

CAVES FORMED IN THE VOLCANIC ROCKS OF HUNGARY

by
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A minor part of the caves develops in non-karstic rocks: in general, these are cavities of smaller dimension brought about by different geological processes. Among them the most important are those formed in volcanic rocks. A part of these was formed simultaneously with the volcanic activity and rock building: thus they may be looked upon as primary forms, while another part of such caves was formed by secondary (tectonical, erosional etc.) processes, independently of the volcanic activity. Of course the cavities brought about by primary processes deserve the greatest interest: some of them may reach — in exceptional cases — very great extent and dimensions.

Let us try to systemize the cavities of volcanic rocks.

I. Cavities formed by primary processes:

1. Lava-caves,
2. Cavities in connection with an emptying eruption,
3. Cavities caused by the expansion of gases and water vapour.

II. Cavities formed by secondary processes:

1. Cavities brought about by mass-movements, such as
 - a) atectonical movement,
 - b) tectonical movement and
 - c) falling in.
2. Cavities subjected to further enlargement.

I.1. Lava-caves develop mostly in basalt- or basaltoid-rocks, where the viscosity of the melted rock-material is low and its flow is rapid: their development is connected with the lava-flows. The surface of the running lava solidifies quickly and under the thin crust the melted material continues flowing. On a certain point of the hillside the lava-stream becomes tapped and the level of the red-hot melted material sinks, leaving a cavity behind. The temporary level of the sinking lava is indicated on the sidewalls of the cavity by markings brought about when the lava-supply is no more able to supply the melted mass flowing out of the cavity.

In connection with the foregoing, another possibility of lava-cave-forming is also known, i.e. when the lava-stream ends in "toe-like" protrusions. The volume under the plastic or very thin crust is filled with red-hot melted material, and the smallest fissure gives the opportunity for the lava to flow out and leave a cavity behind.

I.2. Emptied cavities of lateral craters can be formed on the slope a of previous volcanic construction so that the slope of the mountain opens and lava will flow out. The mechanism is similar to the formation of the lava-caves but they differ from them in that the walls of this kind of cavities are not necessarily formed by lava solidified earlier, but it would be pyroclastic material as well. The lava-material elaves these cavities by means of effusion.

In Hungary no lava-caves or cavities connected with emptied eruption have been recorded. The cause for this may be that the volcanic activity producing our basalts and basic andesit rocks took place at such an ancient time (Miocene) that the cavities while being present surely at a time, had been eroded without leaving a trace.

I.3. The third group of caves connected with primary processes is formed by the pressure of volcanic gases and vapours. The viscosity of the lava-material of the rocks containing the cave must be low also in this case, but if the pressure of the gases is sufficiently high, caves might be formed also in rocks of a lesser basic character. Thus such caves may occur — besides basalts — also in andesites.

There are traces of the occurence of such "gas-bubble"-caves in Hungary too. L. J u g o v i c s thinks that the basalt-cavity of "*Bárnai Kiskő*" (near *Salgótarján*) is of such origin. The acvity of 12 m length and 5—6 m width was formed in bubbled-basalt; according to Gy. O z o r a y tectonical (perhaps mass-movemental) and post-volcanic effects might have played an important role in the formation of this cavity.

We succeeded to observe a bubble-cave of 3 m diameter in a quarry opened in the vicinity of *Sámsonháza* (*Cserhát*-mountains); the cavity has been extracted completely since then. It was formed in one of the andesite lava-flows (Miocene) alternating with tuff-benches (Fig. 1.); its walls were covered by carbonate-minerals. At the same place we could observe some minor cavities (with a size of few decimetres), too (Fig. 2.).

At the W-side of *Mátrakeresztes* on the valley-side a small bubble of about 1 m diameter could be observed as set free by erosion. The small cavity was formed in one of the lava-flows of the andesite series of the *Mátra*-mountains (Fig. 3.).

II. With the caves formed by secondary effects the process forming the cave does not depend immediately on the volcanic activity. The indirect connection is furnished by the quality and physical properties of the rock and its structure brought about in the course of the activity (bankedness, jointing etc.). This kind of caves can be observed not only in lava-rocks, but in volcanic tuffs and agglomerates, too.

Such caves are not typical for volcanic rocks, since they may be formed in the same way either in karstic or non-karstic rocks too. They may become characteristical owing to certain phenomena connected with volcanic rock-structure (jointing, bankedness, volcanic tectonics, special bedding forms) or effects (e.g. postvolcanic activity).

II.1. a) During the movements of volcanic rocks — tectonically or in some other way — rift-cavities are formed. A frequent case of non-tectonical movements is sliding. During this — in a favourable case — a fissure with triangle-shaped cross section will be formed on the boundary of the remaining and of the shifted rocks. The sliding is caused in most cases by the alternation of lava-rock or agglomerate and tuffs. Perpendicularly to this an important quantity of rock breaks off and separates from the bedrock. The process takes place — as a rule — on the boundary of the tuff which became clayly and is favoured by the jointing forms perpendicular to the sliding. The phenomenon takes place on steep slopes.

