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The Sensitivity of Karst Areas in 34 theses

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1# The appearance of every natural area expresses the impact of complex influences of the cycle of events manifested in the functional interrelationships and order of the geomorphic factors active in the past and present in the area. These factors also include, of course, the special crustal structure and rock province types of the area, since the territorial varieties of tectonics and rock quality are the results of the regionally variable crustal effects just as the aggregation varieties of the impact of exogenic energies.

2# The present geomorphological appearance of the land is formed by external factors with greatly differing effectiveness and durability in the present and in different periods of the past. A good example here is the high mountain regions of the Alps under the impact of Quarternary glacial effects, or the surface of the Canadian shield which has been eroded by an inland ice sheet, where hardly anything remained of the formations that existed before the glacial period. On rocky oceanic shores the effectiveness of abrasion can be sufficient destroy all previously formed coastal forms in a short time. Of course, there are beautiful examples of geomorphological conservation as well. We can refer to the development of the tracks of the Hungarian drainage network for example, that were not influenced in the least by loess formation, the most remarkable geomorphic factor in the region. This shows and proves that different geomorphologic properties **can have extreme capacities for resisting** the impact of subsequent surface forming phases.

3# We have to regard **sensitive land types** those that react sensitively to the morphogenetical factors making their special impact today, which are characteristic of the Recent, that is, under the influences of these factors sensitive land types change their trend or rate of development. We are hardly mistaken when we assert that there is only one geomorphic factor that had no part (since it could not have any) in the geomorphologic land formation: the exponentially increasing land energetic role of human society, the **anthropogenic impact**. Therefore the recent degree of sensitivity of different land types can be sufficiently analyzed in terms of the degree, the modes and results of the interactions of the land and the anthropogenic effects.

4# It would be far beyond the objectives and scope of the present study to assess the role of the anthropogenic effect in the formation of all major land types. I believe that this is the most important international duty of the present and of 21th century science of analytical geomorphology. At the same time, this is also an inevitable moral responsibility to the future of mankind. All I can assert now in the light of my research results is that **karsts are one of the most sensitive land types of the Earth.**

5# The extreme sensitivity of karsts is due to the fact that most karsts are **land ecological systems functioning in very complex ways**, that comprise sensitive balances connecting to and depending on each other. The karst as a land ecological system is defined by the **combinations of the interactions** of several petrographic, tectonical, climatological, hydrographical, macro- and microregional chemical, physical and biological factors. These factors are greatly variable in themselves, too, both in space and time. Therefore we had to dismiss the traditional definitions of the karst as a geomorphological notion, which all agreed in the simplicity of regarding the rock of soluble base (usually limestone) and the solvent (usually lime-aggressive) water interacting with it as the genetic conditions of different karst phenomena. This, karsts formed where the long interaction of water and the surface (or subsurface) rock resulted in special i.e. corrosion (solution) forms, that is, karst phenomena. These traditional definitions of karsts, however, do not account for all the processes and phenomena of the karsts, since for example they do not take into consideration the dynamics of the interaction of water and the rock surface, or the temperature of the interacting solid and liquid (sometimes solid and solid or solid and gaseous) phases, or their characteristics.

6# In my book **The Morphology of Karsts** (1971, pp 13-16) I have dealt with the issue of the different **karst definitions** and I have pointed out that it is very difficult to establish a proper definition because karsts are natural features constituted of many factors. Accordingly, they have several variations, where besides the role of water as solvent (or even without this factor) sometimes other karst forming factors can play a role, sometimes even with dominant or exclusive magnitude. Therefore the notion of karst formation **cannot be attributed only to dissolution of rock by water**, since we know such karst phenomena (collapsed-dolines, erosion limestone valleys and caves) where the condition for the formation is not the solubility of the rock in water. For example, a great number of hydrothermal karst phenomena also belong to this group.

