Karszt és Barlang, Special Issue 1989. p. 31—38. Budapest

THE RESULTS OF RESEARCH INTO CAVES OF THERMAL WATER ORIGIN

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Several caves can be found in Hungary whose rich forms and mineral precipitations cannot be attributed to the impact of descending cold karst waters or to the effect of slow subhorizontal streaming of cold waters at the karstic water level. These caves occur at the edge of limestone mountains where uplifted carbonate rock masses in the foothills and intermountainous basins meet with sunken carbonate masses that are covered by thick, water impermeable formations.

The upwellings of our natural thermal springs can also be found in these same regions, but while these were known since prehistoric times, the overwhelming majority of caves were only discovered in our century as a result of some human activity, usually quarrying. Although the genesis of the typical rich forms of certain caves was ascribed by Pávay Vajna (1930) to the work of hot solutions, streams and gases, it was the rather peculiar mineral combination that first convinced specialists that a relationship existed between these caves and the neighboring thermal springs. With the growth in the number of known caves, resulting in expanding investigations and improving hydro-geo-mineralogical research methods more and more details about the genesis and development of the caves became definable.

Hydrothermal caves can be found in greatest number in the Buda, Pilis and Gerecse Mountains, but they also occur in every major karstic region of Hungary: on the SE border of the Aggtelek Karst and Bükk Mountains, in the Keszthely Mountains constituting the SW foreland of the Bakony and in the Beremend section in the S fore land of the Villány Mountains. Quite frequently, these caves are of considerable size: among the 104 longest/deepest caves in Hungary (longer than 200 m and/or deeper than 50 m) 32 belong to this category including the country's third, fourth and fifth longest cave systems.

Some data of discovery of the Hungarian thermal-karstic caves

According to our current knowledge, of all the Hungarian caves formed fully or partly by thermal waters, only some minor caves in the Gerecse and Pilis Mountains, as well as the Castle Cave and the Bátori Cave in Budapest were proved to have been known by prehistoric and medieval man.

The cave opening above Buda's lukewarm Malom lake was first mentioned in 1856 by János Molnár, who explored and surveyed its dry upper section and also carried out hydrochemical examinations there. The first known cave of the Beremend block was a cavity exposed by quarrying in 1863: the fossil bones found there were analyzed by Kubinyi (1863) and Petényi (1864). By the end of the last century, the spatious cavity at the foot of the Bükk Mountains near Miskolc, the Miskolctapolcai Tavas Cave, with its voluminous thermal spring, was also known. The active Tapolcai Tavas Cave in the Balaton Highland filled with lukewarm lakes, was discovered in 1902 during the course of digging wells.

Among the large caves of Buda, the first to be discovered was the Pál-völgy Cave in 1904 during quarrying in the hills of Buda. Cold surface waters were assumed to have played the main role in its formation: thermal waters were felt to be secondary preforming factors via subsequent crystallization (Cholnoky, 1925) or recrystallization (Scharf, 1928).

The nearby Szemlő-hegy Cave was also discovered by quarrying in 1930. By analyzing the abundant, unusual, "popcorn-calcites" covering the walls it was recognized thermal water origin. (Kadic, 1931, 1933, Cholnoky, 1935). While digging a canal, another fissure network covered with "popcorn-calcites" was discovered here in 1933, the Ferenc-hegy Cave.

The largest network of the Keszthely Mountains, the horizontal labyrinth of the Cserszegtomaj Well-Cave, was discovered while digging for a well in 1930, 51 m below the surface.

The Sátorkőpuszta Cave on the NW edge of the Pilis Mountains near Dorog rich in gypsum crystal and aragonite precipitations was explored and examined in 1946. Its peculiar system of spherical niches was regarded as the model of cave formation caused solely by thermal waters origin (Jakucs, 1948). The fissure caves lined with crystalline pre-

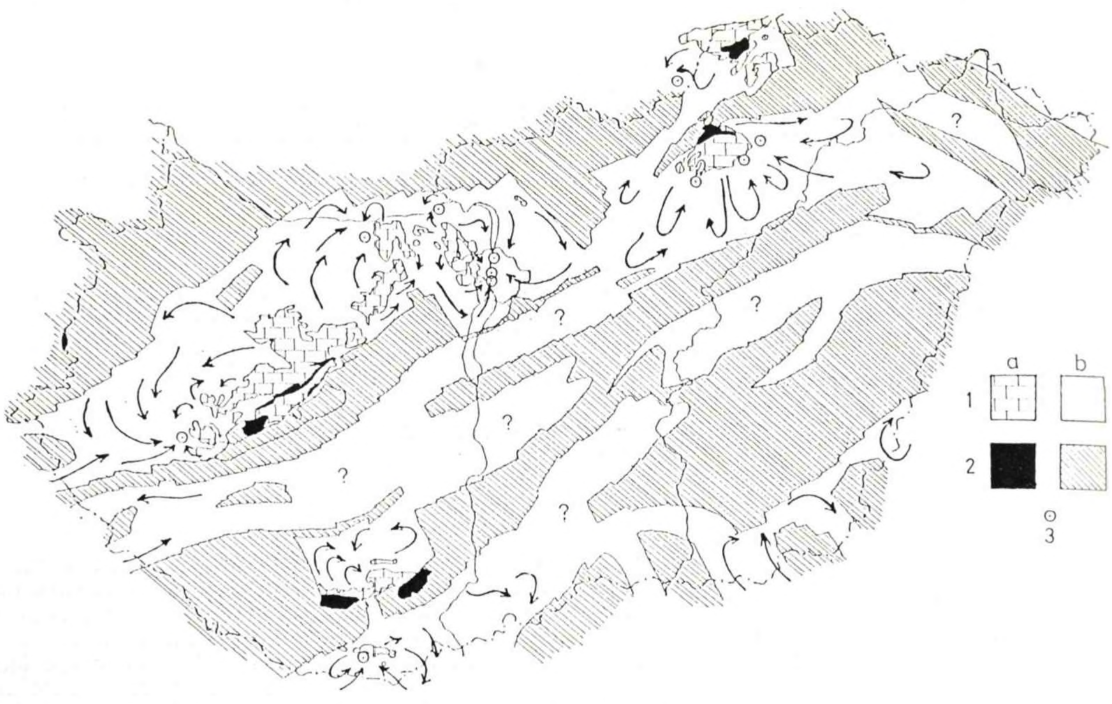


Fig. 1. Directions of the regional karst water circulation in the base-rocks of Hungary (after Alföldi—Böcker—Lorberer). — 1 = karstic base-rocks (mainly mesozoic), 2 = non-karstic base-rocks (mainly paleozoic and pre-cambrian), 3 = bigger thermal spring; a = on surface, b = subsurface

cipitations and crossed by the gangways of the Dorog coal mines were described in 1949 by I. Venkovits.

