetic susceptibility variations are mainly controlled by the concentration of ferromagnetic grains. Variations of magnetic content of the cave sediments may reflect (1) sedimentation of finer material during warm climatic periods, which contain a significant amount of superparamagnetic grains due to an enhancement of pedogenesis on the adjacent open areas, would cause an increase of the magnetic signal, (2) higher concentration of large detrital magnetite particles resulting from intensification of mechanical weathering and higher wind potential during cold climatic periods is another way of magnetic enhancement, and (3) lower susceptibility values could be obtained in layers formed during warm climatic periods, if geochemical conditions (e.g. very low pH, waterlogging, reducing conditions) during and after sedimentation are unfavorable for survival of Fe oxides (Radulov and Jordanova, 1999).

The organic carbon content in cave deposits depends on intensity of pedological processes and plant growth on the surface. Light organic particles are very mobile, which facilitates their transportation into a cave by air, animals and water. In addition, organic debris contributes to enrichment in organic carbon.

Small mammal remnants from studied sequence represent at least 35 species of Insectovora, Rodentia, Lagomorpha and Chiroptera (analysis by V. Popov, Institute of Zoology, Bulgarian Academy of Science). Animal habitat gives important additional information for paleoenvironmental conditions. Remnants found in the cave sediments have been distributed in five units named A, B, C, D, and E (Figure 1). Fauna in each unit indicate paleoenvironment during deposition of several layers.

SEDIMENT SEQUENCE

The upper part, of terrigenous sediments next to the entrance, consists of four main genetic types: weathering detritus, aeolian silts, thermoclastic fragments and speleothems. On the base of structure and color, fourteen lithologic units (layers) are sequestered in the studied site (Figure 1). Layer 1 (light brownish gravelly-silty sand) and layer 2 (yellowish gray sandy silt) contain lenses of thermoclastic bedrock particles, most of which consist of cobble-size grains. In these deposits, allochthonous silt transported by air dominates. Carbonate content and magnetic susceptibility are of low values. The layers most likely originate in cold and arid conditions. Layer 3 (dark brown laminated silt) has a much lower carbonate content (2%), very high magnetic susceptibility and the highest organic carbon content (1.66%). Its most probable zoogenetic origin suggests a temporary break in aeolian deposition and warmer climat. Layer 4 consists of yellowish to gray silt. Calcium carbonate varies from 7% to 28%, and its magnetic susceptibility has a low value. There are six very thin beds of laminated silt and some very thin beds of sandy silt (the sandy content is ca. 30%). The sandy component in coarser beds is calcareous one and derives from bedrock. Higher values observed in these beds imply more active mechanical weathering of limestone bedrock. As a result, detrital fractions contain a limited quantity of ferromagnetic grains, which determines the observed low values of magnetic susceptibility. Aeolian deposits and weathering detritus in layer 4 suggest sedimentation during typical glacial conditions. Layer 5a consists of gray brown pebbly-gravely calcareous sand. Pebbles and gravels are angular. The calcium carbonate content of sandy matrix is 32%; magnetic susceptibility and organic carbon have exceptionally low values. Weathering detritus of thermoclastic origin suggests a severe cold climate during deposition. Lower carbonate content (7%), the highest magnetic susceptibility and higher organic carbon content characterize layer 5b (dark brown silt). Chemical weathering of bedrock prevails. Layer 5b probably originated in a warmer and wet climate. Layer 6 is a thermoclastic scree that is composed of angular cobble-size limestone particles (particle sizes from 10 cm to 30 cm are common). A thin layer within the scree was sampled. All measured parameters show values similar to typical aeolian deposits. These features likely imply a severe cold climate. Layer 7 (reddish sandy silt), layer 8 (brownish sandy silt) and layer 9 (yellowish brown sandy silt) are characterized by weakly variable carbonates, magnetic susceptibility and organic carbon. A lot of animal remnants occur at the bottom of layer 7. The loam of these series mainly consists of chemically weathered detritus, but mechanically weathered particles also occur. In general, the characteristics suggest a mild climate. Layer 10 consists of dark brown sandy silt. The layer is very rich in animal remnants including those of bear skeleton. Chemical weathering of bedrock again prevails. Layer 11 consists of fifteen similar pairs of very thin beds. The boundaries between individual pairs are wavy parallel due to dripping water, which is typical for deposition under subaerial conditions. Each pair is composed of lower brown lamina of sandy-clayey silt and upper yellow lamina of gravely-silty calcareous sand. The transitions between laminae are gradual. The brown laminae are formed due to more active chemical weathering, while yellow laminae are due to more active mechanical weathering. The climate during deposition was changeable; probably frequent cooling occurred. In contrast to the other layers, which originated in a cold climate, layer 11 do not contain aeolian silts. Layer 12 (reddish sandy-clayey silt) and layer 13 (silty clay, partially indurated) are substantially different from the other layers in the site. In this part of the sequence there is a significant lack of variability in measured parameters. The almost complete absence of calcium carbonate can be explained by the low pH. The lower susceptibility values could imply dissolution of Fe oxides due to the presence of very low pH, waterlogging and/or reducing conditions. Limestone and bone particles are rounded due to intensive chemical influence. Based on these features two origins can be assumed: (1) deposition of autochthonous material in subaqueous environment but without any significant turbulent flow (traces from phreatic stage of cave development) and (2) postsedimentological flooding that caused diagenetic changes in both layers. The high clayey content can support infiltrating water at this level. The water source can be erosional streams cut in layer 11 (which caused the hiatus between layer 10 and layer 11) or higher dripping water from the cave roof during later wet periods. The lack of changes in layer 11 (excepting the lowermost part) is due to its high permeability. The presence of bones supports the second assumption about its origin, mentioned above. At this stage of our investigation, it can be concluded that diagenetic changes in these layers do not allow palaeoclimatic reconstruction.

