ON THE DEVELOPMENT OF THE CLASSICAL DINARIC KARST IN SLOVENIA

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ABSTRACT

Geotectonic, geomorpho-hydrologic and climatical position between the Mediterranean and the Alps in the Southern Europe is decisive for the classical Dinaric karst. In the geographic situation between the 45.30° and the 46.30° of the northern latitude and 13.30° and 16° meridian of the eastern longitude the karst developed from the sea level (even below it) to the highest peak in the Julian Alps (*Triglav*, 2864 m). Prevailing part of this karst is built in Cretaceous and Jurassic limestones and dolomites, through partly in Triassic and older as well as in younger Palaeogene and Neogene carbonate rocks.

Recent researches called attention to the traces of Pre-quaternary arid and humidic, warm and cool period transformations (P. Habic, 1992). The differentiated neotectonics decidingly influenced the formation of the Dinaric karst relief as particular units of folded and overthrusted structures either uplifted or subsided and were exposed to variously intensive karst transformation. Development phases are evidenced in the karst relief forms and in the remains of various deposits on the karst surface and in the underground. In fossil caves, fluvial sands f.i. are preserved from the highest areas to the sea shore.

INTRODUCTION

In Slovenia the Dinaric karst is situated among the Adriatic and Pannonian basin and the eastern part of southern Limestone Alps. The karst surface is composed by inherited and recent forms which resulted in geomorphological development in several phases. The traces of old fluvial and fluviokarstic planation are preserved since the period when the carbonate rocks were limited and impounded from all the parts by the impermeable rocks. After general planation of stirred up post-orogene geologic base, the period of erosional or solutional deepening and dissection followed. Particular areas were either uplifted or subsided by consecutive tectonic movements, uncovered and opened limestones and dolomites were exposed to karstification.

There are shapes and sediments preserved in relief which should originate in different climatic conditions. Differentiated exposure of variously resistant rocks against erosion and solution was connected to climate too. In cooler Quaternary periods the surface on impermeable rocks lowered more quickly than in karstified carbonate rocks. The last ones were in general less resistant in warm and humid climatic conditions.

The main relief forms developed within the treated area somewhere from Mio-Pliocene onwards. Karst in southern Slovenia comprises nine thousands of square kilometers only, but morphologically extremely heterogeneous surface developed.

THE REVIEW OF IMPORTANT GEOMORPHOLOGICAL TREATISES

In general quite a lot was written about the Dinaric karst. The first synthetical review was done by J. CVIJIC (1893, 1918, 1960). His treatises are essential as numerous younger researchers followed his examples (D. FORD & P. WILLIAMS, 1989; Ph. RENAULT, 1992. The CVIJIC's scheme of cyclic development of karst surfaces known. After him J. ROGLIC became famous (1957, 1960, 1965) by his original views to deep circulation, rim corrosional widening, fluviokarstic and corrosional karstic transformation.

The former fluvial origin of Dinaric karst surface in Slovenia was sustainingly defended by A. MELIK (1935, 1961, 1963). According to him the karstification did not start earlier than the epirogenetic uplifting of miocenic levelled surface. Thus in cold Pleistocene periods the fluvial processes strengthened, on karst poljes in particular and the waters accumulated mechanical scree there which filled the underground channels too and caused the inundations.

Interesting data about the intensiveness of recent solute processes in Slovenia were gathered by I. GAMS (1965, 1985), the same author wrote the monograph on recent karstological results (1974). He studied the effects of accelerated corrosion, poljes and blind valleys genesis and other forms of contact fluviokarst.

General concept of geomorphological karst development in Slovenia was presented by D. RADINJA (1972). The impact of climate on relief formation in Slovenia tried to define M. SIFRER (1990). He emphasized the difference between Pliocene and Pleistocene periglacial and glacial formation of the relief. Structurally and tectonically controlled forms in Dinaric karst were subject of P. HABIC researches (1968, 1990).