The exploration of the underwater sections of thermal-karstic caves could began with the spread of cave diving. By 1974 one km of the Tapolca Tavas Cave had been explored; the known length of the Molnár János Cave grew to 400 m in 1977. The country's deepest-lying hot spring cave, the Héviz Spring Cave with its opening 38 m below water level was successfully explored in 1975.

Significant explorations have also occured over the past ten years. Since 1980 the length of the Pál-völgy Cave has increased by over 5 km; in 1984, while laying housing foundations the József-hegy Cave, one of the country's richest caves in crystalline formations, was exposed, followed by the discovery of the Beremend Crystal Cave during quarrying. All this clearly shows that we still do not fully know the number and size of our thermal water caverns.

The system of thermal water flow

In regards to the origin of our thermal springs, Zsigmondy (1878) had already determined that rainwater infiltrating through the surface of the carbonate masses of the Transdanubian Mountain Range warms up while flowing in the basin deposit covered carbonate rocks and reaches the surface again in the form of thermal waters. The first model of this circulation was developed by Schafarzik (1924—26). Vendel and Kisházi (1963—64) described the flow of karstic thermal waters in the middle Mountain Range on the basis of heat and water metabolism calculations. Presently, the most current model of the thoroughly examined Budapest thermal waters was developed by Alföldi et al. (1977).

Structural, geological, hydraulic and thermodynamic factors have all had a share in producing these region-wide flows. The surface outcropping (1350 km^2) of the mesozoic carbonates constituting the great majority of karstifying rocks in Hungary, is a mere 10% of their total area, this means that carbonate rock masses covered with young basin sediments have a significent share in the geological constitution of the country. The considerable warming of waters stored in the cracks and cavities of carbonate rocks partly karstified during the cretaceous period and then submerged is due to the geometric gradient of 5° C/100 m, this is well above the global average, and is caused by the thin crust of the earth in this region.

The flow system is kept in motion by the difference in pressure between the free karst water level of the infiltration zones and the tapping points. The pressure difference is caused, on one hand, by the difference in geodetic heights, and on the other, by the difference in specific weights resulting from differing

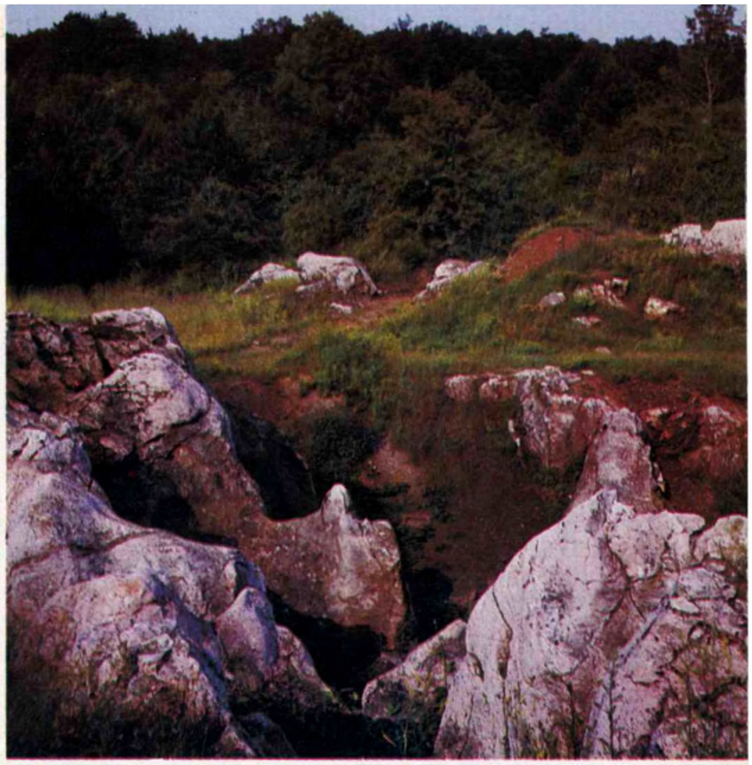
Top left: Hematite and hydrohematite in the Cserszegtomaj Well Cave, Bakony Mts.

Undernith: Rimstone pool in the Pál-völgy Cave, Buda Mts.

Top right: Exhumed paleokarst of Urkut, Bakony Mts.

Bottom: Remete-völgy Cave, Buda Mts. (by P. Borzsák)





