Caves Formed in the Volcanic Rocks of Hungary
Part II: Caves formed in Basalt, Basalt Tuff and Geyserite

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Abstract

Organised research into the non-karst caves, relating to the study of caves formed in volcanic rocks, began in 1983 with the launch of the Volcanspeleological Collective. Their comprehensive activities are still ongoing. The organisation, led by István Eszterhás, consists of a nucleus of 15 persons, who are occasionally joined by several more cavers. They have listed 894 non-karstic caves, and surveyed 741 of them. In 40 caves they have dug and discovered nearly 1000 m of new cave passages. They have studied the development of the non-karstic caves, and have determined new types of cave development (consequence caves, holes formed by alkaline solution, fumarole cavities). They have identified, and described, have speleothems previously unknown in Hungary, such as silica stalactites and isingerite discs. They have solved the problem of ice development in low elevation basalt caves. They have classified 200 species of animals and 18 species of fungii (some of them are unusual) which are to be found in the caves. The results have been summarized in 7 separate volumes and in 160 articles mainly in Hungarian, but occasionally in German or in English. The majority of the non-karst caves in Hungary, numbering 669 caves, developed in volcanic rocks. The study reviews, in two parts the most important achievements resulting from research on these caves. The second part presents the caves formed in basalt, basalt tuff and in geyserite.

1. Introduction

In Hungary 101 caves have developed in basalt and basalt tuff along with the 669 caves, which have formed in volcanic rocks (Bertalan 1958, , Eszterhás 2005, Eszterhás & Szentes 2004-2009, Ozoray 1952), whilst 37 caves are to be found in geyserite (Eszterhás 1987). The second part of our study deals with the development of these caves and includes those which can be considered the most significant. As well as the caves in basaltic rocks and in geyserite there are many spectacular genotypes and interesting interesting caves which have originated tectonically. Significant mineralogical and climatological observations have been carried out. Detailed information on the caves formed in basalt, basalt tuff and geyserite can be viewed on the website http://geogr.elte.hu/nonkarstic. The list is updated every year (Eszterhás & Szentes 2004-2009).

2. Geological locations of the basalt, basalt tuff and the geyserite

Basalt occurrences related to caves in Hungary are to be found in the Bakony Mountains, the Kemenesalja, the Budai Mountains and the Medves-Ajnácskői Mountains. (Eszterhás & Szentes 2004-2009). Caves do not exist either in the Cretaceous phonolite and trachybasalt in the Mecsek Mountains or in the 9 million year old basalt near the town of Sárospatak.

Caves have formed in *geyserite* in the *Tihanyi Peninsula*, which is part of the Balaton Highland in the Bakony Mountains (Eszterhás 1987a).

Sixty million years ago upper Cretaceous pyroxene and olivine phenocrystic basalt intruded 60 million years ago into the Triassic limestone in the *Budai Mountains*. A small cave traverses the intrusion (Emby *et al.* 1989).

The basalt volcanic activity in the *Bakony Mountains* can be divided into three phases. The first explosion resulted in tuff layers, which are dotted with lapilli and volcanic bombs. The second phase produced lava streams and the liquid basalt lava spread out on the surface. The third explosion phase resulted in toadstone, which is known as “bread stone” by the locals. Basalt lava layers are to be found in the Western Bakony Mountains, in Mount Kovácsi. Holes filled with calcite crystals and zeolite can be observed in the basalt.

The Tapolcai Basin is typical of the landscape of the Bakony Mountains. The region is remarkable for the whiteness buttes. Basalt and basalt tuff have shaped the truncated cones, which overlay the Pannonian sediments. Also remarkable are Mount Badacsony and the basalt columns of Mount Szent György, although the other cones are also geomorphological curiosities and several smaller caves have been listed as occurring in their basalt. The Pannonian sediments which lie between 270 m and 290 m a.s.l. are overlain, by 4 m to 5 m thick basalt tuff, the material of the first explosion phase. Basalt 40 m thick basalt covers the tuff formation, which is overlain by toadstone. Basalt tuff also outcrops on the Tihanyi Peninsula. A geological curiosity of the tuff is the large back fallen volcanic bombs, which were torn from the

depths. Some of the bombs are composed of Permian red sandstone (Juhász 1987). Following the lava flow hot steam and water geysers erupted. The precipitated hydrosilicate has formed 79 geyserit cones (Eszterhás 1987a).

In the South Bakony Mountains, basalt volcanoes overlay the Pannonian sediments, the Triassic limestone and dolomite. The highest peak of the Bakony Mountains, the 601 m high Mount Kab, is composed of basalt. Basalt volcanism also can be seen in the northern part of the mountains. The 435 m high Mount Somló is composed of Pannonian clay which is overlain by a tuff ring and basalt lava .