Among the important treatises on speleogenesis let us mention the work of S. BRODAR (1952) and R. GOSPODARIC (1976, 1986), who deepened the speleogenetical knowledge by chronostratigraphy of cave sediments.

THE DISTRIBUTION OF KARST IN SLOVENIA

Some 9000 sq. km or 44% of the territory of Republic Slovenia can be classified as karst area. Over two thirds of this territory (6300 sq. km) consist of limestone, mainly Mesozoic, whereas karst areas on other rocks (dolomite, conglomerate, calcarenite and breccia) occupy some 30% of the entire karst areas of Slovenia.

The karst in Slovenia is commonly divided into three major units: a) **the Alpine karst**, b) **the Dinaric karst** and c) **the isolated karst of the intermediate area** (sub-Alpine karst and sub-Dinaric karst).

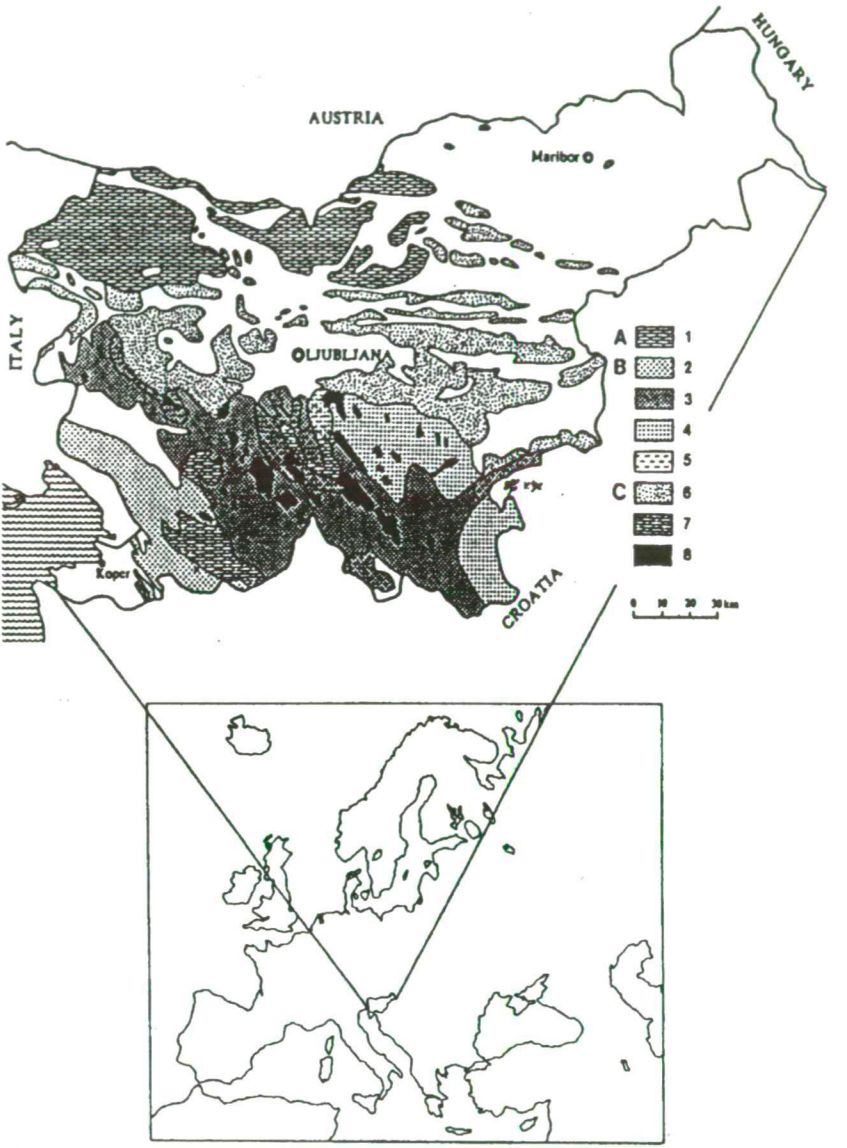
a) **The Alpine karst** (the *Julian Alps*, The *Karawanke*, the *Kamnik* and *Savinja Alps*) can be classified, using M. HERAK's (1977) tectogenetic criteria, as the fractured orogenetic karst. The Palaeozoic carbonate rocks remain preserved only in form of lenses and are the basis of the karst in the Karawanke Mountains.

