FACTORS RESPONSIBLE FOR THE EFFECTIVENESS OF CERTAIN KARST CAVES IN RESPIRATION THERAPY

L. JAKUCS

Since the first observation and publication of the alleviation of certain respirator diseases in the Béke Cave (1), a vast quantity of subjective and scientifically objectiv experimental evidence has accumulated on the therapeutic effects of the atmospher in some Hungarian caves. Similar experience has been acquired in a number of cave abroad (2) and, just as in Hungary but initially quite independently of one another in numerous points of Europe successful attempts have been made with the systematic speleotherapeutic treatment of certain bronchitic and asthmatic diseases (3).

However, the nature of this matter meant that attention was drawn to the curative action of the atmosphere in caves not by specialist physicians or the professional leaders in public health, but by speleologists (considered laymen from a medical aspect) and by the very subjective reports of patients whose conditions had improved in caves. Accordingly, the official position of public health for a rather long time remained non-committal. Another circumstance contributing to this attitude was the fact that, although a number of part-factors could be conceived, giving rise to the observed speleotherapeutic effect by joint action, in fact it did not prove possible to detect fundamental differences between the physical, chemical, bacteriological, climatological, etc. parameters in effective and ineffective caves, and thereby to give a general interpretation of the causes of the improvement (4). Further, if it is also considered that a large proportion of caves are ineffective, despite the lay efforts to alleviate symptoms in these caves too, it is very easy to understand the attitude of scepticism which long hampered the introduction of speleotherapy.

It is all the more encouraging, therefore, that from the very beginning there were brave physicians (5) and later health service, mining and trade union institutions in Hungary (6) who undertook to carry out the scientific experimental control of the questions that had been raised. It is due only to them that a rapid increase was soon seen in the number of medically confirmed cases in which there was a surprising degree of improvement, or even the disappearance of the symptoms in numerous instances. This finally broke the ice of official aloofness, and within twenty years speleotherapy had attained a scientific rank and official recognition, as demonstrated among others by this international symposium. Merely as an aside, it may be noted that the time is ripe for this official recognition to be more adequately reflected in official budgeting and investments.

It may now be stated, therefore, that we have succeeded in overcoming the primary difficulty; the simple fact of the therapeutic effect of certain caves, the extent of this action, and the efficiency of climatic therapeutic treatment in underground areas have now been convincingly demonstrated by a mass of correctly documented scientific evidence relating to a large number of patients.

This is a very fine result, but unfortunately it is not yet enough. The successful completion of the stage of documentation and confirmation of speleotherapy by no means denotes the satisfactory clarification of all of the problems of speleotherapy. Further steps must be taken towards the *discovery of the active factors*. From a comparison of my own research results from a period of some 30 years with the huge mass of excellently processed Hungarian and foreign observations, in part reflected by the speleotherapeutic patient-statistics (7), in part the exact experimental data of speleo-climatologists (8) and public health workers, it appears to me that the time has come to put forward *a theory concerning the causes and mechanism of action of climatic therapy in caves.*

First of all, I should like to state that in this lecture I do not intend to deal with cavity systems in which the temperature differs appreciably from the mean annual temperature of the region, or in which hot springs of hydrotherms rise. Though the mechanisms of action (essentially balneological) of these cavities means that they can at times be classified as therapeutic caves (Monsummano, Görömbölytapolca, etc.). their study does not bring us closer to an understanding of the main therapeutic factors involved in the low-temperature (now virtually classical) "asthma caves", which necessitate quite particular research aspects.

From similar considerations, I do not wish to deal here with those rock-salt chambers which have been fitted out for purposes of underground climatic therapeutic cures in the depths of certain salt mines. I think that a satisfactory explanation can be given for these in terms of the extremely high concentrations of Na^+ and Cl^- ions, or of fine rock-salt powder, in their atmospheres: we may also speak of a fairly special active factor (9).

The situation seems much more puzzling in the cold karst caves in limestone hills. Really favourable experience by patients with bronchitis and asthma has emerged from only a small proportion of these. In the large majority of them, in spite of the apparently identical parameters, there are no, or barely any positive findings indicative of therapeutic success.

To illustrate this, the following Table lists certain cold "asthma caves" which have proved highly effective (group I), and other karst caves where no such effect was observed (group II).