Northwards, in the Kemenesalja Region, in Mount Ság and in the Tuff Ring of Miske, basalt and basalt tuff are to be found above the Pannonian sediments. The basalt of Mount Ság has been almost completely quarried away. The remains of the basalt quarry outcrops demonstrate nicely the structure of the lava flow, the tuff deposition and their contact zones.

The Medves-Ajnácskői Mountains in North Hungary are composed of basalt, which is the product of the volcanoes at the end of Pliocene and at the beginning of Pleistocene. The fluid lava reached the surface through vents and spread on the surface. The extended basalt plateaux are the witnesses to this volcanic activity. The 100 km^2 Medves Plateau is the largest basalt plateau in Europe. The volcanic activity began with an andesite laccolite intrusion, which was followed by tuff deposition and extended basalt lava streams. The 4-5 m thick tuffaceous layers are subordinate to the basalt lava formation. As a consequence of the several eruptions the geomorphology of the basalt formation is diverse. There is dark grey thick-bedded basalt and black columnar jointing basalt. Especially spectacular are the basalt columns of Somos-kő, Szilvás-kő and Bagó-kö. The basalt formation extends northward into Slovakia and some interesting and scientifically significant caves are also to be found in the basalt (Fig 1.).

3. The most significant caves and their genotypes which have formed in basalt, basalt tuff and in geyserite

In Hungary only a few syngenetic cavities are known in basalt, as the youngest lava flow of the country is over one and a half million years old. Thus the cavities near to the surface, for instance the lava tubes have fallen victim to denudation.