The Alpine karst region is dissected by deep valleys, lying between ridges of an altitude from 1000 to 2800 m. The plateau-like segments below the highest peaks are small, but quite extensive in *Komna, Pokljuka, Jelovica, Mezakla* etc. in the border part of the Alps.

In high levels of Alpine karst one can find all karst forms known in the Northern and Southern Limestone Alps (big dolines - *kontas*, snow dolines with vertical walls - *kotlic* (sing.), all kind of karren etc. Recently the 11 km long alpine cave Poloska jama and some potholes with depth between 700 and 1200 m (*Crnelsko brezno* 1198 m, *Skalarjevo brezno* 911 m, *Brezno pri gamsovi glavici* 817 m, *Poloska jama* 704 m) have been discovered. In other Alpine karst areas the karstic hydrology is often the only karst phenomenon. The underground waters can rise to the impervious ground but flow out to normal valleys. The karst waters come out in the sources in the Quaternary deposits at the bottom of the valleys or directly from the steep rocky slopes in waterfalls (the *Savica*, the *Boka*, the *Soca* etc.) The Alpine karst waters are comparatively pure because the surface is barren, without thicker layers of soil and less populated.

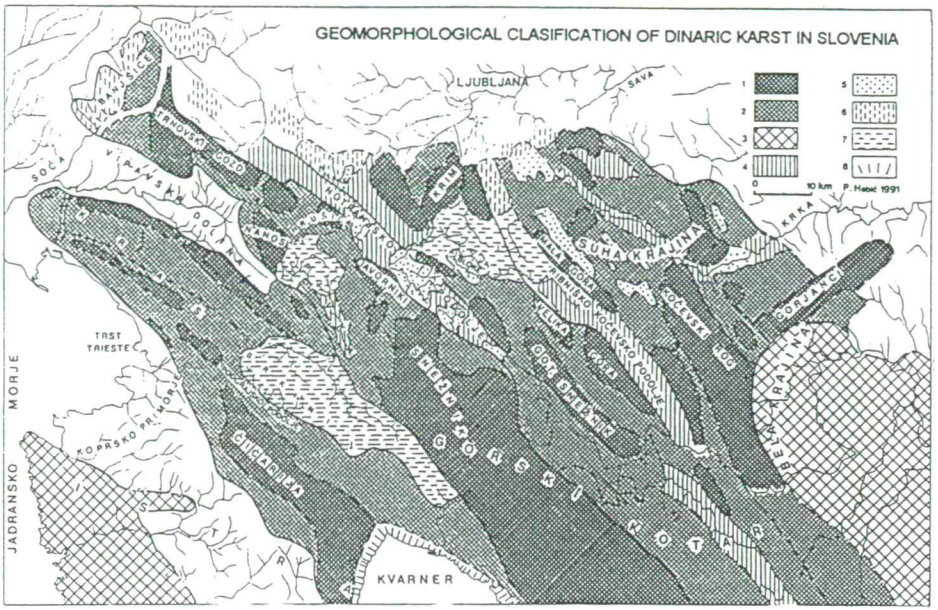
b) **The Dinaric karst** includes continuous karst areas in western and southern Slovenia. This is the orogenetic accumulation karst (M. HERAK, 1977) consisting mainly of Mesozoic and Palaeogene, tectonically fractured limestones and dolomites that are often overthrusted and thus attain, secondarily, great thickness. The impervious rock basis is lying deep under the surface, but really important are the lithological and structural differences, in particular the inserted layers of less permeable dolomites and of the Eocene flysch which constitute, in places, the basis or are inserted between karstified rocks and thus hinder or direct the outflow of water along the tectonical units. In this deep karst almost all phenomena that are characteristic of the out-flow, through-flow or impounded contact karst are to be found.

