SOME DATA ABOUT THE PROPERTIES OF THE DISSOLVING DOLINES OF THE BÜKK MOUNTAINS

Ilona Bárány

The dissolving dolines of the temperate zone morfometrically differ from the tropical and subtropical dolines in a considerable way. The development of the temperate zone dolines is slower than that of the former ones; their forms are preserved for a longer time. Both the smaller corrosive surface and the thinner soil surface of the slopes delay the dissolving processes.

The majority of the dissolving dolines is assimetrical. According to a part of the authors assimetry is due to tectonical preformation. Our investigations so far have proved that the assimetrical form can be explained by the combination of microclimate, plant association and vegetation of the differently exposed dolines of different zones (I. BÁRÁNY — G. MEZŐSI 1978, I. BÁRÁNY 1980, 1983, 1984).

These dissolving dolines are not identical with those assimetrical dolines which developed under the long duration remaining snowy surface as a result of their favourable exposition. In these cases the biogene factors do not have an important role, or just minimal (I. BÁRÁNY 1982).

The majority of the Hungarian dolines — among them the Bükk dolines — are either dissolving or corrosion dolines.

The corrosive activity of the dissolving dolines is strenghtened by the areal runoff in course of the doline development. During infiltration rearrangement of substances may also occured mechanically, which is regarded as a suffosion process by some authors. The corrosive, gravitational and suffosion processes can either strenghten or weaken one another. It makes erosion or accumulation of the negative form faster but it does not change the basic genetical type.

The rate of karst formation and the character of the developing form is considerably dependent on the litological factor. In our investigated area, on the karst plateau of the Bükk Mountains, the main rock forming component is the witish grey or grey flint-free upper Ladinian and Carnian limestone in 1300–1500 meters thick complex. In this thick complex mainly the limestone facies of the great plateau and the small plateau of Subalyuk and Berva-völgy provides an adequate surface for doline formation. The limestone facies of the great plateau — settled on the Ladinian-shale — consists of thin-stripped, finely layered parts which are