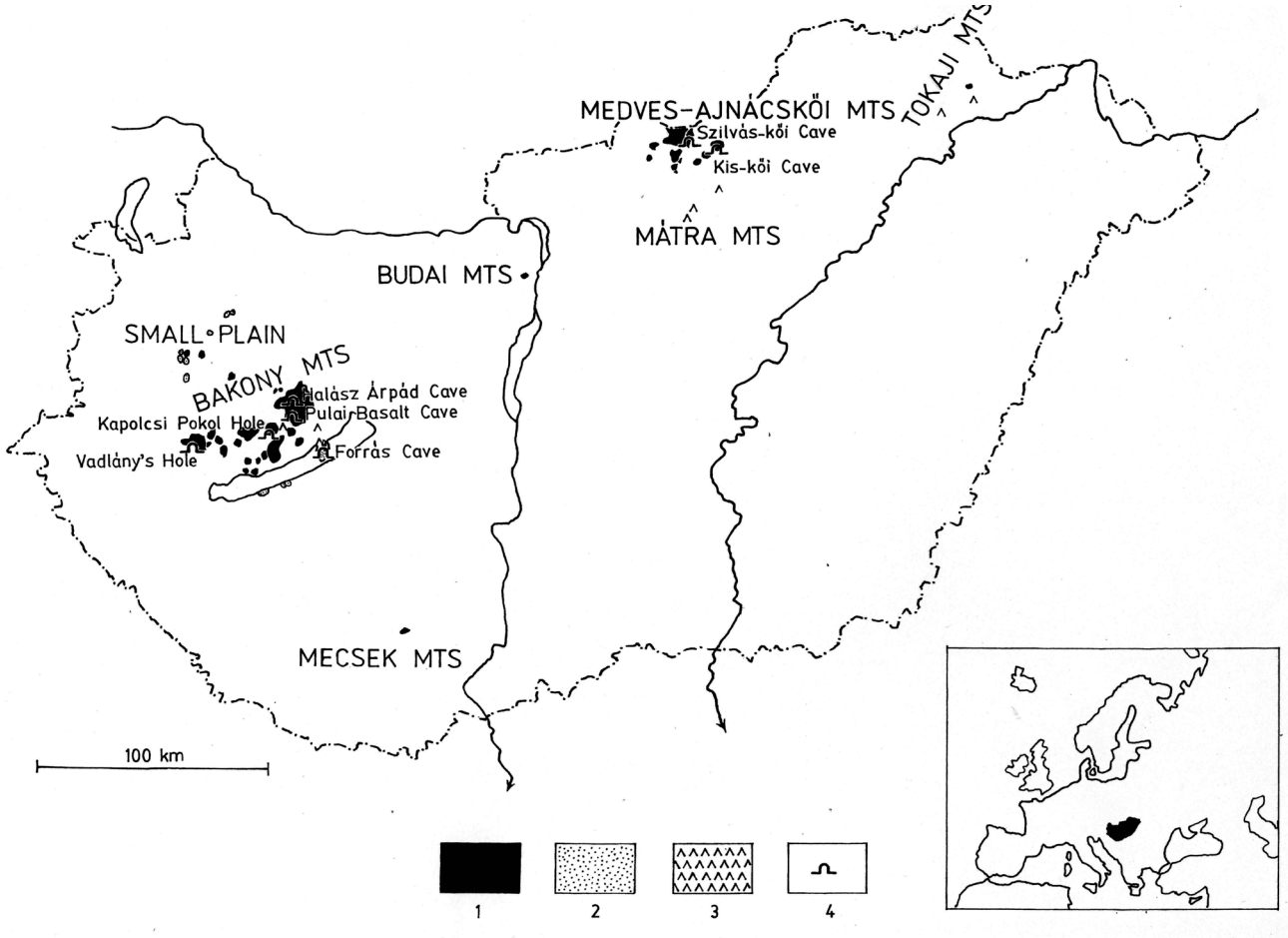

Fig. 1. Caves formed in basalt, basalt tuff, and geyserite in Hungary, showing the most remarkable caves in the formations. 1. basalt, 2. basalt tuff, 3. geyserite, 4. remarkable cave

Fifty-six caves are to be found in basalt in the Bakony Mountains. Caves occur in almost every basalt plateaux and in the whiteness buttes. Eight caves are longer than 20 m. The longest is the 151 m long Pulai Basalt Cave (Fig 2., Fig. 3). The cave is a 151 m long and 21 m deep breakdown cave. The 25-30 m thick basalt is underlain by soluble limestone. Along cracks in the basalt, seeping water has dissolved holes in the limestone, into which the basalt layer has broken. The cave is accessible through a narrow shaft, which leads to a bigger chamber. From this chamber various small passages and shafts open in different directions. The cave wall shows clearly the different basalt layers, which are witness to several thousand years of volcanic activity. In the cave a rare silicate mineral has been found, the disc-shaped isingerite.

The flooded Halász Árpád Cave on Mount Kab is 72 m long. The cave is partly artificial, because a series of gas bubble cavities have connected with the tunnel of a mining company. The fifty-one metre long Pokol Hole is also to be found in the basalt of the Bakony Mountains (Eszterhás 1994) (Fig 4, Fig. 5). The basalt overlays a loose sandstone layer and the basalt