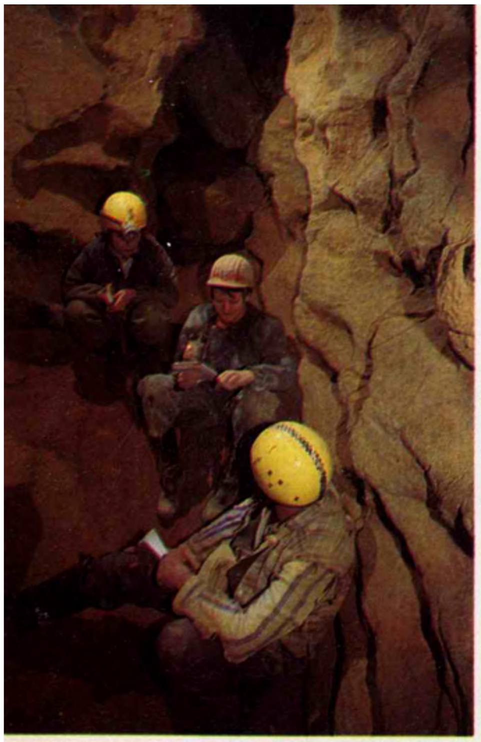
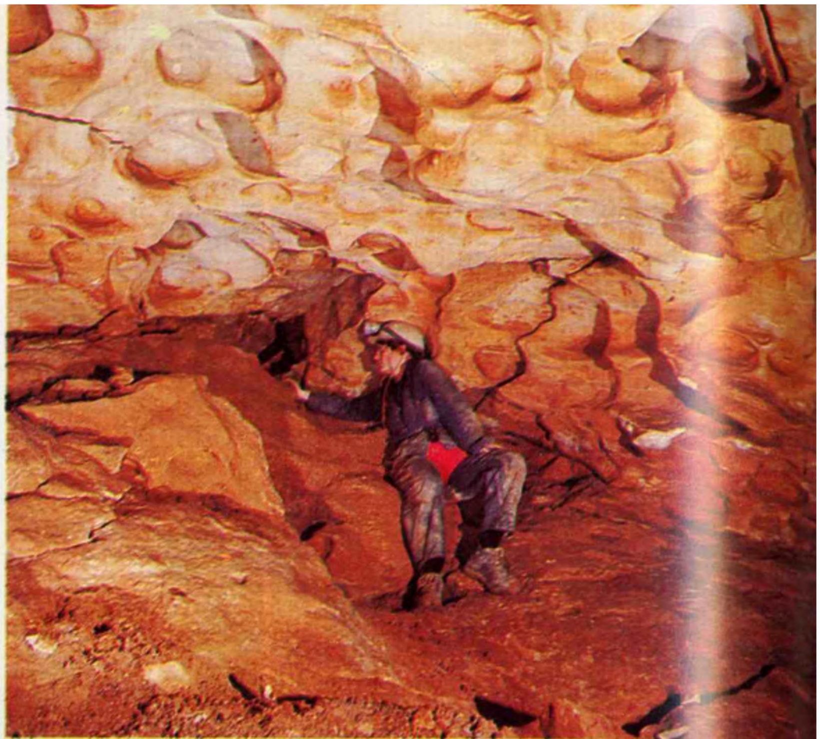
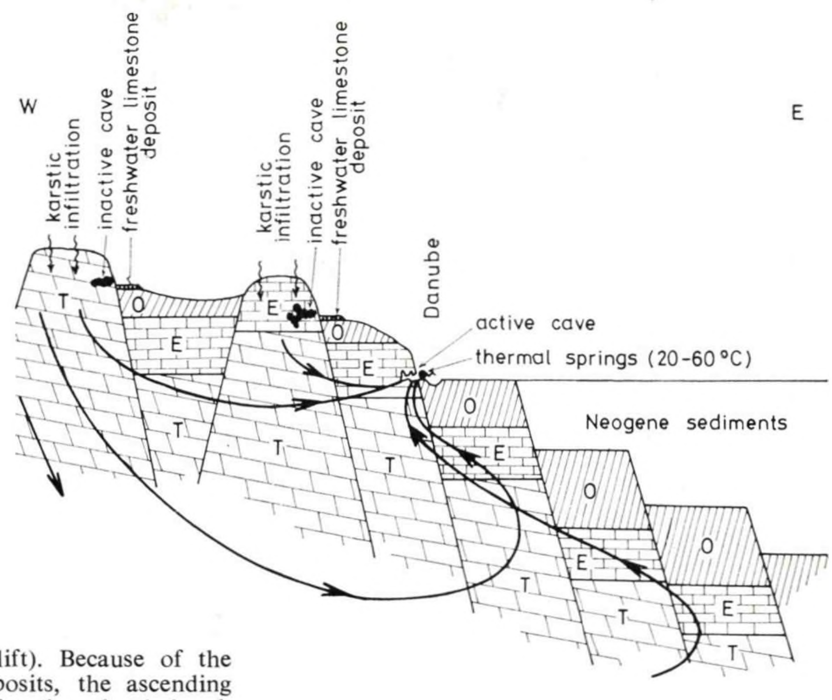





Fig. 2. Scematic profile of the hydrothermal activity of the Buda Hills. — T = Triassic carbonatic formations, E = Eocene carbonatic formations, O = oligocene clay and silts (after Kovács and Müller, 1980)



water temperatures (thermo-lift). Because of the impervious young basin deposits, the ascending thermal waters follow a forced path and only break the surface where the water guiding carbonate masses jut out from the impervious formations at the boundaries of mountain ranges; in other words, this upward flow is conditional upon certain structural zones (Fig. 1).

These structural zones usually coincide with the tapping points of the descending cold waters in a given group of mountains, thus in the spring zones cold and warm components are mixed (Fig. 2). The blending of the two components can be proved by the difference in temperature and tritium-isotope water age between the waters of drilled wells immediately drawing the warm component and the waters of the natural thermal springs (Deák, 1979). It can be observed in our active thermal water caves as well: in the Molnár János Cave water temperatures of 18 and 26° C can be measured (Plózer, 1972), in the Héviz Spring Cave 17 and 40° C waters gush forth a few metres apart (Plózer, 1977). The strong corrosive effect of the mixing of waters of various temperatures and solutions accounts for the karstic networks broadening into cavernous passages in the spring zone (Müller and Sárváry, 1977).

In accordance with the karstic origin of the thermal waters, these caves are not hydrothermal but thermal-karstic systems, since geological terminology ascribes hydrothermal solutions to postvulcanic processes. At the same time, in view of the mixing corrosive factor playing the main role in dissolving most of these caves, these caverns are actually not of thermal water but of warm water origin.