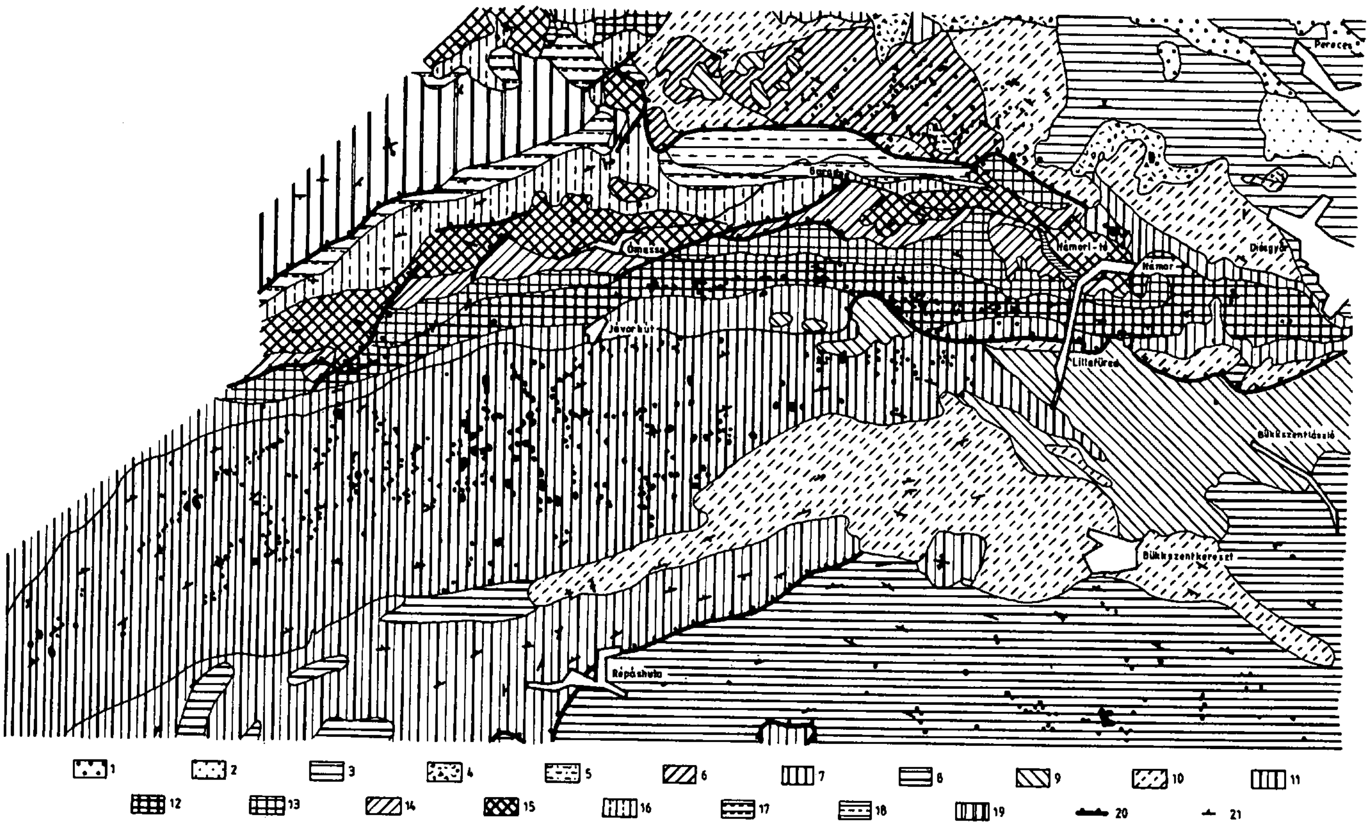

Fig. 1. Correlation between geological facies and regional location of the karstdolines in the Bükk Mountain (Hungary)

arranged into 5–7 meters deep. This limestone is chemically very pure. The small plateau limestone facies is settled, a micro-crystalline formation with multicoloured limestone settlements on the lower part and with a big oolite structure on the upper one. (Fig.1.)

The karst-plateau is divided into two parts by the eruptive complex of pressed diabase and diabase tuff as well as quartz porphyry and quartz porphyry tuff, which has become a green shale.

The karst formation of the above mentioned rocks is a result of the developing processes of the surface. The development of the present surface began in the Miocene when the mountain had already undergone land-denudation (PINCZÉS Z. 1968).

Quarternary sediments can be found in the southern foreground of the mountain, mixed with the erosion products of older formations.

In the Pleistocene, owing to the periglacial-climate a great amount of regolith was accumulated many places. As a result of rising process — which was still going on at that time — the relief energy increased and together with the effect of the climate influenced the stabilization of the valleys. Linear erosion became dominant (A. HEVESI 1980).

The river network of the covered karst gradually inherited to the uncovered karst, because at the end of the Pliocene and at the beginning of the Pleistocene the emersion of the mountain had accelerated.

1. Sand and andesite pebble	Pannonien	Pliocen
2. Pyroxenandesite, pyroclastics and reefs	Sarmatien	Miocen (2–5)
3. Clay, sand, sandstone, pebble, brown coal	Helvetian (3–4)	
4. Base pebble, sand, clay		
5. Pebble, sand, sandstone, conglomerate, variegated clay and pebble	Burdigalian	
6. „Kisfennsíki" limestone (Bükk)	Ladinian (6–12)	Middle Triassic (6–14)
7. „Fennsíki" limestone (Bükk)		
8. „Répáshutai" limestone (Bükk)		
9. Diabase, porphyrite, poriferous quartz and their tuffs (Bükk)		
10. Flinty grey limestone and dolomite (Bükk)		
11. Dark grey shale complex, sandstone with intrusions of flinty limestone and shale (Bükk, Rudabánya)		
12. Clearly layerd white limestone (Bükk); Wetterstein limestone with red stained and clearly flinty limestone (Gömöridák)		
13. Porphyrite, diabase and their tuffs (Bükk)	Anisian (13–14)	
14. Grey dolomite (Bükk, Rudabánya), Guttenstein dolomite (Gömöridák, Rudabánya)		
15. Lower triassic in general		Lower Triassic
16. Black bituminous limestone complex (Bükk) Permian	Upper	Permian (16–17)
17. Variegated shale and sand complex (Bükk)	Middle-Lower	
18. Granular limestone with diabase tuff and tuffite	Upper	Carboniferous (18–19)
19. Dark grey argillaceous shale and sand complex with limestone lens in its upper part	Middle	
20. Fault line		
21. Tilted streak		

The rivers show the phenomenon of batucapture and indicated the places of formation of the doline rows and "hanging" dolines (Á. HEVESI 1980). In the middle period of the Pleistocene rising of the mountain slowed down and only in the last two phases of the glacial accelerated. In the humid interglacial of the Riss and the Würm the doline formation became intensive.