CLIMATIC RECORDS AND AGE

Proportions between different ecologic groups of fauna remnants in separate units reflect paleoenvironment. Remnants from each unit reflect average paleoenvironment during deposition of several layers building an unit. Fauna poorly differ in units (Figure 1). Species and quantitative proportions between species indicate relatively cold, continental and arid climate; and open area dominates. Unit B distinguishes from others because of prevalence of high mountain and boreal species. Unit D also contains boreal representatives. Unit A contains largest variety of species. They indicate deposition in cold to mild, and relatively arid climate. Fauna in unit C is similar to that of unit A but steppe mammals prevail.

In deposits of the studied sequence, evidence for four periods of severe cold climate (layer 2, layer 5a, layer 6 and layer 11), two periods of aeolian deposition (layers 2 and 1 and layer 4) and three mild periods (layer 3, layer 5b and layers 10 - 7) are preserved.

A bear skeleton has been found in layers 8, 9 and 10. The remnants could be defined as *Ursus deningeri romeviensis* known in Mindel-Riss and Riss or transitional form between *Ursus deningeri* and *Ursus spalaeus*.

A continous speleotem level bellow aeoloan deposits represented by layer 4 in the studied sequence is well developed in the cave. Stratigraphic position of that speleotem has been observed in several excavations in the cave. One of stalagmites has been dated. U-series date of the base is 137±6 Ka BP and the active growth occurred in MIS 5 (H. Hercman and T. Nowicki, pers. commun., 1999). Taking into account position of the bear skeleton and dated stalagmite units A and B should be younger than MIS 5, and most of unit C should be older than 137±6 Ka BP.

CONCLUSSION

Parent material in the upper 1.50 m section of cave sediments close to the entrance derives mainly by mechanical weathering of bedrock and aeolian transport of outer material. Both processes occur more likely in glacial periods. Thus depositional rate during glacial periods is much higher than during interglacial periods. Speleothem growth and deposition of chemical weathered detritus are typical for interglacial periods.

