

THE SEDIMENTOLOGY OF THE BEAR CAVE OF ALMOPIA SPELEOPARK (PELLA, MACEDONIA, GREECE)

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Abstract: The small grain size of the clastic sediments in the floor of Bear Cave is evidence of slow water flow in the deposition site, which is the result of the increase of water mass surface flowing inside the cave, as well as of probable climate change from wet to dry. The filling of floor cavities with claysilt material indicates that these holes were formed before the deposition of fluvial-terrestrial sediments from the adjacent area during Pleistocene. The extended presence of Ca-Mg rich primary and secondary minerals (clinozoisite, tremolite, talc, chlorite, chlorite/vermiculite) in the fine-grained sediments of the cave floor is indicative of the composition of the parent rocks of the broader drainage basin, which have been weathered. The absence of the discrete minerals smectite and kaolinite from the examined sediments means there was action of weathering factors of limited time duration, as well as small distance of transportation from the adjacent environment to the interior of the cave.

Key words: Climate, claysilt, Ca-Mg minerals, Bear Cave, Macedonia, Greece, Pleistocene.

INTRODUCTION

The sediments found in the floor cavities of karstic caves, present important evidence of their evolution in relation to the broader area of their occurrence. The creation of these cavities is the result of karstic weathering of carbonate rocks from meteoric waters flowing downwards along faults, fissures and bed surfaces. The genesis of cavities is always followed by deposition of clastic and chemical sediments under different conditions. VAVLIAKIS *et al.* (1995) studying the grain size distribution and the mineralogical composition of the sediments from floor cavities of the Eptamyloi Cave (Serres), found that they are influenced greatly by the increase or decrease of the water flow rate at the deposition site. The examined Bear Cave is located at an elevation of 540 m and has an area of about 875 m² (APOSTOULOU *et al.*, 1995).

In this work the conditions and the environment under which the sediments of the floor cavities were formed, using granulometric and mineralogical analyses, are studied.

GEOLOGICAL SETTING

The broader area of the Bear Cave which is flowed through by streams, consists of a great variety of litho-

logical formations such as limestones, dolomites, marbles, schists (chloritic, epidotitic, sericitic), phyllites, flysch, ophiolites, as well as clastic sediments with various granulometric and mineralogical composition (TSIRAMBIDES, 1998).

MATERIALS AND METHODS

A thin section of one sample from the Cave floor crust was prepared for optical examination. Another four samples were collected from different depths of a floor site (D) and were analyzed in detail using petrographic and X-ray diffraction (XRD) techniques. Prior to mineralogical analysis samples were dried overnight in an oven at about 65°C and then were disaggregated by use of an agate mortar and pestle. Disaggregation was done gently in order to retain, to the extent possible, the intrinsic grain sizes of the samples. A 20 g split of the <2 mm fraction of each sample was subjected to the following chemical treatments (JACKSON, 1979) to remove the non-silicate phases: 1N sodium acetate-acetic acid buffer solution (pH = 5.0) for carbonate removal; 30% H₂O₂ for organic matter and Mn-oxides removal; and 0.3M sodium citrate-1M NaHCO₃ buffer solution (pH = 7.3), to which 4 g of Na₂S₂O₄ were added during digestion in a water-bath

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Table 1
Depth (cm) from the cave floor and grain size distribution (wt.%) of the samples analyzed.

Sample	Depth	C.O.I. ¹	>20 μm	20-2 μm	<2 μm
D ₁	70-83	36	30	11	23
D ₂	83-86	21	46	12	21
D ₃	93-104	15	29	17	39
D ₄	117-122	19	56	14	11

¹Total percentage of undesirable materials [Carbonates + Organics + Fe oxides + (Fe + Al hydroxides)].

Table 2
Mineralogical composition of separated size fractions (μm) of the samples analyzed.

Sample	Size	Q	F	M	Tr	Clz	Ch	T	C	D
D ₁	whole	E	X	E	X	E	E	E	E	E
	20-2	X	X	E	X	X	E	E	-	-
	<2	-	-	E	X	-	E	E	-	-
D ₂	whole	E	E	E	X	E	E	X	X	X
	20-2	E	E	E	E	X	E	E	-	-
	<2	-	-	E	X	-	E	E	-	-
D ₃	whole	Y	X	E	X	E	E	X	E	E
	20-2	E	X	E	E	X	E	E	-	-
	<2	-	-	E	E	-	E	E	-	-
D ₄	whole	E	X	E	X	X	X	X	Y	X
	20-2	E	E	X	E	X	E	E	-	-
	<2	-	-	E	E	-	E	E	-	-

Y: >40%, E: 40-10%, X: <10%.