In the valleys the gradually accumulating regolith and soil strenghtened the surface karst corrosion (karr and doline formation).

In phases of changing climates of Pleistocene (according to the kryotorph and kryophyl characters) the denudation took place gradually and it depends on conditions the avens and ravines were formed.

The spring caves were raised onto a higher level as a result of the accelerating emersion in the Würm. On the slack sediments of the tertiary period land-slides falls, soil, mud, and stone flows formed the surface.

Since the end of the Würm the Bükk is a mountain of uncovered mixed karst where karst formation is responsible for surface development.

Only a few authors (J. KEREKES 1937, G. BIDLÓ 1954, Á. JÁMBOR 1959) have examined the Bükk formations of the Quaternary. The cold-dry climate of the Pleistocene provided the conditions for loess formation in Hungary. In the lower periods of the Riss and the Würm red deposit settled ontop of the Trias limestone in the Bükk Mountains and later on in the Würm a yellow, loess-like deposit settled ontop of this free from lime. In Hungary the thickness of Quaternary formations is the slightest in the Bükk Mountains.

The erosion was so strong here in comparison with the neighbouring areas because of the big relief that a complete layer can be found only a few places. From this point of view, dry valleys and dolines can be taken into consideration, expecially those among the dolines which are at the initial stage of their development. According to JÁMBOR these depression are filled up by yellow, brown and red Pleistocene loam in vertical extention of 1–5 meters. A soil surface of 10–50 centimeters has developed ontop of it. These red and reddish brown clays are the transformational and decompositional products of the Miocene and Pleistocene formations, consequently they can be regarded as local decay products. It was G. BIDLÓ (1954) who found mainly quartz minerals in the terra rossa and the dissolved remains of limestone in the Bükk Mountains. The incidence of clay minerals is subordinate.

According to our opinion the dissolved decay remains had their role in the formation of the above mentioned soil layer, especially in case of slope position. However, it is true that at the bottom of the depressions, so thus in the dolines, a sediment of such a thickness was accumulated that the soil here mainly bears the marks of exogeious effects, and the litological guidance is not important.

Both the soil and the thicker sediments play an important role in the formation of the dynamism of karst corrosion (L. JAKUCS 1971, Z. ZÁMBÓ 1970).

The frequency of dolines on karst surfaces and their morfometrical characteristics are very diversified. In case of different karst areas all kinds of size may appear, from dolines of $1m^2$ extention to the great depressions of $4km^2$. The density of dolines is strongly differentiated even inside the same area. In case of the areas of warm-humid climate the density of dolines is generally low, while as far as the Mediterranian and the areas of warm-temperate climate are concerned, it is getting higher. (Although, it must be mentioned that besides the climate, the dissolvability of the base rock may also influence the density.)

The frequency of doline presence for an area unit can help to judge the rate of karst formation in a given area. (The data relating to this subject can obviously be only informative in the complex analysis of karst formation.)

On the high-raise, „A"-type karst plateau of the Bükk Mountains, the litological factors are favourable for the karst and doline formations either.

The whole area of the Great-Plateau is nearly 100 km^2 while that of the Small Plateau is 30 km^2. We found 39/km^2 dolines as a maximum on the Small Plateau but the rate of 20–30/km^2 is also frequent here. In case of the Great Plateau the maximum was 32/km^2 dolines. (Fig.2.)

The number of dolines was determined by the help of map scale of (1:10.000) which was checked on the land.

On the Great and Small Plateaus the number of dolines is over 800. However, it must be added that this number is to be regarded as approximate, since the inaccurate accounting of some embryonic dolines or those that had developed into an uvala, may change the data. Relating to the whole area of 130 km^2, it means a 6,3/km^2 doline density. The area is 77 km^2 altogether, where the presence of dolines is higher, so in the narrowed area under strong karst formation is much higher — 10,6/km^2.

A quarter of the dolines can be found on the Small Plateau, on 12km^2. Accordingly, the occurence of dolines here is higher, 14,1/km^2. (Comparing it to the whole area of the Small Plateau, the density of dolines is only 5/km^2.)