7# The traditional understanding of karsts is very poor and ambiguous in shedding light on the corrosion karst processes as well, because it has attributed the formation of the karst phenomena to the dissolution of rocks by rainwater. The essence of this concept, still prominent in textbooks, is that the water falls on bare limestone rocks and escapes in its fissures and joints, then, due to the carbon-dioxide it receives from the air, it dissolves the limestone acting as weak carbonic acid. As a result, special formations appear on the surface rocks, **karr fields** are formed, and, as a result of the joint-widening effect of the solution, repeated limestone crumbles appear, forming dish-shaped, cauldron-like depressions, **dolines** on the plateau. The waters filtering deeper and deeper meet in the depth, and their concentrated, increased solution results in spacious alveoles, cave water passages. That is, the traditional understanding explains all special forms of limestone mountains, from surface dolines to caves in the depths, with the rock-solving impact of rainwater. **This model of karst genetics, however, does not hold any longer.** Today it is unjustifiable, groundless.

8# The classical karst theory received the first attack when researchers, on different continents and almost at the same time, started to examine the changes in the chemical composition of the rainwater filtering into the rock. It was asserted that the rainwater filtering into the joints of the rock becomes a decalcified solution very soon, **in a depth of almost only a few meters.** The **saturated lime solution** proceeding deeper, however, cannot dissolve more rock, except under very special circumstances. Thus the water reaching down to the caves in a hundred meters or more depth is, in most case not solvent. The 'karstwater', rather than dissolving, **deposits** the minerals dissolved and carried down from above. Dripstones build up from the lime deposit of the millions of falling waterdrops. So the vesicularization of the cave **can in no way be originated** in the dissolving work of the karstwaters.

We had to realize that the vesicular system itself is always washed out by the current of another, external water course **of a foreign water basin** in the inside of the of the limestone mountains, primarily by means of **scouring, abrading** of the solid alluvium of the streams (rivers) flowing in the karst. (The water filtering into the joints of the karsts essentially does not have such solid and hard deposits.) That is, **the cave is not the result of solution** but it is an **erosion stream-valley, a riverbed under the surface.** Thus a grand cave system is **not** necessarily a karst phenomenon, since it can form only in karsts which have a system of water courses receiving supply from outside and carrying along solid alluvial particles as well.

9# The stroke of grace for the traditional explanation of karsts came also from the chemical analysis of the filtering waters. The explicit chemical analyses confirmed that the average carbon dioxide content of the atmosphere of the Earth is only 0.03%, that is, so minimal, that rainwater cannot absorb even 1 mg of carbon dioxide per litre from the atmosphere. The carbon dioxide absorbed from the free atmosphere **does not increase** the limestone dissolving appetite of chemically clean (distilled) water, which is thus sufficient for the dissolution of only 10-15 mg limestone per litre. Had it been only for this amount, the wonderful solution karst phenomena of the limestones would hardly have formed, as the loss of 10-15 mg rock per litre is insignificantly small. Every other rock, even granite is soluble in water to an almost similar degree.

10# The water samples collected from the network of carbonate joints or from the inside of the caves, however, show something different. Their dissolved lime content reaches several hundred, sometimes even thousand (!) mg per litre.

Where does water absorb so great an amount of carbon dioxide that makes it possible to dissolve such amount of limestone? Studies have proven that it comes from the soil in all cases. Where the rock is covered by a layer of soil, the rainwater first has to filter through this soil cover. Only after this can it reach the limestone. In the gas compound filling the pore space of the soil, however, there is more CO_2 than in the air. The proportion of this gas here is almost always more than 1%, but it can frequently exceed 10%. That is, compared to the atmosphere, **soil-atmosphere** concentrates at least thirty, and not infrequently three hundred or even many times more carbon dioxide.

