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INTENSITY OF KARSTIFICATION OF LIMESTONE IN THE ZONE OF THE VERTICAL CIRCULATION IN THE MILD CLIMATE OF CENTRAL EUROPE

Intenzita krasovění vápenců v zóně vertikální cirkulace ve středoevropském mírném klimatu na příkladu Moravského krasu. — Předložená práce přináší základní údaje o intenzitě rozpouštění vápenců v zóně vertikální cirkulace v současných klimatických podmínkách. Zkoumány byly vody skapávající s krápníků v jeskyních Punkevních a Sloupsko-šošůvských, tj. srážkové vody, které dopadají na krasovou plošinu, prosakují tenkou vrstvou humusu, pokryvných útvarů a vápencovým masívem, a bezprostředně se podílejí na rozšiřování puklin, na vzniku jeskyní, propastí a komínů v zóně vertikální cirkulace (změny v chemickém složení skapávajících vod v průběhu jednotlivých ročních období jsou znázorněny na přilehlých grafech).

Množství odnášeného vápence činí za období od května 1960 do dubna 1961 v jeskyních Punkevních 0,004 08 m^3, v jeskyních Sloupsko-šošůvských 0,000 39 m^3. Získané hodnoty jsou extrémně vysoké uvážíme-li, že prosakující vody mají minimální plochu povodí a mocnost vápencového masívu jímž procházejí měří 150 a 50 m. Získané hodnoty odpovídají nejvyšším hodnotám odnosu v zoně horizontální cirkulace na zemi, uváděným v literatuře. Ukazují na intenzívní rozčleňování vápencového masívu ve svislém směru v současné době.

The karst searchers turn their attention at present time more and more from the study of the individual karst phenomena or of whole areas to the study of the processes passing on limestones. This change in the orientation of the karst research is influenced by the development of the karst geomorphology, which emphasizes more and more the share of the climate in the origin of the karst relief. The change in opinions of the main factor in the karst processes must necessarily carry with it also an other view of the genesis of many karst forms and of whole areas. The geomorphologic classification of the karst areas elaborated by A. Penck (1924), J. Cvijić (1893), A. Grund (1914), Emm. de Martone (1948), W. M. Davis (1930) and others, based on the opinion, that all the karst forms develop successively, in a cycle, the end stage of which are large plains, does not agree with the knowledge acquired recently. The searchers are therefore trying to improve the older classifications, resp. to substitute for them a new one, the base of which would be formed by the groups of the karst forms characteristic for areas with a certain type of climate. For the compilation of such a classification a series of data is missing up to this time, especially the reliable data about the intensity of the dissolution of limestones in different climatic zones. As far as such data are given, they are

usually concerning areas, the climate of which is assumed not to have changed substantially during Tertiary and Quaternary. These are the zones, where the karst forms developed by the activity of predominantly one of the factors forming the relief. But a proportionately small attention is paid to the karst areas, where substantial climatic changes took part during the Younger Tertiary and Quaternary and in consequence of it even several kinds of the modelling of the karst forms by different factors forming the relief occurred. First of all the areas with a mild humid climate, which include even the Moravian Karst, belong to these zones.

This study gives the basic data of the intensity of the dissolution of limestones in the zone of the vertical circulation, which enable to establish the velocity of the karst processes on present climatic conditions. The basis for this work was acquired by long range investigations carried out in equal intervals during 14 months (March 1960—April 1961) in the north part of the Moravian Karst. The water dropping down the dripstones, i.e. precipitation water falling on the karst plain, soaking through the thin humus bed and the sheet forms and having an immediate share in the opening of the fissures, in the origin of the caves, of the light holes and chimneys in the zone of the vertical circulation is of decisive importance for the origin of the dripstones too. The research showed the chemical composition of the soaking water and its changes during the individual seasons.

The mode and the conditions of the water sampling

The waters soaking through the limestone massif and dropping down the dripstones into the underground hollows were caught on two places — in the Punkva caves in the part called Zadní dóm and in the Sloup-Šošůvka caves in the Eliška-cave and later (from September 1960), after the interruption of the circulatory ways in the corridor called "U řezaného kamene". In both cases large systems of caves and corridors are concerned here. The caves of Sloup and Šošůvka have developed in the east steep slope of the half-blind valley of Sloup, about 50 m below the surface of the relief. The upperst dry cave level is formed by them today. The entrance into the cave is in the height of about 465 m above sea level. The Eliška-cave is found near the way in the labyrinth of Sloup-Šošůvka and it belongs to the largest caves in the Moravian Karst. Its height reaches 18 m, its length 40 m and its width 30 m. On NE the bottom of the cave is covered by thick debris of the collapsed ceiling. The water samples were caught from the big stalactite in the NE part of the cave. The distance between the stalactite and the collecting vessel was about 5 m. After the interruption of the system of circulation the stand was transported

into the corridor "U řezaného kamene", founded on the bedding plane. The corridor is 2—4 m high and 2,5 m wide on average. In the place of the sampling the west wall of the corridor is enlarged in a small niche with little stalactites, from which the dropping down water was caught. The distance between the stalactite and the collecting bottle was 1,3 m.