Top left: Teaching in Mátyás-hegy Cave, Buda Mts. (by P. Borzsák)
Top right: Solution forms in Mátyás-hegy Cave (by K. Fehér-Kárpát)
Bottom: Archaeological site in Jankovich Cave, Gerecse Mts. (by P. Borzsák)

On the basis of analyzing freshwater limestones deposited by warm springs in the Buda and Gerecse Mountains (Scheuer and Schweitzer, 1981) as well as paleogeographic investigations it can be assumed with certainty that the above outlined flow systems have been unchanged since the Pliocene and Pleistocene periods. The action of warm water springs over hundreds of thousands of years must have created several levels of freshwater limestones and caves in the gradually rising mountain groups during the Pleistocene era (Fig. 3). The relatively well discernible levels also reflect the climatic fluctuation in the glacial period, greatly affecting the volume of rainwater which provided additional water supplies. These climatic changes can also be monitored by examining vertebrate fossils found in the fills of some caves of thermal water origin (Jánossy, 1979).

Due to heavy water extraction for mining, the karst water level of the Transdanubian Mountain Range has significantly dropped in the past decade. As a result of the altered pressures, lukewarm springs of great yield ran dry in Tata and Tapolca, while in Héviz there has been a considerable decrease in yield and temperature.

The process of cave formation

The spatial pattern of our caves formed by thermal waters (the thick maze of practically equivalent passages condensed on a small area and extending several km in length, the sudden changes in section sizes, the spatious corridors and cavities joined by surprisingly narrow passages) can all be attributed to the mixing corrosive effect in the spring zone. The difference between mixing waters, and hence the corrosive effect, can be enhanced by the hypothetical process of the ascending warm component

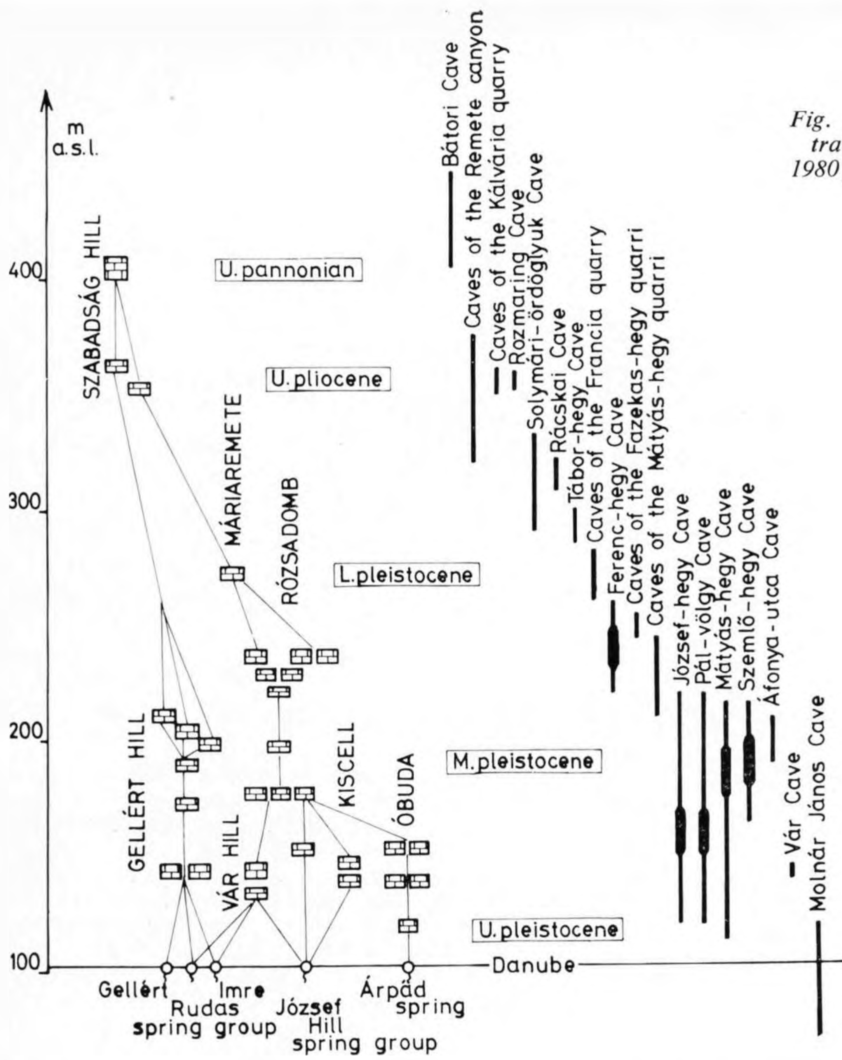


Fig. 3. Vertical locations of the travertine formations (Scheuer, 1980) and the more important caves of Buda Hills

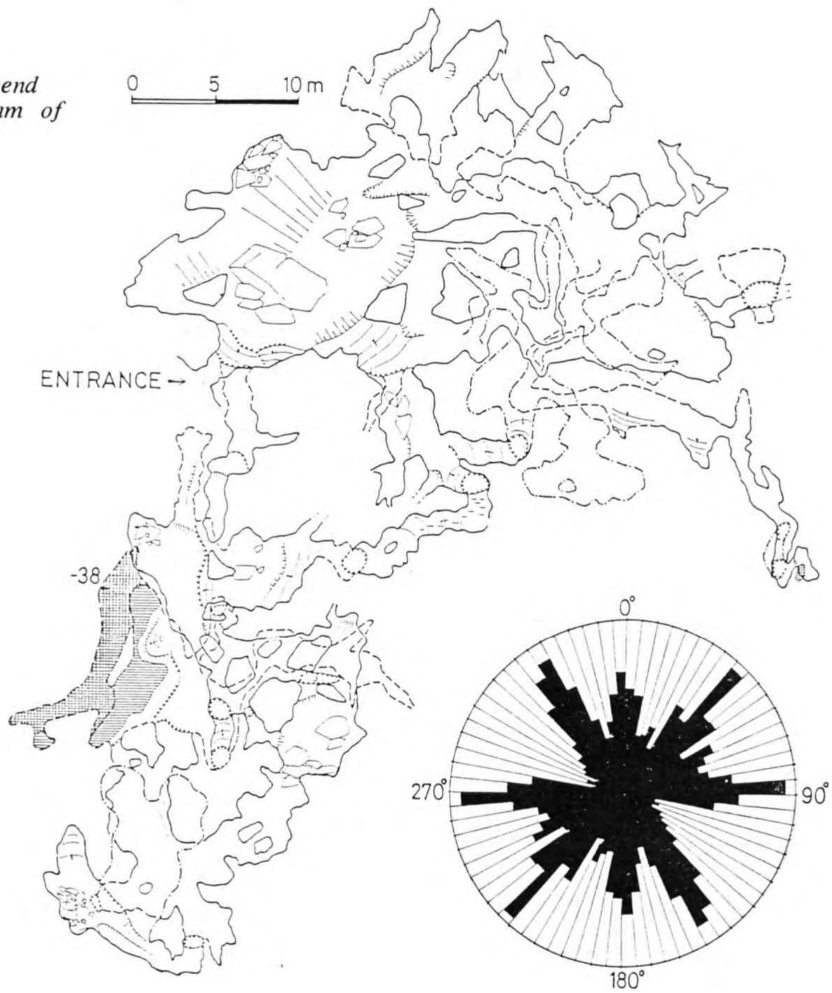
absorbing the CO_2 freed by the metamorphosis taking place in the deeper regions of the sunken carbonate mountains (Müller, 1971).