Therefore it seems certain that the karst waters with high carbon dioxide contents dissolving large quantities of limestone receive their aggressivity from the soil covering the karst and not from the air. The more carbonic acid develops and is stored in the soil, the quicker and more effective the deterioration by the dissolution of the limestone, or the karst development, will be. Consequently, karst development is not the result of the interaction of rock surfaces and rainwater poor in carbonic acid, but **it is the product of the interaction of the rock, the covering soil and the lime-aggressive compounds developing it, which happens through the mediation of water.**

11# Carbon dioxide in the soil is produced by the millions of **microorganisms** (soil fungi and bacteria) living there. In other words, this means that, beside the quantity of the filtering precipitation, the speed of karst development in an area is primarily controlled by **the activity of the biological processes of the soil** covering the surface. That is, the dissolution of the limestone or **karst development is, in essence, the formal reflection of the biological and chemical developmental phenomena of the soil covering the rock in the soluble base rock.**

12# The plausible statement of the classical karst schools (Cvijić, Cholnoky, and others), that the Dinaric Karst Mountains became karsts because following the deforestation the soil was also washed away by rain and thus precipitation can now freely dissolve the barren limestone, is shown to be incorrect. The statement is true in the other way round: the formation of the karst phenomena, the corrosion of the dolines and the development of the bizarre forms of the karren occurred **during the forest- and soil-covered period** of the mountains, and the denudation of the slopes only revealed this, at the same time slowing down the dynamics of karst development. An analogy here could be the development of the skeleton of a cat. It would grow only as long as it is covered by living animal tissues, that is, until it is invisible for the eye. When the skeleton is exhibited in the biology laboratory for everybody to see, we can be sure that it is not growing, not developing any more.

13# The bioactivity of karst soils is not limited to the carbon dioxide production of the bacteria and fungi populations only, but the chemical impact of the **roots** of the grassy, bushy or arboral vegetation reaching down, or the composting of the organic waste and leaves, the disintegration of animal carcasses in the soil and many other processes can also be contributing factors in the production of carbon dioxide and other acids. Soils with greater bioactivity can be compared to real chemical factories, where mostly several kinds of organic acids are produced. The most important of these are formic, acetic, oxalic, lactic, propionic acids, different fulvo- and crenic acids, humus and humic acids etc. Besides the most important carbonic acid these also participate in the dissolution of the limestone, since the water filtering through the soil dissolves these, too, and takes them to the limestone base.

14# In the network of the roots of different plants, grasses, shrubs, trees, etc., in the **rhizosphere**, different microorganic populations appear according to the different plant species. Consequently, there will be qualitative and quantitative differences between the chemical processes of the neighbouring rhizospheres or soil areas, resulting in different acid and gas concentration in the neighbouring areas of the soil. A real plant species adequacy emerges, which is characterized by the well distinguished CO_2 production in the soil of the rhizosphere of each plant species, the maximum of which is associated with different periods of the vegetation period. The ventilation of soil depends on the fixed, moist nature and aspect of the soil surface, the thickness of the bioactive soil layer and on many other factors, and this also influences the concentration of the accumulating liquid and gaseous compounds. Thus great **divergences** can occur in the chemical composition of the filtering water even within a few centimetres. This difference in aggressivity is then reflected in the irregular solution forms of the rock, in the bizarre forms of the rock **karren.**

15# The bacterium population of the soil is always denser around the roots than elsewhere. Therefore the roots pushing into the joints of the rock will, in time, to widen the narrow fissures into spacious solution canals, mostly round or oval profile meandering conduits. The limestone perforated by root-canals is the **root-karren**, while the vast, barren rock surfaces that have lost their soil are called **karr fields**.

In the tropics, where both the vegetation and the hidden organisms of the soil develop more dynamically, the impacts of biogenic karr development are naturally greater. The canals of the root-karren frequently reach down to 20-25 m into the limestone, while root corrosion can result in even 60-70% solution rock losses. The **varying intensity of biogenic karst development** can be shown remarkably by the example of trees crushing through thick layers of limestone. In Cuba, but elsewhere in the tropics as well, there are several caves through the thick ceiling of which trees have grown, in canals they themselves deepened.