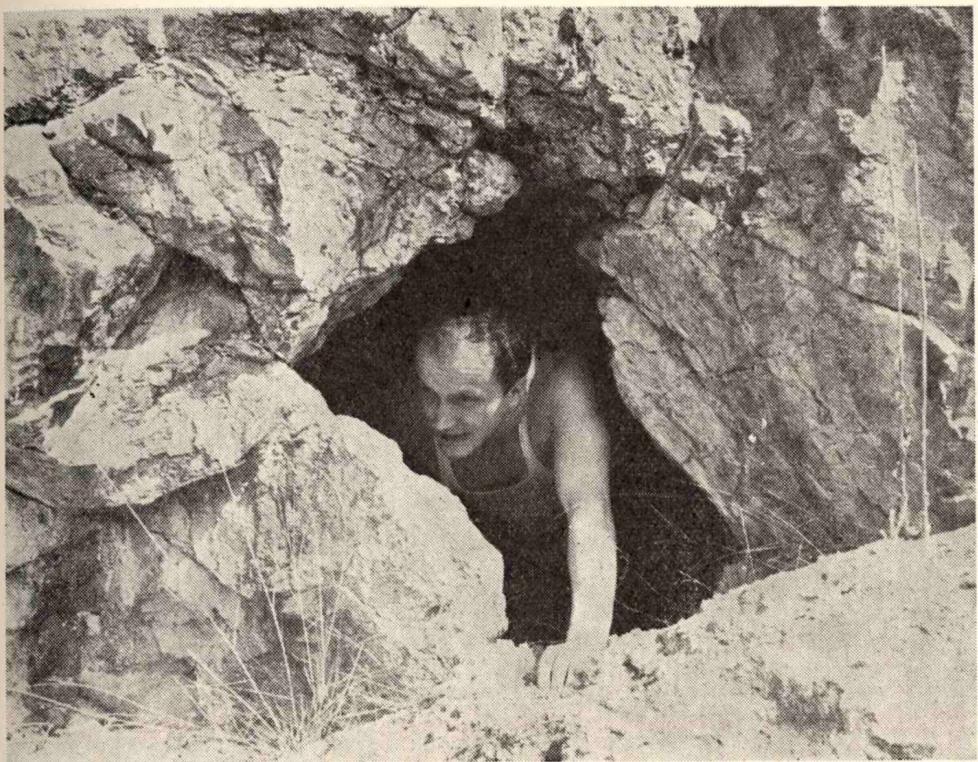


Fig. 1. Gasbubble-cavity in one of the Miocene andesite lava-flows of the quarry of Sámsonháza (Cserhát-mountains). The diameter of the cavity is about 3 m; It has been destructed after the survey (1966) in the course of mining operations. (Foto by Gy. Varga).

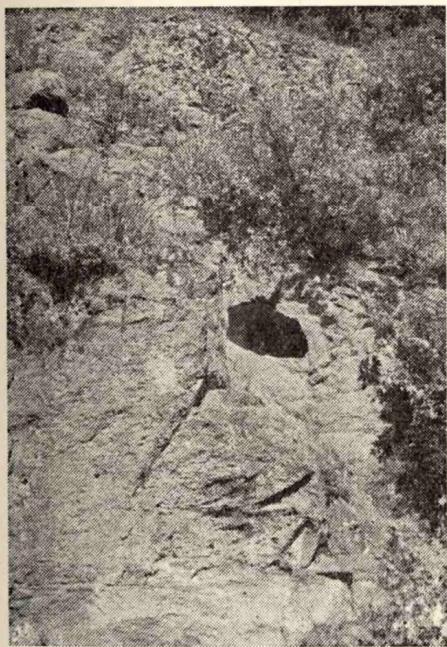


Fig. 3. Gasbubble-cavity in andesite near Mátrakeresztes (Foto Gy. Szentes



Fig. 2. The cave of gasbubble-origin of the quarry of Sámszonháza in andesite (Foto by Gy. Varga).

In the *Pilis*-mountains, on the North-side of the *Kőhegy* at *Pomáz*, there is the so called *Vasas*-rift-opening as well as three minor cavities (Figs. 4–5.). The open rift of 33 m length, and the cave III. (of 23 m length) starting from this, then the cave II. (of a length of 20 m) and cave I. (15 m) connected with it were formed during an approximately NE-SW-shifting of arched character. The steep rock wall above the caves — consisting of andesite agglomerate — is the bedrock, along which the rock-mass tumbled down perpendicularly to the sliding. When moving on towards the valley a chaotic piling up of agglomerate rock-blocks indicates the landslide. The valley shows the clayed andesite-tuff furnishing the sliding surface. The movement is still going on and one can observe quite recent fissure crossing the roadway. The cave III. shows well the characteristical triangle-shaped cross section. In the cavities themselves three are many collapses, thus causing their destruction sooner or later. The sliding sets in motion and disintegrates vast rock masses.

