

## THE EFFECT OF ACIDIC ATMOSPHERE POLLUTION UPON STALAGMITES IN KARSTIC CAVE-SYSTEM

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### Preliminaries. Recognition of Occurrence

It was first in Hungary in 1983 that I first reported the occurrence of re-dissolution of some dripstones (mainly on the surface of stalagmites) in karstic cave-systems, a phenomenon which some 5—10 years earlier could not be observed. Unanimously this was to be derived from the corroding effect of karstic waters resulting in the degradation of dripstones. In that phase of researches, relying upon the experimental results of some water samples gathered after realizing this strange occurrence we supposed that all this might have been caused by the softening of dripping water what, in an unknown way, is connected mainly in deep karstic soils with the microbiological and soil chemical equilibrium shifts caused by acidic rains. Namely in the course of my studies I found that the pH of karstic soils covered with natural (mostly arboraceous) vegetation was on an average 1 grade less than the earlier mean pH values.

On the basis of the observed degradation of dripstones and the simultaneous modification of soil processes I had to presuppose a cause and effect interdependence, pointing out that „I am inclined to suppose that acidic (sulphuric, etc.) precipitation infiltrating the soil does *change not merely the chemical characteristics* of the latter but, as proved by a trend of marked degradation of cave dripping waters, *largely inhibits the earlier level of life conditions for the root-respiration of karstic soils, of microorganisms population, of soil bacterii and soil fungi.*” I suppose that, because of the above mentioned reason, the level of production of biogeneus carbon dioxide becomes restricted what later results in the weakening of hydro-carbonate limestone dissolving effect of the precipitated water oozing through the soil and/or leads to the softening of dripping waters in caves and to the newly observed corroding degradation of dripstones.

It means that the new type of corrosion of cave calcic sediments was regarded already in the early stage of researches as a kind of indication under the surface of the population of the outer atmosphere. Therefore after 1983 I started a wider observation of the occurrence, covering several countries, thus it has become possible to decide whether we have only local or moreover, processes of general validity.

The present paper gives a summary of the result of researches carried out in this field since 1983.

**Erosion and corrosion types of degradation of cave  
dripstones, occurrences and morphological properties  
of a new type of degradation syndrome**

It is very important to make it clear that *not all natural degradation processes of cave dripstones and/or morphological changes of dripstones as a result of the former* are connected with recent changes in the dripstone forming characteristics of karstic waters oozing into caves. Namely we know of lots of dripstone degradations in the most various levels and parts of different karstic caves which were formed postgenetically, that is *after* the development of the dripstone formation itself upon the effect of an actually working natural factor; however, these cannot be regarded as a group of phenomena connected with a most recent degradation syndrome of dripstone formation.

Among the manifold secondary dripstone varieties produced by different factors we can often find such ones, the appearance of which might be very similar to the morphological characteristics of the recent degradation syndrome, but genetically they have nothing to do with the latter. To separate unequivocally and to define the occurrences it was necessary to examine other types of degradation of dripstones and even the causes of these, since the real proportion and quality of occurrences which I examined as a main profile can be seen in this way.

Below I am going to show my experimental results which have made possible to separate the different variations of dripstone degradations.

*1. Erosion types of dripstones degradation*

The water entering the active karstic caves wash in through sumps some deposits with more or less solid granules what is washed further on in the caves by underground water flows. Sometimes and somewhere more or less of the deposit is sedimented in the level of caves. Grains of sediment moved by water flows underground do a great deal of mechanical eroding, polishing work, not only on the rock soil or the walls of the caves but on the dripstone formations there, too, if they get into contact with the cave water flow. An especially dynamic degradation of dripstones happens when high waters come (cave flooding), when the amount, the average diameter of grains and even the rate of collision therein of deposits carried by the water are manifold. This effect leads to a rapid degradation of dripstones, what is called flood degradation. We distinguish here five subtypes:

*A.) Degradation of dripstones by underwashing the bed*

It occurs in stalagmite formations standings by the side of the cave stream when low water, the bottom of which is loose sediment. During high flood the stream may underwash the formations which in times are so enormous that their own weight may cause them to overturn. If the overturned dripstone falls into the stream it will quite soon be worn by the stream deposit erosion. This form of dripstone degrada-

tion is very rapid when the water washes sediments consisting of minerals and pieces of rocks harder than limestone (e.g. quartz sand, pebbles, etc.). Degradation of dripstones by underwashing the bed is a very frequent and general feature in karstic caves with active flow of water and it has characteristics which make it easy to distinguish from other types of degradation.

#### B.) *Break of dripstones by deposit collision*

In most of the greater active karstic caves there are levels and galleries where time by time the water gets higher. These floods (depending upon the rate of stream) carry floating, salting and rolling deposit. The higher the water the greater is the amount of salting and rolling deposits. In some karstic caves these can be pieces weighing some kiloponds but the occurrence of grains weighing 200—300 g is not rare even in salting deposit (e.g. Baradla, Peace Cave in Aggtelek, Demanova, Punkva in Czechoslovakia, Postoina, Skotzian caves in Yugoslavia.) When, during such events, larger pieces of sediment collide with thin stalagmites got in the flood or pending dripstones, respectively, they easily can break. Dripstone degradations coming from breaks of the above type are well known in each karstic cave with extreme waters, but the identification is the easiest and the most sure in newly discovered parts of caves where there are no antropogenetically degraded dripstones.

#### C.) *Shelly flood degradation*

Dripstones (stalagmites or rarely even stalactites) which during high flood get into the stream but are strong enough not to break by collision, through erosion take a characteristic shell-shape first of all upon the effect of the erosion by floating deposits. Their surface is as if hollow of spoons were taken. These incurvations touching each other often with sharp edges — but each having smooth surface — can genetically be regarded as stream undulations which correspond to rhythmic thickening and thinning cells of streamlines with different dynamism because of the frictional breaking in every rock surface getting in friction with a stream which does polishing with floating deposit.

In Hungary we can find very fine examples of shelly flood degradation, like e.g. the entrance of "Dripstone Chapel" in Peace Cave.

The effect of erosion by floating deposit streams during high waters can be seen in some dripstone curtains with large surface but of moderate thickness, where we observe the perforation of the formation and the enlargement of the hole with fringed trimming. Such formations are to be observed on dripstone flags in many caves, as a prototype we can mention „Harpoon" near the Rope Ladder Siphon. A sure distinguishing feature of similar formations is that dripstone degradation traces of erosion by deposits can be found on the side of dripstone curtains facing the stream of flow.

At the same time the side of dripstone curtains free of stream show no signs of erosion.

#### D.) *Degradation caused by lasting high water-level*

In caves where because of different reasons even in periods of low water there are parts where the water level is for a longer time high as compared with the earlier one, we can find an interesting form of dripstone degradation on the surface of dripstones covered by water. This form got the name „emaciation of dripstones”. It is mainly characteristic for parts of caves with redamming streamflow, where e.g. the growth of tufa dams across the bed make deeper and deeper the lakes formed from the stream water thus dammed. Damming in caves can of course be caused by other reasons as well, e.g. by landslide or formation of a deposit plug. Practically dripstones got under water this way are not worn by the strong eroding effect of deposits, mostly of the rolling and salting kind, because as a rule deep and wide parts of streambed are formed in the redammed flow where the stream is slow even during the flooding of the underwater stream, thus the effectivity of erosion by water is relatively low as well. Naturally, fine fractions of the floating deposits are present even then and so the dripstones washed for a long time and in the same way by the relatively slow waterflow undergo erosion in a way similar to the effect of rivers on bridge piers. After a time the shape of dripstones becomes sphinx-like, that is, get streamlined as the sphinx rocks in deserts, and mainly the bottom of dripstone columns becomes thin.

The horizontal cut of dripstones degraded in this way by time changes in the manner shown in Fig. 1., viz., because of the more marked erosion of sides parallel to the direction of streaming the dripstone „gets thinner” laterally and the front side changes into a narrow edge (face). We can study this process in Hungary, better to say the results of this process, in some parts of the Radish-Branch of Peace Cave as well as in waterdammed by travertine lower parts of Peace Cave.

#### E.) *Erosion degradation accompanying recaving*

This is observed in caves or parts of caves which, in a given phase of development, are filled up by a stream, thus not only the cave gets thinner or completely disappears, but the dripstone formations therein are buried as well. If later the material stuffing the cave is evacuated thus the dripstone formations are disintermented we can find very characteristic changes on their surface, partly by soil corrosion and partly by deposit erosion. As a rule side by side or strictly each other we find corrosion substance deficiencies, cavities of irregular shape, sometimes belonging to particular places, sand and pebble are cemented to them obviously from the deposit of the stream, furthermore we can see characteristic degradation of dripstone of wave shell or collision with deposit type. The surface of disintermented dripstones usually is very rough, so called screeny, what itself is a proof that the surface of dripstones has got its present form through a series of poligenetic, complex events.

Very fine examples of dripstone degradation formed in the course of repeated vacuation of holes are to be found in Sloupi Cave of the Morava karst, in several parts of Domica in Czechoslovakia first of all in the Dry Corridor and in the Aggtelek part of Baradla; the giant stalagmites at the Black Hall side of the Concert Hall.

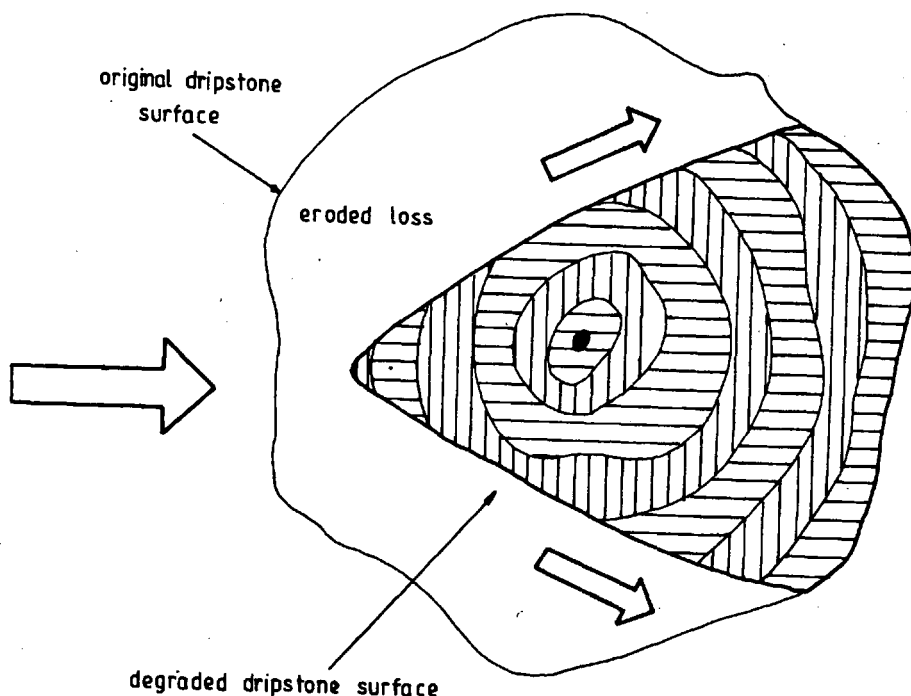


Figure 1. Original and erosion deformed new section of a stone candle attacked by dripstone degradation by lasting high stream water („underdevelopment of dripstone”)  
Arrows show the direction of floating deposits (original)

## 2. Types of recrystallization dripstone degradation

To this group of phenomena belong dripstone degradations which somehow have casual connection with the swelling of the mass or recrystallization processes taking place in the material of dripstones, in their crystal interspaces or on their surface. Since these postgenetical processes never show signs which could be mistaken for the effect of recent dripstone corrosion syndrome, we only give a rather short description, or only an enumeration.