16# The invisible organisms of the soil have their favourable and unfavourable life conditions just like the organisms we know. The vital functions of the organisms of the soil react sensitively to the **changes in temperature**. The change of the number of bacteria sensitively follows even daily temperature fluctuations. On the basis of long experiments and data collected through observation, however, we also know that the optimal temperature is not a sufficient condition in itself to enhance the microorganism population of the soil. This can only be ensured by **the simultaneous impact of optimal temperature and soil moisture,** naturally complemented by the proper conditions of soil ventilation. An increase or decrease in any of these conditions would lead to the drastic, immediate decrease of the number of bacteria. That is, the acid factory of the soil is extremely **sensitive to climatic changes.**

In the tropical soils with optimal temperature and moisture, therefore, a hundred or several hundred times more carbon dioxide and other organic acids form than in the soils of karsts under temperate climates. But the carbonic acid production of the karsts under temperate climates is the multiple of that of the poor soils covering the karsts in cold climates or the cold surface karsts of the high mountains. It is obvious that there are vast differences between the **intensity of karst development** of the different climatic zones (Tropical wet, Desert, Mediterranean, Oceanic, Moderate, high mountains and other cold regions), for the dissolution aggressivity of the water, will become **dependent of the climate** itself because of the climatic sensitivity of the biogenic factors. We can be sure that these differences explain the striking variation in size and the special regional morphological differences of karst forms found in distant parts of the Earth.

17# Under our climate, that is, in the temperate climatic zone, biogenic solution is a major genetical component of **dolines** as well. These dish-shaped or cauldron-like surface depressions are sometimes only some meters in diameter and depth, but sometimes they can be several hundred meters wide and 40-60 m deep. Researchers in the near past thought them to be simple rock disintegration regarding them as the crumble phenomena of the caves and solution caves underneath. Recently it turned out that dolines and caves have not much to do with each other.

The crumble origin of dolines was also contradicted by the fact that the rock layers almost always keep their **original** strike direction and dip angle on the sides of the dolines, that is, during the formation of the doline the situation of the layers in which it develops does not change.

The reconciliation of the contradictory observations and the modern interpretation of doline formation was made possible only by the discovery of biogenic karst development, which claims that the doline is a **rock solution surface depression** that comes to existence on every karst plateau where the soils covering the rock become the most active. The loosely structured, humus-containing soil particles of the higher reliefs easily merge in the initially flat rock solution incurations, thus the **locations of optimal corrosion** start to concentrate in more restricted areas. With time, the soil-mediated rock solution process will be increasingly concentrated in hollows corrosion ensues precipitation washes away the soil more and more effectively from the crests between the dolines that also function as local sediment reservoir basins. The relatively quick deepening of the doline is further reinforced by the fact that karst development slows down with the deterioration of the vegetation on the ever steepening ridges and on the saddles separating the dolines.

18# Among the bioecologically regulated karst phenomena we find not only solution forms. We had to realize that the formation of most **karst-accumulation phenomena** were initiated by organic activity, and this is also what defines their dynamics and sometimes the quality of their forms. The different aspects of limestone deposits in caves, calcite stalactites and stalagmites, different encrusting dripstones, the travertine tetaratas developing as transversal dykes in the beds in cave channels and the travertine appearing on the surface of the valley near karst springs (thus for example the vesicular travertine hill under Hotel **Palota** in Lillafüred or the famous and beautiful waterfall travertine dams of the Plitvice Lakes), but also the travertine curtains of the ridges of the tropical karsts - in fact these all are biogenic karst phenomena.

This concept is not in the least modified by the fact that we find among these karst sediments of **indirect biological regulation**, where only the aggressivity of the solution and the phases of the solution had been dependent on bioecological processes (for example cave limestone deposits, dripstone formations,) but there are such among them that reflect the activity of organisms a **second time** as well, during precipitation from the solution, in which case for example the mode of the lime separation phase is also regulated by plant assimilation. (Among others, the travertine accumulation of karst springs and karst brooks can be mentioned here.)