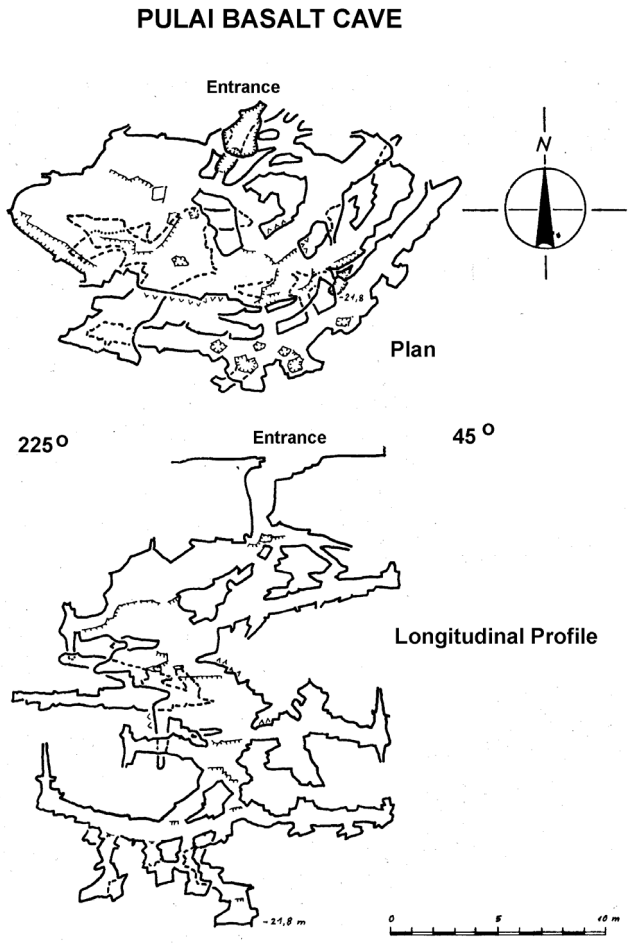

Fig. 2. Survey of the Pulai Basalt Cave, Bakony Mountains

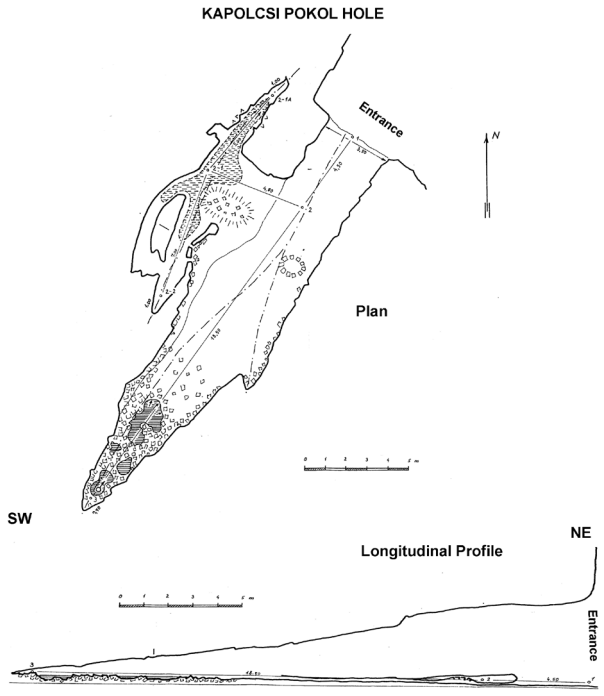

Fig. 4. Survey of the Kapolcsi Pokol Hole, Bakony Mountains

rim has broken away. The basalt blocks have not slid down the slope, but have fallen back against the bedrock, forming a leaning pseudocave. The Fissure Cave of Mount Tátika which originateed tectonically has developed perpendicular to the rim of the outcrop. The thirty nine metre long Hermit Cave near the village of Zalaszántó has formed parallel to the rim of the outcropping rock formation. Atectonic caves were formed by the equalization of tension as the rock mass moved down the slope. In the talus deposits of the basalt cones, typical extensional atectonic pseudocaves such as the Vadlány Hole in the Mount Kovácsi are to be found. The 32 m long Nagy Sárkány Ice Cave opens in the basalt of Mount Szent György in

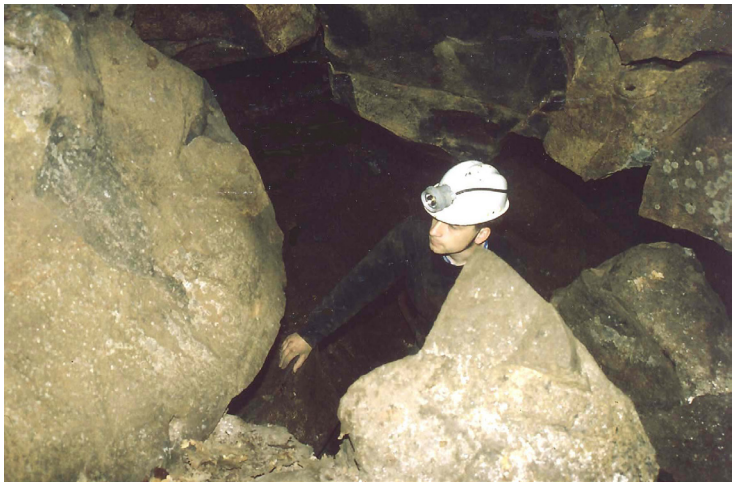

Fig. 3. Pulai Basalt Cave, Bakony Mountains

Fig. 5. Kapolcsi Pokol Hole in basalt, Bakony Mountains

the Bakony Mountains. This cave is unique in that the annual average temperature is +10°C . The entrance is 270 m a.s.l. The cave consist of a narrow labyrinth, which has developed in the debris of the collapsed basalt columns. Many small cavities have developed between the basalt columns of Mount Szent György (Fig. 6). The twenty six metre long Araszoló Cave has formed along a fault which is parallel to the basalt rim in the Mount Szent György. The symmetrical Gas Bubble Cavity of the Castle Hill near the village of Szigliget is syngenetic in origin (Eszterhás 1988, 1993, Szentes 1971).

Seven caves have developed in basalt tuff. The longest is the 16 m long Gödrösi Explosion Cave on the Tihanyi Peninsula. The cave is the result of a steam explosion, which took place concurrently with the deposition of the basalt tuff. On the Tihanyi Peninsula some other, partly demolished, smaller caves are also known. The 22 m x 3 m wide Nyereg-hegyi Rock Shelter has formed in the outcrops of the basalt tuff and geyserite layers. To the West of Pula village in the valley of Eger Creek the Pulai Basalt Tuff Cave opens. Rock fragmentation has been responsible for the formation of this 10 m long, flat cave, which has developed as a result of variations in temperature and moisture.