The listed systems of the caves in both groups are well known. Careful measurements have been made of their speleoclimatological conditions, and their temperature, humidity, atmospheric composition, biological, bacteriological, hydrological, pedological, petrological, physical, electrical and various chemical parameters. The interesting finding emerges that, if these parameters are compared for the individual caves, there are no significant features characteristic only of caves of group I, or only of caves of group II. Although various differences are to be observed between the karst caves as concerns the values of some of these parameters (excellent examples are tabulated in the valuable speleoclimatological book by *István Fodor* (10)), no specific group characteristics have yet been identified. Accordingly, this contradictory fact means that we are in a very difficult position if we are to make a correct assessment of the mechanism of action of the climate in these therapeutic caves, i.e. the *therapeutic factors.*

Table 1

Group I (karst caves with a therapeutic effect)	Group II (karst caves with no therapeutic effect)
Békebarlang (Peace Cave) (Aggtelek—Jósvafő, Hungary)	Baradla Cave (Aggtelek—Jósvafő, Hungary)
Klutert—Höhle (Ennepetal, DDR)	Dachstein Mammoth Cave (Austria)
Tavas (Kórház) barlang (Lake, or Hospital Cave) (Tapolca, Hungary)	Kecskelyuk-barlang (Bükk Hills, Hungary)
Gombaszög Cave (Czechoslovakia)	Punkva Cave (Czechoslovakia)
Abaliget Cave (Mecsek Hills, Hungary)	Postojna Cave (Yugoslavia)
	Höllöch (Switzerland)
	Skocijanska-jama (Yugoslavia)

Table 2

SPELEOTHERAPEUTIC FACTORS AND THEIR MECHANISM OF ACTION (L. JAKUCS)

Active factor	Mode of action
Freedom of cave atmosphere from dust, toxic agents, stimulants and other allergens	Exclusion of excitation
Bacterial and viral sterility of cave atmosphere	Exclusion of possibility of reinfection
Possible antibiotic production by mould fungi	Possibility of antibiotic effect
Elevated CO_2 content of cave air	Enhancing of breathing depth,
Coolness of subterranean environment, at around 10 °C	acceleration of metabolic processes
The dissolved ions of the continuously reproduced aerosol	Spasmolytic, anti-inflammatory, mucolytic and antiseptic effect
No temperature variations	Elimination of stress effects,
No appreciable cave air currents (wind)	soothing of the organism,
No rapid atmospheric fronts; no electric or barometric changes	neuroendocrine regulation,
Increased radon content (α-radiation) of karst caves, poorness in surface radiation, Faraday chamber effect	restoration of biological rhythm,
Psychological effects of restricted movement, unusual environment, quiet, absence of strong light, etc.	equilibration of neural tonicity of vegetative nervous system

It is widely known that the majority of authors both in Hungary and abroad consider that the therapeutic effect of asthma caves is due to the manifestation of a number of factors in a complex manner, these factors favourably strengthening one another. Table 2 summarizes the currently generally accepted main active factors.

However, my investigations suggest that the 12 factors listed in the Table must be treated rather carefully, and only with some reservations. The reason is that the vast majority of these factors are *factors generally observed* in all cold karst caves, and hence it is improbable that they play a significant role among the active factors in caves with striking therapeutic effects.

Thus, a freedom from allergens must be considered with caution; it is a proved fact that in all large cave systems with kilometres of passages, the atmosphere is practically dust-free, particularly in the inner halls and passageways far from the entrance openings. That is, under natural conditions toxic or other allergenic particles (pollen, soot, rock powder, etc.) scarcely occur in them. Only one or two quite extreme cases of exceptions to this rule are known, for example if a smoke-generating substance is ignited in a cave, if photographs are taken with the use of magnesium powder, or if some concentrated sewage or chemical is discharged into a stream flowing through the cave. The freedom of the atmosphere from allergens is temporarily lost in the passageways of cave systems visited by crowds of tourists, but these well-defined inducing circumstances can be methodically eliminated from the caves, and by this means the cave atmosphere recovers its original features in an autoregulatory manner within a short time.

The *bacterial-viral sterility* of cave air is likewise a general property of large underground cavity systems. This is correlated with the fact that the conditions for the multiplication, movement and metabolism of pathogens inducing the customary infectious diseases on the surface are not present in the subterranean aphetic and inorganic environment. From the aspect of the atmospheric conditions, caves are completely abiotic.