The entrance in the Punkva caves can be found in the canyon-valley called Pustý Žleb, about 140 m below the surface of the extensive limestone plain, in the height of 355 m above sea level. The caves join the bottom of the canyon-valley with the bottom of the Macocha-chasm. They belong to the central cave level inundated from time to time by the underground karst streams. The Zadní dóm developed in 2/3 of the length of the caves and it occupies the highest positions of the dry caves of Punkva. Its maximum width is 10—15 m, its length is 40 m and its height 8—10 m. The dóm is tilted towards SE, in the direction to the Macocha-chasm. The water was caught in the central upperst part of the dóm, from a big stalactite. The distance between the stalactite and the collecting vessel was about 5 m.

The dropping waters were caught into special stoppered bottles of 1 litre, which were immediately after the filling transported to the laboratory for treating.

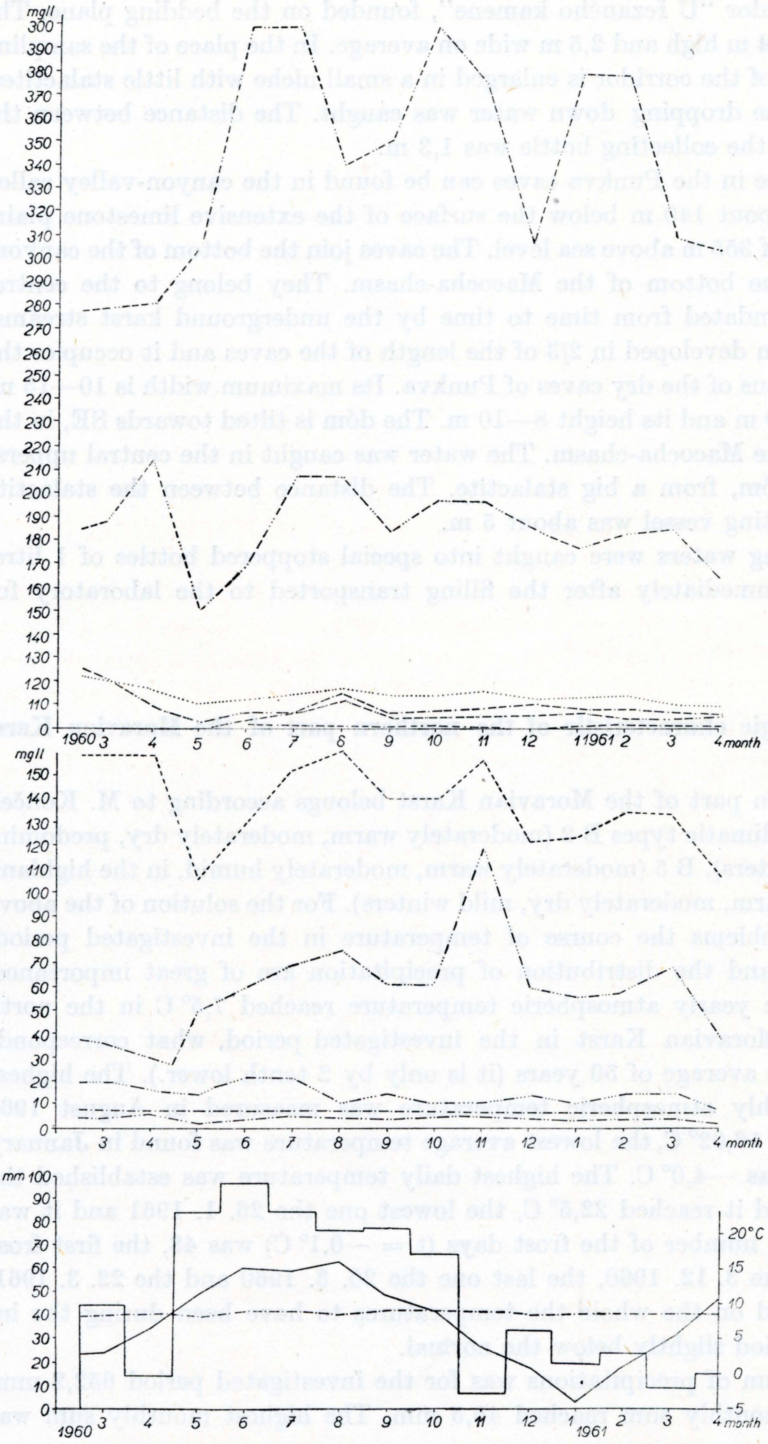
The climatologic characteristic of the northern part of the Moravian Karst