On the Tihany Peninsula in the Bakony Mountains 37 caves have developed in geyserite. The caves

Fig. 6. Cavities between the basalt columns, Bakony Mountains

have formed as the result of alkaline solution. Unfortunately many caves have broken down and only some remnants are reminiscent of their former existence. The longest geyserite cave is the 16 m long Spring Cave (Fig. 7, Fig. 8). The cave consists of a single chamber and is a show cave, illuminated by electric light. It is worthwhile to mention the 2.5 m long Upper Hole of the Aranyház, the 6 m long Hármas-hegyi Through Cave, the 5 m long Csúcs-hegyi Hole and the small Csúcs-hegyi Spring Cave. A geyserite cave was also to be found in the Koloska Valley near the town of Balatonfüred, but this has long disappeared (Eszterhás 1987a).

The 200 km^2 large Kemenesalja area lies north of the Bakony Mountains. The 6.5 m long Mount Pet Cave is to be found in basalt tuff in a tuff ring near the village of Miske. It is a tectonic cave, which has formed along a fault line parallel to the rim of the outcropping tuff. The basalt cave in Mount Ság, the so called Vass Pál Cave, was the most significant cave of the area, but it was demolished in 1914 during quarrying operations. There is not no reliable information about the cave.

South of Solymár village in the Budai Mountains limestone quarrying has opened several minor karst caves. In one of the quarries, a smaller Upper

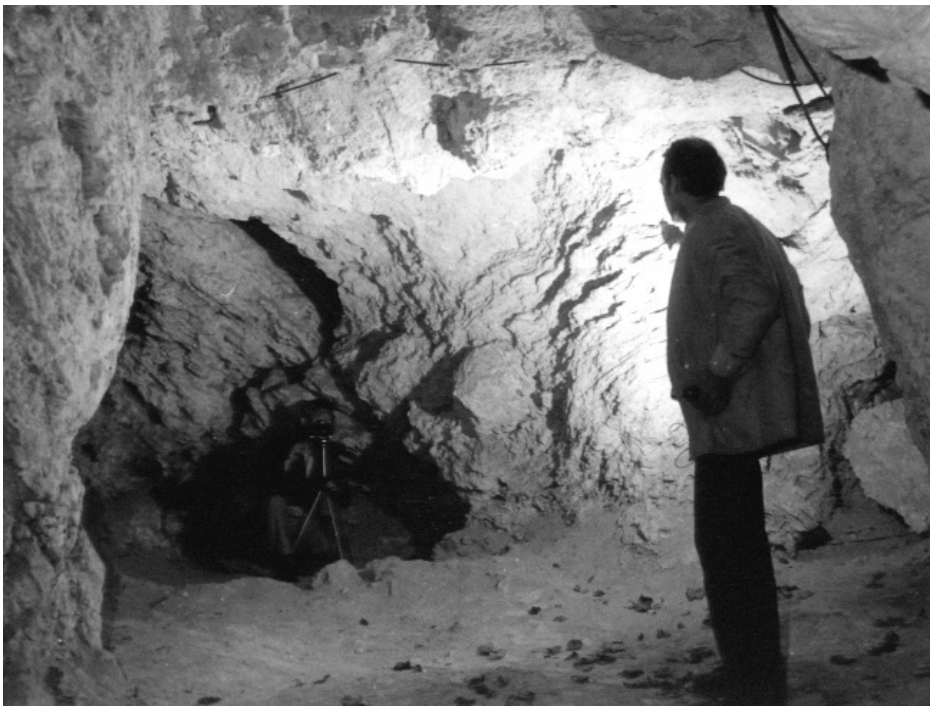

Fig. 7. Spring Cave in geyserite, Mount Szent György, Bakony Mountains, Tihanyi Peninsula.

with two andesite laccolith intrusions at the boundary of Pliocene and Pleistocene. Later basalt lava flowed on the surface from about hundred explosion centres. Between the basalt plateaux deep erosion valleys have formed. Thirty-four caves are to be found in the basalt (Eszterhás 1991). Two syngenetic caves have been discovered in the region. The 30 m long Kis-kői Basalt Cave (Fig. 9, Fig. 10) originated from steam explosion whilst the 13 m long Baglyas-kői Basalt Hole is a fumarole cave. The consequence caves represent an interesting genotype, as they have