### A.) Expanding of dripstones

This can be evoked by different process. I could several times observe dripstones growing like an inflated balloon where the tension of gas inclusions had been working or they were stretched by the extension movement of gas particles first pressed down by oozing karstic water particles and then getting free of this pressure in the cave thus the blisters of the dripstone formed upon the surface of the water drops are enlarged. Very often the high water pressure inside stalactites can play a

role so that the rearrangement of material in the recrystallization of the wall-material of the dripstone helps the crystal to go outwards, rising above the crystal surface.

The radiated-fibrous dripstone globes of „radish-dripstones”, very often with a hollow inside, are products of postgenetical crystal formation centres developed from the stalactite material. Very often there are gases or lublinitic brushes inside consisting of very fine cottonlike fibres.

Undoubtedly the material of dripstones following the formation of stalactites and stalagmites is working on, and a definite recrystallization process appears especially in the material of pure, not contaminated dripstones. In most of the cases this leads to a marked increase in volume, and we could often observe empty spaces between crystal surfaces of calcite romboeders formed postgenetically which had not been there in the time of dripstone development and in its primary sediment.

#### B.) *Twisting of dripstones, translation degradation*

A subsequent twisting of the formation is a very frequent phenomenon. This always occurs in the direction of a lasting and undisturbed unilateral diverting force, in part of the cases through slow inner molecular rearrangement following the lasting pressure, or through recrystallizations of crystal translations. We can always observe that the otherwise intact and hard dripstones, breaking very rigidly when hit, become plastic upon the effect of a permanent twisting force.

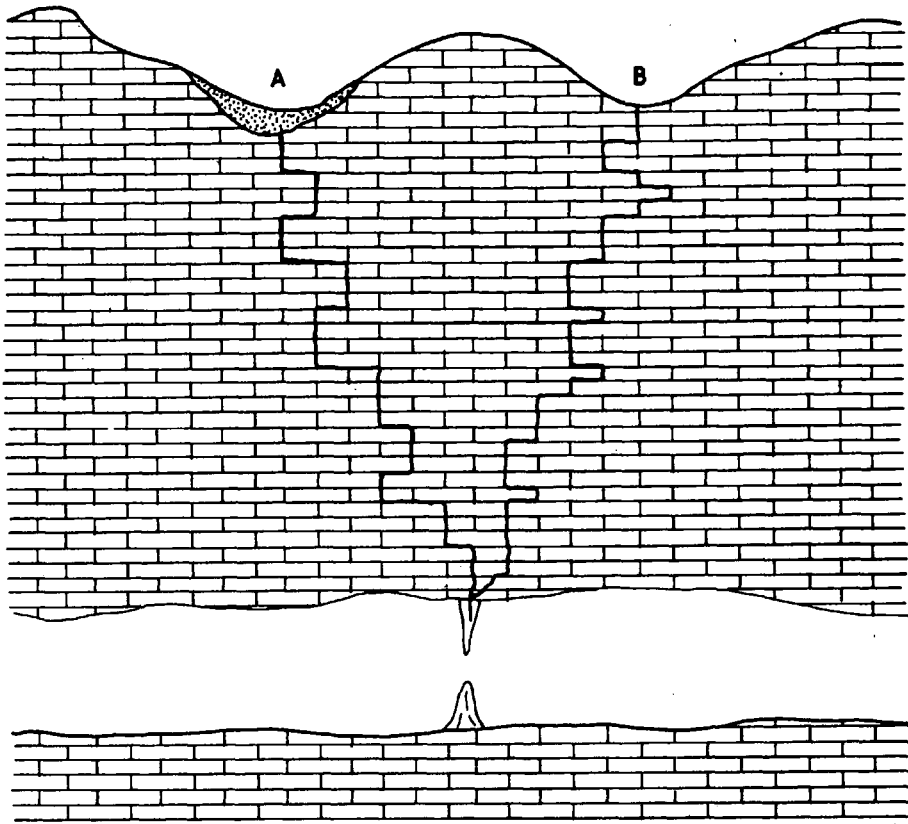
A very characteristic example of plastic dripstone degradation is the formation of the so-called *dripstone-drum*, what can be regarded very common in some caves (Domicia, Postoiana, Peace Cave, etc.). These drums are explained in the literature in various — and quite contradicting — ways.

We think that when a big stalactite does not stick any more on a larger surface to the ceiling, the plane of sticking leaves the ceiling and upon the effect of gravitation it still pends on the edge of hanging and owing to the translation (or hidden) movements of the hanging hinge the whole formation bends downward (see Fig. 2).

#### C.) *Clay swelling dripstone degradation*

There are stalactites, sometimes even stalagmites in which a considerable amount of clay has been washed in. As a rule the material of terra rossa, covering the surface or of other soils is carried down in the caves and mostly colloidal clay minerals, various silicates and hydrosilicate gels, iron oxides, aluminium, sodium etc. hydroxides and carbonates can build partly in the material of the dripstone, partly between the dripstone layers building upon each other. Dripstone with high clay content can especially frequently be found in carstic caves where the original vegetation coverage had been damaged on the surface and this phenomenon was accompanied by the devastation caused by strong soil erosion.

If the disintegration of clays in dripstones and the chemical reactions of different decay derivatives go further on inside the dripstone (what is not a very rare phenomenon) fairly peculiar dripstone degradations may occur. Mostly irregular crackings, sometimes whole networks of fractures are formed on the surface of dripstones and through these different substances „boil out” of the inside of the dripstone.



**A** = Dolina with thick soil counterbalancing oozing

**B** = Barren dolina leading to (temporal) extreme oozing

Figure 2. Three phases of the formation of „stalactite drums“ (Interpreted by L. Jakucs)

Very often white calcite welding ridges bulge alongside the cracks which are lighter than the dominating colour of the dripstone, very often white. Moreover crystal needles or helictites of different length and obliquity may protrude. These are degradation phenomena being in very close causal connection with the swelling of the mass accompanying the disintegration processes of the colloidal clay minerals inside the dripstones.

#### D.) Frost-swelling dripstone degradation

A very characteristic form of dripstone degradation in parts near the entrance of caverns where the air circulation is very strong (and in winter is moving inwards)

as well as of bigger cavern entrances is the crumbling of dripstones caused by freezing. In Hungary it is rarely found, I saw traces in the 150 m long part under the Aggtelek main entrance of the Baradla Cave (in „Bone Castle” and in the bed of the Acheron — down to Királykút —, in caves with wide entrance in Istállóskő and Selim Caves, The aggressive ice cracking effect accompanying the freezing of water in the texture of dripstones resulted in a very marked crumbling of dripstones at all the places.

### 3. „Traditional” types of corrosion dripstone degradation

It is not rare in karstic caverns that we find traces of dripstone degradation processes caused by corrosion i.e. the recrystallization of the material of the dripstone in some way. This may have lots of causes and the system of effect mechanism of reasons and of degradation phenomena are quite well known. There are types of dripstone degradations caused by corrosion, the genetics of which are independent of age, i.e. which can be formed *in all the phases* of development of a cavern; the conditions of their formation were given in the ancient history of the cave (or of some parts of it) as well as in our time. The results of our researches prove the existence of corrosion processes which destroy dripstones in the caves only *recently*: these could not be observed in the cave formations some decades earlier.

The first group, namely corrosion changes independent of age comprise *corrosion of unsaturated cave waters, mixing corrosion*, dripstone corrosion by condensation of vapours, corrosion of the cave soil and clay in karstic waters, guano corrosion and corrosion of dripstones at the cave entrances. All these are *traditional* or *permanent* types of corrosion dripstone degradation, because they were present thousand or even twenty thousand years ago and their effect is to be felt even today. But we have to distinguish a very peculiar group of degradation which *nowhere* appeared *before* but it is characteristic feature of the twentieth century and therefore is called „*recent dripstone degradation syndrome*”.

In this part of my paper first I deal with the permanent sorts of dripstone corrosion then the new type of degradation syndrome will be treated with in the next (II/4) Chapter.

#### A.) *Dripstone corrosion of unsaturated cave waters*

Under natural conditions smaller and larger amounts of water get into the karstic caves. This water does not yet contain dissolved limestones in a quantity equivalent to its limestone — dissolving capacity. Such unsaturated waters are the temporal *floodwaters*, coming together from the non-karstic drainage basin and entering the caves through ponors and in the case of caves having constant non karstic flow-in streams the source of which is in a non-karstic area. To this can be added in karst plateaus with more or less impermeable clay or other rock cover waters from dolinas and other karst fissures which drain water after heavy rains and snow melting. But especially in areas with cold climate and highland karst plateaus near snow-limit where there is no vegetation or bioactive layer of soil and the

temperature of the rock where the cave is has a very low temperature, near  $0^{\circ}\text{C}$ , even karst waters oozing down very slowly can reach cave level in unsaturated state.

Of course, unsaturated waters can dissolve the material of the dripstones when getting in touch with them. In some cases this process does not leave conspicuous traces on the dripstone surface but sometimes its degrading effect easily can be seen. Traces of corrosion by unsaturated cave waters are difficult to detect first of all on dripstones which stand in the cave river-bed or hang in there because these dripstones are destroyed by the erosion of deposits which has a more marked degrading effect than dissolving has. Thus the intensive marks of erosion degradation hide or even demolish the much less visible prints of corrosion degradation. However, traces of corrosion by unsaturated waters can well be seen on dripstones or rock surfaces in the line of the run of water which are not exposed to the effect of flood waters because they lay higher. In these dripstones and parts of rock walls marked dissolved holes, drain canals exactly reflecting the direction of gravitation, so called *cave karrs* are being formed by corrosion.

Naturally, cave karrs are first of all peculiar forms of corrosion of the rock wall of the cave itself, since where unsaturated waters from the surface regularly and repeatedly can penetrate there the conditions of formation of dripstones are usually absent. In spite of this I know of a few cave karrs formed upon dripstones as e.g. in Amateurska-Cave of the Morva karst. But it seems very probable that these occurrences in all cases reflect a process of formation in several phases connected with changes in the climate. For example there is no recent formation of dripstone on the enormous corroded dripstones in Amateurska Cave. Therefore the dripstones themselves which, by the way, at the mentioned place cover with thick layers the rocks in the cave unequivocally were formed in a time (probably during a warm interglacial) when the climatic conditions were much more favourable there for the development of bioactive soil process. But it can also be imagined (the question is to be decided by further topographical investigations) that in out time the surface of related region of inflow has got deserted, its soil eroded and this is the reason why the waters oozing in the karstic area are so markedly unsaturated.

#### B.) *Mixing corrosion dripstone degradation*

In principle mixing corrosion can produce dripstone degradation which is morphologically equivalent to the effect of recently formed dripstone degradation. Therefore I have paid special attention to this problem.

It is well known that during mixing equilibrium hydrocarbonate solutions (e.g. natural subsoil waters and karstic waters) we get excess carbon dioxide in the solution, that is the solution becomes aggressive towards limestone, dissolves it, since excess carbon dioxide depending upon the conditions either evaporates or results in further dissolving  $\text{CaCO}_3$ .