In the same way developed the longest volcanic cave — known for the longest time — of Hungary, the “*Csörgő-lyuk*” of *Ágasvár*. The most important part in its development was caused by atectonic movements, although its genetics may have been a rather complex one. J. Szabó organized an expedition in May 1869 for its study and mentioned its development by sliding. He writes: “It was formed in the pumice-conglomerate so, that the whole layer-complex was in continuous, slow sliding towards

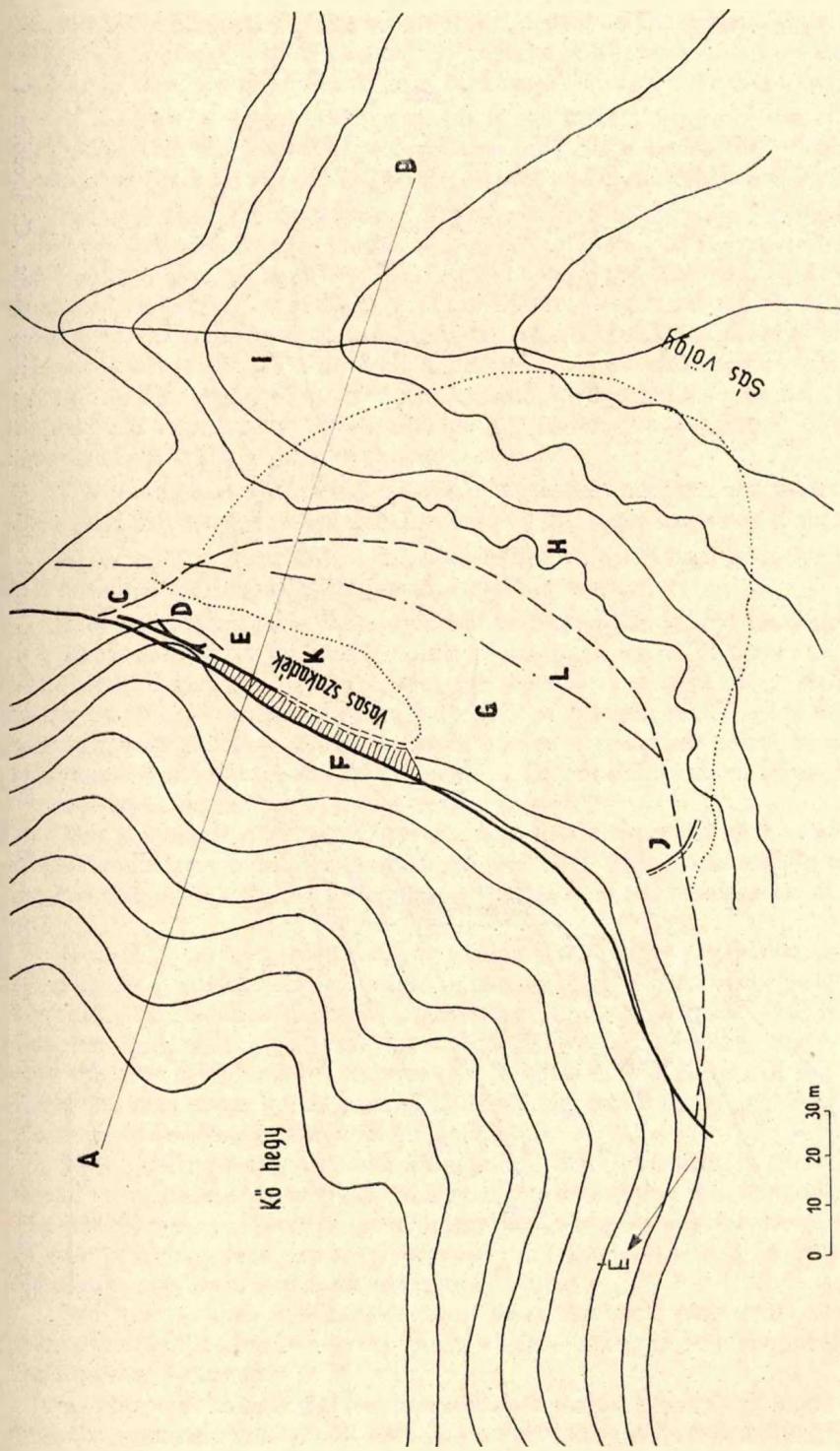


Fig. 4. Scheme of caves of the Vasas-rift of Köhegy. A—B: geological profile shown in Fig. 5., C: cave I., D: cave II., E: cave III. F: steep rock-wall indicating the sliding, G: more flat surroundings, H: rockmass shifted, I: disclosures of the clayey andesitetuff causing the sliding, J: fissures indicating recent movements, K: path L: road-way.