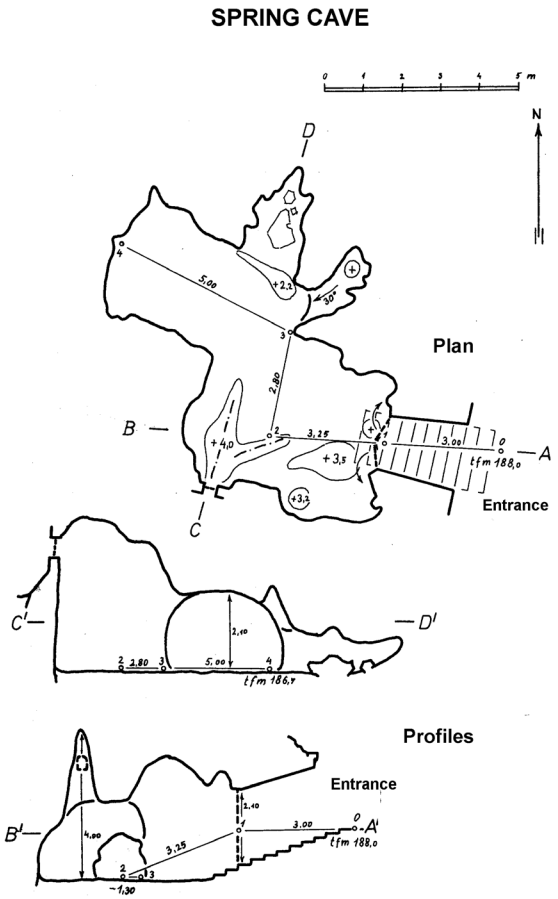

Fig. 8. Survey of the Spring Cave, Bakony Mountains, Tihanyi Peninsula

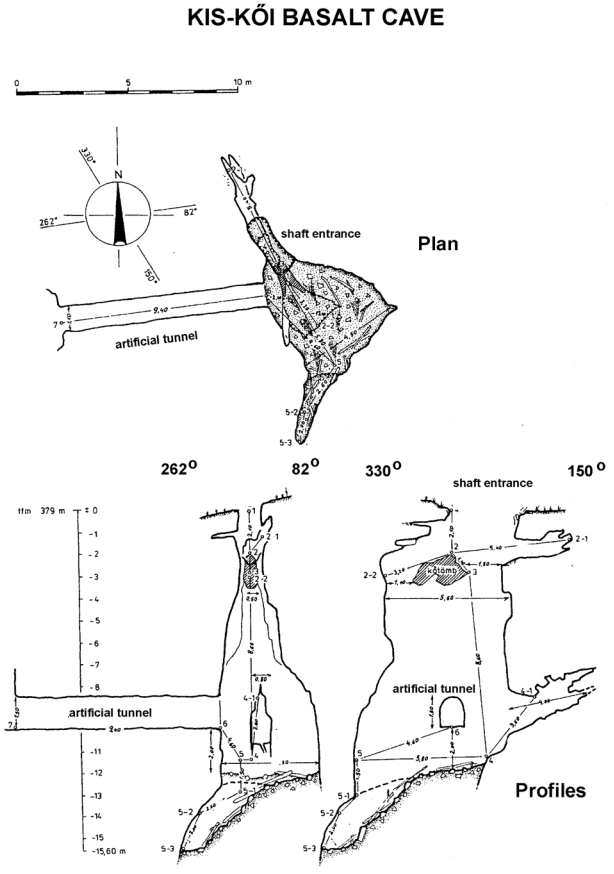

Fig. 9. Survey of the Kis-kői Basalt Cave, Medves-Ajnácskői Mountains

Cretaceous basalt intrusion has been revealed. Here a cave, the so called Budaligeti Basalt Cave, intersects the intrusion (Emby *et al.* 1989).

In the Medves-Ajnácskői Mountains volcanism began formed as a result of the collapse of the abandoned coal mines beneath the region. In the early 20th Century, below the basalt, a 3 m thick coal seam was mined out. In May 1917 the mine collapsed. As a consequence of this collapse the 80 m thick basalt

Fig. 10. Kis-kői Basalt Cave, Medves-Ajnácskői Mountains

layer downfaulted about 1 m and a 600 m long 20-25 m deep crevice has developed. The basalt blocks formed part of the ceiling of this fissure system and 30 known consequence caves were created with a total length of 350 m. Two caves are longer than 50 m, four caves are longer than 20 m and 24 caves are between 2 m and 15 m long. The largest cave is the 68 m long and 14 m deep Szilvás-kői Cave (Fig. 11,

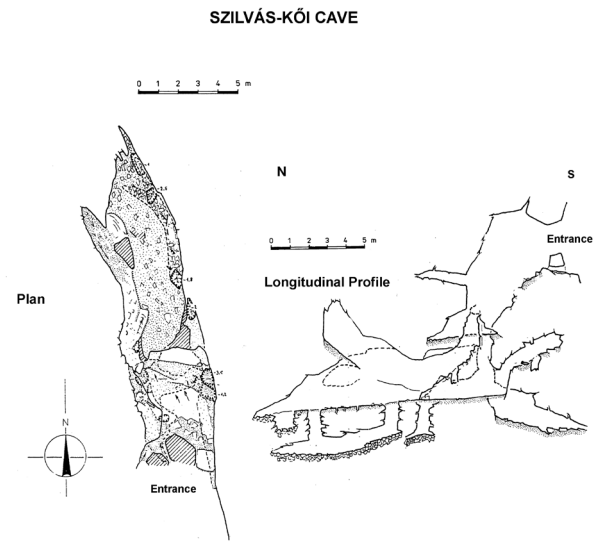

Fig. 11. Survey of the Szilvás-kői Cave, Medves-Ajnácskői Mountains

Fig. 12. Szilvás-kői Cave, the biggest consequence cave in the Medves-Ajnácskői Mountains