Practically it is not, but theoretically it is possible that in the dripstone caves there are creeks carrying karstic waters of different hardness which meet just at the point of fixation of a stalactite. In this case — from the point of view of the development of the dripstone — we can consider the following variations:

- a.) water is carried to the stalactite only by one creek (the *dripstone is growing*);
- b.) water is carried simultaneously to the stalactite by both creeks (the *dripstone is degraded because of mixing corrosion*), and finally
- c.) water is carried constantly by one and recurrently by the other creek to the dripstone (then *the latter sometimes grows sometimes is degraded or redissolved.*)

Naturally sometimes both creeks may be inactive but this bears no interest for us. (See Fig. 3).

Further potential places of mixing corrosion dripstone degradation are lineaments which are the line of meeting of adjacent basement of two or more stalagmites each with an own feeding. Namely here karstic waters oozing down the sides of adjacent stalagmites, while they constantly build their own stalagmites, become corroding when they flow together and behave like an aggressive solution along the line of flow.

The degradation of mixing corrosion can naturally be felt where the surface of the dripstone (mainly stalagmite) is drizzled by the spray of water falling upon another dripstone. However, as a final result one effect (either the growth or the decay of the dripstone) becomes dominating because the resultant of forces with opposing characteristic is constant and so the dripstone is further growing or its formation, development is radically inhibited.

Either of the variations of dripstone degradations by mixing corrosion had been examined we had to see that in spite of the similar morphology of degradation this cannot be mistaken for recent degradation syndromes, since these latter appear only on the surface of dripstones recently formed and they are at most a few years old.

#### C.) Vapour condensation dripstone degradation

Near the entrance of larger caverns where the opening is relatively high, summer vapour condensation on the surface of rocks and dripstones is quite typical. The phenomenon is caused in a way that these caverns have marked dynamic air circulation and through high openings, chimneys a strong inward air current develops. The air which is warmer than that inside the cavern gets cooler upon the fact of the cold rock wall of the cave, and in the meantime the relative vapour content becomes so high that on the cooler surfaces the vapour precipitates. Of course this humidity has a corroding effect since it is practically a totally unsaturated solution. Upon the effect of precipitation (happening repeatedly and many times) the surface of the dripstone becomes *blind*, by time it is *encrusted*, touches almost like earth, and naturally in the meantime the glassy, even bright surface disappear. This process can clearly be traced in the Bat-branch of the Baradla Cave. what is more, through this branch vapour condensation sometimes permeates the Black Chamber.

There is a winter variation of vapour condensation in caves. Then, through low openings the cold winter air enters caverns with dynamic air circulation and getting

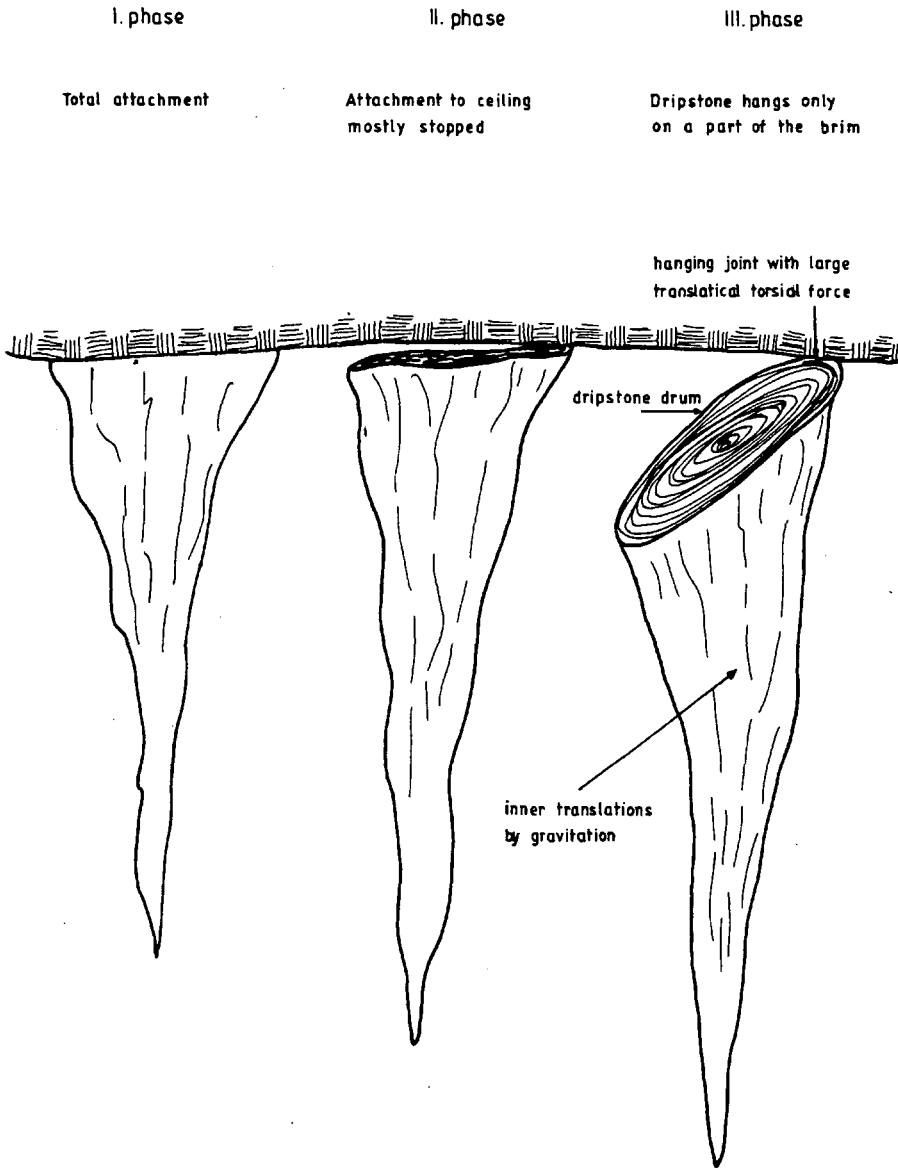


Figure 3. An attempt to interpret temporal mixing corrosion dripstone degradation (original)

warmer there exerts a drying effect. But it is not rare in a region where outside cold air and warmer inner one are mixing, sometimes form layers upon each other, that cave mist is formed, what is a typical form of the appearance of winter vapour condensation in caves. True, this mist is soon absorbed on the surface of dripstones and rocks so it has no corroding effect.

#### D.) *Corrosion by cave soil and karst water clay*

Deposits carried by waters flowing in caves often cover the dripstones thus these latter often get under the effect of corroding solutions while thus buried. A considerable dripstone corrosion can mainly develop under layers containing organic substances, humus-like earth and debris which can further disintegrate under the conditions of the cave — the intermediate cause of this are mainly solutions which exert acidic effect. But under deposits composed of chemically neutral end products (quartz sand, dolomit sand, quartz pebbles etc.) there is generally no corrosion — these deposits can conserve the buried by them dripstones quite intact for a relatively long period.

A rather peculiar type of dripstone degradation is the so called *quartz water clay corrosion* what is mainly characteristic for cave levels under quartz surfaces which become desolated. According to our investigations dripstones of barren quartz are mostly inactive, their surface is blind and colour is brown, ochre or clayish-grey. Because of the clay- and iron-content eroded on the surface and being step by step washed in the recent developing caves have a lower carbonate content and the newly formed layers are soft, containing a lot of non-carbonate mineral contamination. Of course, these alien „inclusion” materials building inside the dripstone, moreover into the texture of dripstone, further work there, demolish the material of the dripstone.

#### E.) *Guano — corrosion*

This is a dripstone degradation process characteristic for caves where bats dwell. Especially at places where crowds of the animals stay for longer periods (regions of the winter sleep) on the effect of various acidic compounds in the manure of that the dripstones are demolished, craters are formed and even they can completely dissolve. In consequence of dissolution mineral brushite ( $\text{Ca HPO}_4 \cdot 2\text{H}_2\text{O}$ ) can be formed. A classical place of this occurrence is Domica in Czechoslovakia.

#### F.) *Corrosion of cave entrances*

In regions with a milder climate it is very rare that dripstones are formed near the entrance or even if they are the breaking effect of frosts, the frequent changes in temperature ruin them very soon, therefore not much of the effect of postgenetical dripstone corrosion can be studied near cave entrances. But it is also true that in regions with a climate much more favourable for dripstone formation than ours is (e.g. tropical karst) the extent of dripstones formation is so considerable at the entrances (and even at the outer rock surface of the mountainside) that the special corrosion factors revealing themselves there (as e.g. corrosion by direct rainfall,

biogenic acid corrosion of the roots of plants and direct rock dissolving role of various mosses and ferns living upon dripstones) can be deciding in the morphology of dripstones.

Since these are effects more or less of the same nature, we have to mention here the so called *lamp floracorrosion* of parts of caverns which are brightly lit for the tourists. This is a process which have already been exerting degrading effect on dripstones in several caves in Hungary. On the surface of dripstones brightly lit for longer times with very strong lamps (when warming effect is considerable as well) green plant covers have developed. Under this cover holes, hollows are formed and the moisture coming from the green plant coat paint the limestone back and corrosion occurs as well. To solve the task how to avoid this damage is well known: lamps with cold light must be used and a very close illumination is also to be avoid.

#### 4. The syndrome of recent dripstone degradation

To the symptoms of recent dripstone degradation observed and described by us the first time belong damages of dripstones of only a few years (perhaps decades) of age what almost always appear at the most constant places of dripping of the caves and similar changes can be found in older layers or surface of the same formation. It is fairly easy to check these observations in caves which have been widely known and frequented for ages and as a memory of the time when visitors came with torches (as late as the early twentieth century) the surface of dripstones and rocks at that time were covered by soot. The essence can easily be summarized: *under the cover of soot the degradation syndrome of dripstone redissolution what we are looking for can never be found.* Thus in the process of development of our caves we can clearly distinguish an undisturbed period of development "prior to sooting" and a very short (lasting at most for only a few decades but we have known of this for a few years) period of active degradation what left a trace of a very effective recorrosion on the surface of many cave dripstones and, in some cases, destroyed the whole dripstone formation.

According to my observations this recent dripstone degradation is mostly characteristic for the young and light (sometimes white) dripstones and results in sharp edged irregular craters, calderas with cracked sides, ditch-beds of oozing with sharper brims, sometimes in the zone of the spraying of drops falling down there is an areal dripstone surface redissolution and not rarely a total dissolution or softening of the greasing substance of the dripstone.

**Researches on areas of development on recent degradations  
syndrome in some karstic countries of middle-east Europe  
and the Balkan peninsula**

Some years ago the phenomenon of recent redissolution of dripstones was observed in the Aggtelek dripstone cave (Baradla Cavern). Soon after the same process was found at several points of Gombaszög Cave in Czechoslovakia. During the 1984-85 research period our studies were carried out in several other European countries, first of all in those having a common border with Hungary.

The investigated karsts and caves, resp., are shown in Fig. 4.

In the caves examined from the point of view of recent dripstone degradation the syndromes were almost everywhere found where dripstones of active development were characteristic. However, this syndrome could not be detected where there are no dripstones or the cave dripstones are inactive, mostly very aged.

The regional peculiarities and magnitude of occurrence are described in the following, relying upon results so far gained.

*Austria*

In summer 1985 two caverns were examined, Eisriesenwelt in mount Tennen and the Mammuth Cave in the Dachstein mountains. Both caverns have their openings in the highlands, the karstic areas over the caves are barren, practically there is no soil and throughout the year are covered by ice or snow.