As the waters mixing in the spring zones move along the network of crevices in the rock mass, normally the most important preforming factor of caves is tectonics. It is most conspicuous in the case of the large grid-like cavity systems in the Buda Mountains (Kraus, 1978), but the effect of tectonic preformation can also be demonstrated by statistical examination of passages directions in intricate spatial mazes like the Beremend Crystal Cave (Mrs. Takács, 1985). In keeping with the strong tectonic preformation, the passages of our thermal-karstic caves are fissure-like, their height far exceeding their width *(Fig. 4)*.

Stratigraphic and petrological preformation also played a significant role in several caves. For instance, in some Buda caves the uppermost level of the main cavity is confined by marl which settled in the cover of the Eocene limestone. This could only be breached by spring vents where more powerful water activity was able to remove the large amount of dissolved remnants in this type of rock (Müller, 1974). The Cserszegtomaj "well-caves", once belonging to the water system of the Hévíz lake were carved at the confluence of the Triassic dolomite and the superimposed young impermeable sandstone. There are minor caves of warm water origin in Esztergom that emerged where the Triassic limestone and Oligocene silicious sandstone met.

In some caves in the Buda Mountains a characteristic metamorphosis of rock can be observed to a width of several dm around certain fissures. The yellowish white porous material containing typical Eocene fossils and not soluble in acids was interpreted by Scharf (1928) as rocks recrystallized by hot waters welling up along the crevices; Cramer (1929) showed the presence of 67—90% SiO_2 in it. The process of silicification was first conclusively separated from warm-water activity causing the formation of caves by Kovács and Müller (1980); they argued that these alterations as well as the emergence of certain mineral veins cannot be ascribed to the pressure and temperature relationships in a system of thermal water flow. According

Fig. 4. Plan of the Beremend Crystal Cave and a diagram of their passage-directions



to their two-phase model, the phenomena, which can be studied in surface rock exposures as well are the products of a hydrothermal phase connected to the Miocene andesite volcanism of the Dunazug Mountains, when it took place, the area of the Buda Mountains was still covered by clay several hundred meters deep.

This early phase must have caused some cave formation, but evidence can only be adduced in caverns whose walls are covered by the minerals of this high-temperature phase. The insoluble, silicified rock zones had a preforming effect due to their porous, and thus aquiferous quality, e.g. the wide passages of the Mátyás-hegy Cave and Pál-völgy Cave evolved along such silicious zones (Kárpát 1983, Mrs. Takács 1980). Frequently, only one side of the silicious zones was carved out, producing a typical passage section shaped like the letter 'd' (Kraus 1982).

The most characteristic forms in our thermal-karstic caves are the spherical niches. These nearly regular spherical or hemispherical cavities, several meters in diameter and joined in a head like fashion, are usually found in the upper levels of caves, often as the closing formation. At first Müller (1974) explained their genesis as the result of condensation dripping from the walls of fissures opening above the water surface. This argument, however, failed to account for the fully closed cupolas, and other similar forms which can also be found in cold-water caves, though in far fewer in number. According to the current hypothesis, these forms were created by convection currents in passages filled with water (Müller, 1977, 1983). Both the corrosion model by condensed water (Szunyogh, 1982, 1984) and the model of underwater corrosion (Rudnicki 1978, Dubljansky, 1987) have been proven by theoretical physics. It is noteworthy that the calculations of the time involued in the evolution of these forms also confirm the latter process (Szunyogh, 1987).

The large forms of the passages are enlivened by a variety of minor forms derived partly from selective corrosion, partly from the point-like effect of mixing corrosion, from water current, as well as from the movement of gas bubbles arising from the warm water. The best known minor forms are the hemispherical "kettles", several dm in diameter occurring by the dozen on certain wall sections

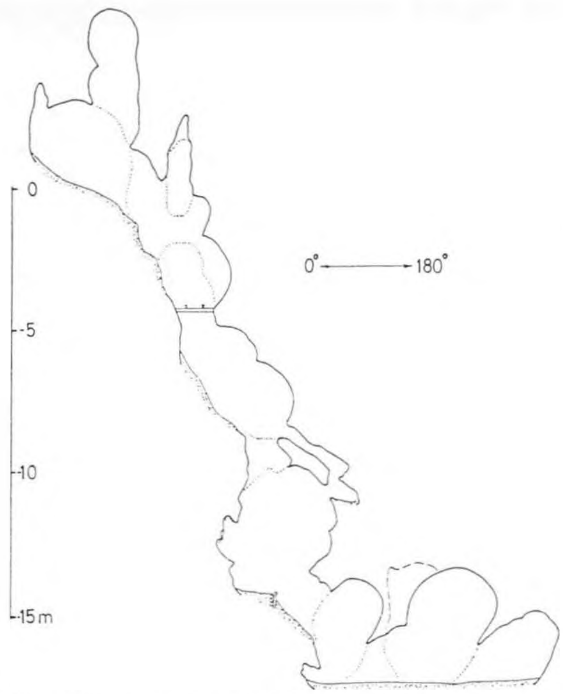


Fig. 5. Long section of the Bátori Cave with the line of spherical niches (by P. Borka and J. Kárpát)

(earlier attributed to vortices) as well as the ceiling canals and narrow bubble tubes in the roofs of passages or overhanging wall surfaces.