Naturally, this does not mean that bacteria do not live in these caves. A very high number of types of special bacteria (e.g. manganese bacteria, sulphur bacteria, etc.) are native to these dark subsurface rock chambers; however, these are all non-pathogenic microorganisms that are indifferent as concerns the human organism.

Particularly in the interior of the Béke Cave and the Baradla system at Aggtelek–Jósvafő, very careful studies have been made by mycologists and pharmacologists (11) on the *troglobione fungi mould species and their ability to produce antibiotics.* In collaboration with the Biogal Pharmaceutical Works, the Medical University at Debrecen has discovered previously unknown species among the moulds native to the Béke Cave; these new species are simultaneously Gram-positive and Gram-negative, and produce antibiotics with new effects. (These species have been utilized in the production of the drug Grubilin, named after the great Hungarian expert on fungi, Dávid Gruby.)

In spite of all this, however, it appears probable that the significance of cave moulds as active factors were initially somewhat overestimated. Under natural in vivo conditions, the number of spores entering the cave air space has been shown experimentally to be much too low to exert an appreciable antibiotic effect in the human organism. Further, it has not even been demonstrated that the spores themselves can mediate antibiotic.

The elevated *CO_2 content* and the uniformly *cool temperature* of the cave air must also be treated with some reservation. The temperature in karst caves is cool everywhere (especially in the temperature zones), and generally corresponds to the mean temperature of the surface of the rock-mass through which the cave network runs.

A high CO_2 content regularly develops in the air of the deep cavities in all karst caves where dripstones are deposited, i.e. where calcium carbonate separates out in solid form from calcium hydrogencarbonate solutions. It is now known exactly that the degree of CO_2 saturation of cave air expresses some direct interaction function of the lime-deposition dynamism and energy turnover (rate of air exchange) in the cave. The CO_2 concentration is particularly high in caves of karsts covered by vegetation, and hence by a bioactive surface soil layer; this is especially the case in summer and autumn, when the more highly saturated hydrogencarbonate solutions seep down to the depths of the cave. If the air exchange in the cave is impeded, the enhancement of the gas concentration can become unhealthy, and even fatal for man. Such critical gas levels are also known in Hungary, mainly in poorly ventilated well-caves, etc.

There is no such CO_2 enrichment in the caves of karsts with bare rock surfaces or those covered by ice. It is understandable that such caves are correspondingly poorer in dripstone formations.

With the exception of the Mammoth Cave in Austria, the air in the caves of the two groups illustrated in Table 1 has been shown everywhere to have a CO_2 content higher by a factor of 2—3 than that of the surface atmosphere. It must be stressed that this is true everywhere, i.e. in both the therapeutically effective and the ineffective caves. It seems probable, therefore, that the CO_2 level is not an important therapeutic component.

Similarly, various other parameters can not be regarded as individual ones either. These include the *uniform temperature*, the *absence of wind*, the *absence of electric storms*, the *absence of atmospheric barometric fronts*, the *higher radon content* (*α-radiation*), the *high humidity*, the *Faraday-chamber effect*, the *unusual environment*, the *absence of strong light* and the *silence*, for these effects are similar, both qualitatively and quantitatively, in effective and ineffective caves.

Naturally, I have considered all the consequences of treating the generally accepted causes of the therapeutic effects of cave climates with such overall reservation. In a search for the scientific truth, however, the consequences must be accepted: a true stimulus for further inquiry into unsolved questions can only be given if it is first admitted that these questions really are still unsolved.

The results of my investigations in the second half of the 1950-s led me to look for the most important active factors of therapeutic caves in the composition properties of the aerosol, mentioned in Table 2.

In a publication in January 1959 (12), I dealt with this question and reported numerical data: the water condensate obtained from the air space in the various Hungarian caves exhibits very great differences in chemical composition. For example, *condensation water obtained from the Béke Cave (demonstrated to have a therapeutic effect) generally contained about 10 times more Ca^{2+} ion than analogous samples collected from the Baradla Cave; the HCO_3^- content was also higher in the condensation water from the Béke Cave.* The other anions and cations likewise displayed differences in concentration, but the levels and proportions of these in the condensation water were essentially lower. To illustrate the results, Table 3 presents some chemical characteristics of condensation water samples analysed at the end of 1957 and the beginning of 1958.