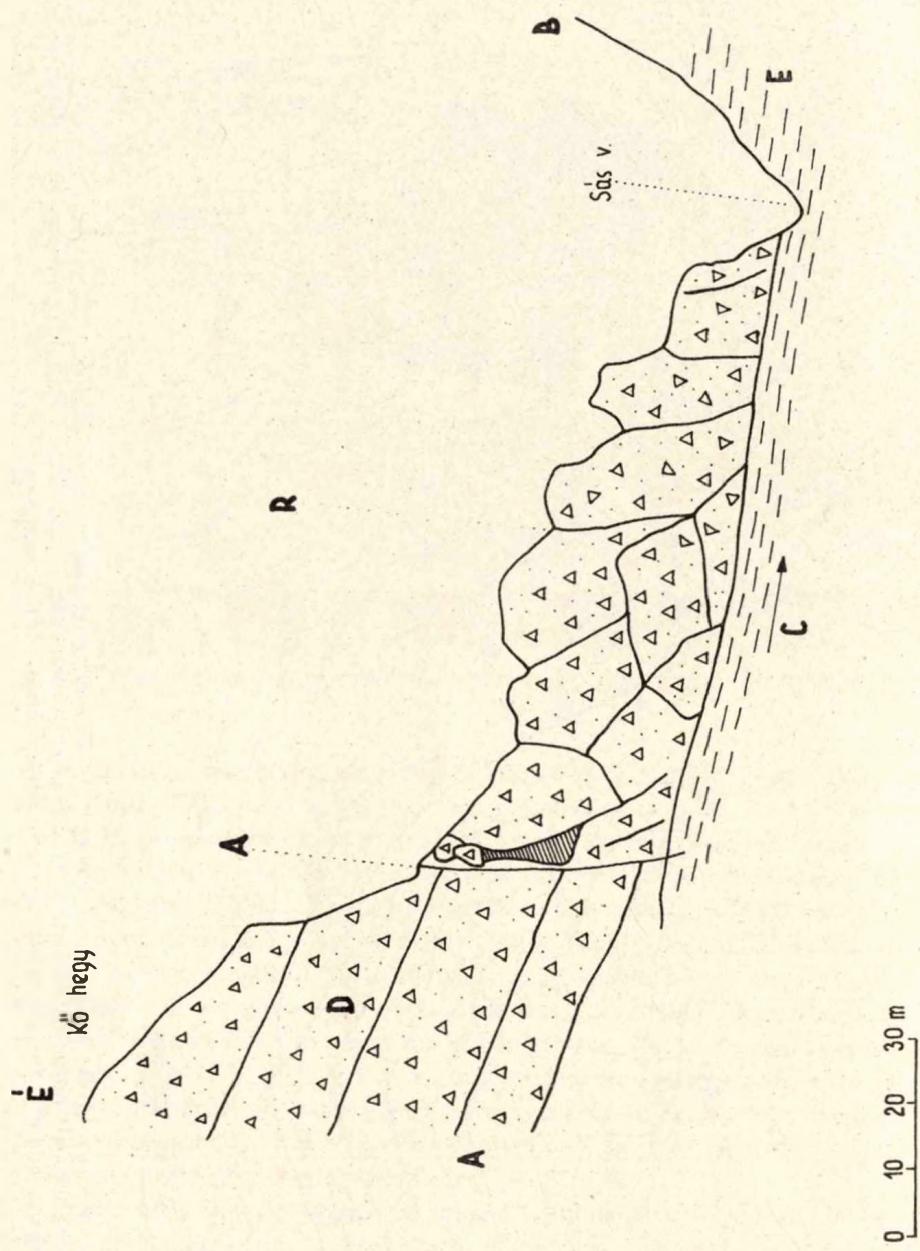


Fig. 5. Geological profile along line A—B of Fig. 4. A: line of break-down, B: rock-mass shifted, C: direction of shelling, D: clayed andesite tuff, E: andesite conglomerate benches.

the bottom of the valley". The separation is indicated by tectonic lines, which were brought in connection by Szabó with andesite volcanoes coming up later. Thus the genetics of the cave-system have been outlined by him in their main lines.

A. Székely determined the length of the cave (139 m) but did not agree with Szabó in that the tectonical preformation took place during the volcanic outbreak. He deduced the main lines (NE-SW) from faults at the end of the Pannonian age.

The investigations of Szabó have been verified by recent geological studies. Along the *Csörgő-lyuk* an andesite and clayed tuff-series of Helvetic age is running, upon which a hard dacite-tuff was settled, containing the cave, too. This tuff is less disintegrated (at best on its surface), it is rather stable as against the rhyolith-tuffs which show a strong tendency of becoming clayed. This complex was broken through by the parasite cone of the *Ágasvár* bringing about a strato-volcanic pyroxenandesite. The volcanic activity produced by all means important tectonical movements, thus determining the basic directions of the cave-building. This does not exclude — of course — the renewal of the faults by late Pannonian movements.

The sliding took place on the surface of the Helvetic tuff and andesite becoming clayed and this process was greatly favoured by the water seeping in along fissures.

At some 150 m distance from this opening there is a thin fissure which is in connection with the area mentioned above showing mass movements.

