Speleogenesis of huge passages and domes in Bohemia Cave, New Zealand.

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Abstract

The Bohemia Cave (South Island of New Zealand, Nelson Province, Mt. Owen) has the length 10.600 m. Its depth from upper entrance (1.430 m a.s.l.) is -713 m. The part of the cave, which is about 1.800 m long and consisting of huge dome, is developed dominantly in partly calcified phyllites below the contact with overlying crystalline carbonate rocks. The erosion within phyllites reached the depth of 15 m. Carbonates form the ceiling of huge spaces and show no traces of karstification. Accumulation of limonitised pyrhotite can be found at the contact. Sufhide weathering could accelerated the origin of initial karstic porosity along the contact. The feature of describes caverns lies on the boundary of pseudokarst and karst phenomenon.

Introduction

The Bohemia Cave in New Zealand was discovered in 1990 by the Czech Speleological Society - club Albeřice (Tásler ed. 1991). Czech cavers returned to the area in 1994, 1997 and 2000 to discover several km of new passages and to connect the cave to a higher Rhapsody Cave. The cave was visited by several local caving groups and new passages were discovered. The „1997“ expedition studied several cross-sections in the cave and collected nearly hundred samples of speleothems and basic rock types mainly in giant chambers. The 16 characteristic rocks were analysed (microprobe, X-ray diffraction) and studied in cross sections by petrological optical microscope.

Bohemia Cave: character and geology

The cave is located in Nelson Province of the South Island in the karst area Mt. Owen. The lower entrance can be found at the tree limit some 1.250 m a.s.l., while the upper entrance to the Rhapsody Cave is located in 1.432 m a.s.l. Total length of all system is 10,6 km of mapped passages and the depth is 713 m. The cave can be divided into three basic parts as follows:

- The first part between 1.250-1.300 m is formed by a maze of phreatic channels and tunnels partly filled with sediments. It is developed in Ordovician dolomitic marmors of Mount Arthur Group (Coleman ed. 1981).

- The second part is modelled as meanders with vertical steps, high and often narrow deeply incised passages, vertical chimneys and interconnecting shafts. It is developed in marmors.

- The third - central part - of the subterranean system is shaped as several large interconnected domes and passages developed on the contact of overlying crystalline carbonates and lower formation of phyllites. The dominant position is occupied by a system of huge domes (or one large dome) called Dream of Albeřice Cavers or DAC. (Albeřice is a site in Giant Mts. in Czech republic, where the speleological club was established two decades ago). The dome (if we shall count it as one unit) is 810 m long, 50 -110 m wide and about 4-20 m high. The volume of DAC is 750.000 - 1.000.000 m^3, the estimate of the volume of whole „main“ part is approximately 1.200.000 m^3. The general inclination of the course of DAC is 25°. The dome contains huge quantities of well developed aragonite decoration and it probably represents the biggest aragonite cave accumulation of the world (Tásler, Cílek 1999).

Description of the central part of the cave
From the fig. 2 - cross-sections is visible that the spaces follow the contact of marbles and underlying phyllites. Both passages and domes are predominantly located in phyllites. The cave passages are developed up to 10-15 m below the contact (see cross-sections B-B´, C-C´, L-L´, M-M´). The contact, respectively the marble bedding plane forms at certain places ceiling without any traces of karstification or dissolution (see cross-section B-B´and J-J´, K-K´ - right side). Some smaller passages are developed only in phyllites. A more extensive karstification is not even present around ceiling tributaries. Near the exit of tributaries from the limestones small domes are created beneath the contact in phyllites.
The ceiling morphology of large domes is affected at some places by rockfalls.
The ceiling is formed by visible tectonical plane and almost untouched by gravitational processes in neighborouging passages of DAC. When we compare the volume of fallen blocks with the volume of cavity formed in phyllite we clearly see that some other mechanism than gravitational processes is involved in formation of these vast spaces. The boulder size ranges from 0,01 to 2 m^3, but the giant size (up to 500 m^3) is not exceptional. The thickness of chaotic boulder debris is maximum 15 m and on the lower part of boulders old aragonite decoration can be frequntly found. Not a single large phyllite block has been found, because it underwent rapid weathering and deterioration.

Several big chimneys lead to giant dome only in the northern part. The further course of the dome is interrupted with two chimneys only. The large underground spaces suddenly end on a probable fault line which limits the cave system in the north. The chambers on the SW (lower point) are abruptly becoming narrower and the subterranean creek continues to meander further into limestone massif.