Q=quartz, F=feldspars, M=mica (illite in <2 μm), Tr=tremolite, Clz=clinozoisite, Ch=chlorite (+ vermiculite + interstratified chlorite-vermiculite), T=talc, C=calcite, D=dolomite.

at 75-80°C, to remove free Fe-oxides and interlayer Fe- and Al-hydroxides.

The cleaned residues were separated into three size fractions (>20 μm , 20-2 μm and <2 μm) by gravity settling and centrifugation and were dried overnight in an oven at about 65°C. X-ray diffraction was performed using a Philips diffractometer with Ni-filtered $\text{CuK}\alpha$ radiation. Both randomly oriented samples and samples with preferred orientation were scanned over the interval 3° to 43° 2 θ at a scanning speed of 1° per minute. Some samples were re-analyzed after overnight glycolation. Semi-quantitative estimation of the amounts of minerals present is based on peak heights and intensity factors on XRD patterns of randomly oriented powder samples, using the method of KLUG & ALEXANDER (1974). XRD patterns taken from preferentially oriented and glycolated samples were used for the semi-quantitative estimation of clay mineral phases using specific reflections and intensity factors (MOORE & REYNOLDS, 1997).

RESULTS

The microscopic study of thin sections of the cave floor crusts revealed that they consist of elongated calcite crystals with radial arrangement and size up to 1 mm. In the rest mass sparitic calcite crystals predominate (size up to 0.2 mm), as well as many micritic calcite crystals (size smaller than 4 μm). Noteworthy is the presence of dolomite crystals, too.

Among the non carbonate minerals and in small percentages, angular crystals of quartz, needle crystals of muscovite (length <0.2 mm) and fine aggregates of metallic minerals, predominate. The last give in some crust horizons a red brown tint.

The total percentage of the undesirable materials is significant (tab. 1) as expected for a cave environment. The carbonate salts, organic matter, Fe oxides and Fe and Al hydroxides are abundant, because of the easy transportation and deposition with the rest fine grained constituents.

The most important non carbonate minerals in the untreated whole samples are (tab. 2): quartz, sericite,

clinozoisite and chlorite (+vermiculite + interstratified chlorite/vermiculite). Feldspars (especially plagioclases), tremolite and talc follow in abundance. Calcite is the predominant carbonate mineral with dolomite in second place. In the treated 20-2 μm and <2 μm fractions the clay minerals predominate (carbonate minerals have been dissolved and removed through repeated centrifugations).

CONCLUSIONS

The small grain size of the clastic sediments in the floor of the Bear Cave is evidence of slow water flow in the deposition site, which is the result of the increase of water mass surface flowing inside the cave, as well as of probable climate change from wet to dry.

The filling of the floor cavities with claysilt material indicates that these holes were formed before the deposition of the fluvial - terrestrial Pleistocene sediments transported from the adjacent area. The great consolidation they present is secondary and is due to the deposition of cement material (calcite) during or after the deposition of this material.

The high participation of carbonate salts, organic matter, Fe oxides and Fe and Al hydroxides in the floor sediments indicates an environment of low oxidation potential (Eh) during the processes of weathering, transportation and deposition.

Usually the dark coloured horizons consist of fine grains (they contain mainly clay minerals and organic matter) and represent periods of high humidity. The light coloured horizons consist of coarser grains and represent periods of extended dryness.

The extended presence of Ca-Mg rich primary and secondary minerals (clinozoisite, tremolite, talc, chlorite, chlorite/vermiculite) in the fine-grained sediments of the cave floor is indicative of the composition of the parent rocks of the broader drainage basin, which have been weathered.

The predominance of Mg-chlorite over Fe-chlorite is confirmed from the higher peaks of odd order reflections of this mineral in the XRD patterns taken.

The absence of the discrete minerals smectite and kaolinite from the examined sediments means action of weathering factors of limited time duration, as well as small distance of transportation from the adjacent environment to the interior of the cave.

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