A non-tectonical mass movement can be brought about by the destructive action of external forces too. On the W-border of the basalt-cover of the Kovácsi-hill on the Balaton-highland some minor cavities can be observed (*Kükamra*, *Vadlánlik*). As a matter of fact we are dealing here with cavities between rock-masses fallen from the brim of the basalt-cover. The huge basalt masses were broken down, because the loose Pannonian sand representing the bed-rock of the basalt was taken off by deflation and the rock layer has broken in owing to its own weight.

This geological structure is characteristic for the basalts of the Balaton-highland so that similar phenomena can present themselves at other places too. So was developed the *Pokollik* of *Kapolcs* (41 m long) on the SE-side of the basalt-cover of the Bondoró-hill.

Generally, on steep rock-walls consisting of andesite agglomerate the erosion can bring about a situation where lesser or greater blocks may break away and so rift-labyrinths and between the blocks some cavities may be formed. That is the case e.g. with the *Zsivány*-cave lying on the southern slope of *Dobogókő*. Today we can find only the rifts here, while of the one-time cavities only some traces can be observed. There are also some minor cavities to be found between the agglomerate-masses at the slope of *Godó-vár* in the *Börzsöny*-mountains.

II. 1. b) The tectonical cave-formation is also important in the volcanites. The role of tectonics must be emphasized here also in connection with the preforming effects. The movements may prepare the slidings, they may give way for the enlarging effects. In case of a favourable harmony between the fracture-lines and jointing forms better conditions may be provided for the cavity-forming.

We have to take into consideration three tectonical phases of volcanism. From them these are the most important for us, which — according our suppositions — favour the forming of the caves.

α. The prevolcanic tectonism prepares the volcanic activity and along the structural lines the magmatic activity will start. In that case there is no possibility of cave forming.

β . The synvolcanic tectonism in the course of the magmatic activity moves the rock-masses. The products of the activity destruct — as a rule — the cavities formed by it. Nevertheless, there is a possibility of preformation of primary caves, e.g. volcanic channel-formation etc.

γ . At times of postvolcanic tectonism there is an opportunity for cavity-forming. In the vicinity of a resting or extincted volcano there are still active movements working along the fault lines, thus forming rift-like cavities. If the activity interrupts, the cavities can remain for geological times.

Such cavities can be found in a great number on the areas of extincted volcanoes, thus in Hungary too. Here are some examples.

On the slope of the *Vár-hegy* of *Tátika* — along a tectonic rift of N-S-direction — the *Remete*-cave (20 m long) was formed.

On the *Kovács*-hill — mentioned above — in the greatest basalt-quarry a rift-cave of tectonic origin opens.

In the *Pills*-mountains, 800 m SW from *Dobogókő* there is the *Hideglyuk*-cave which is in a filled state at present. It was formed along the fault-lines of the andesite.

Also in the *Pills*-mountains, in the coarse-grained andesite-tuff of the *Bölcső*-hill, the *Kolevka*-rock-cavity was formed (20 m, in form of a mountain-chimney) along a fault of NE-SW-direction.

The *Saskő*-cave opens N of *Szentendre* on the SE-slope of the *Nyerges*-hill along a tectonical-fault of the andesite-tuff. It has been enlarged artificially: its length is 46 m.

In the vicinity of the *Kámor*-peak of the *Börzsöny*-mountains open — sloping downwards — the rockrift of *Kámor* (5 m) and near to it the *Kámor*-“foxhole” (12 m long) and a few minor cavities in the surroundings. All these caves were formed in an andesite-agglomerate along tectonical lines and show traces of an enlargement of unknown artificial origin.

In the course of exploitation of the *Rózsabánya* in the *Börzsöny* along the ore-vein a large rift of tectonic origin was found enlarged by hydrothermics. We will return to this later.

On the slope of the *Baglyaskő* at *Salgótarján* along a tectonic line of N-S-direction a 7 m long cavity was formed in the basalt. The cavity was supposedly modified by the effects of postvolcanic gases and vapours as well as by secondary collapses (Fig. 6).

On the *Mátra*-area there is a small tectonic rift of ENE-WSW-direction in rhyolites on the slope of the *Csákkő* near *Gyöngyössolymos*: it is not longer than 3 m.

On the *Ágó*-highland representing the S-protrusion of the *Agár*-peak of the *Balaton* highland a cavity of 8–10 m length is to be found in basalt -tuff.

In the surroundings of *Egerbaktá* we find a rift of 4 m length formed in diabase.

II.1.c. The developed cavities can later be enlarged by collapsing. This is at first true for the arched structures, therefore we encounter it most frequently in case of the primarily formed volcanic caves. The collapsing of the roof produces new openings and cavities: sometimes the entrance of the cave is formed by that. In Hungary no such cave is known, only the basalt-cavity of the *Kiskő* of *Bárna* was modified somewhat by collapsing.