Geology of the central part of the cave

The geology a petrology of basic rock types concentrated on the study of the most important and enigmatic part of the cave system - giant domes of Bohemia Cave. The central part of the cave – system of giant domes and interconnecting passages - is developed on the contact of overlying crystalline carbonates and lower formation of phyllites. The contact is generally lying in direction and inclination of 160-170°/40-45° and the tectonic plane forms the cave ceiling at some places. The contact is at some places folded as miniature undulating waves. The subvertical faults (330-350°/70-85°) cause the vertical movement along the carbonate plane mainly in northern part of the cave (Tásler, Tomášek 1999).

The overlying crystalline carbonates can be described as grey to almost black massive, laminated marmors, which are concordant with contact.
The phyllites are black – coloured by graphite and disseminated ore minerals or they have silver-green lustre caused by chlorites. They contain quartz lenses and tuffitic intercalations. Phyllites are concondart with contact. They are are soft, deeply weathered and composed mostly of clay minerals close to the contact with marmors. The accumulations of limonitised disseminated pyrhotite can be found there. This observation maybe crucial for the understanding of cave origin. We know from some other sites in Southern Bohemia (Český Krumlov area) that crystalline rocks containing suphides can be changed to easily eroded clayey weathering product at the contact with karstified marmors chanelling ground water to crystalline complexes.

The tuffites occur as a big body of unknown extent in the northern part of the cave.

Hydrological situation of the central part of the cave
Two streams , the first one coming from the north, the second one coming from the east unite in a confluence in the middle DAC as a single main stream. Both northern and eastern streams are fed by several smaller streams in „limestone" part of the cave. The capacity of main stream ranges from 5 to 10 l/s, but during heavy rain we estimated the overall capacity as apr. 50 l/s. We observed at several places recent water lines corresponding to a calculated flow capacity of 1 500 l/s! Only small and unsignificant feeders can be found in the big domes (Havlíček, Tásler 1999). Smaller bifurcations of main stream and later confluences take place in the widest place of DAC within the accumulation of large blocks.

The evolutionary model of the main part of the cave
Main (1988) considers the extensive phreatic passages in Owen region to be older than Pliocene. Probably in Pliocene or Lower Pleistocene deep phreatic systems of initial karstic anastomoses originated along the contact of karstic and non-karstic rocks. Groundwater pennetration to initial system could by caused by differential seepage into high-porosity planes (Klimchouk and Ford 2000). Sulphide weathering was responsible for creation of some free spaces and the phyllite desintegration to depth of at least 10m. The uplift of the whole mountain range procceeding in several stages accelerated the downcutting and erosion into phyllites - several single passages originated during this stage (1. stage).

The constant climatic shift from more humid to more dry conditions (with many minor peaks in both directions) is characteristic for the large part of the whole Australian area in Kenozoic. We have to expect at least some more humid climatic phases in respect to contemporary climates (e.g. Pliocene). Therefore we suppose than more watery fossil streams formed in the weathered phyllites several, possibly 2-3 parallel passages (profiles H-H´, J-J´, K-K´, 1st phase). The initial seepage followed the overlying karstified structures but the principal mechanism of cave formation was in this part subrosion (underground erosion) of soft, weathered phyllites. The sulphide weathering and carbonate cement leaching contributed to the formation of free spaces under marmor bedding plane and further enhanced the subrosion. The whole process could be accelerated by tectonic uplift.

The second, younger phase of large dome formation was characterised by side erosion and unification of formerly simple parallel passages into one huge channel. This channel incised some 15m under the marmor contact. It resulted into static deterioration of the massif and the rockfall followed (3rd phase).

Discussion

The several problems are associated with the plausible explanation of cave system origin. The „mixed" nature of the cave formation where dissolutional (karstic) features are amalgamated with sulphide weathering and mechanic removal of the decayed phyllites and thus pseudokarstic origin is beyond discussion. These questions are crucial to decipher the cave origin as follows:

- Under which climate the process of subrosion took place ? It is obvious that the cave systems develops now in the limestone parts but only minor modifications can be seen in the phyllite part (besides gravitational processes and speleothem formation). We suggest that the cave developed under different hydrological regime. This regime was at least seasonaly more humid (Pliocene?).

- The transport of weathered phyllites is enigmatic because today we do not find any traces of significant erosion and transport in lower (marmor) part of cave. We may propose several mechanisms – the transport of fine and ultra-fine particles in suspension or removal of clayey material under hydrological pressure in a flooded system during high water episodes.

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