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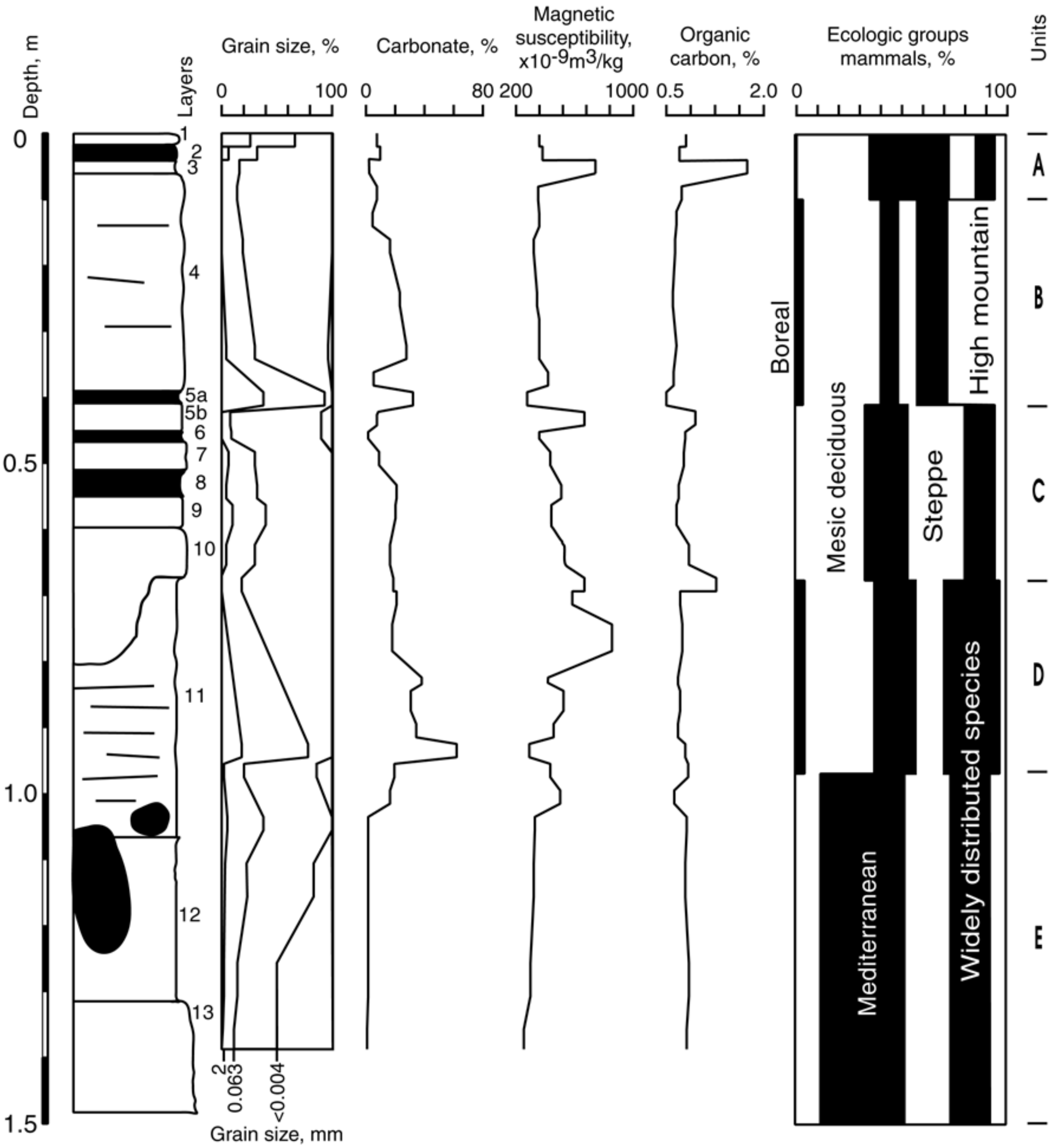
FIGURE CAPTION

Figure 1. Stratigraphic sequence in Orlova Chuka Cave. Grain size distribution, carbonate content, magnetic susceptibility, organic carbon content, and small mammal ecologic groups in sediments.



Depth, m
Layers
Grain size, %
Carbonate, %
Magnetic susceptibility, x10-9m3/kg
Organic carbon, %
Ecologic groups mammals, %
Units
Grain size, mm
2
0.063
<0.004
Boreal
Mesic deciduous
Steppe
High mountain
Mediterranean
Widely distributed species
A
B
C
D
E