Fig. 12). The Sárkánytorok Cave is a 51 m long and 16 m deep through cave. In the southern part of the cave compacted snow accumulates 7-8 months of the year. The twenty-six metre long Dornyai Cave has developed along a narrow crevice. The twenty metre long Kis-szilváskői Fissure Cave is to be found at the end of an open crevice Compacted snow also occurs in this cave. Near the Fissure Cave the 45 m long and 14 m deep narrow Spider Hole opens (Eszterhás 2003).

4. Mineralogical, Hydrological, Climatological, Biological and Archaeological Observations

Among the 101 basalt caves and 41 geyserite caves in Hungary, mineral formations only occur in 20 caves. In some basalt and basalt tuff cavities calcite precipitation can be observed. The precipitation occurs in those caves, where the seeping water dissolves lime from the overlaying calcareous rock formation. The overlaying limy sand is responsible for the white, spectacular, calcite coating in Remete Cave near the village of Zalaszántó. Less significant calcite coating is also to be found also in Pokol Hole near the village of Kapolcs. In Explosion Cave near the village of

Gödrös calcareous pisolites occur. The pisolite coating has precipitated from the hot solutions which filled the cave after the steam explosion. The amygdales in the Pulai Basalt Cave were plugged with so called second generation calcite or with kaolinite. On the wall of the Basalt Cave a large number of 2-3 cm diameter, thin discs can be observed composed of isingerite, a rarely occurring silicate mineral. Different zeolite minerals (natrolite, phillipsite, desmine) are to be found in the small amygdales on the walls in the Basalt Caves of Mount Kovácsi. Limonite coating, calcareous pisolites and opal inclusions occur in some geyserite caves on the Tihanyi Peninsula.

Only two basalt caves contain significant water masses in Hungary. Seeping water completely fills in Halász Árpád Cave. Most of the time the two shaft entrances of the cave look like lakes. Only at the end of very dry summers does the water sink the and airspace appears in the passages. In the Kapolcsi Pokol Hole the thick basalt blocks dam up the seeping water, which emerges in the cave as a spring. This spring feeds a small lake. The size of the lake varies, because after the water reaches a certain level a siphon system drains it. The lake appears mainly in the spring, after thawing.

The climatic conditions in the relatively small basalt and geysirite caves (3-5m) in Hungary do not show significant deviation from the surface climate. In the larger caves the temperature is more or less constant throughout the year, relative to the annual average surface temperature. The exceptions are those caves, which have developed in porous or detritic rock formations. Here evaporation on the large rock surface causes such a significant a heat extraction, that the surroundings are cooled below freezing point. Each of these caves has developed in porous detritic volcanic rocks (Eszterhás 1999). Three of the five small ice caves which are to be found in Hungary have developed in basalt. The Kis Sárkány Ice Cave and the Nagy Sárkány Ice Cave (Fig. 13) can be found in the basalt debris of the Mount Szent György in the Bakony Mountains at 270 m a.s.l. The caves are dynamic ice caves. The ice (ice coating, icicles) can be observed only in summer. During this time the cold air flows over the stone slope outwards from the cave. In winter the air flows in the opposite direction and the ice formations thaw. The Sárkánytorok Cave opens in slaggy basalt in the Medves-Ajnácskői Mountains at 625 m a.s.l. The cave is a static ice cave, having a minor air flow. In winter the falling snow firnificates in the cave and remains throughout the year. Because of evaporation on the large surface of the surrounding slaggy basalt walls, not even in summer does the temperature exceed freezing point. Interesting alternating air flow has been observed in some interconnecting basalt caves. In these caves the

Fig. 13. Ice formations in summer in the Nagy Sárkány Ice Cave, Bakony Mountains. The cave has formed in basalt.

direction of the air flow alternates half-yearly. As a consequence the temperature between the two caves varies 10-20ºC . It is obvious there is a connection through the debris between the two caves. Examples of such interconnected caves are the Nagy Sárkány Ice Cave and the Warm Shelter Cave on Mount Szent György and Marcinek Cave and the Dornyai Cave in the Medves-Ajnácskői Mountains.

