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New morphometrical parameters for explanation of karst development

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As it is known, either because of the sparse water network of karst areas or part because of the difficulties in determining the order numbers and water course densities of the subsurface water systems in addition to other properities, we cannot examine the morphometric conditions of a karst region with the method developed by Horton and Strahler (Williams, P.W. 1975, La Valle, P. 1968). In our previous studies (Mezősi, G.-Bárány, I. 1978, Bárány I. - Mezősi G. 1979, Bárány-Kevei, I. 1990) the morphometrical investigations of the micro- and mesoforms eg. springs, swallow-holes, dolines, karren were examined in Aggtelek and in Bükk Mountains (N-Hungary). We proved that the swallowhole density can be given by the value $D^s = \Sigma S/A^a$, where ΣS is the number of swallow-holes and A^a is the size of the area examined. The decrease of the number of swallow- holes per unit area confirms the more developed nature of the area. In similar way we can also give the number of springs per unit area: $D^r = \Sigma K^r/A^a$, where ΣK^r is the number of springs. The quotient swallow-hole/spring ($R = \Sigma S/K^r$) indicates the magnitude of the extent of the subsurface flow. We have established the regularity in case the autogenic - A-type (Jakucs, L. 1971) karsts the value of R is less than 1; in the case of allogenic, erosional - B-type karsts R is greater or equal to 1. This can be explained in the B-type erosional channel network is fed only by the swallow-holes of the convergence zone, but other swallow-holes of the karstic terrain too. At the same time, in the divergence zone every karst spring is mobilized only in the case of a large amount of water.

In the present study a morphometric investigation of dolines, which are the most important forms of karst, is given for the above mentioned territory from the point of view their genetic questions. It is known that in many case the morphometrical results must not utilize to solve genetic problems, so we tried to control our conclusion in many respect.

More than 80 dolines from Aggtelek and Bükk Mountains have been studied. First the elongation ratios (ratios of the largest and smallest diameters) and the orientations (azimuths of longer axes of the dolines) were investigated. The elongation ratios and extents of dolines depend on the variations in geological, hydrological and ecological elements of landscape. From the aspect of the elongation, the most important role is the structural preformation (the longer diameters of the depressions are parallel to the breaks of fractures). Here the most effective infiltration permits more effective corrosion or more intensive karst development for a certain time. It was found that in Aggtelek Region the uvalas are characterized by an elongation ratio larger than 1.65 and in Bükk Region over 1.25.

The direction of the main axis of the dolines - the orientation - in both regions is NE-SE or W-E. The proportion and direction of elongation as well as the proportion of the internal relief are roughly the same and this means that a general tendency referring to genetics is expressed in the asymmetry.

While the orientation is connected to the tectonic or fracture directions, the assymmetry is mostly the result of the expositional differentiation of ecological factors. The decisive exogenic factor in the development of dolines is climate, which roughly controls the impackts of the ecological factors. The dolines modify the radiation effects creating an independent microclimatic system. The different slopes further dissect the microclimate of the doline within the microclimatic area resulted from the closedness of the karst depression. The symmetry axis of the air temperature in N-S segment shifts in the direction of slope facing S. The minimum temperatures shift in the direction of slopes at night in case of fog (Bárány-Kevei I. 1985).

The microclimate results in considerable differences in soil of the dolines depending on their exposition. The microclimatic changes can influence relation of humidity, microbiological processes, flora, fauna, intensity of corrosion of the soil. This altered parameters may influence the morphometry of dolinas (Bárány-Kevei,I. 1987).

The relief ratios of the dolines may be measured with the depth/average diameter quotient; this has already been employed by Cvijic. We found that the relief ratios of the tectonically more directed "row-dolines" are smaller (generally beeing below 0.1) than the "plateau-situated" or tectonically not directed, ordered dolines (above 0.1). The apparent contradiction arising here - for it would be expected that the deeper dolines would be found in the area with the more extensive tectonic effect - seems to be solved in following way. The row-dolines of the temperate zone (which may occupy a tectonically preformed fracture, or earlier river valleys) display more effective development, because of the more intensive infiltration than the isolated "plateau dolines".

Our investigations verified the following assumption. Whereas karst corrosion is promoted by redeposited soil cover that is not very thick, it is strongly hindered by very thich soil (mainly washed down to the bottom of the dolines) because of the impermeability of the red clays. The dissolution will then be most effective on the doline rim. Hence in the continental regions the development of dolines proceeds by widening rather than by deepening. With a decrease in absolute height of the surface or the col between the dolines. The dolines covered by thinner soil cover are mostly developing lingeringer than the thicker soil cover ones.