On the Great Plateau the density of dolines is 10/km^2 in the area of 65km^2 under strong karst formation. (Comparing it to the whole area of the Great Plateau the density of dolines 6,5/km^2.)

The above mentioned data has proved that it is not enough to relate the density of dolines to the whole area, as it distorts the real situation.

In the areas of great doline density the microtectonical and structural characters of the base rock are favourable for doline formation, and it is strenghtened by the oecological conditions of the surface.

Dolines on the Great Plateau can be found in the valleys and in undersides of the expanding dry valley running in the direction of ENE — starting from Almád-hegy to the Savós-völgy. The dolines can be found in a row-like arrangement in the direction of the valley ranges or on the preformated lands of lower position surrounding a few 100 m high emersion.

A very good example for this is the Northern part of the Káposztáskert-völgy and the dolina row of Kecskeláb-rét and Kis-Mező. Most of the dolines can be found in the district of Nagymező, Kismező and Vadkert.

Similarly, dolines can be found in great number and density on the western part of Lustavölgy and in the district of Borókás and Vesszős.

The greatest number of dolines on the Small Plateau are situated surrounding

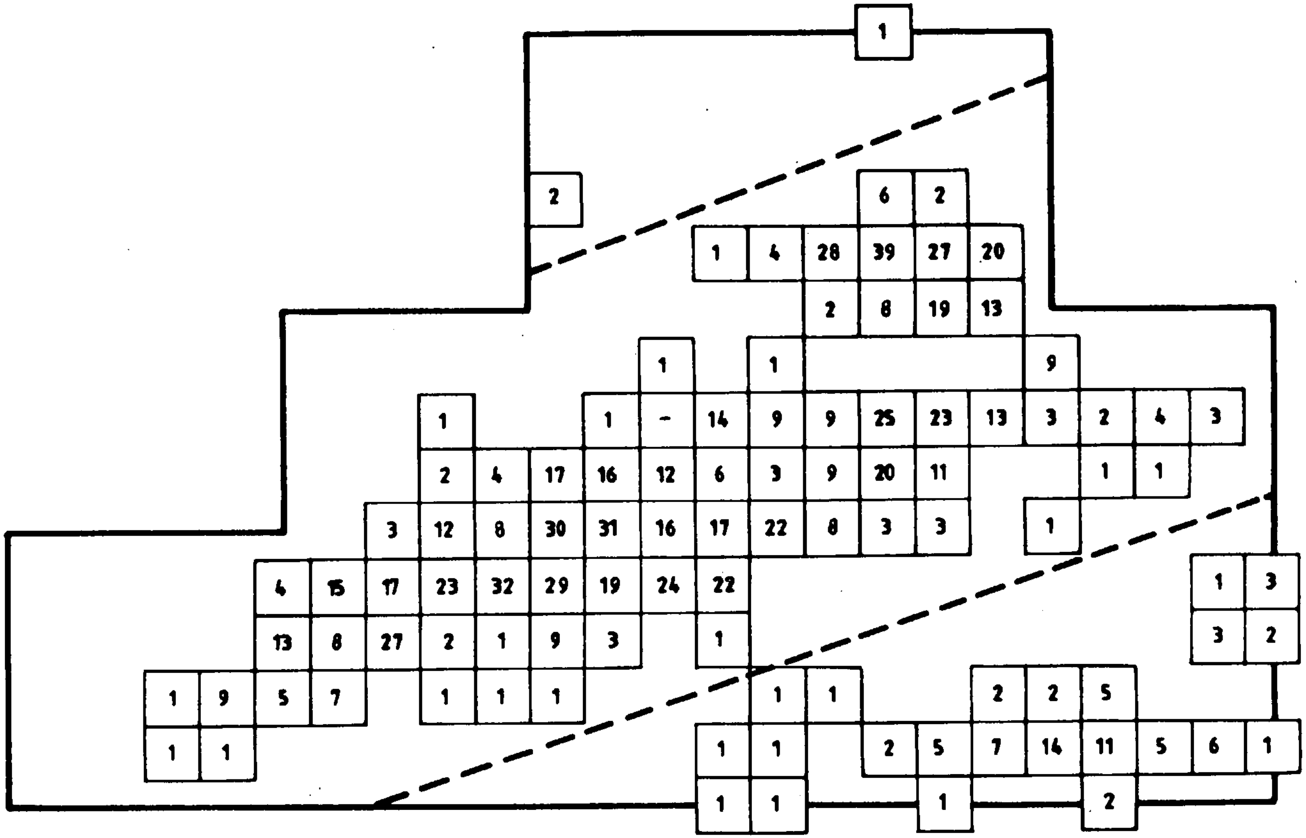

Fig. 2. Number of doline (doline rata per 1 km²) in the Bükk Plateau (Hungary). Fractional scala 1:10.000