It can be demonstrated in several caves of thermal water origin that the extent of water coverage periodically changed during their evolution. This can be attributed to the combined effect of the climatic fluctuations during the Pleistocene era and the gradual rise of our mountains. During the glacial, dry periods of the Pleistocene era the decreased quantity of precipitation diminished the yields of springs, probably causing some to go completely dry. In the carved out system of caves the decreased water level produced practically stagnant lakes in contact with the air-space, and from these characteristic minerals settled on the walls and floors of the caves.

In areas where the rise of massifs opened up new tapping points, there was a relocation in the area of spring activity in the forthcoming milder, wetter period and the formation of caves continued in new spring zones. The stations of this process can be retraced by examining the caves and freshwater limestone deposits at different levels (Scheuer and Schweitzer, 1981). Where no considerable shift was possible, the warm water refilled the former passages or a part of them when thermal water activity resumed. It can be observed in some thermal karstic caves of the Buda Mountains that the renewed water movement broke through the accumulations and thus produced characteristic "thermal spring tubes" (Kessler, 1961); elsewhere hemispheric "kettles" were carved into the precipitations and some precipitations partly dissolved again, then continued to grow (Kraus, 1982).

In the Pál-völgy Cave, however it can be proved that some of its thermal karstic mineral precipitations settled on a previously sere base (Kiss—Mrs. Takács, 1987), the remains of this earlier filling level is sometimes several meters higher than the present floor. That is, there occured at least three water filled periods. In some caves in the Beremend block, of the Pilis Mountains and in the Esztramos Hill, dripstone formations started in the periods between thermal karstic activity, and returning ascending warm waters then dissolved their surfaces and subsequently covered them with precipitations. The stalactites found deep under the present water level in our active warm water caves reflect the karst water level changes in the recent past history of the Earth.

The further expansion of completely dried out caves by the gradual rise of the massifs was only caused by collapses and the slow draining of the silicious zones, though in the case of some caves of thermal water origin the passages opening on the surface came to act as swallets later. This is attested by the paleontological finds of the Solymári Ördöglyuk Cave (Vértes, 1950), the cold-water corrosion created forms known as the Stream Passage in the Mátyás-hegy Cave (Kárpát, 1983) or the remains of carbonized plants in the sediment fill of the Pál-völgy Cave.

Mineral precipitations

Minerals of the high-temperature phase preceding the dissolution of caves, precipitations of warm waters filling the caves, and dripstone formations o cold waters oozing in the dried systems may all be found among the varied mineral associations of our caves formed by warm waters.

Minerals linked to high-temperature solutions are obviously not limited to the caves; they can be located in rock outcropings on the surface and on the walls of quarries and mine shafts. Cave passages merely expose these minerals, much as they do the paleontological remains of the bedrock or its limonitized pyrite concretions.

Among the minerals formed at high temperatures, calcite is the most widespread; its massive loads sometimes appear in meter-wide veins, while its "dogtooth spar" crystals of a few cm, line the walls of open fissures and crystal cavities (geodes). Barite veins consisting of tabular crystals are also common in the Buda Hills and the Gerecse and Pilis Mountains.

Because the mineral veins were barely soluble due to their material and the large specific surface area of their crystals, they were a hindrance to the subsequent formation of caves; thus, they appear deeply jutting into the passages on the walls and ceiling. Partly due to this fact and partly because the crystalline forms were indicative of high temperatures came the recognition that prior to the thermal-karstic activity that created these caves they evolved through "closed cell" redeposition in the rock mass buried beneath a thick clay cover (Kovács and Müller, 1980).

Recent mineralogical researches has confirmed the above hypothesis. The examination of the fluid inclusions in the vein and "dog tooth" calcites (Gatter, 1984) proved their separation the 135—200° C waters of the confined karst. Based on the composition of the enclosed solutions, the samples from the Buda Mountains suggested volcanic activity as the origin of the thermal effect, while those from the Bakony and Bükk Mountains indicated geothermal heating. According to U/Th dating and ^{13}C—^{18}O isotope tests to which the samples from the Buda Mountains were subjected, by Ford these minerals differed sharply from mineral precipitations caused by warm waters (personal communication, 1985).

In the Buda Mountains we can find several generations of calcites and barites characterized by different crystalline forms (Schafarzik, 1928), and in some places alternate calcite and barite formations (Koch, 1966). This indicates that the closed-cell redeposition of material was intermittent, renewing several times. These phenomena can be observed in caves as well. The warm waters that carved the caves dissolved a part of the older calcite crystals e.g. in Beremend the surface of the thick calcite veins falls into match stick thin calcite chips, and at several places on the surface or tip of the "dog tooth" calcites deep grooves can be seen.

In contrast to the previous genetic group of mineral formations, those of warm water origin generally do not appear outside of the caves except as occasional precipitations near the surface of drilled thermal well sites. Their concentration at certain levels inside caves suggests that they were deposited during the invervals between thermal karstic activity through the precipitation of dissolved materials in lakes of partly air-filled caves due to the gradual rise of the massifs (Kraus, 1982). Mineralogically, most of these deposits are calcite.

The most frequent form that warm water precipitations assume is the "popcorn-calcite", white or yellowish-white stratified pellets which cover cave walls like bunches of grapes clustered along thin stalks. Originally this formation, first found on a mass scale in the Szemlő-hegy Cave was thought to be aragonite and led to the recognition of the thermal water origin of the cave. Modern research techniques proved them to be of calcite, probably the result of subsequent recrystallization.