In comparison of row-dolines in Bükk and Aggtelek Mountains we have described some new morphometric parameters. We have drawn relative levels with level differences in one meter in the dolinas investigated, than we have determined the size of areas belonging to certain level and intersected by that (A^1, A^2,...) and we have measured intersected margins by certain levels too (P^1, P^2,...), see Fig. 1.

1. At first we have compared the size of areas and peripheries (above mentioned) to the depth (d). The quotient of A/d proved to be 1.0 - 1.15 in case of Bükk Mountain and 0.9 - 1.0 in case of Aggtelek ones (Table 1 and 2).

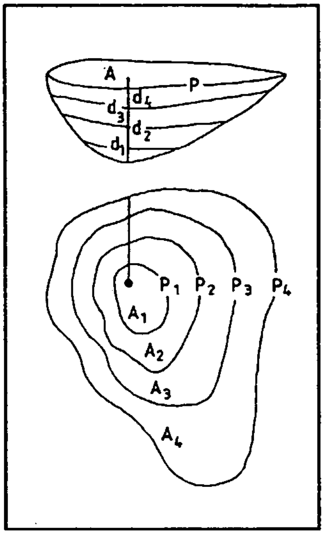

Figure 1 The A^i and P^i parameters of the dolinas

2. An other characteristic quotient could be established when A^i is compared to A^j. In the change of quotient we have observed a characteristic feature. On the slopes of the dolines of Aggtelek Mountains on their slopes from up to down the quotient is increasing moderately at first, than decreasing slowly or stagnates.

3. We have introduced a new quotient for the determination of assymmetry of dolines. We have compared the total slope length of a certain direction of cardinal point. This means we have calculated the quotients in the following manner:

$$N / N + S , E / E + W \quad \text{etc.}$$

The representation of the average quotient in a systemcoordinate (where the point of intersection is center of symmetry) may result in the following conclusion: the E-W component of the dolines in Bükk Mountains are much larger than the Aggtelek ones (Fig. 2.).

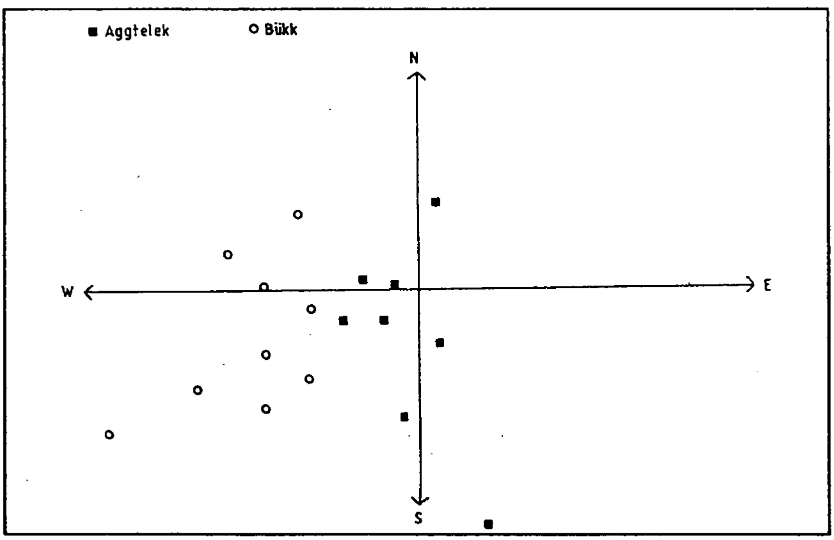

Figure 2 The deviation of the axis-components of the Aggtelek and Bükk dolines from the symmetrical

To distinguish between the doline types on the Aggtelek Karst Region a most obvious task is to establish the number and total area of the dolines. In this region we differentiated three doline types, mainly on morphometric and lithological basis. These three groups were examined from a morphometric aspect, at present on the basis of the following three indices:

a/ the number of dolines per km (doline density)

b/ The percentage ratio of the total area of the dolines to the size of the given karst surface (this is reciprocal of the index of pitting used by Williams)

c/ the average area of the dolines.

Our results are listed in Table 3. and on Fig. 3.

Table 1 Morphometrical parameters of typical dolines in Aggtelek Mountain (N-Hungary)

Parameters	Dolines							
	B1	B2	B3	B4	B5	B6	V1	V4
1.	45	157	7	73	56	51	35	157
2.	10	13	11	14	14	8	10	18
3.	108	115	185	120	95	120	185	320
4.	78	101	83	54	29	61	31	137
5.	93	108	134	87	62	98	108	228
6.	21060	37748	42226	22680	9642	14640	14337	197280
7.	1.80	1.09	2.25	2.19	1.08	0.86	1.08	1.48
8.	0.11	0.12	0.09	0.08	0.16	0.10	0.14	0.10
9.	54630	73781	113143	48149	24756	51069	73564	327476
10.	0.98	1.40	0.98	0.98	0.99	0.88	0.98	1.03
11.	0.84	0.83	0.80	0.81	0.86	0.78	0.58	0.87
12.	0.75	0.65	0.70	0.64	0.76	0.76	0.70	0.78