Eisriesenwelt is a system with fairly dynamic air current through the entrance of which, in an altitude of 1656 the outer cool air moves inward the cave so a part of the passage is glacified (ice formations cover about 20 000 m<sup>2</sup> of the cave). However, in most of the corridors of the cavern which has been explored in about 42 km length the temperature is over zero, thus water is not glacified. From the point of view of dripstone formation, however, this enormous network of caves is rather poor. We could easily study inside erosion cave-genetics, water deposits coming from the non-karstic drainage basin can easily be seen everywhere and very often well developed cave karrrs are upon the rocks as a proof that the limestone-dissolving velocity of waters with a low saturation of carbonic acid, oozing into the cold karst is weak so these solutions can get deeper down being unsaturated. (See: L. Jakucs: Morphogenetics of karsts, 1971, pp. 136—138). No traces of the recent dripstone degradation were found in the cave. We suppose because recent dripstone formation is not characteristic for the cavern either.

The formations and speleoclimatological conditions of *Dachstein-Mammuthöhle*, 20 km of which are disclosed, remind of the conditions of the ice-free parts of Eisriesenwelt. The cave karr-formation and *dynamic corrosion* of oozing waters, respectively, of the cave is more expressed what in several places resulted in considerable crushing of the rock formations, in developing sharp rock edges with steep sides, remaining ridges, at some places real „badland” phenomena. The

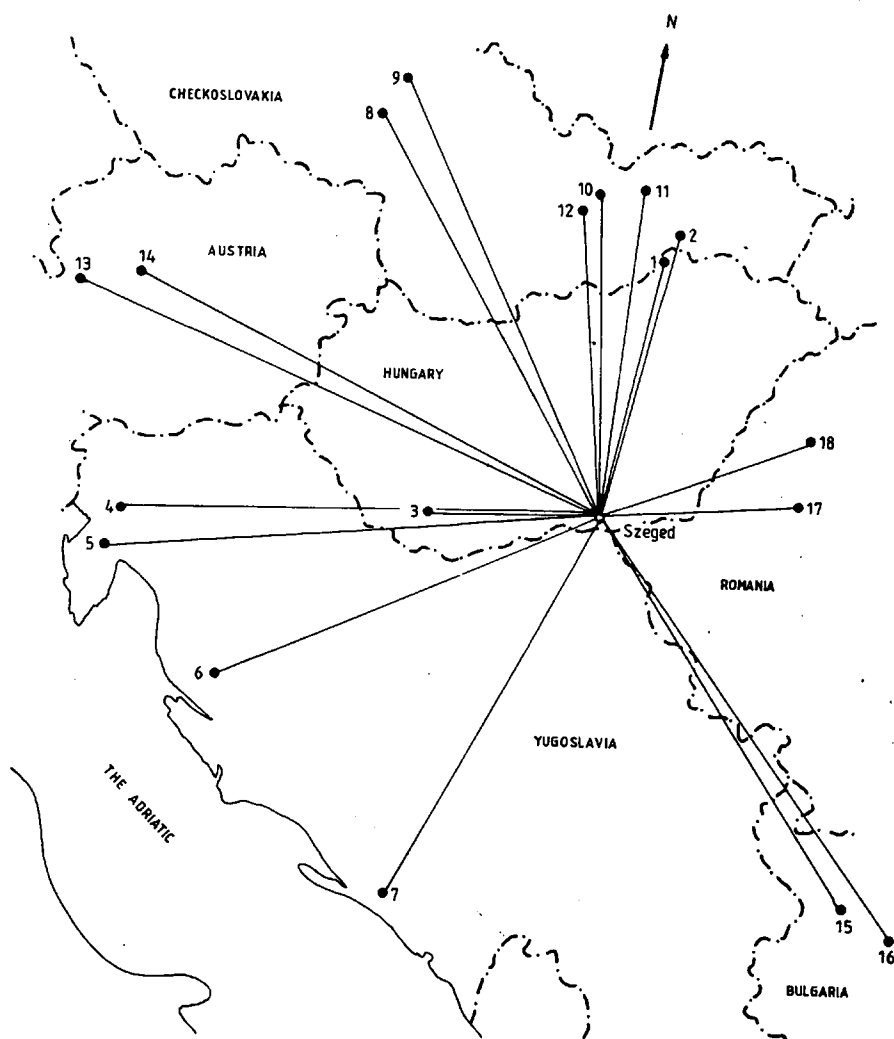


Figure 4. Localities of researches in 1983-85 for the new type of recent dripstone degradation

- |                                     |  |
|-------------------------------------|--|
| 1) Aggtelek karst area (Hungary)    | 10) Demánova cave (Czechoslovakia)             |
| 2) Gombaszögi cave (Czechoslovakia) | 11) Vazecka cave (Czechoslovakia)              |
| 3) Mecsek karst area (Hungary)      | 12) Bystra cave (Czechoslovakia)               |
| 4) Postojna cave (Yugoslavia)       | 13) Eisriesenwelt (Austria)                    |
| 5) Skocjani cave (Yugoslavia)       | 14) Dachstein Karst (Austria)                  |
| 6) Gračac cave (Yugoslavia)         | 15) Ledenika cave (Bulgaria)                   |
| 7) Popovo polje (Yugoslavia)        | 16) Seeva Doupka (Bulgaria)                    |
| 8) Moravia karst (Czechoslovakia)   | 17) Caves surroundings Pades plateau (Romania) |
| 9) Javoričko cave (Czechoslovakia)  | 18) Király-Erdő caves (Romania)                |

poorish dripstones and the relatively rare points of recent limestone accumulation explain why we could not meet the new type of degradation syndrome, in spite of the fact that at some places remains of demolished, dissolved dripstones could be observed. But these latter are not recent degradations; their formation evidently is due to permanent corrosion and/or erosion orifices prior to the present time.

### *Czechoslovakia*

In 1985 two exploration trips were conducted in Czechoslovakia. In both cases several caverns of the Morava karst near Brno were studied, namely Javoricko Cave in the North-Moravia karst, the Demanova Cave in the low Tatras, Vazec Cave in the valley of White-Vág river, the Bystra Cave in the southern side of the Low Tatras as well as Domica and Gombaszög Caves in the South Slovakian karst.

The most marked devastation of the new type of dripstone degradation could be observed in Javoricko and Gombaszög Caves. There is also a considerable dripstone degradation (2—3 times greater than found in the Aggtelek Caves) in Freedom-Caves in Demanova, especially the middle- and upper levels of the cavern. The same can be said of Vazec Cave, while the redissolution of dripstones in Bystra Cave and Domica is somewhat weaker. There is no considerable recent degradation in the two thoroughly studied caverns of the Morava karst (in Caves Amateurska and Katerinska) — true, in these caverns the recent dripstone formation is rare.

Practically there is no difference in the climate of the caverns in Czechoslovakia. Therefore the marked difference of the new type of dripstone corrosion among caves must be looked for in the diversity of other conditions. In order to explore the really working conditions we had to study the *extent of vegetation coverage of karstic surfaces over the caves and the depth of caves underground*. We found that both factors may play their part in the extent of cave corrosion and perhaps the depth underground is the more important.

We know that a clausal interdependence system relying upon some observed data cannot be regarded as deciding, however, we describe our observations on the ground that similar experiences in the Yugoslavian and Roumanian karsts exhibit identical trends. Summarizing: *it seems the thicker is the soil layer over the karst and the deeper are the roots of the macro-vegetation there (trees in leaf) the more frequent and marked is the new type of dripstone redissolution*. According to the present state of knowledge it is probable that the role of pine-wood forests differ from that of others' (oak, beech, hornbeam etc.).

Another aspect of the correlation can be that *the less is the depth of the cavern underground* the more frequent can be the new type of dripstone degradation.

Naturally, these general relations are mostly of hypothetical character and further investigations are to be carried out. Even now there are exceptions contradicting these rules. But this time we think that in spite of exceptions the interdependence between surface and cave, as shown in Figs 5 and 6, seems to be fairly real.

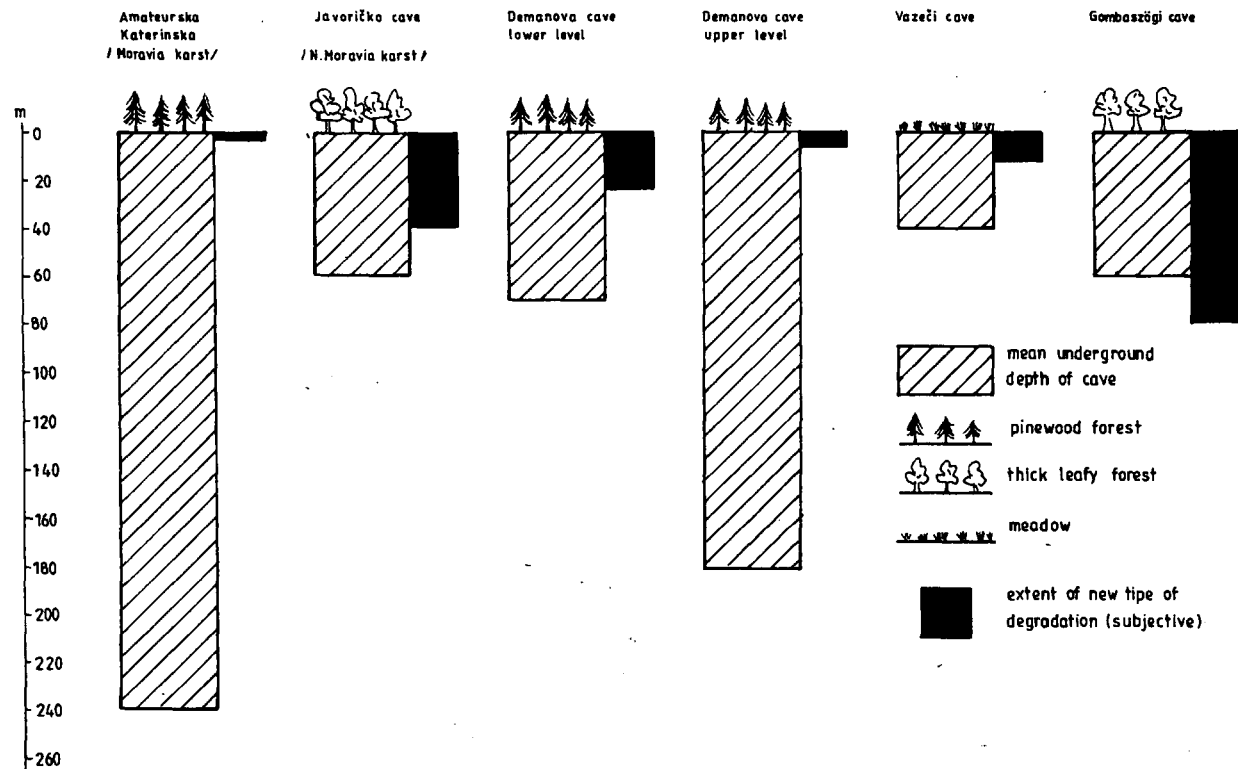


Figure 5 Supposed interdependence between underground depth, type of vegetation coverage and recent state of dripstone degradation in some cave system in Czechoslovakia (original)