In some caves one can find formations similar to "popcorn-calcites", consisting of spar-shaped units, but each unit consits of a selfcontained crystalline structure. These were probably calcitic from their conception (Kiss—Mrs. Takács, 1987). The "cauliflowers", more densely clustered than the "popcorn-calcites" lacking a stratified structure (Kraus, 1982), probably evolved in areas sealed from streaming.

Another typical formation is the calcite platelets containing calcite sheets a millimeters to centimeters thick. These evolved from thin calcareous films which separated from surface of cave lakes. As these broke apart and sank to the bottom, they acted as crystal niduses, thus thickening and adhering together (Kraus, 1978). Due to redeposition in the original fill the remains of these often occur several meters above today's walkways; at their bottom edge pieces of debris from the one-time fill can also occasionally be recognized. In some passages horizontal ribs can be observed indicating the gradual lowering of the water level in the se caves.

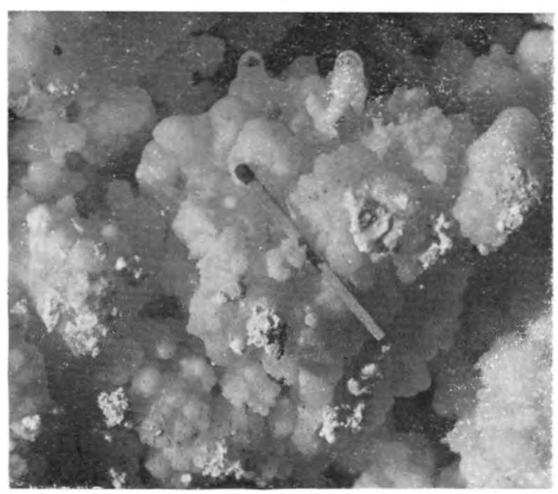
"Christmas trees" are a rare formation. The 30—200 cm tall, 20—50 cm wide, "popcorn-calcites" covered conic columns found in the Szemlő-hegy Cave were supposed to have been warm water geysers (Panos, 1960) or inundated stalagmites, but samples cut during the development of the cave and those found in the József-hegy Cave demonstrate that they were formed by local accumulation of calcite platelets.

The crystalline variant of calcium carbonate which is unstable below 29° C, the needle aragonite, only appears in a few caves, but their mass concentration turns the József-hegy Cave and the Beremend Crystal Cave into the most spectacular of our caves of thermal water origin.

In some of our caves there are gypsum formations as well. Their genesis probably is connected to the pyrite content of the bed rock. By the effect of the thermal waters this is oxidized into limonite and the sulphur content of the pyrite is released. Gypsum occurs either as this scales or as densely plated fiber: in some places the gypsum creates "flowers" and "corkscrews" as it pushes through the pores of the rock. Rarities of the József-hegy Cave include the "gypsum daggers" of several decimeter length and the tenth of a millimeter wide "hairs" which can stretch to 1 m in length (Adamkó—Leél Össy, 1984).

It can also be attributed to petrological relations that marcasite blocks of several kg each can be observed at the bottom of the Héviz Spring Cave formed in sandstone (Plózer, 1977).

Huntites in the Beremend Crystal Cave (Photo T. Hazslinszky)



Among the special minerals of Hungarian caves is the milk-white, soft knobs or creamy grains of huntite ($CaMg_2/CO_3/_4$), which in Hungary occur only in three caves of thermal water origin. (Ozoray, 1961, Mrs. Takács, 1985).

Fluid inclusion tests on warm-water precipitations have only been carried out in the Pál-völgy Cave. The findings revealed that the temperature, density and chemical composition of solutions creating the mineral formations were very similar to the present-day warm water springs in Buda (Gatter, 1984).

The dripstone formations of thermal karstic caves differ only in size and quantity from those of other karstic caves. As there are often slightly permeable rocks above the caves, dripstone formations are confined to certain areas, thus generally these caves are poor in dripstones. Because of the accumulated loose fill at the bottom of the caves stalagmites often assume a subordinate position instead, extensive saturations and incrustations occur on the floor. In the Acheron Well Cave the rare stalactites of limonite can be seen at the boundary between dolomite and sandstone these occur due to the leaching of iron from the sandstone cover (Kárpát, 1983).

Various mineral formations are documents of the different stages of evolution of our caves of thermal water origin. Thus further research into the age of these formations and the physico-chemical properties of the medium from which they separated can greatly aid in the investigation of the origin and in understanding the differences in the morphology and mineral associations of these caves.

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REFERENCES

ADAMKÓ P.–LEÉL-ÖSSY SZ. (1984): Budapest új csodája: a József-hegyi-barlang. – *Karszt és Barlang, I. p. 1–8.*

ALFÖLDI L.–BÖCKER T.–LORBERER Á. (1977): Magyarország karbonátos repedezett hévíztárolóinak hidrogeológiai jellemzői. – *Magyarország hévízkútjai. VITUKI kiadvány. p. 17–28.*

ALFÖLDI L.–DEÁK J.–LIEBE P.–LORBERER Á. (1979): A középhegységi hideg és meleg karsztvízkészletek összefüggése, különös tekintettel a bányászat víztelenítési törekvéseire. – *VITUKI Közlemények, 23.*

CHOLNOKY J. (1925): Elnöki megnyitó. – *Földrajzi Közlemények, p. 141–145.*

CRAMER, H. (1929): Einige Beiträge zur Geologie und Morphologie ungarischer Karstgebiete. III. Das Budaer Gebirge. – *Mitteilungen über Höhlen- und Karstforschung, H. 3.*

DUBLJANSZKIJ, J. V. (1987): Теоретическое моделирование динамики формирования гидротермокарстовых полостей. – Методы и изучения геологических явлений. *p. 97—111.*

GATTER I. (1984): A karbonátos kőzetek érkitöltéseinek és a barlangok hévizes kiválásainak folyadékzárvány-vizsgálata. – *Karszt és Barlang, I. p. 9–17.*