Parameters: 1- Asimuth(°), 2- Deep (m), 3- Diameter (m), 4- Diameter As+90 (m), 5- Average diameter (m), 6- Volume (m), 7- Elongation ratio, 8- Relief ratio, 9- Area (m), 10- A/d ratio, 11- P/d ratio, 12- A/A ratio

Table 2 Morphometrical parameters of typical dolines in Bükk Mountain (N-Hungary)

Parameters	Dolines							
	S1	S2	S5	S6	S7	S8	G2	G5
1.	145	85	72	136	92	128	35	14
2.	9	10	9	11	8	21	23	13
3.	72	107	72	78	54	102	120	84
4.	33	72	38	36	46	75	111	54
5.	52	90	55	57	50	88	115	69
6.	5346	19260	6156	7722	4986	40162	76590	14742
7.	1.08	0.85	1.01	1.27	0.95	1.09	1.01	1.17
8.	0.19	0.16	0.18	0.21	0.16	0.23	0.20	0.20
9.	17235	51182	19251	20784	15901	50017	84714	30430
10.	1.88	1.00	1.09	1.02	1.09	1.06	1.00	1.16
11.	1.09	0.85	0.85	0.87	0.89	0.97	0.87	0.90
12.	0.72	0.67	0.61	0.62	0.58	0.68	0.77	0.65

Parameters: 1- Asimuth(°), 2- Deep (m), 3- Diameter (m), 4- Diameter As+90 (m), 5- Average diameter (m), 6- Volume (m), 7- Elongation ratio, 8- Relief ratio, 9- Area (m), 10- A/d ratio, 11- P/d ratio, 12- A/A ratio

Table 3 Doline types of the Aggtelek Mountains.

	row-dolines	plateau dolines	
		dolomitic	limestone
doline density	11 - 13	32 - 36	7 - 9
total area of dolines as % of karst surfase	23	32	31
average area of dolines (km)	0.01	0.002	0.016

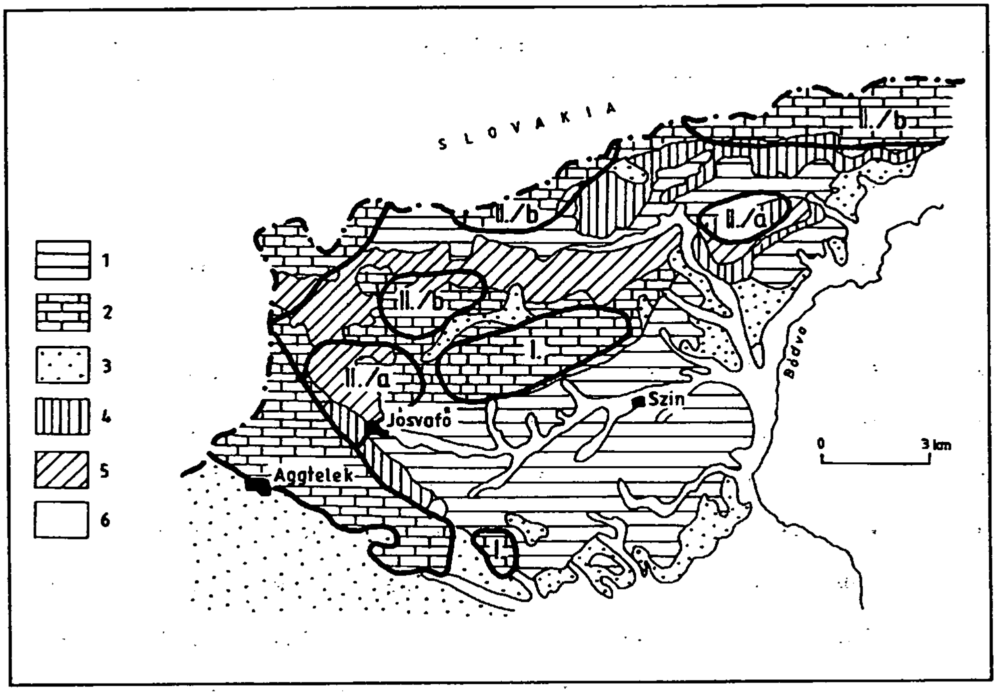

Figure 3 Geological map outline and doline types of the Aggtelek Hills
1 - Lower Trias limestone, clay slate; 2 - Lower Anisus (Gutenstein) limestone, dolomite; 3 - Wetterstein limestone; 4 - Wetterstein dolomite; 5 - Pliocene sediments; I - row dolines; II - plateau-dolines; a - dolomic types; b - limestone types;

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