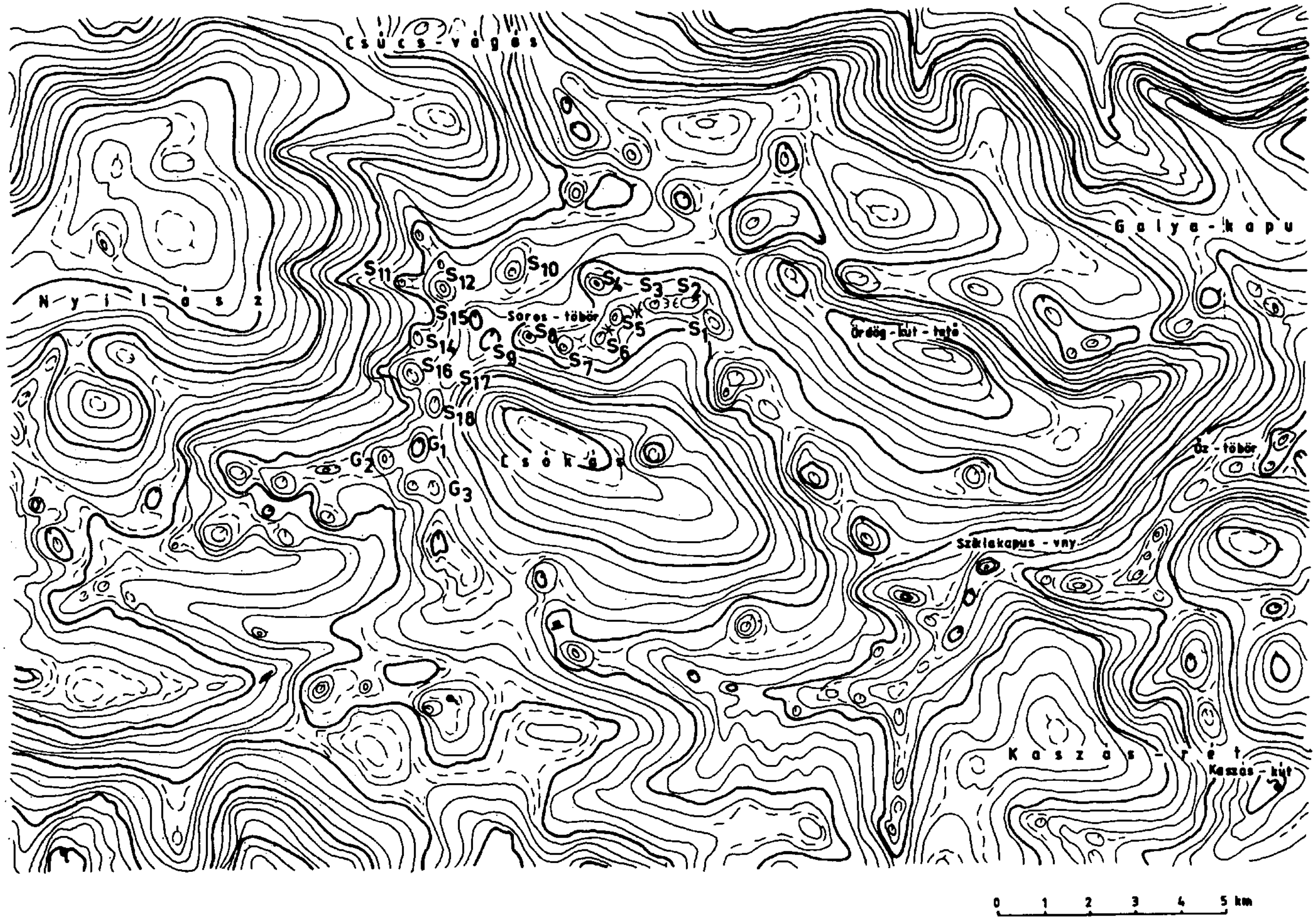

Fig. 3. Topographical location of the investigated dolines on the Small Plateau in the Bükk Mountain (Hungary)

Čsókás and in the district of Kaszásrét, but their occurence is frequent dispersedly westward to Sólyomkút.