The fauna and flora do not show significant differences from those found in karst-caves, although variations in proportions found can be observed. For instance the proportions of the penicillin flora and the lepidoptera fauna are higher than in karst-caves. In almost every cave springtails (Collembola) occur, as do rove beetles (Staphylinidae), humpbacked flies (Phoridae), spiders (Araneidae), mosquitoes (Nematocera), small carrion beetles (Catopitae), butterflies and moths (Lepidoptera) and bats (Chiroptera). Some unique species have been identified in basalt caves. In the Basalt Caves of Mount Kovácsi two rare beetle specieses *(Orobainosoma hungaricum, Hungarosoma bokori)* and a rare land snail species *(Aegopis verticillus)* occur. The rare cave harvestman *(Holoscotoleman jaquati)* and another rare spider

species *(Kratochviliella bicapiota)* have been identified in the basalt caves of the Medves-Ajnácskői Mountains.

The palaeontological findings in the basalt and geysirite caves are not particularly interesting. Only Holocene remains were discovered, and the species belong to animals still living today.

Archaeological remains occurred in three caves, formed in basalt. The most abundant remains, 79 potsherds, were found in the Kapolcsi Pokol Hole in the Bakony Mountains. The oldest finds are Neolithic, thick, black, potsherds both thrown and shaped by hand dating from the Bronze Age. Furthermore, red, unglazed thrown potsherds were unearthed dating from the Middle Ages. Above the Kis-kői Basalt Cave in the Medves-Ajnácskői Mountains there once stood a fortification, although today this is completely ruined. However,in the cave potsherds are to be found, dating from the 13th to 14th centuries. A half horseshoe, of unidentified age, was unearthed from Dornyai Cave in the Medves-Ajnácskői Mountains. The age of the findings is unidentified.

References

Bertalan, K. 1958 Magyarország nem karsztos eredetű barlangjai. *Karszt-és Barlangkutatási Tájékoztató* (jan-jún), Budapest pp. 13-21

Emby, I.G., Dobosi, G., Noske, F., Árva-Sós, E. (1989): Petrology of a new basalt occurrence in Hungary. *Minerology and Petrology* 40, (3): 183-196

Eszterhás, I. 1987a A Tihanyi-félsziget barlang-kataszterе. *A Bakony természettudományi kutatásának eredményei* (18. kötet), Zirc pp. 1-84

Eszterhás, I. 1987b A Bakony bazaltbarlangjai. *Föld és Ég* (22. évf. 12. sz.), Budapest pp. 360-364

Eszterhás, I. 1988 A magyarországi bazaltbarlangok kutatásának eredményei. *Karszt és Barlang* (1. füzet), Budapest pp. 15-20

Eszterhás, I. 1991 *A Medves–Ajnácskői-hegység barlangjai – kézirat a szerző tulajdonában, Isztimér* pp. 1-100

Eszterhás, I. 1993 Genotypes of caves in volcanic rocks in Hungary. *Conference on the karst and research activites of educational and research institutions in Hungary*, Jósvafő pp. 81-86

Eszterhás, I. 1994 A Pokol-lik. *Lychnis, a Vulkánszpeleológiai Kollektíva kiadványa,* Kapolcs pp. 1-64

Eszterhás, I. 1999 Eishöhlen des gemässigten Gürtels in Basalt. *Proceedings of the VIIth International Symposium for Pseudokarst, Arad-Moneasa* pp. 5-13 & *Jahresbericht der Höhlenforschegruppe Rhein-Main* (Jg. 20.), Frankfurt a.M. pp. 107-112

Eszterhás, I. 2003 A nemkarsztos barlangok kutatottsága Magyarországon. *Karsztfejlődés* (VIII. kötet), Szombathely pp. 347-361

Eszterhás, I. 2005 Magyarország nemkarsztos barlangjai. *kézirat a Vulkánszpeleológiai Kollektíva Évkönyve az MKBT és a BI adattárában,* Budapest pp.162-200

Eszterhás, I. & Szentes, Gy. 2004-2009 Magyarország nemkarsztos barlangjainak katasztere – http://geogr.elte.hu/nonkarstic

Juhász, Á. 1987 Évmilliók emlékei. *Gondolat Kiadó,* Budapest pp. 1-562

Ozoray, Gy. 1952 The genesis of non-karstic natural cavites as elucidated by Hungarian examples. *Karszt- és Barlangkutatás* (II. kötet), Budapest pp. 127-136

Szentes, Gy. 1971 Caves formed in the volcanic rocks of Hungary. *Karszt- és Barlangkutatás* (VI. kötet), Budapest pp. 117-129