H. Cauer (13) reported similarly interesting analytical data relating to the Klutert Cave at Ennepetal, and also put forward the view that the primary condition for the curative effect there was the high ionized calcium content of the aerosol.

Since the initial steps in the 1950-s, the composition of the air moisture has been examined in numerous other caves. The results confirmed a *direct correlation between the therapeutic efficiency of the climatic treatment and the calcium content of the condensation water obtained from the cave air.* It may now be regarded as certain that *the high soluble calcium content of the air in therapeutically important caves plays a deciding role in influencing the state of speleotherapeutically treated pulmonary diseases.* It may be presumed that these ionized calcium solutions come into direct contact

Table 3

QUANTITATIVE DATA ON SOME CHARACTERISTIC CHEMICAL COMPONENTS OF CONDENSATION WATER OBTAINED FROM CAVE AIR (L. JAKUCS)

Cave site	Sampling date	Ca^{2+} mg/l	Mg^{2+} mg/l	HCO_3^- mg/l	Cl^- mg/l
Baradla	8—9 Dec. 57	6.4	3.0	27.4	0.6
„Óriások-terme"	28 Dec. 57	8.5	3.1	35.0	0.2
	7 Jan. 58	13.6	2.8	51.0	0.4
	25 Jan. 58	10.9	3.0	42.0	0.4
Béke Cave	25 Dec. 57	86.8	0.9	197.3	2.7
„Nagy-tufagát"	28 Dec. 57	84.2	0.7	186.0	3.5
	9 Jan. 58	98.6	0.9	205.5	2.1
	27 Jan. 58	73.8	—	155.0	2.0

with the mucous membranes and with the capillary network of the bronchi, then exerting their spasmolytic, anti-inflammatory, mucolytic and antiseptic effects. Of course, it is highly probable that other of the active factors listed in Table 2 also play a part in the therapeutic action, in addition to the *aerosol factor*. The overall effect is thus a complex one. However, I believe that if the aerosol factor is absent, then the overall effect will be too weak to explain satisfactorily the striking results on patients.

From the very beginning, the characteristic quantitative and chemical qualitative differences concerning the humidity of cave air impelled me to make a deeper study of the *conditions under which the chemical composition of the condensation water obtained from some cave will be essentially more concentrated than that from other caves.* It became my conviction that this fundamentally speleogenetic or speleoclimatological problem might prove the key question to the whole speleotherapeutic theory.

It would be possible for me to present a huge mass of research documentation here, illustrating how I was able to make progress on this topic. Following my first publication on this subject, I made measurements and collected data in caves not only in Hungary, but also in Yugoslavia, Czechoslovakia, Austria, Switzerland, the Soviet Union, Cuba and Germany. I was able to utilize a large number of valuable data from the results of other researchers (14), and to compare these with my own results. Here, however, I must be satisfied with a brief survey of the consequences of this research, put forward in propositions.

Propositions

1. The moisture to be found in the air of caves originates partly from the surface, and partly from under ground. Surface moisture enters caves through the entrance openings and through cracks in the rocks. Depending on the temperature and saturation conditions in the cave, the humidity either remains as an invisible constituent of the atmosphere, or it condenses. In small caves, or in the sections of branched large cave systems close to the entrance or with a dynamic air flow, this "exogenous" hu-

midity may at times be characteristic. In the interior of truly extensive cave systems, however, it must be regarded merely as a subordinate modulating factor which does not play a determining role in the humidity content of the overall system. For this reason, in an interpretation of the therapeutic value of humidity phenomena within caves it is practically sufficient to concentrate on the humidity originating in situ in the cave.

2. The cave air moisture content produced under the surface may be comprised genetically of two components: the *evaporation component* (*α component*), due to evaporation from free water surfaces, and the *spray component* (*β component*), due to the mechanical "atomization" of water dripping from some height or flowing in some water-fall.

3. The α component of air moisture in caves is essentially homogeneously distributed humidity consisting of water particles of molecular dimensions, which, similarly to the vapour from distilled water, does not contain any other chemical substance. In contrast, the β component consists of mechanically diminuted water droplets of microscopic magnitude; these droplets are comprised of karst solutions with the same compositions and concentrations as those of the cave water from which they are formed.