The northern part of the Moravian Karst belongs according to M. Konček (1958) to the climatic types B 2 (moderately warm, moderately dry, predominantly mild winters), B 5 (moderately warm, moderately humid, in the highland areas), A 3 (warm, moderately dry, mild winters). For the solution of the above mentioned problems the course of temperature in the investigated period, the quantity and the distribution of precipitation are of great importance.

The average yearly atmospheric temperature reached 7,5° C in the north part of the Moravian Karst in the investigated period, what corresponds roughly to the average of 50 years (it is only by 2 tenth lower.). The highest average monthly atmospheric temperature was measured in August 1960 and it reached 16,02° C, the lowest average temperature was found in January 1961 and it was —4,0° C. The highest daily temperature was established the 28. 8. 1960 and it reached 22,5° C, the lowest one the 26. 1. 1961 and it was —11,7° C. The number of the frost days (t = —0,1° C) was 48, the first frost was noticed the 3. 12. 1960, the last one the 20. 3. 1960 and the 22. 3. 1961. It may be said on the whole the temperatures to have been during the investigated period slightly below the normal.

The total sum of precipitations was for the investigated period 652,2 mm, the average monthly sum reached 46,5 mm. The highest monthly sum was

Fig. No.1


mg/l
13
12
11
10
9
8
1960
1961
month
mg/l
7
6
5
4
3
month
mm
20°C
2
1
1960
1961
month

measured in June 1960 by 96,1 mm, the lowest one in November 1960 by 68,00 mm. The greatest quantity of precipitations during one day occurred the 12. 5. 1960 and it reached 41,8 mm. The snowing lasted 43 days, the snow-cover kept up 59 days. The precipitations were not distributed equally during the investigated period. In the time from May to October 74,2% of all precipitations have fallen. The temperatures as well as the precipitations were slightly below the normal in the investigated period.

The chemical composition of the water dropping down the dripstones in the caves of Punkva and Sloup-Šošůvka

The waters dropping down the dripstones are pure, colourless, or with a slight light-grey mudding, they are smelless. The extraordinarily high contents of a series of elements shows the soaking of the precipitation water to be slow, what enables all the phases of the chemical solution to pass (Bögli 1960). The chemical composition of water as well as its changes during the individual seasons are drawn for the both investigated localities on the figures 1 and 2. It may be seen from the enclosed figures that the maximum removal of limestones occurs in the zone of the vertical circulation in summer, which lasts 6 months (May—October). This period is characterized by maximum temperatures and great precipitations. The precipitation water soaks through the humus bed, where it is enriched by the biogenic CO_2, so that it is strongly aggressive when reaching the limestone. In contradistinction to it in winter, when the upper humus bed is frozen through and covered by snow, the removal of limestone is substantially smaller. The water circulation passes below the frozen bed, the enrichment of the water with the biogenic CO_2 is substantially