This explains why there are no dripstones in the caves of the polar regions covered by abiogenic surfaces and of the high mountains where there is no vegetation, and this is why the karst springs and brooks do not build travertine either. In the karsts of the rich vegetation tropics, however, magnificent dripstone formations appear, covering and turning the intertwined green vegetation of liana, tendril and clamatis of the steep rock walls into a stone idol.

19# The natural appearance of the karsts of tropical and temperate zones is, therefore, limestone mountains covered with soil and vegetation. **The denudation of the limestone surfaces** in these climatic zones always means **a disturbance in the natural balance of the karst-ecological conditions**, the definite denaturalization of the process of karst development, its real decay. We can find naturally formed bare karsts in intrazonal location only in deserts, or in the regions of adverse climatic conditions in high mountains and polar regions. Therefore the denuded karst, for example on the Balkan or in Hungary, is an expressly extrazonal occurrence, an unnatural phenomenon, sometimes exhibiting anthropogenic reasons that can be analyzed in detail.

20# The occasional radical and irreversible denudation of the karsts of the temperate climates of Europe is most frequently caused by **overgrazing**. The main reason of the almost endless bare karsts of Greece, Montenegro or Dalmatia is the extensive goat keeping of the Medieval societies of these regions. Especially in Albania and Greece, hundreds of years ago the number of goats increased and they were even running wild in so high numbers that they could consume the buds and foliage of the sapling of the woods ruthlessly and entirely in whole regions. Thus they induced the ageing, then the extinction of the woods, and, with this, the erosion of the soil deprived of the network of roots.

Of course, the destructive processes of the soil were intensified by the mechanical agitation of the **trampling of the herds**. Soon the increase of stray goats and its undesirable impacts reached such a magnitude in this region that not only the animals could hardly find food for themselves, but there did not remain enough soil to be able to provide the basic minimum level of the agricultural and timber production, even though this had been low before as well. This is why we can find so many ruined towns in the mountains of Dalmatia and Montenegro, deserted by the inhabitants as the earlier sustaining potential of the land vanished because of the mistaken choice of concept for land-use. Thus the earlier population density of 77 people/km^2 of Montenegro decreased to 33 people/km^2 by today.

21# It is also a well-known fact that the enormous amount of timber needed for the construction of Venice, of the Adria trawlers and then the early modern commercial galleys was the death warrant of the forests of the Croatian and Dalmatian coastal karsts. The unlimited and complete logging of the woods was of course followed by intense soil erosion and the soil degradation of the steep ridges soon led to the unlimited and irreversible denudation of the region. The interference with the ecological balance of the karst without considerations resulted not only in upsetting the biological balance, but the complete change of surface conditions, a decrease in the productivity and sustaining capacity of the land as well, and it made new qualitative aspects expressed in the geomorphological development of the land.

22# Denudation, however, also had **another reflection in karst degradation**. Karst soils covered with woods or even grass-associations secure a groundwater output balanced out toward the limestone base before the periods of degradation. This is in connection with the natural water preserving capacity of the soil, which is capable of absorbing and storing sometimes great quantities of rainwater. When this happens, most of the interspace between the soil particles are filled with water and the soil might even significantly swell.

In contrast to this, precipitation rushes down from the karst surface, usually with the help of the joint network of the karst and thus one or two hours after summer storms the limestone surface may be completely dry again. Consequently, we can observe in dripstone caves in Hungary and abroad that the relatively balanced output cave dripping points that are active all year round are always found under the forest covered karst reliefs while the distinctively alternating dripping intensity stalactites are found in the cave parts under barren karst surfaces. Among the latter dripstones we can often find ones whose water supply periodically or even completely stops.