4. Since the symptoms of bronchitis and asthma are presumably influenced strongly by the chemical substances and ions present in the aerosol inhaled with the air, *the degree of effectivity of the air in a cave from the aspect of therapy will be determined by the proportion of the β component in the air moisture, and by its chemical characteristics.* Those caves in which the endogenous air moisture originates predominantly from evaporation, i.e. the α component is in excess in them, do not exhibit therapeutic effectiveness, independently of the relative humidity level. In contrast, *the degree of therapeutic efficiency undergoes an enhancement directly proportional to the increase in quantity of the β component in the air moisture, and also to the degree of calcium hydrogencarbonate (and possibly chloride) saturation of the β component.*

5. In all closed natural subterranean cavities, regardless of what regulatory factors are involved, the α component of the air moisture will sooner or later itself give rise to a relative humidity of 100%. The state of moisture saturation naturally becomes an obstacle to further evaporation from the water surfaces in the cave; however, this circumstance has no influence whatsoever on the entry of additional β component moisture into the air space. Thus, the seemingly absurd condition may easily arise when much more condensation water can be obtained from the air in the cave than the humidity necessary for a relative content of 100%. This proves the agressive enrichment of the mechanically produced cave spray under all conditions (12).

6. In connection with proposition 5, however, it must be mentioned that the quantitative participation of the β component in the cave air moisture is in my experience always much higher than expressed by the level of humidity. In the vast majority of the cases, even in cave air which does not attain absolute humidity saturation, a very considerable proportion of the cave air moisture originates from the β component. My measurements show that in caves where the air is not saturated with water vapour, the β component itself plays an important role in the increase of the relative humidity: the water droplets in the air evaporate apart (they are converted to the α component), while the diameter of the spray particles becomes ever smaller, while the chemical composition of the water remaining in spray form grows increasingly more concentrated.

7. It is a demonstrable fact that, *because of the enormous possibilities for surface gas diffusion for cave spray particles generally consisting of supersaturated calcium hydrogencarbonate solution, the CO_2 passes out as gas into the air space from the spray at an enhanced rate. This has the result that the atmospheric moisture becomes supersatured in the β component, and solid crystal seeds of calcium carbonate some millimicrons (at most a micron) in size may appear in the air space. These are subsequently capable of extremely rapid growth, and they adhere to certain formation vertices, thereby giving rise to an extreme form of dripstone growth.*

8. In cave systems possessing the possibility of air exchange, the cave somewhere constantly loses part of its air of high relative humidity, and acquires surface air from outside in its place. However, the external air generally differs in temperature and moisture content from the air in the cave. Thus, such air exchange must cause either the drying of the air in the cave, or the elevation of the moisture content. A *tendency to drying* is characteristic in the colder half of the year, whereas a *tendency for the humidity to rise* is typical for the warmer half of the year in larger cave systems. As far as the speleotherapeutic consequences are concerned, however, both tendencies have very *deleterious* effects overall. When cold air from outside warms up in a cave, the water vapour content of the cave air falls considerably, which leads to the conversion of the therapeutically valuable β component to the indifferent α component, with a decrease in the quantity of the former. When warm air enters from outside, it too has a harmful effect: on cooling down, it generally causes an excess of the α component in the cave air, thereby worsening (diluting) the natural moisture composition in the cave air. On this basis, therefore, it can be stated as a rule that *in caves with free air exchange (even in the case of the continuous reproduction of the β component), the conditions of development and prolonged existence of the concentrated aerosol effect necessary for therapy are absent.*

9. My investigations demonstrate that the ionic concentration conditions of cave aerosols vary fairly considerably from place to place and from time to time within all karst cave systems. Consequently, the extent of the therapeutic effect attributable to the aerosol factor is a proporitonal reflection of these changes. The alterations may be so great that even the most effective known therapeutic caves can (in certain sections or in certain periods) exhibit a *decrease of the therapeutic value,* even to the level of ineffectiveness. The evidence provided by the experience of the patients in this respect is amply contained by the carefully medically controlled documentation from the Béke Cave and other caves used for therapy.

10. Definite correlations can be recognized between the therapeutic efficiency of caves (discussed in proposition 9) and the variable dynamism of some natural factors influencing the quantitative and qualitative value of the β component of the air moisture in the caves. The main confirmed correlations are compiled in Table 4.