II.2. Now I would like to review briefly the secondarily enlarged cavities in volcanic rocks. The enlarging activity is going on along a volcanic cavity previously formed, or along a structure. E.g. a thin tuff-bed settled between lava-benches can be washed away by water, thus leaving a flat cavity behind (Fig. 7.). Or the water flowing down a terrain

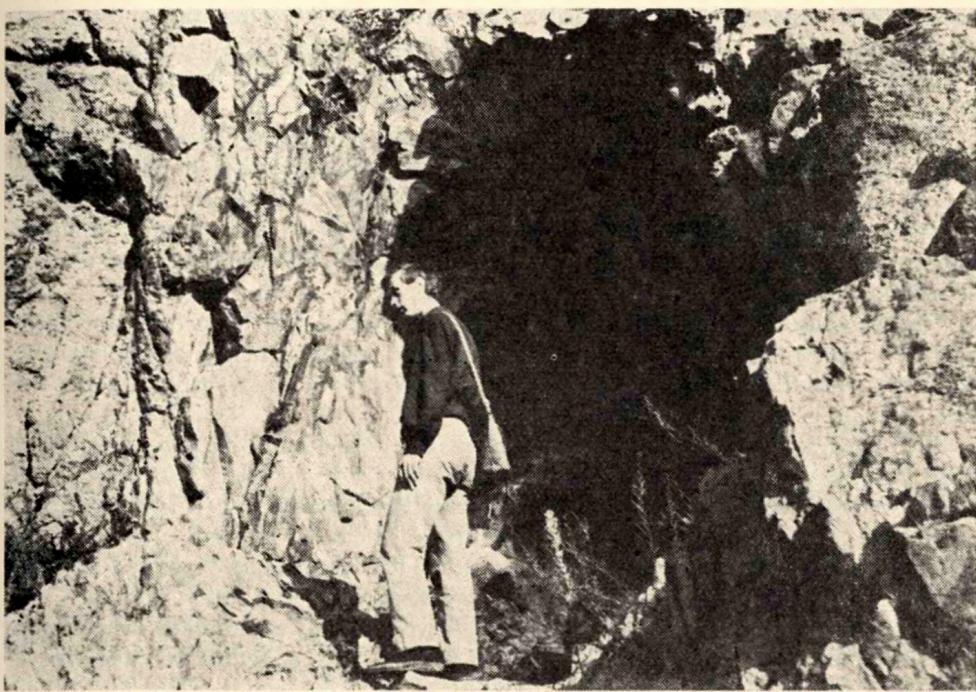


Fig. 6. Basalt-cavity of Baglyaskó (Foto Gy. Varga).

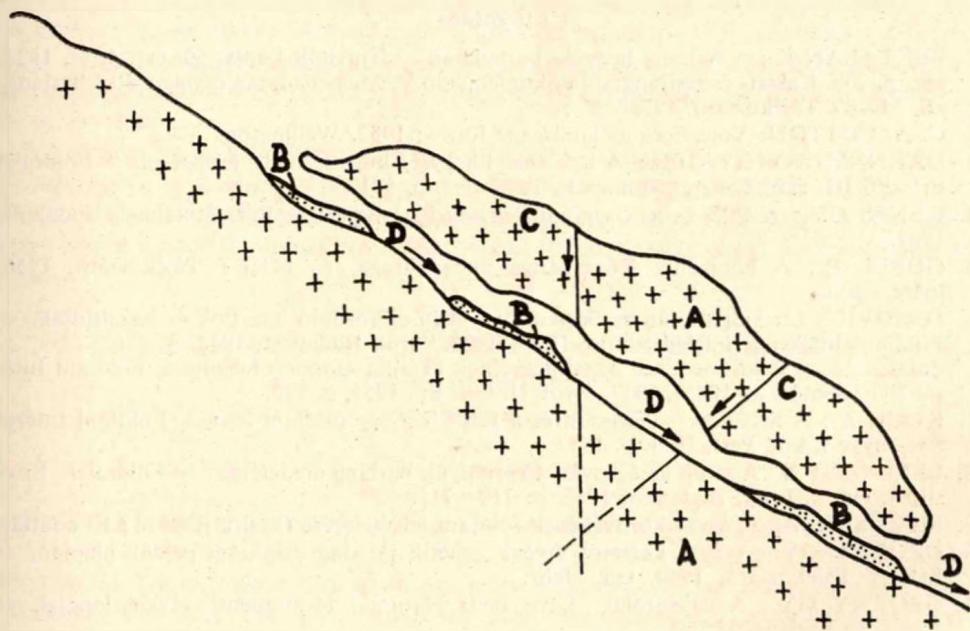


Fig. 7. Cave development by erosion in volcanic rocks. A: lava-rock, B: remnants of an embedded thin tuff-bench, C: faults, D: direction of water-flow and sweeping.

consisting of alternately softer and harder rocks can attack the softer rock and so small cavities can be formed. That was the case with the *Karolina*-trench in the *Pilis*- and with the cavities of the *Rózsa*-brook in the *Börzsöny*-mountains: both were formed in andesite-tuff.