For making the model of doline formation and for ordering in groups the doline types, the morfometrical parameters (the type of protraction, orientation, the whole surface, the rate of relief etc.) can be employed. We carried our land-surveying in the chosen area of the Small Plateau with the intention of determining the most important morfometrical parameters. The orientation of the dolines is north-western, south-eastern but there are few east-western north-north-eastern, and south-south--western orientation too. Besides structural characters there is the fact, which also plays an important role in orientation, that on the different slopes — among different temperature and soil humidity circumstances — other oecological factors are variable and this differentiates the degree of efficiency of karst corrosion from place to place. (Fig.3.)

The rate of protraction (the longest diameter, devided by the shortest diameter) is generally the lowest in case of the Plateau dolines, while as for the rows dolines it is higher. (Table 1.)

Table 1.
Morphometrical parameters of dolines in Bükk Mountain (Hungary)

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
S_1	145	9	72	33	52	5346	1,08	0,19	17235
S_2	85	10	107	72	90	19260	0,85	0,16	51182
S_3	85	6	80	34	57	4080	0,79	0,18	20517
S_4	142	10	100	72	86	18000	1,10	0,22	46760
S_5	72	9	72	38	55	6156	1,01	0,18	19251
S_6	136	11	78	36	57	7722	1,27	0,21	20784
S_7	92	8	54	46	50	4986	0,95	0,16	15901
S_8	128	21	102	75	88	40162	1,09	0,23	50017
S_9	128	6	88	59	73	7788	1,50	0,09	33579
S_{10}	138	22	158	121	139	105149	1,31	0,16	122856
S_{11}	72	13	91	80	85	23660	1,14	0,16	45904
S_{12}	98	10	71	59	65	10472	1,21	0,16	26847
S_{14}	89	12	100	60	80	18000	1,67	0,15	40644
S_{15}	87	8	78	42	60	6552	1,86	0,14	22809
S_{16}	74	20	88	38	63	16720	2,32	0,32	26181
S_{17}	43	7	65	54	59	6142	1,21	0,12	22015
S_{18}	52	8	68	58	63	7888	1,18	0,13	25126
G_1	80	14	112	102	107	39984	1,04	0,13	72515
G_2	35	23	120	111	115	76590	1,01	0,20	84714
G_3	14	13	84	54	69	14742	1,17	0,20	30430

1 = Designate; 2 = Asimut (°); 3 = Deep (m); 4 = Diameter α (m); 5 = Diameter α + 90° (m); 6 = Average diameter (m); 7 = Volume (m^3); 8 = Elogation ratio; 9 = Relief ratio; 10 = Area (m^2).

The rate of relief (deepness of doline devided by average diameter of doline) is higher, where clayey crumbled is less and the deepening process is stronger. The average diameter is generally not so big in case of the dissolving dolines of the Bükk Mountains, and it explains that the rate of relief is higher in case of the plateau dolines with faster deepening.

On the basis of our former investigations in Aggtelek (I. BÁRÁNY — G. MEZŐSI — I. TÓTH 1978), with computation of area, we have proved by the example of a doline of average diameter and depth, that on the areas of the temperate zone the smaller doline surface results in the longer lasting preservation of the form, while the larger surface has the result of slow doline growing.

The settlement, density and the characteristic parameters of the dolines refer to the fact that in the limestone facies of the Great Plateau and Small Plateau (upper Ladinian and Carnian) in the Bükk Mountains the structural characters determining the direction of the Pliocene — Pleistocene water-network, the strongerly cracked base rock of the valleys, surrounding the local heights as well as the sediments redeposited from the higher relieves, strenghtened the inclination for karr formation and as a result of it, for doline formation.

Under the suitable climate condition the doline formation started at first in the lines of valleys. Nowdays the karst formation is most intensive in the valleys surrounding the local hights and in the dry valleys of former rivers.

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