11. It is a very important circumstance that the effects in Table 4 include some which are permanent and constant within a given cave. These are the *invariant active factors.* Examples of such factors determining the quantity of the β component are the *cave height factor,* or the *fall curve of the cave water flow.* In connection with the latter, it should be noted that the quantity of the β component originating from the cave stream may also be modified by the considerable *variations in water yield* of the stream. In periods of high flooding, for instance, there are increases not only in the amount of water transported and in the flow rate, but also in the quantity of karst spray formed. However, this does not have much practical significance from a

Table 4

SURVEY OF THE QUANTITATIVE AND QUALITATIVE NATURAL ACTIVE FACTORS REGULATING THE AMOUNT OF THE β COMPONENT IN THE MOISTURE IN CAVE AIR (L. JAKUCS)

I Factors causing an increase in the amount of the β component	II Factors causing a fall in the amount of the component	III Factors causing an enhancement of the ionic concentration of the β component	IV Factors causing a fall in the ionic concentration of the β component
a) Increase in precipitation proportion constantly seeping in (increase in drip density)	a) Decrease in precipitation proportion constantly seeping in (increase in drip density)	a) Increasing virulence of plant cover on karst surface	a) Decrease or total loss of vegetation on karst surface
b) Large number of high cave chambers and passages (relatively high drip height)	b) Lack of high cave chambers and passages (relatively low drip height)	b) High biological activity of karst soils (mass multiplication of soil bacteria and soil fungi)	b) Low (e.g. winter) biological activity (lack of functions of soil bacteria and soil fungi)
c) Many waterfalls and water-races in cave stream (bed curve with high and nonuniform fall)	c) Lack of waterfalls and water-races in the cave (bed curve with low and uniform fall)	c) Optimum rock quality (chemical) and seepage (physical) conditions for development of high dissolved calcium concentration	c) Increasing denudation of surface and degradation of soil
d) Inhibition of air exchange (energy turnover) in cave	d) Enhanced degree of air exchange (energy turnover) in cave	d) Lowest possible CO_2 partial pressure in cave air	d) Unfavourable (poorly soluble) rock material and inhibited or too fast seepage conditions
e) High relative humidity (optimum value $> 99\%$)	e) Decreasing or low relative humidity ($< 96\%$)	e) Guarantee of possibility of slow conversion into the α component (relative humidity 96—99.9%)	e) Periodic development of conditions of moisture condensation

therapeutic aspect: appreciable cave floods occur rarely in active karst caves, and at the time of flooding the climatic therapy must be discontinued for safety reasons.

Other invariant factors include the *degree of denudation of the karst* or the *nature of the rock* in a given system, and also the *stratification and fissuring properties* determining the seepage, for these lead to the *cave-specific characterization* of the chemical composition and ionic concentration of the β component.

12. It is clear that assessment of the invariant factors is primarily of importance in a comparative study of the factors in the various caves. However, the situation is quite different for the factors that vary in quantity or quality even within a given cave, i.e. the *variable spray-determining factors.* These include the systematic changes in *drip density,* modifications in the *dynamism (energy turnover) of air exchange* in the cave, the characteristic differences in the *degree of relative humidity,* and the periodicity in the *bioactivity level* of the surface vegetation cover and the soil microorganisms in the various seasons. It is essentially due to the variable factors that the therapeutic effectiveness of caves changes so sensitively from time to time. For example, the chambers used for therapy in the Béke Cave at Jósvafő completely lose their effectivity in the cold half of the year. When the external air temperature falls to below +10 °C for a prolonged period, an *inflowing air current system* develops at the Jósvafő end of the cave, radically deteriorating the effect of the β component of the air moisture in a section several hundred metres long. At the same time, it is striking that the level of therapeutic effectiveness of the Béke Cave remains, or is even *enhanced,* in the sections reached from the Szomorhegy main entrance. In winter, the air movement here tends to be from the interior of the cave towards the outside.

Naturally, any free opening or other air-exchange possibility is unfavourable for the β component of the aerosol in therapeutic caves, for they decrease the high relative humidity of the system and thereby spoil the favourable background conditions for aerosol reproduction.

13. In my view, the main reasons why the Baradla Cave has no therapeutic effect are as follows:

a) The Baradla possesses a number of entrance openings ensuring air exchange.

b) The karst surface above the Baradla is barer than that above the Béke Cave.

c) There is relatively little open water surface in the Baradla, and accordingly the optimally high values of relative humidity can develop only rarely.

d) The large numbers of tourists regularly visiting the Baradla cause a temperature increase and therefore a drying effect (the lamps too are responsible for this), while they also pollute the air in the cave.