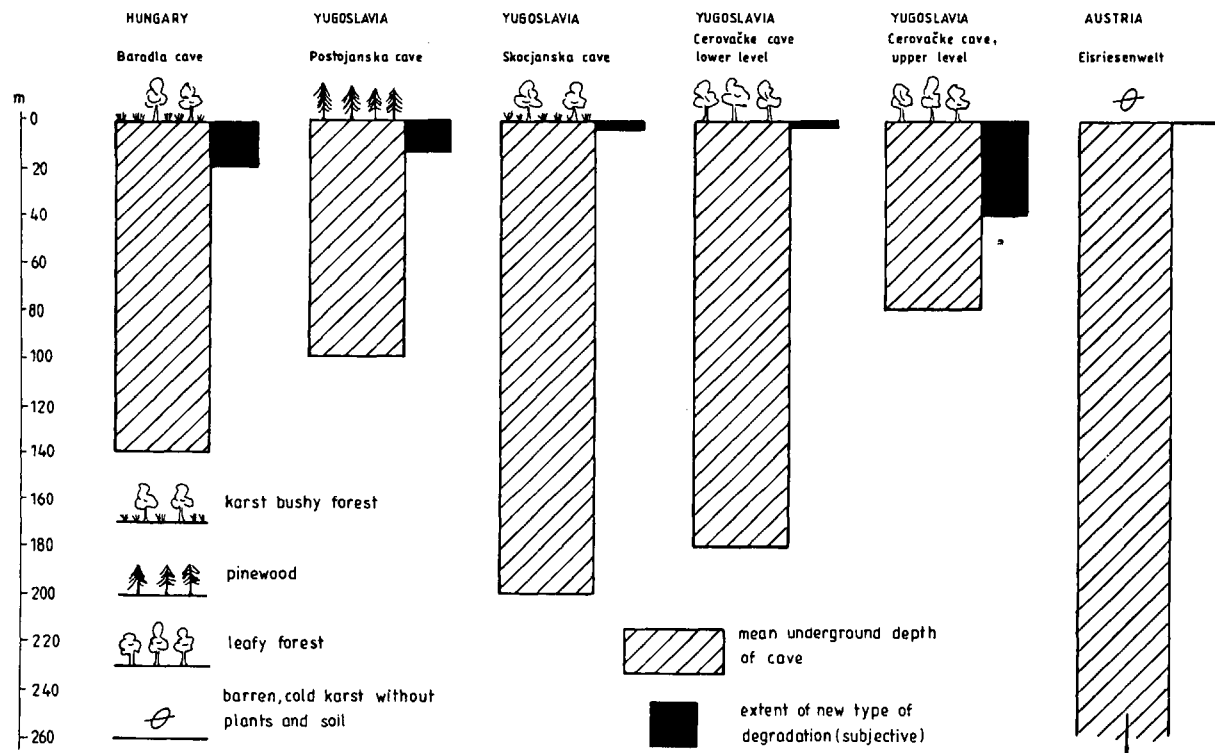


Figure 6 Supposed interdependence between underground depth, type of vegetation coverage and recent state of dripstone degradation in some cave system in Hungary and abroad (original)

### *Roumania*

Two times, in 1984 and 1985 on location observations were carried out in Roumania, in the valley of Speedy-Körös river. The caves more thoroughly examined were: *Biro Lajos Cave* in Királyerdő where quite recent, mainly embryonal dripstone corrosion syndromes were found; *Rév Cave* where beside oozing of corroding water, forming beds of dissolution, a rather marked softening of the dripstones was experienced. At present this can be explained so that the aggressive solution got into the material of the dripstones and brought about changes in the texture itself. A quite similar occurrence was found in the upper level of Cerovacke Cave in Croatia. The new type of dripstone corrosion was found — what is a surprise — in the very beautiful light stalagmites in *Bear Cave* in the Bihar mountain, as well as in *Mikula Cave* in the area of the Pades plateau, where the traces were quite obvious not only on some stalagmites but on stalactites, too.

### *Bulgaria*

Several caves were investigated here and the results varied. Coming down from Vratschanska plateau to the entrance of *Pestere-Ledenika*, a cave of about 600 m length was examined (the level difference between the lowest and highest points was 56 m) but no traces of the new type of degradation were found. Anyway, the cave is rather poor in dripstones, their recent formation is also restricted, scarcely any dripping of water was found at a few points.

Near Teteven in the Balcans the two-level *Geadezniska Cave* was examined (the level of difference between the floors is only 15-20 m) where a few dripstones and peastones could be found only at the upper level and no traces of redissolution observed.

However, in the *Seeva Douпка Cave* near Jablanica settlement (discovered in 1883 and open for tourist) the studied syndrome could be distinctively found at three places. This cave is rich in enormous dripstone formations therefore it is even more astonishing that most of the formations are aged and active developing stalagmites could hardly be found. However, recent dripstone degradation appeared here on the rare, recently formed white dripstone spots.

### *Yugoslavia*

Special care was taken to control the occurrence of the studied syndrome here. Not only because here one can find enormous karstic areas and huge caverns (the karstic area in Yugoslavia is about 90 000 km<sup>2</sup>) but also we could count upon the air currents coming from the Mediterranean together with the precipitation exerting effects different from that in the centre of the continent what can be reflected in the peculiarities of the corrosion degradation of the caves. These in view we tried to

make explorations in caves of various parts of the country, namely in Slovenia, Croatia and Bosnia and Herzegovina.

The *Postojna Cave* (Postojnska-jama) is one of the oldest and most frequented caves in Europe, with big tourist traffic today, inside electric train transport. At many places, deep in the cave far from the entrances recent degradation syndrome was found, the frequency and order of magnitude of development similar to that in Hungary.

This cavern offered excellent possibility to control the dripstone surface „before soot”, since during the Second World War Slovenian partisans set fire the ammunition depo of the Fascists, which was hidden in the cave and the big fire underground covered everything with black soot a few hundred meters back from the entrance. In spite of a very careful study, however, under the black cover, the age of which is well known, not a single corroded dripstone was found, proving that before the forties type of redissolution of dripstones did not occur.

In the gigantic underground caves of *Skocianska* caverns recent dripstone redissolution was found only in caves of the Silent cavern (Ticha-jama) near the surface but not in the deep-lying main channel. True, here the formation of dripstones is rather poor and because of the sometimes 60—80 rise of the water level (the redamming effect of a tight syphon system) it would be very difficult clearly to state the reason of a possible degradation.

The *Cerovacka Cave* near the town Gracac in Croatia proved to be a fairly favourable place for researches in dripstone degradation because this is a two-level cavern, the floors of which are almost exactly over each other and there is a 90—100 m level difference between the two floors.

In the upper level of the Cerovacka Cave there is a large number of dripstone formations in the big cavities, most of them in active development even today. Here the new type of degradation has done enormous devastation. Here we could find not only corroded crates and corrosion canyons starting from them but also a very peculiar softening of dripstones embracing the covering crust of the calcite material of some stalactites and stalagmites in a few centimetres. This interesting phenomenon is not accompanied by morphological changes of dripstones. We can put our finger into the material of the dripstone which is apparently unharmed, with normal colour, forms as if it were soft soap paste (see photos 36—41). Laboratory results of the dripstone material softened postgenetically are given in Chapter IV of this paper.

In the lower and younger level of Cerovacka Cave (we think Röss-Würm Interglacial) there is much less dripstone than in the upper and we have found scarcely any developing ones. Practically there is no dripstone degradation either in the form of redissolution of the bed or softening of the dripstones. Seeking the cause of this we think that it cannot be ascribed to the damages caused by the stream erosion since there is no living waterflow here — even at times of the highest water not a single drop of the water of Gracaci Polje gets here. Namely there is a third deeper (so far unexplored) level assuring the water conducting of the Holocene.

In Southern Bosnia-Herzegovina, at the border of Popovo Polje is the *Zavala*

*Cave* under completely barren karr plateaus without soil or vegetation. This is an ancient — today inactive — sump cave with fine dripstones. But the traces of recent degradation are rare and weak here, what can be explained somewhat by the fact that recent growth of the dripstones proves a low level of lime accumulation dynamism. Probably this is connected with the remarkable erosion of the karstic surfaces.

### *Hungary*

Obviously in the Hungarian caverns the new type of dripstone degradation is rather considerable, true, its frequency varies. The most marked redissolutions are in some caves in the Bükk mountains (e.g. Létrásivizes Cave), in certain areas of the Baradla in Aggtelek this syndrome is weaker but can't be disregarded (see photos 2—8), it has appeared in the Abaliget Cave and on some dripstones in the Peace Cave.

To tell the truth, we can't unequivocally decide that this on that cave is characterized by a certain frequency of occurrence and/or degradation. So it is very difficult to compare these caves since regarding only a single cavern (e.g. Baradla) the extent of damage widely changes by chambers or by sections. In long corridors rich in dripstones there are hundreds of meters where no recent redissolution syndrome can be found and then, in a single chamber there are a dozen places where the syndrome is apparent.

Three-four years of study of this syndrome are a very short time even to decide whether *since the first observations places of recent occurrence have grown in number or the extent of known forms of redissolution have increased*. These are questions demanding a sure answer soon but at present we cannot say anything sure. True, in our standard caves we almost always find newer earlier unseen damages of dripstones, but we do not dare to decide even for ourselves whether these are recent ones or not. Perhaps they could have been found a few years earlier but we not notice them. Namely, our eyes are getting accustomed to catching sight of the dripstone degradation syndrome and we, having already gained experience, can notice the phenomena in an unknown for us cave while others do not know exactly what is to be looked for.

In the X-ray Laboratory of the Department of Petrography and Geochemistry, University of Szeged, Professor J. Mezösi made the X-ray diffractometry analysis of the materials of softened dripstones gathered in Vazecki Cave. (Already?) no considerable contamination was found.

### **Researches for causes of the syndrome of the new type of dripstone corrosion**

After the first observations of the syndrome naturally the problem of cause(s) stood before us. It was quite obvious to think of an indirect effect of acidic rains

(and/or acidic precipitation) since we already knew then that the acidic precipitation affects the soil, the life condition of microorganisms in the soil and even the macrovegetation growing there (grass, trees, bushes, etc.) suffers a lot. When noticing the phenomenon, the composition of several cave dripping waters was examined and their German degrees of hardness was 4—5 degrees less than that of the dripstone — building stalagmite waters of the same type, studied earlier. At the same time pH values of waters in the soil of a few dolines of Mount Bükk and the Aggtelek karst were generally found one grade less than the earlier measured pH values.

In view of all this as a first step we can explain the syndrome in the following way: the effect of acidic rains, the increasing degree of acidity of the soil, the rearrangement or even dissolution of some chemical substances in the soil create new comfort relations for the soil microorganisms in the bioactive level of the soil what disturb the population, virulency and life functions of micro and/or macrobiological organisms in the soil and their equilibrium is so much overbalanced that the usual level of carbonic acid production of the soil drops. If this happens, the partial pressure of  $\text{CO}_2$  in the soil spheres can markedly decrease, therefore the oozing precipitation waters change into only a weaker carbonic acid solution, that is their limesolving capacity would be less. Perhaps solutions with low lime saturation can cause redissolution of dripstones in a cave. After repeated analyses at a later time of waters of stalagmites affected by the new type of dripstone degradation we get some impulse to modify and further develop our interpretation of the causes of the syndrome. E.g. it became clear that a few data of analysis on the softening of cave dripping waters do not show a trend since later at the same places the values of lime saturation were much higher. Other researchers as e.g. *László Maucha* and *Ferenc Cser* pointed out in their reports in my paper on the new type of dripstone degradation written in 1984 (see Legend) that these corrosion signs of dripstones could not be caused by the softening of karstic waters because these latter, in an experienced degree, do not change the chemical character of water lime aggressive.