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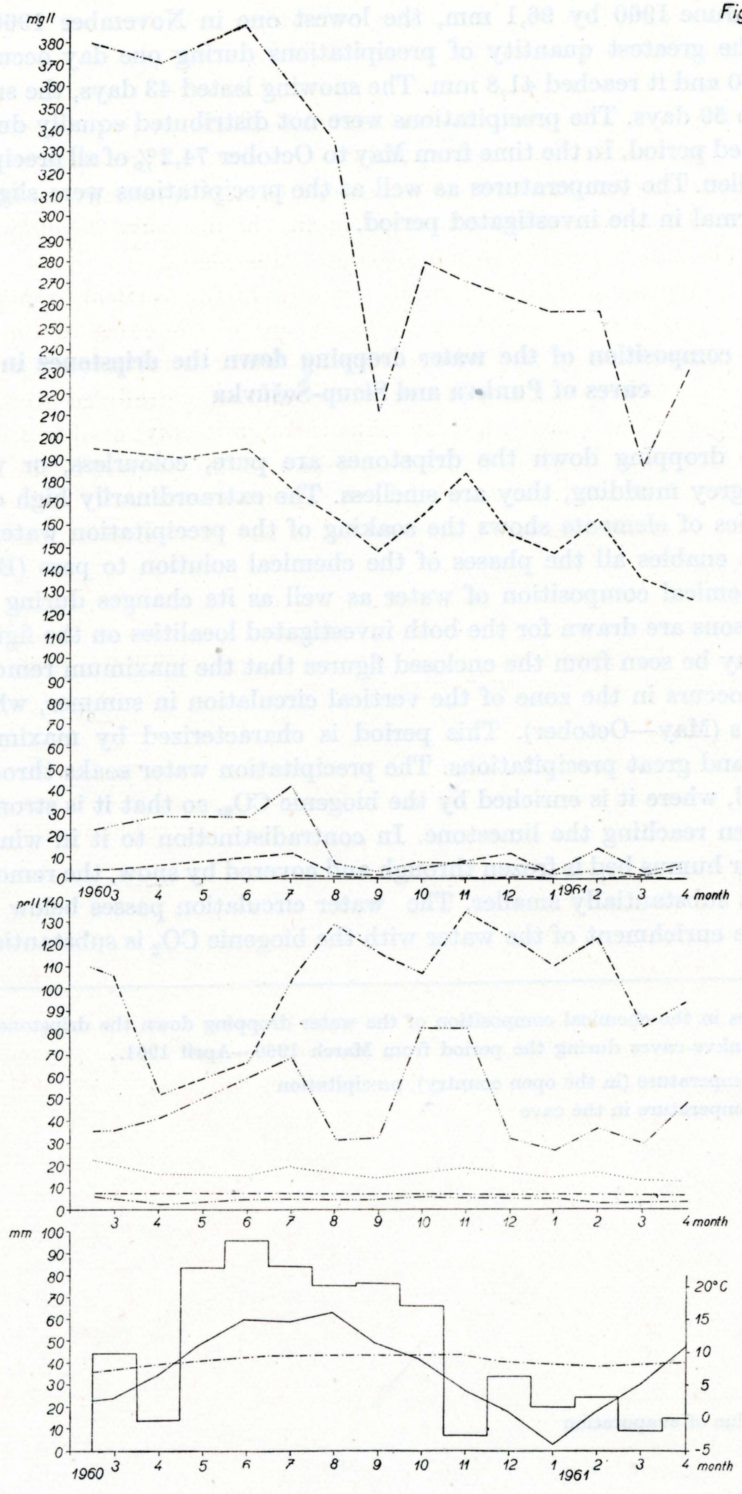
Fig. No. 1 Changes in the chemical composition of the water dropping down the dripstones in the Punkva-caves during the period from March 1960—April 1961.

1 atmospheric temperature (in the open country), precipitation
2 atmospheric temperature in the cave
3 alkalinity
4 pH
5 SO_4''
6 Cl
7 CaO
8 NO_3'
9 MgO
10 CO_2
11 total hardness
12 organic matter
13 calcinated residue of evaporation

Fig. No. 2


mg/l
12
11
10
9
8
1960 3 4 5 6 7 8 9 10 11 12 1 1961 2 3 4 month
mg/l
7
6
5
4
3
3 4 5 6 7 8 9 10 11 12 1 2 3 4 month
mm
20°C
2
1
1960 3 4 5 6 7 8 9 10 11 12 1 1961 2 3 4 month

smaller than in summer, so that the water comming to the limestone is less aggressive.

The transport of the calcium carbonate passes exclusively in the form of chemical solutions on ways, some of which developed already during previous geological periods. These ways are at present time intensively enlarged resp. restored. Due to this process the lapiés, chimneys and especially sinkholes were formed on the surface of the limestone plain, the intensive development of which changes substantially the microrelief of this plain.

The quantity of the removed limestone in the zone of the vertical circulation reached for the period from May 1960 to April 1961 in the caves of Punkva 0,00408 m^3, in those of Sloup-Šošůvka 0,00039 m^3. These values are extremely high, considering, that the soaking water has a minimum drainage area and that the thickness of the massif which it soaks through is only 50 upto 150 m. The acquired values correspond to the highest values of the removal in the zone of the horizontal circulation on Earth mentioned by J. Corbel (1959). They prove the intensive dissecting of the karst relief in the vertical direction.

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Fig. No. 2 Changes in the chemical composition of the water dropping down the dripstones in the caves of Sloup—Šošůvka during the period from March 1960—April 1961.

1 atmospheric temperature (in the open country), precipitations
2 atmospheric temperature in the cave
3 pH
4 alkalinity
5 SO:
6 CO:
7 total hardness
8 Cl
9 CaO
10 MgO
11 organic matter
12 calcinated residue of evaporation