14. It follows quite clearly from porpositions 1—13 that *all caves with therapeutic climates could lose their effectiveness in response to incorrect treatment.* The greatest error in this respect would be the construction of entrances and other openings suitable for air exchange, or the ventilation of the cave. Of course, the opposite too is true: *the therapeutic effectiveness of all caves can be enhanced* if draughts are eliminated with a system of lock-like doors, and the possibilities of air exchange are reduced to the minimum.

The propositions likewise demonstrate that the therapeutic effective of a cave atmosphere can also be elevated if the dense vegetation is regenerated on the denuded surfaces of the karst hills enclosing the cave, and mainly if a forest cover with undergouth is provided, in the rhizosphere of which a population of soil bacteria and soil fungi with high and lasting virulence can develop (e.g. oaks). The exchange of the forest vegetation that is natural to the area above a therapeutic cave with new tree species (e.g. pines) may have dangerous consequences, however, from the aspect of the therapeutic effectiveness. Even today, we do not know exactly the ecological conditions in the soil and vegetation that give rise to the effects observed by the patients.

15. In view of the discussed research results, I consider that *in all those extensive karst caves in which the conditions in columns* 1 *and* 3 *of Table* 4 *are ensured at an optimum level, the therapeutic effectiveness will automatically be good.* It appears to me that, of all the cave systems I know in Europe, it is in the recently discovered *Krasna-Horka dripstone cave* in the vicinity of Rozhnyo in Czechoslovakia that these optimum conditions are given most satisfactorily. As far as I am aware, no therapeutic experiments have yet been conducted there, and I therefore have no empirical medical arguments to support me. Nevertheless, on the logical basis of the generality of the research results I should like to take this public opportunity to forecast that this cave should prove a highly effective therapeutic cave. It would be interesting if our colleagues from Slovakia could carry out appropriate trials with patients under medical guidance in *the are of the Giant Dripstone* in the Krasna-Horka system, not only to prove or disprove the correctness of my conclusions, but also because there are so many patients in need of therapy.

NOTES

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4. In this connection, see the well-known studies by *Cauer* (1954), *Spannagel* (1961), *Ágoston—Biró—Hajós—Kirchknopf—Vadász* (1968), *Páter—Pintér—Somogyi—Timár—Tóth—Fodor* (1974) and *Kessler—Mórik—Morlin—Várkonyi* (1973), and the book by Fodor I. on the climatological and bioclimatological features of caves (1981).
5. *Dr. Ferenc Nagy*, director of Edelény Hospital (Miskolc), Prof. *Dániel Oláh* (Debrecen Medical University), *Prof. Tibor Vályi* Nagy (Debrecen Medical University), Dr. *József Uri* (Debrecen Medical University), Dr. *Márton Kirchknopf* (Ózd), Dr. *Zsigmond Biró* (Miskolc), *Prof. Károly Hajós* (Budapest), Dr. *János Páter* (Pécs), Dr. *Tibor Horváth* (Tapolca), and many others.
6. The initiators were: Debrecen Medical University, Biogal Pharmaceutical Works, Debrecen, BAZ County Public Health Station, ORFI Budapest, Ózd Municipal Hospital, Borsod Coal—Mining Trust, Health Division of BAZ County Council, Health Division of Baranya County Council, Tapolca Municipal Hospital, etc.

7. Besides the source-works listed in the above notes, see the following:
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8. The authors of the most important Hungarian speleoclimatological studies relating to this subject: *Dénes Balázs, Dénes Berényi, Béla Béll, Endre Dudich, István Fodor, István Kérdő, Menyhért Kéri László Kordos, László Markó, Gyula Szabó,* and many others.
9. Pálffy—Veres—Horváth—Berecz—Pálffy: Die Verfolgung des Krankheitsverlaufes ein Jahr vor und nach der unterirdischen Kur im Salzbergwerk von Praid (S. R. Rumänien) durch die tägliche Aufzeichung der Krankheitssymptome und des Arzneimittelbedarfes. Symp. für Höhlentherapie und Höhlenmedizine 1976 in Horny Hradok. Lipt. Mikulás, 1978, pp. 87—88.
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11. Primarily Dr. *Dániel Oláh,* Dr. *Tibor Vályi Nagy* and Dr. *József Uri.*
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