Accepting, and thanking for, the valuable corrections of our experts in chemistry, it is quite natural that we hold as a working hypothesis that the redissolution of dripstones remains in some way in connection with the effect of acidic rains (deposit) upon karstic surfaces. We have a deciding argument supporting this — and it so far has not been denied or substituted by some other argument. This is the following: *The time of acidic rains and the appearance of the new type of dripstone corrosion syndrome coincide and the „after soot state” could unequivocally be proved.* Then remains only to collect newer and newer observations and analytical data, then, relying upon these to look for that real interdependence by which the effects of a so characteristic for our era contamination of the outer sphere go deep down under the earth, to the horizon of dripstone caverns.

The following part of the paper summarize the most important scientific information about the explored caves and karstic surfaces in Hungary and abroad.

### Recent changing trends in the chemical characteristics of karstic waters getting to dripstones

There are abundant data on the chemical composition of dripping waters both in Hungarian and foreign literature, among these there are lots on results of time sequence investigations, first of all in Aggtelek. All these data and sequences unequivocally prove that the chemical composition of waters getting to dripstones move in a very wide scale both in space and time. That is there can be a considerable difference between the values of volume of some chemical constituents, pH of karstic waters both when comparing simultaneously the different places of dripping and between water samples taken from the same place at different times. This is, of course, a consequence of that the waters oozing into rock layers above the caves, depending on the season, type and thickness of the soil, type of vegetation, duration of oozing, conditions of evaporation and airing of the soil are of considerably different composition, since waters get their own chemical characteristic in cells of soils covering the karsts which produce widely changing qualitative and quantitative chemical processes time by time and place by place.

To illustrate this data in Table 1 deserve some attention.

The comparison of these data makes not only possible to state that the chemical characteristic of water samples gathered at different places and/or times can be very widely various but also that there may be a kind of trend in the change of the proportion of certain ions. The progressivity is the most striking with the sulphate, nitrate and perhaps chloride ions but in the calcium and hydrocarbonate ions of water samples analyzed in March 1982 there was a marked decrease as compared with water samples gathered in Baradla and the Peace Cave in 1957 and 1960.

In 1984-85 the composition and changes in composition, respectively, of dripping karstic waters were examined at several points. We tried to repeat our experimental results as places where exact analytical data were obtained several decades earlier. These were first of all in Baradla Cave in Aggtelek where *Rezső Maucha* carried out water analyses of the dripstones „King's Well” and „Beggar”. Taking these more than fifty year old data as etalons, the perhaps trend-like changes in present time water composition characteristics measured there can be taken as safe much more than if we have samples taken in some years' time. (See Tables 2 and 3 and Figures 7 and 8.)

Data in Table 2 show that much more dissolved limestone can be found in the karstic water of King's Well in summer than in winter. The sulphate root unequivocally grew as compared with the 1929 etalon value (a growth of 400—600%) but rations of the nitrate and chloride content change so widely that they can be rejected as a basis for a trend.

Data of analysis for „Beggar” summarized in Table 3 essentially support the above. Water samples taken in November and March are relatively soft while karstic waters from the end of April and August are hard. The amount of sulphate ions was manifold of that of the etalon while the ration of nitrate ions is of various magnitude. However, there was more chloride in the karstic water.

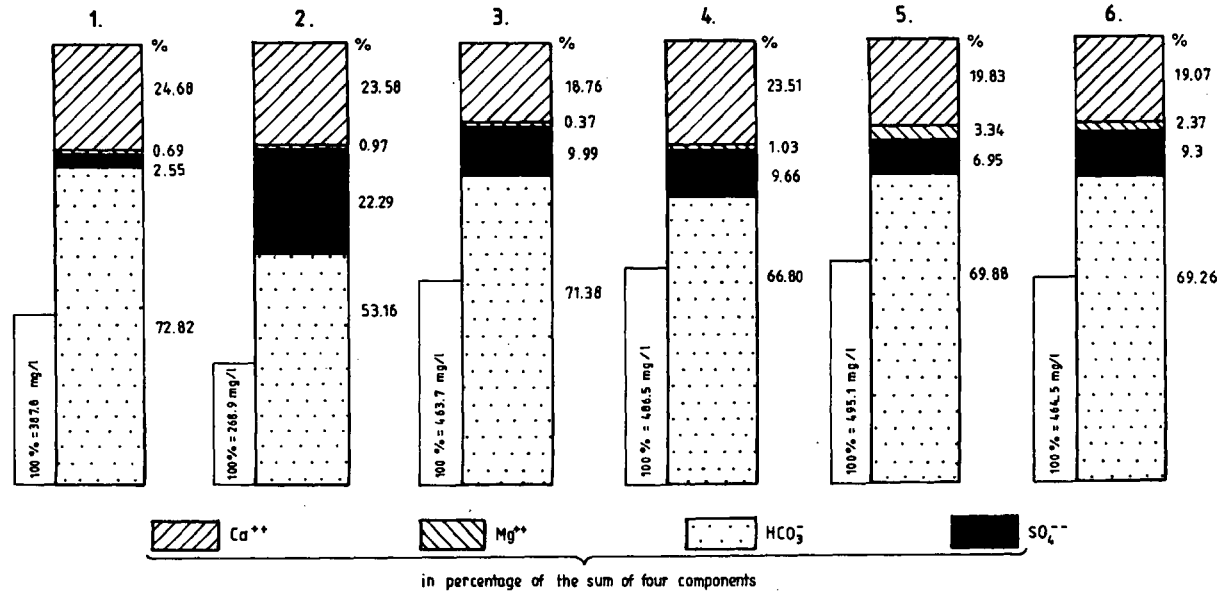


Figure 7 Water of „King's Well” dripstone basin (Aggtelek, Baradla cave)

1 = 30.07. 1929. (data by R. Maucha)

3 = 15.03. 1985. (original)

5 = 20.08. 1985. (original)

2 = 30.03. 1984. (data by Csernavölgyi-Major)

4 = 26.04. 1985. (original)

6 = 27.10. 1985. (original)

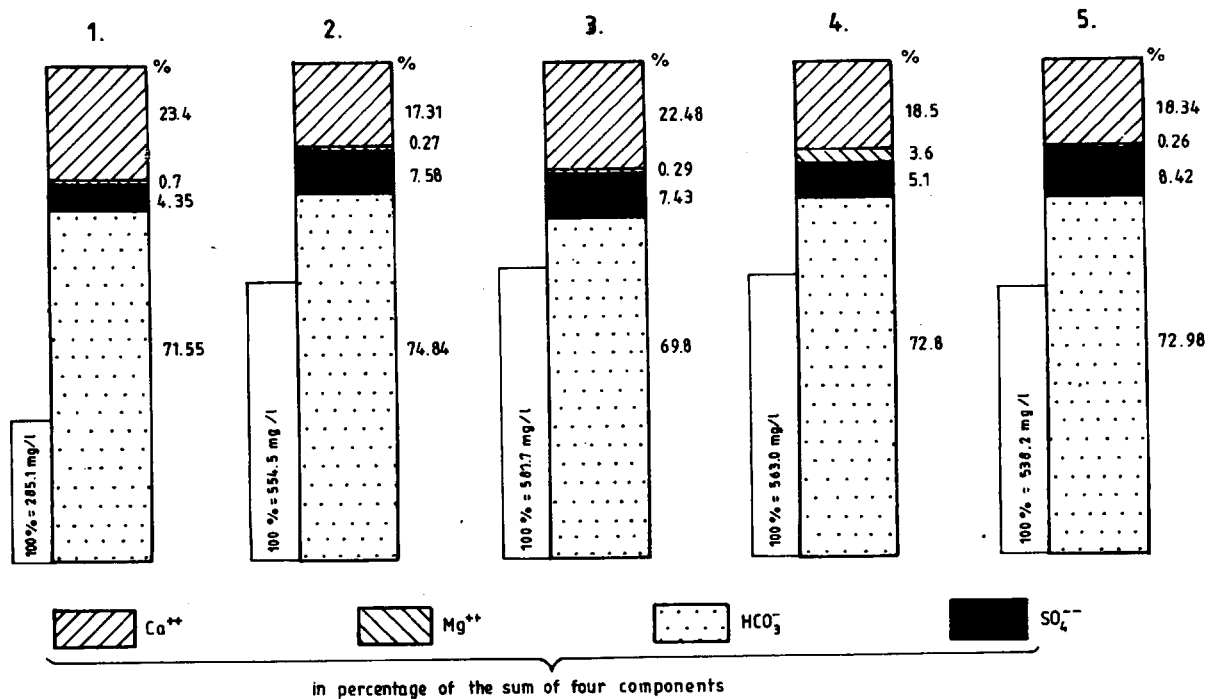
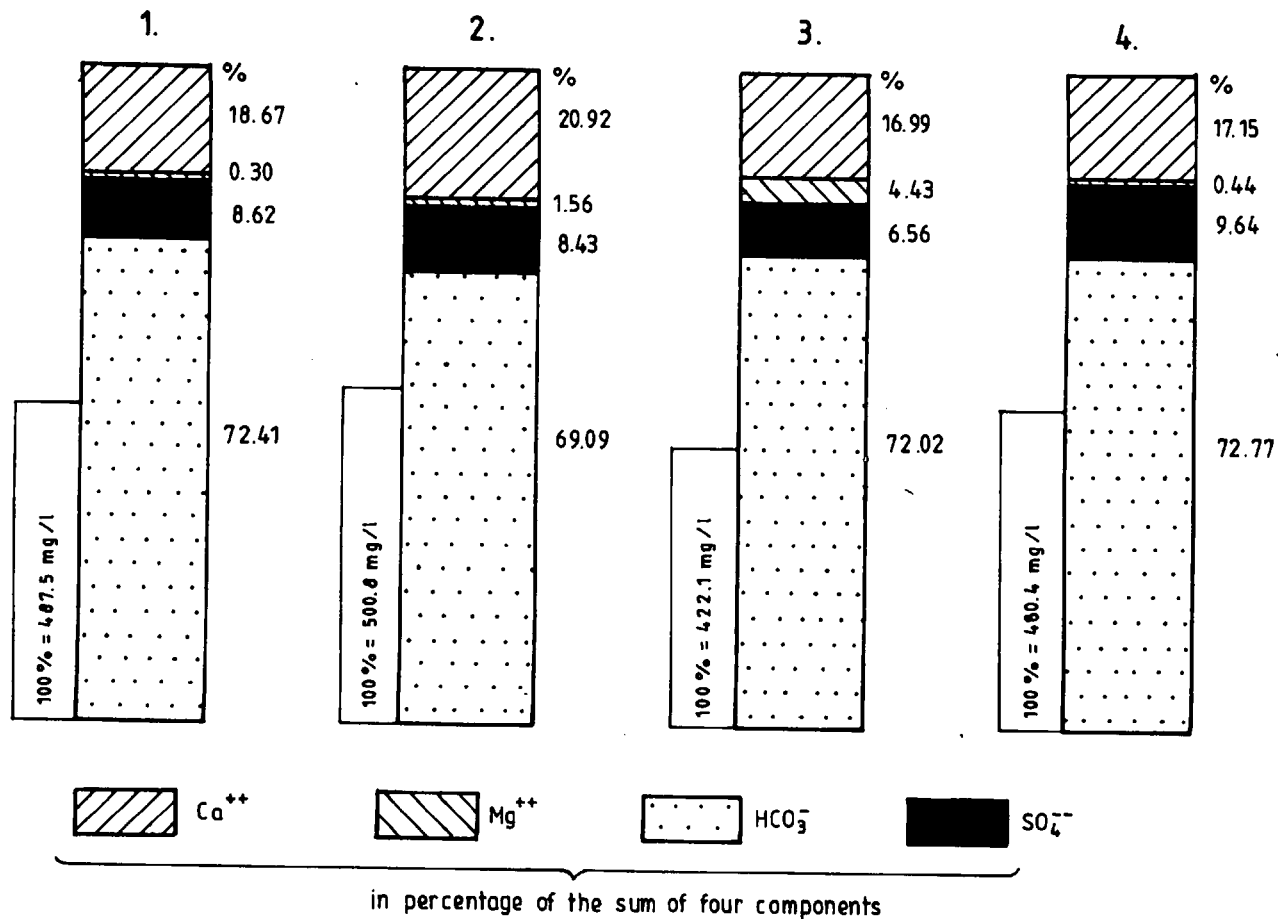


Figure 8 Water of the stalagmite „Beggar” (Aggtelek, Baradla cave)

1 = 29.10.1929. Etalon (data by <i>R. Maucha</i> )	2 = 15.03.1985. (original)
3 = 26.04.1985. (original)	4 = 20.08.1985. (original)
5 = 27.10.1985. (original)	



The information given in these tables is visually shown as percentages of the four most characteristic chemical components. The 1929 norms are given in both figures as the first column. The other columns have a part coloured dark indicating the growing thickness of the „sulphate field”.