JAKUCS L. (1948): A hévforrásos barlangkeletkezés. – *Hidrológiai Közlöny.*

JÁNOSSY D. (1979): A magyarországi pleisztocén tagolása gerinces faunák alapján. – *Akadémiai Kiadó, Bp.*

JASKÓ S. (1948): A Mátyáshegyi-barlang. – *MÁFI Évi Jelentés, X. p. 133–141.*

KADIĆ O. (1931): A Szemlő-hegyi-barlang kutatása és felmérése. – *Turistaság és Alpinizmus, XXI. p. 22.*

KADIĆ O. (1933): A Szemlő-hegyi-barlang. – *A Földtani Intézet Évi Jelentései, 1929–32.*

KÁRPÁT J. (1983): Az Acheron-kútbarlang. – *Karszt és Barlang, p. 25—28.*

KÁRPÁT J. (1983): Mátyás-hegyi-barlang. – *Magyarország barlangtérképei 4.*

KESSLER H. (1961): Földalatti ösvényeken. – *Móra Kiadó, Bp.*

KISS A.–TAKÁCSNÉ BOLNER K. (1987): Újabb jelentős feltárások a Pál-völgyi-barlangban. – *Karszt és Barlang. p. 3–8.*

KOCH S. (1966): Magyarország ásványai. – *Akadémiai Kiadó, Bp.*

KOVÁCS J.–MÜLLER P. (1980): A Budai-hegyek hévizes tevékenységének kialakulása és nyomai. – *Karszt és Barlang, II. p. 93–98.*

KRAUS S. (1978): A budapesti Szemlő-hegy és Ferenc-hegy hévizes eredetű üregrendszereinek tektonikai vizsgálata. – *Szakdolgozat, ELTE Földtani Tanszék, Kézirat.*

KRAUS S. (1982): A Budai-hegység hévizes barlangjainak fejlődéstörténete. – *Karszt és Barlang, I. p. 29–34.*

KUBINYI F. (1863): A beremendi juramészképletről, kivált az abban talált csonttorlatokról. – *Magy. orvosok és természetv. Munkálatai, VIII. p. 73.*

MOLNÁR J. (1856): A budai melegforrások physikai és vegytani viszonyairól. – *Term. tud. Évkönyv, 1851–56.*

MÜLLER P. (1971): A metamorf eredetű széndioxid karsztkorróziós hatása. – *Karszt és Barlang, II. p. 53–56.*

MÜLLER P. (1974): A melegforrás-barlangok és gömbfülkék keletkezéséről. – *Karszt és Barlang, I. p. 7–10.*

MÜLLER P.–SÁRVÁRY I. (1977): Some aspects of developments in Hungarian Speleology Theories during the last 10 years. – *Karszt és Barlang, Special Issue. p. 53–60.*

OZORAY GY. (1961): Magnéziumkarbonát-ásványok előfordulása barlangokban. – *Karszt- és Barlangkutató, II. p. 81–82.*

PANOŠ, V. (1960): A Budai-hegység hévforrásos karsztja. – *Hidrológiai Közlöny, 5.*

PETÉNYI S. J. (1864): Petényi hátrahagyott munkái. – *Magy. tud. akadémia, Pest. p. 35–81.*

PLÓZER I. (1972): A Malom-tavi Molnár János-barlang vízalatti járatainak kutatása. – *Karszt és Barlang, p. 13–16.*

PLÓZER I. (1977): A Hévizi-tó forrásbarlangjának feltárása. – *Karszt és Barlang, p. 65–66.*

RUDNICKI, J. (1978): Role of convection in shaping subterranean karst forms. – *Kras i Speleologia, 2. (XI.) p. 92–101.*

SCHAFARZIK F. (1928): Rückblicke auf die Entwicklungsgeschichte der budapester Thermen. – *Hidrológiai Közlöny, I. p. 57–61.*

SCHERF E. (1928): Hydrothermales Gesteinmetamorphose im Buda–Piliser Gebirge. – *Hidrológiai Közlöny, 2. p. 107–206.*

SCHEUER GY.–SCHWEITZER F. (1980): A budai hévízforrások fejlődéstörténete a felsőpannontól napjainkig. – *Hidrológiai Közlöny, 11. p. 492–501.*

SCHEUER GY.–SCHWEITZER F. (1981): A hazai édesvizi mészkőösszletek származása és összehasonlító vizsgálatuk. – *Földtani Közlöny. p. 67–97.*

SZUNYOGH G. (1982): A hévizes eredetű gömbfülkék kioldódásának elméleti vizsgálata. – *Karszt és Barlang, II. p. 83–88.*

SZUNYOGH G. (1984): A gömbfülkék kondenzvíz-korróziós kialakulásának elméleti fizikai leírása. – *Karszt és Barlang, I. p. 19–24.*

SZUNYOGH G. (1987): A hévizes eredetű gömbfülkék víztükör alatti kioldódásának elméleti vizsgálata. – *Karszt és Barlang. p. 29–31.*

TAKÁCSNÉ BOLNER K. (1980): Új feltárások a Pál-völgyi-barlangban. – *Karszt és Barlang, II. p. 87–92.*

TAKÁCSNÉ BOLNER K. (1985): A Beremendi-kristálybarlang. – *Karszt és Barlang, p. 3–12.*

VENDEL M.–KISHÁZI P. (1964): Összefüggések melegforrások és karsztvizek között a Dunántúli-középhegységben megfigyelt viszonyok alapján. – *MTA Műszaki Tud. Oszt. Közl.*

VENKOVITS I. (1949): Adatok a dorogi mezozóos alaphegység szerkezetével kapcsolatos üregekhez és vízjáratokhoz. – *Hidrológiai Közlöny, 29. p. 160–168.*

VÉRTES L. (1950): A Solymári-barlang rétegviszonyairól. – *Földtani Közlöny, LXXX. 4–6.*

ZSIGMONDY V. (1878): A városligeti artézi kút Budapesten.