On slopes consisting of lava-benches and soft tufts the tuff can be taken off by the winds and a small cavity remains. We find this on the *Kiskő*-rock-ledge (SE from the *Kékes* at a distance of 3 km), where a cavity of 2–3 length was formed. In the *Mátra*-mountains, on the E-border of the *Benebérc*, along the fault of andesite-tuff, the *Nagyparlag*-rock-cavity was developed, supposedly owing to the effect of temperature-oscillations.

The postvolcanic vapours and hot waters can exert — along the surfaces previously formed — an enlarging influence owing to their chemical effects. Such caves are, however, rather rare, since the vapours and gases cause the precipitation of minerals which — as a rule — fill in the cavities completely.

Such an effect was working to a certain extent in the basalt-cavity of the *Kiskő* of *Bárna*. But the most interesting case is the andesite-cavity of the *Rózsabánya* in the *Börzsöny*-mountains. This rift — formed in decomposed andesite — of a length of about 8–10 m, width of 2–3 m and height of 4–5 m was detected in the course of mining operations. The cavity was formed along a tectonic line in the zone of the ore-vein and its walls are covered with ores and accompanying minerals.

Finally I would like to emphasize that the aim of my study was to draw the attention to the interesting speleological and geological features of the cavities of such type of Hungary. At the same time I would like to thank Mr. L. Schönnvitsky for his help in looking for and studying the Hungarian cave-occurrences.

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MAGYARORSZÁG VULKÁNI KÖZETEIBEN KELETKEZETT BARLANGOK

Összefoglalás SZENTES GY.

A szerző a dolgozatban ismerteti Magyarország vulkáni közeteiben keletkezett barlangokat. Ismert módon rendszerezi ezeket a képződményeket. Megkülönböztetünk elsődleges és másodlagos üregeket. Az elsődleges üregek a vulkáni működéssel közvetlen kapcsolatban jönnek létre és a következő fajtákat ismerjük: lávabarlangok, ürített erupcióval kapcsolatos üregek, gázok és vízgőz kiterjedése által keletkezett üregek.

Ebből a csoportból Magyarországon csak a gázok és a vízgőz kiterjedése által létrejött üregek ismeretesek kis kiterjedésben *Mátra*-hegység területén. Láva és ürített erupciós barlangjaink nincsenek, illetve lepusztultak, mivel a vulkáni tevékenység Magyarországon igen régen (miocén) játszódott le és az így az erózió az idők során megsemmisítette azokat.

A másodlagos úton vulkáni közetekben számos üreg jött létre Magyarországon. Atektonikus, tektonikus és beszakadásos tömegmozgások útján, valamint továbbítágítás által. Ezek az üregek elvileg bármely szilárd kőzetben keletkezhetnek, azonban a vulkáni közetek speciális település módja (elválás, padosság stb.) tág teret biztosít képződésükhez. Atektonikus csúszásos üreg a pilisi *Vasas*-szakadák és az ágasvári *Csörgőlyuk* a *Mátrában* (139. m. hosszú).

Tektonikus úton keletkezett a *tátkai Vár-hegy* oldalában a *Remete*-barlang és a *Pilis*-hegységen a *Kolevkai*-sziklaüreg. A beszakadásos tömegmozgások inkább csak módosították ezeket az üregeket. Másodlagosan tágult hévforrások hatására a *börzsönyi* bányászkodás során az andezitben feltárt üreg. Falait kvarcos-érces ásványkiválások borítják.

DIE IN VULKANISCHEN GESTEINEN ENTSTANDENEN HÖHLEN VON UNGARN Zusammenfassung von GY. SZENTES

Verfasser bespricht zuerst die — allgemein angenommene — systematische Klassifizierung dieser Höhlenbildungen. Es werden dabei primäre und sekundäre Bildungen unterscheidet. Die primären Bildungen entstehen in unmittelbarem Zusammenhang mit der vulkanischen Aktivität und werden wie folgt unterschieden: Lavahöhlen, Höhlen in Zusammenhang mit einer entleerenden Eruption und Höhlen, die durch die Ausdehnung von Gasen und Wasserdampf hervorgerufen werden.

Aus dieser Gruppe sind in Ungarn nur die durch die Ausdehnung von Gasen und Wasserdampf entstandenen Höhlen aufzufinden, und zwar in kleinerem Ausmaße im *Mátra*-Gebirge. Lava-Höhlen und Höhlen mit entleerender Eruption sind nicht vorhanden oder sie wurden vernichtet, da sich die vulkanische Tätigkeit in Ungarn in sehr alten Zeiten abgespielt hatte (in der Miozäne) und die dann entstandenen solche Höhlen im Laufe der Zeit durch Erosion zerstört wurden.

Im Gegenteil dazu entstanden in Ungarn sehr viele Hohlräume in vulkanischen Gesteinen auf sekundärem Wege, und zwar durch atektonische, tektonische und Einbruchs-Massenbewegungen, sowie durch weitere Ausweitung. Solche Hohlräume können prinzipiell in allen festen Gesteinen entstehen, aber die spezielle Lagerungsweise der vulkanischen Gesteine (Trennung, Bankbildung usw.) bieten einen weiten Spielraum für ihre Bildung. Ein Beispiel eines atektonischen Rutsch-Hohlraumes ist die *Vasas*-Schlucht im *Pilis*-gebirge und das *Csörgő*-Loch von *Ágasvár* im *Mátra*-Gebirge (Länge 139 m).