23# There are other sensitive correspondences between the aspect of the vegetation and the related soil conditions of the surface and the nature of the karst process. Thus sometimes there are remarkable differences between the **dynamics of dripstone accumulation** of cave parts under covered and uncovered karst surfaces. Compared to the ones under the degraded planinas, observation shows the growth rate of the dripstones under forests in given time periods to be many times greater. Especially the comparison of shorter periods showed significant differences in the degree of dynamics, sometimes even the order of magnitude of thousand. This is understandable, because in the barren karsts it is usual that some cave water drippings stop periodically.

24# As the water preservation in the soil and the infiltration-balancing effect of the surface radically decreases in denuded karsts, the mentioned factors also lead to a **degradation in the reliability of the water supply of the karst springs**. The water output of springs in denuding karsts becomes fluctuating, and, corresponding to the degree of denudation, **extremities** will be characteristic of them in the output and even in the composition of the water. Before the general soil degradation the differences between minimum and maximum outputs were at most of the order of magnitude of ten. After denudation, the maximum output can increase hundredfold or more compared to the small water output. This is an unfavourable phenomenon that naturally affects the cleanness, filteredness of water and the possibility of bacterium contamination.

25# The denudation of the karst drainage results in a certain quantitative growth of the annual average water output of the karst springs because the proportion of constant filtering precipitation increases. At the same time, however, the **extremities of output fluctuation** and the **pollution of the water** are highly unfavourable in the case of springs supplying human settlements with water. Therefore forestation is a social priority in the catchment of karst springs providing drinking water for an area or town (for example Miskolc, Pécs or Borsodnádasd in Hungary). Neglecting this, or disregarding the degradation processes pointing to the opposite direction or even amplifying these would inevitably result in the degradation of the reliability and quality characteristics of the spring, that is, the deterioration of the drinking water base of the settlement.

26# There are other sensitive **karst-process** indicators of the **anthropogenic** degradation of karst soils. Such are for example the **colour changes of cave dripstones** which are perhaps the finest registers of the present and past changes of the rate of degradation.

The general **red colouring** of the wall coatings and the dripstones in the caves under limestone planinas with terra rossa subsoil of high ferric oxide content indicates the degradation of the soil and the vegetation, as the balance of several thousand years had been upset in the karst surfaces where the forest vegetation deteriorated and the waters wash the eroding soil into the caves through the joint network of the limestone. By comparing the maps of the caves and the surface we showed that for example in the area of the *Vörös-terem* or the *Kőgombás-kapu* of the Aggtelek Béke cave, where the red surface colouring of the cave formations is especially frequent, denudation took place in the last one hundred years because of **clearcuting**.

27# At places clay can be washed in so fast in the depths of denuded karsts that during even a few hundred years the inactive cave sections can become silted up significantly or sometimes completely. The silting up of the *Mese-ország*, the *Arany-utca*, the Retekág upper corridor of the Baradla cave, and several syphon by-passing upper corridors in the Béke cave, etc., in the last centuries (in the period of the general surface degradation of the areas) resulted in thicker clay accumulation than that had accumulated in them in 3-4,000 years.

28# In karst caves we extensively find the traces of such dripstone deterioration processes that were caused by corrosion, that is, **the subsequent dissolution of the substance of the dripstone**. The corrosion dripstone deterioration, may have several reasons, and we know quite well the interrelations of the developed degradation symptoms and their causes and the pattern of impacts. There are several known types of corrosion dripstone degradation which have genetics **independent of age**, that is, they can occur in any phase of the development of the cave system, the conditions of their formation have been given in the past of the cave (or its certain periods) as well as today. However, my research data shows that (unfortunately) there are such corrosion processes which destroy the dripstones **only in the present**, but which had never and nowhere been present on cave formations before the last one or two decades and which, therefore, are called **new dripstone degradation syndrome**.

The deformations are caused by the corrosive effect of the karst waters dripping on the dripstones. The spread of the syndrome is general in Central Europe, though it occurs in caves of different natural potential with different amplitude.