Similarly we gathered and analyzed water samples in the research period of an eroded standing dripstone with channelled sides near the entrance of „Fairy Land”, a stalagmite formation in the Baradla Cave attacked by recent corrosion degradation. Water samples taken and conserved duly were analyzed in Szeged in the Water Laboratory of Lower Tisza Water Authority by *Dr. E. Fekete* and coworkers. Results are shown in Table 4 and Fig. 9.

Unfortunately there is no earlier data on the water of this dripstone so it is impossible to decide upon a trend. The time elapsed between the examinations is about seven months what is a very short time to decide on any characteristic changes. Water continuously drips upon the dripstone (even in time of the longest cave „droughts”) under a karstic surface covered by thick soil and leafy forests, so the water supply is fairly even. Perhaps the fact is connected with this that in contrast to other dripstones there was not a characteristic summer and winter difference between either the pH values or degrees of water hardness. Obviously the study must be carried on and extended to other components (perhaps trace elements) and the periods of taking samples must be accompanied with determining the amount of dripping.

The most important chemical parameters of samples of stalagmite water corrosion in caverns in Czechoslovakia, gathered 5—8 June 1985 are given in Table 5 Fig. 10. We note that a comparison with a winter water sample series would be very useful together with old time etalon values of the same area. It is a pity, so far we could not get these, although researchers of the Academy Institute in Brno (*Jan Pribyl, Jaroslav Vasatko*) and the scientific leaders of „Ustredic stájnej ochrany prírody” in Lipótszentmiklós promised us to look for and send some data of analysis. Anyway, after some years to gather comparison material from the same places seems desirable.

Data of analysis of waters gathered from dripstones in Czechoslovakian caves attacked by recent corrosion unequivocally show that *degrading karstic waters have a very great sulphate content.*

Figure 9 Water of a degrading dripstone (Aggtelek, Baradla cave)

1 = 15.03. 1985. (original)	2 = 26.04. 1985. (original)
3 = 20.08. 1985. (original)	4 = 27.10. 1985. (original)

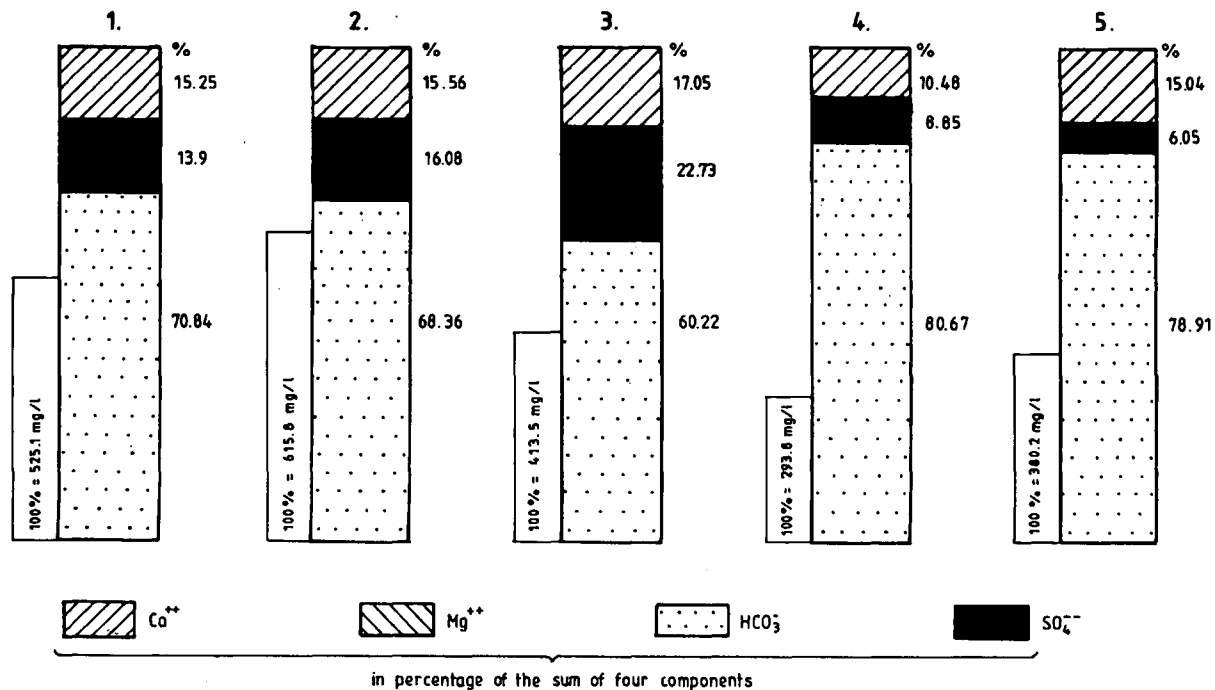


Figure 10 Waters of degrading stalagmites (caves in Czechoslovakia)

- 1 = Amateurska Cave, Moravia karst 05.06.1985. (original)  
 3 = Javoricko Cave II. n. Moravia karst 06.06.1985. (original)  
 5 = Vazecka Cave, High-Tatra region 08.06.1985. (original)

- 2 = Javoricko Cave I. N. Moravia karst 06.06.1985. (original)  
 4 = Demanova Cave, Low-Tatra 07.06.1985. (original)

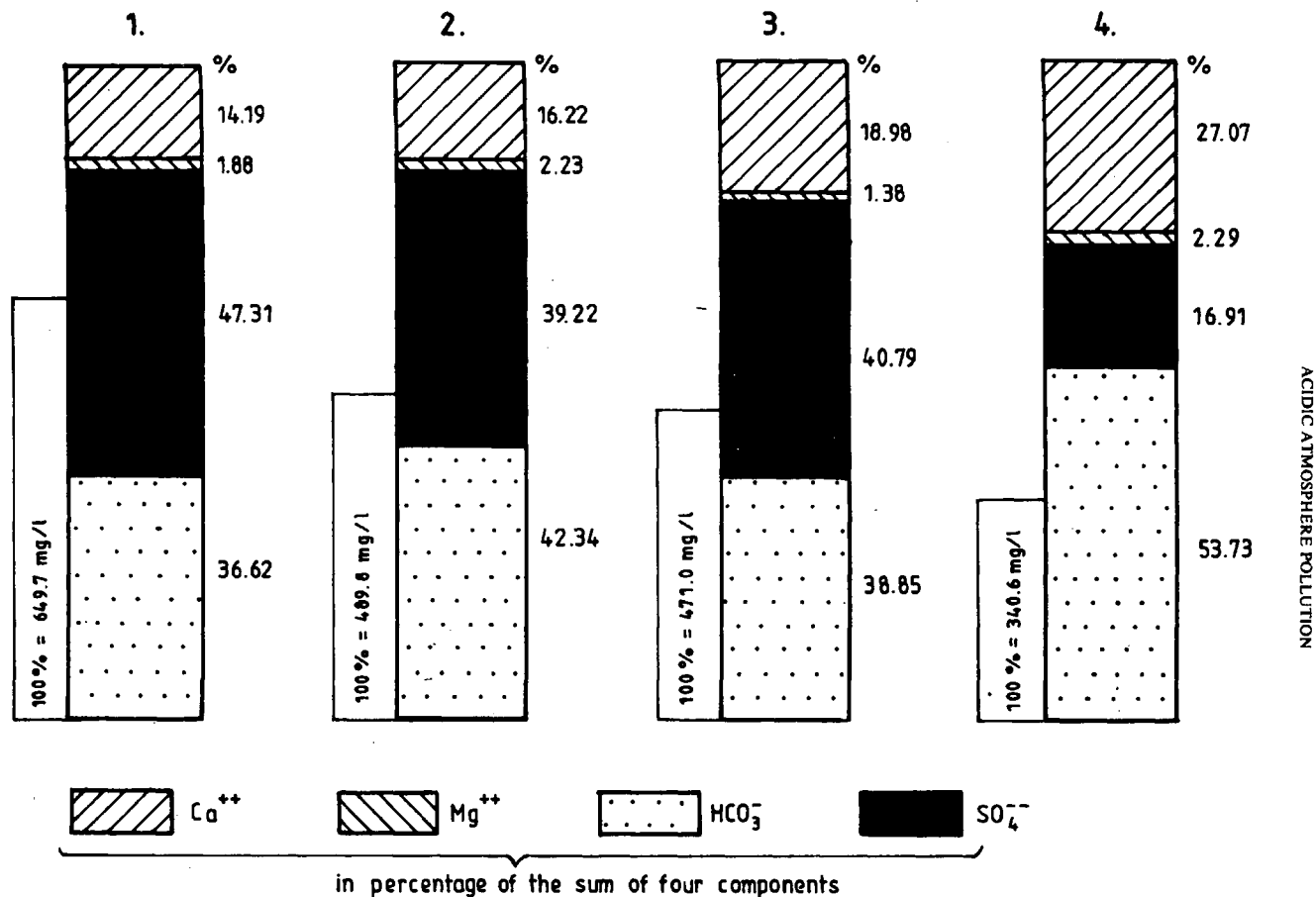


Figure 11 Water samples of Létras water-cave (Mount Bükk) calculated according to data by L. Lénárt

1 = sampling place No.5. 22.09.1979.      2 = sampling place No.5. 03.11.1979.  
 3 = sampling place No.6. 22.09.1979.      4 = sampling place No.6. 03.11.1979.

Since almost in all (not documented here!) water samples gathered from points of the new type of dripstone degradation the sulphate content is much more higher than in karstic waters of classical composition (see Rezső Maucha: Chemical analysis of the waters in Aggtelek. *Hidrológiai Közlöny* Vol. X, 1939 pp 201—207) we tend to be convinced that *recent syndromes of dissolution are caused either by increased sulphate concentration or indirectly by the same causes which lead to an increased sulphate content of karstic waters.*

In this connexion we must remember that László Lénárt documented with extensive and very careful water analysis in Létrási water cave in the Bükk mountain where there is recently very weak dripstone formation and very strong redissolution of dripstones, and the sulphate content of karstic waters there is much higher than in all the caves examined by us. It is almost natural, since the Bükk mountain is surrounded by the Miskolc-Diósgyőr-Kazincbarcika-Ózd-Bélapátfalva etc. industrial region what means a considerable contamination of the soil and air. The main results of analysis of sample places No. 5, 6, 9 and 10 which represent very well the chemical characteristic of the dripping waters in Létrási Cave are shown in Table 6 and Figures 11 and 12. (Paper by L. Lénárt: Water chemistry study of Létrási Cave, *Karszt és Barlang*, 1980 pp 57—64.).