Tektonisch entstandene Hohlräume sind: die *Remete*-Höhle an der Seite des Schlossbergs-*Tátika* und der *Kolevka*-Hohlraum im *Pilis*-gebirge. Die Massenbewegungen wegen Einstürze brachten meist nur geringe Modifikationen mit sich. Ein Beispiel eines durch Warmquellen sekundär erweiterten Hohlraumes ist der Hohlraum, der im *Börzsöny*-Gebirge durch Bergbauarbeiten aufgeschlossen wurde. Seine Wände sind mit Mineralablagerungen von Quarz- und Erz-Charakter bedeckt.

ПЕЩЕРЫ ВЕНГРИИ ОБРАЗОВАВШИЕСЯ В ВУЛКАНИЧЕСКИХ ПОРОДАХ

Резюме
ДЕРДЬ СЕНТЕШ

В своей работе автор рассматривает пещеры, образовавшиеся в вулканических породах Венгрии. Классификацию этих образований проводит известным способом. Он различает первичные и вторичные полости. Первичные полости появляются в непосредственной связи с вулканической деятельностью; среди них известны следующие виды: лавовые пещеры, полости, связанные с эрруптивным излиянием и образовавшиеся в результате расширения газов и водяных паров.

В этой группы в Венгрии известны лишь полости, которые образовались путем расширения газов и водяных паров, имеющие небольшие размеры и находящиеся в горах *Mátra*.

Лавовых и, возникших путем эрруптивных излияний, пещер у нас нет, вернее, они исчезли, поскольку вулканическая деятельность в Венгрии протекла очень давно (миоцен) и с течением времени эрозия уничтожила их.

Многочисленные полости в вулканических породах Венгрии возникли вторичным путем: тектоническим, нетектоническим и проседанием масс пород, а также за счет дальнейшего расширения. Теоретически эти пустоты могут возникать в любых твердых (расщепление пласта, уступ и т.д.) дает широкую возможность к их образованию. Полость возникшая в результате

нетектонических движений — авраг *Vashash* в агашварский Чергеюк в *Mátrę* (длиной 139 м).

Тектоническим путем возникли пещера *Ремете* на склоне горы *Var* (*Татика*) и пещера *Колевка* в горах *Пилиш*. Проседания масс пород скорее лишь изменяли эти полости. Вторично расширилась под влиянием термальных вод, полость, вскрытая в андезитах в процессе бёргенских горнорудничных работ. Ее стены покрыты кварцом и рудными минералами.

GROTOJ ESTIGINTAJ EN VULKANAJ ŠTONAJOJ DE HUNGARIO

Resumo
GY. SZENTES

La aŭtoro konigas la grotojn estigintajn en la vulkanaj ŝtonajoj de Hungario. Li ordigas ilin laŭ konata sistemo, distingante primarajn kaj sekundarajn kavernojn.

La primaraj kavernoj estigis en direkta interrilato kun vulkana funkciado; ni konas la sekvantajn specojn: lafogrotoj, kavernoj koneksaj kun malpleniĝinta erupcio, kavernoj estigintaj sekve de dilatigo de gasoj kaj akvovaporo.

En Hungarlando el tiu grupo estas konataj nur malgrandaj kavernoj, kiuj estigis sekve de dilatigo de gasoj kaj akvovaporo, en la montaro *Mátra*. Ni ne havas lafajn kaj malpleniĝintajn erupcian grotojn, pli ĝuste ili detruigis, ĉar en Hungario la funkciado de la vulkanoj okazis antaŭ tre longe (en mioceno), kaj tiel la erozio dum la paſo de la tempo detruis la grotojn.

Multe da kavernoj estigis en Hungarlando en vulkanaj stonajoj, laŭ sekundara proceso, nome per netektonikaj, tektonikaj, ekfendigaj movoj kaj plidilatigo. Tiaj kavernoj povas estigi principe en iu ajn solida ŝtonospeco, sed la speciala surlokiga maniero (disigo, tavoleco ktp.) donas multe da eblecoj al ilia estigo.

Netektonikaj perglitaj kavernoj estas la fendego *Vasas* en la montaro *Pilis* kaj *Csörgőlyuk* ĉe *Ágasvár* el la montaro *Mátra* (139 m longa).

Tektonikaj estas *Remete*-gredo en la fortikajmonto *Tátika* kaj *Kolevkai*-kaverno en *Pilis*. La ekfendigaj movoj nur modifis tiujn kavernojn.

Sub la efiko de la varmegaj fontoj sekundare plivastiĝis la kaverno, kiun oni malkovris dum fosado en andezito en montaro *Börzsöny*. Kvarcaj-ercaj mineraloj kovras ĝiajn murojn.