29# The **symptoms** of the new dripstone degradation syndrome are: irregularly shaped craters with sharp, hackly edges, 'calderas' with compressed sides, sharp edged, bed-like trickle ditches, areal dripstone surface recorrosion in the spray zone of the waterdrops falling from above, in certain cases almost total dripstone solution and, not rarely, the subsequent mollification of the material of the dripstone so that it becomes creamy.

The new dripstone recorrosion is the degradation symptom usually of the youngest dripstone formations that are light (often white) in most cases and have an active water dripping even today. It can be found only in certain sections of the caves. The degradation occurs usually in groups, but there are stalagmites not showing degradation symptoms in the immediate environment of the degrading dripstones.

30# The new dripstone degradation syndrome occurs almost exclusively at the points of the most stable dripping in the dripstone caves. Similar transformations can never be found in the older layers or surfaces of the same formations. It is especially easy to control this correspondence in the caves which have been known and visited for a long time and in which during the period of torch-visits (up to the beginning of the 20th century) thicker or thinner **soot-coatings** settled on the dripstone and rock surfaces then. **Under** the soot-coatings the new dripstone degradation is nowhere present. That is, we can distinguish a 'pre-soot' symptom-free development lasting several hundreds of thousands of years and a very short, maybe a few decades long 'post-soot' active degradation period, which imprinted effective recorrosion marks on the surface of many cave dripstones and in some cases it has destroyed the whole dripstone formation.

31# The research to identify the reasons is underway, but it seems we have enough evidence to assume some relationships in the impacts. These are the following:

- The recorrosion or the dripstone is caused by the very same cave water dripping that augmented, built the dripstones (primarily stalagmites). The fact of degradation is therefore the proof of a change in the chemical, physicochemical, or perhaps microbiological character of the water dropping on the stalagmite.
- The thicker the bioactive and permeable soil covering the karst rock and the deeper the roots of the (broadleaved, woody) macrovegetation, the more frequent or greater the new dripstone recorrosion. It is also likely that the role of pine forests is somewhat different than that of broadleaved forests such as for example oak, beech, hornbeam, etc.
- There can be shown a certain inverse ratio between the frequency of occurrence of the dripstone degradation syndrome and the **depth under the surface** of the cave section. This means that, the closer to the surface a cave system is, the more frequent the new dripstone degradation can be in it.

32# We have extensively analyzed the relationships of the pH value, microbiological and compositional characteristics of karst soils and the observed degradation phenomenon. It was established that compared to the data of the retraceable 1929 standardized water-analysis the dripping water of the same cave points **the sulphate content of the karst water has increased** 400-600%, and there is a fluctuating, though smaller, increase in nitrate and chloride contents as well. In those caves and on those dripstones where dripstone recorrosion is especially significant, the sulphate content of the karst water is even greater than the average. Therefore the new dripstone degradation can occur in connection with the significantly increased sulphate content of recent karstwaters, or it can be caused indirectly by one of the reasons that also induce this increase.

33# As in the composition and microbiological relations we can document the trends of change in connection of the acid settlings of the atmosphere (for example the decrease of the pH values of the soils by one grade), it seems confirmed that the modifications of the chemical characteristics of the karst water have a kind of (likely indirect) relationship with the trends of physicochemical changes of the karst soils and the present day distortions the ecological systems of the microorganisms of the soil. Therefore the new dripstone degradation syndrome basically indicates **the impact of acid rains and deposition** in the deeper karst horizons **in a complex system of a chain of impacts.**

34# I consider the scientific arguments and evidence detailed in 6-33 to be sufficient for the acceptance of the statements of the 4th and 5th theses, namely, that the **karst is a land ecological system with very complex functioning**, which comprises correlated and interdependent delicate balances. The karst as land ecological system is defined by the **combination of the interactions** of petrographical, tectonical, climatic, hydrographical factors and macro- and microregional chemical, physical and biological factors and these are greatly variable in themselves as well, both in time and space. Because of these reasons, the karsts are perhaps the most sensitive land types with regard to the anthropogenic impact.

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