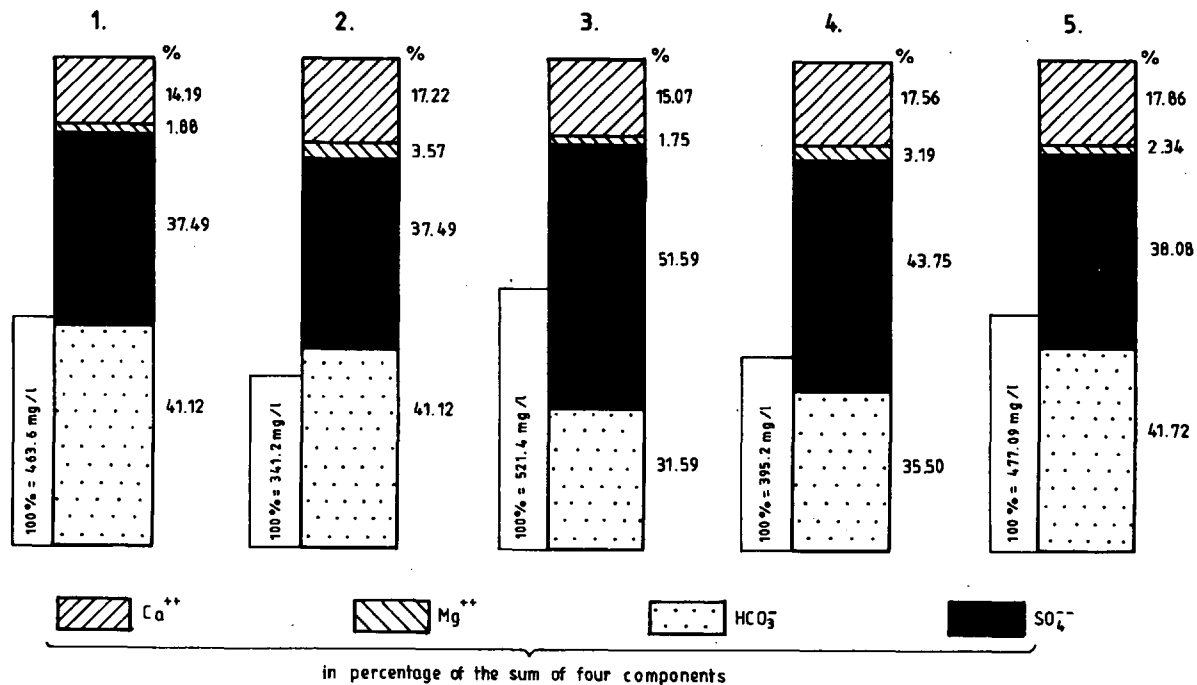


Figure 12 Water samples of Létras water-cave II. (Mount Bükk) calculated according to data by L. Lénárt

1 = sampling place No. 9. 22.09.1979.  
 3 = sampling place No.10. 22.09.1979.  
 5 = mean of 19 samples 11.03.-08.09.1979.

2 = sampling place No. 9. 03.11.1979.  
 4 = sampling place No.10. 03.11.1979.

Table 1.

COMPARISON OF CHEMICAL ANALYSIS OF CAVE DRIPPING WATERS  
AT THE SAME TIME AND AT VARIOUS TIME

Place of the water sample	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.
Datum of examination	10. 02. 1960.	21. 08. 1960.	05. 03. 1982.	20. 11. 1957.	05. 03. 1982.	22. 11. 1957.	19. 08. 1960.	06. 03. 1982.	22. 09. 1979.	22. 09. 1979.	26. 11. 1929.	23. 07. 1962.	08. 07. 1981.	07. 03. 1982.
pH	7.1	7.3	6.6	7.2	7.0	7.2	7.1	7.0	6.9	6.9	7.5	7.2	7.0	6.9
Ca <sup>++</sup> mg/l	103.0	124.0	86.0	92.0	83.0	101.0	122.0	99.0	92.2	98.6	54.2	106.0	111.0	83.8
Mg <sup>++</sup> mg/l	1.0	2.2	1.4	4.5	2.2	1.9	1.9	3.7	12.2	11.3	3.2	2.1	3.1	3.3
HCO <sub>3</sub> <sup>-</sup> mg/l	298.0	370.0	281.0	322.0	267.0	288.0	380.0	235.0	238.0	226.0	174.0	303.0	310.0	266.0
SO <sub>4</sub> <sup>-</sup> mg/l	14.0	9.2	47.0	8.5	33.4	12.2	17.0	27.7	307.0	250.0	16.1	8.9	24.1	29.9
Cl <sup>-</sup> mg/l	3.0	3.6	8.2	4.1	6.8	2.3	2.1	16.1	11.0	11.0	3.6	5.0	14.3	6.5
NO <sub>3</sub> <sup>-</sup> mg/l	16.2	14.8	43.2	13.7	40.9	12.2	14.2	9.7	5.9	2.2	1.0	4.2	20.3	23.5

1, 2, 3 = Baradla-cave, „Csipkésút” (L. Jakucs) 4,5 = Baradla-cave, „Kinai-pagoda” (L. Jakucs) 6, 7, 8 = Béke-cave „Amfora” (L. Jakucs)  
9 = Létrási-vizes-cave, 4<sup>th</sup> point (L. Lénárt) 10 = Létrási-vizes-cave, 7<sup>th</sup> point (L. Lénárt) 11 = Baradla-cave, „Dessewffy kútja” (R. Maucha)  
12, 13 = Postojanska-cave, „Kálvária” (L. Jakucs) 14 = Domicá-cave, „Índiai pagodák terme” (L. Jakucs)

Table 2.

DATA OF ANALYSIS OF IONS EXPRESSING A TREND IN THE CHANGE OF WATER COMPOSITION. „KING'S WELL" DRIPSTONE BASIN IN THE BARADLA CAVE

	30.07.1929. (R. Maucha) ETALON	30.03.1984. (Csernavölgyi- Major)	15.03.1985. (Jakucs- Franczia)	21.03.1985. (Jakab- Major)	26.04.1985. (Jakucs- Franczia)	20.08.1985. (Jakucs- Franczia)	27.10.1985. (L. Jakucs)
Ca <sup>2+</sup> mg/l	93.4	63.4	87.0	64.3	114.4	98.2	88.6
Mg <sup>2+</sup> mg/l	2.7	2.6	1.7	12.7	0.5	3.3	2.4
HCO <sub>3</sub> <sup>-</sup> mg/l	282.4	143.0	331.0	267.3	325.0	246.0	321.7
SO <sub>4</sub> <sup>2-</sup> mg/l	9.9	59.9	44.0	46.9	47.0	34.4	43.2
NO <sub>3</sub> <sup>-</sup> mg/l	12.3	— ?	20.2	— ?	11.4	17.9	8.2
Cl <sup>-</sup> mg/l	2.7	25.4	7.1	1.8	14.4	21.0	5.8

Table 3.

DATA OF ANALYSIS OF IONS EXPRESSING A TREND IN THE CHANGE OF WATER COMPOSITION. STALAGMITE „BEGGAR" IN THE BARADLA CAVE

	29.10.1929. (R. Maucha) ETALON	15.03.1985. (Jakucs- Franczia)	26.04.1985. (Jakucs- Franczia)	20.08.1985. (Jakucs- Franczia)	27.10.1985. (L. Jakucs)
Ca <sup>2+</sup> mg/l	66.7	96.0	130.8	104.2	98.7
Mg <sup>2+</sup> mg/l	2.0	1.5	1.7	20.2 (?)	1.4
HCO <sub>3</sub> <sup>-</sup> mg/l	204.0	415.0	406.0	410.0	392.8
SO <sub>4</sub> <sup>2-</sup> mg/l	12.4	42.0	43.2	28.6	45.3
NO <sub>3</sub> <sup>-</sup> mg/l	8.5	14.2	1.8	17.5	8.2
Cl <sup>-</sup> mg/l	1.5	7.8	6.6	9.3	4.5

Table 4.

KARSTIC WATER OF A STRONGLY DEGRADED STALAGMITE AT THE ENTRANCE OF  
„FAIRLY LAND” IN BARADLA CAVE

	15.03.1985. (Jakucs- Franczia)	26.04.1985. (Jakucs- Franczia)	20.08.1985. (Jakucs- Franczia)	27.10.1985. (L. Jakucs)
$\text{Ca}^{2+}$	91.0	104.8	71.7	82.4
$\text{Mg}^{2+}$	1.5	7.8	18.7	2.1
$\text{HCO}_3^-$	353.0	346.0	304.0	349.6
$\text{SO}_4^{2-}$	42.0	42.2	27.7	46.3
$\text{NO}_3^-$	13.5	9.0	8.5	14.8
$\text{Cl}^-$	7.1	15.5	11.3	9.9
pH	7.47	7.59	7.18	7.30

Table 5.

DATA OF ANALYSIS OF KARSTIC WATERS GATHERED FROM DRIPSTONES ATTACKED  
BY THE NEW TYPE OF CORROSION IN SOME CAVES IN CZECHOSLOVAKIA

	Amateurska cave 05.06.1985.	Javoníčko I. cave 06.06.1985.	Javoníčko II. cave 06.06.1985.	Demánova cave 07.06.1985.	Vazecka cave 08.06.1985.
$\text{Ca}^{2+} + \text{Mg}^{2+}$ mg/l	80.1	95.8	70.5	30.8	57.2
$\text{HCO}_3^-$ mg/l	372.0	421.0	249.0	237.0	300.0
$\text{SO}_4^{2-}$ mg/l	73.0	99.0	94.0	26.0	23.0
$\text{NO}_3^-$ mg/l	1.77	11.0	15.0	6.03	1.80
$\text{Cl}^-$ mg/l	10.65	8.88	8.88	3.55	5.33

Table 6.

## DATA OF CHEMICAL ANALYSIS OF THE KARSTIC WATERS OF LÉTRÁSI WATER CAVE IN MOUNT BÜKK (BY L. LÉNÁRT)

Number of the test place	5	5	6	6	9	9	10.	10.	Mean of 19 samples
Datum	22.09. 1979.	03.11. 1979.	22.09. 1979.	03.11. 1979.	22.09. 1979.	22.09. 1979.	22.09. 1979.	03.11. 1979.	08.09.—03.11. 1979.
pH	6.9	6.9	6.9	6.4	6.9	6.9	6.9	6.9	6.94
Ca <sup>++</sup> mg/l	92.2	79.4	89.4	92.2	65.8	60.8	78.6	69.4	85.21
Mg <sup>++</sup> mg/l	12.2	10.9	6.5	7.8	8.7	12.2	9.1	12.6	11.16
HCO <sub>3</sub> <sup>-</sup> mg/l	237.9	207.4	183.0	183.0	158.6	140.3	164.7	140.3	199.05
SO <sub>4</sub> mg/l	307.4	192.1	192.1	57.6	230.5	127.9	269.0	172.9	181.67
NO <sub>3</sub> mg/l	4.3	2.6	2.2	0.2	2.2	2.6	5.9	6.2	4.23
Cl mg/l	11.0	13.2	11.1	8.4	10.9	12.6	8.2	9.7	11.77