The Dinaric karst can be divided into three enlogated parallel belts according to geological, geomorphological and hydrological characteristics. They are, first, the littoral Karst or Periadriatic Karst, second, the Karst of Notranjsko or High Karst, and third, the karst of Dolenjsko or Peripannonian Karst. On a small scale different morphological units alternate in longitudinal Dinaric zones.



A Alpine karst
B Dinaric karst: 2 - Low Littoral karst
3 - High karst of Notranjska and Dolenjska
4 - Low karst of Dolenjska and Bela krajina
5 - High karst on dolomite
C 6 - Isolated sub-Alpine and sub-Dinaric karst
7 - Fluvial surface with underground out-flow through karst
8 - Karst polje, bigger karst depression

Figure 1 *Karst in Slovenia (P. HABIC, 1992a)*



1- higher conical karst
2- karst margin plains and pediments
3- lower karst plains
4- lowered surface with karst plains
5- karst poljes
6- contact fluviokarst
7- fluvial relief encircled by karst
8- litoral tectonic karst scarp

Figure 2 *Geomorphological classification of NW Dinaric karst (P. HABIC, 1991)*

The Littoral karst extending along the Adriatic coast is further divided into original Kras area (called also *Trzaski Kras* or *Trieste Karst* or *Carso di Trieste*) in the background of the *Timavo spring*, and, second, the karst of northern Istria, i.e. the *Materija dry valley* and the *Slavnik mountains* in the background of the *Rizana* and *Osp karst springs*. Classical Kras is built of Cretaceous limestones and dolomites, Paleocene limestone and Eocene flysch. In Neogene these series were folded and faulted. Rivers from Vipava flysch rim and the surface flowing *Notranjsko Reka*, draining till now the flysch of the *Brkini mountains* in the southeast, have downcut wide dry valleys and karst plains in the Classical Kras. D. RADINJA (1972) found the rest of gravel accumulation of neogene rivers. The brooks from Mts. Brkini have eroded 12 blind valleys on the southern footslope (I. GAMS, 1962). The longest blind valley is that of the *Notranjska Reka - Vremska dolina* with its terraced bottom (D. RADINJA, 1967). The river Reka sinks in the caves *Skocjanske jame*. There are two fresh collapse dolines and many older collapse dolines there. The Skocjanske jame present the biggest natural curiosity of the whole Classical kras, they make part of the typical morphogenetical unit of contact karst, unique in Europe regarding its phenomena

and dimensions. The natural reserve Skocjanske jame and the vicinity was listed in 1986 as natural and cultural heritage of the world at UNESCO as the example of caves of extreme dimensions and karst landscape with rich history and interesting cultural traditions. By gradual karstification starting after erosional or tectonical lowering of impermeable flysch border of Kras, the valley of the Reka incised more and more. At the ponors into the surface under 450 m a.s.l. a blind valley, 130 m deep, 5 km long and up to 2 km wide, was cut in four terrace levels. The actual Reka ponor lies under 108 m high wall of Skocjan on 317 m a.s.l. The entrance passage is narrow and high, developed along a bigger fissure therefore the passages reach 50 to 80 m. The axis of Skocjanske jame is presented by 2,5 km long underground canyon which has no lateral active water channels, at the end of which a deep explored syphon exists. Underground continuation of the Reka between Skocjanske jame and 8,6 km long Kacna jama near Divaca is unknown on the distance of 1500 m. Unknown is also the underground flow between *Kacna jama* and the 30 km distant *Timavo springs*. With its dry higher channel rich in speleothem, with its mighty huge water channel, with its archaeological and biological importance this cave is besides the Postojna cave, the greatest jewel of the Slovenian karst, which is not yet fully appreciated in tourism. Cave research organizations of Slovenia have till now registered more than 700 caves and potholes in the area of ca. 500 sq. km of the classical Kras, but over 6500 caves are known in whole Slovenian karst.

The **Karst of Notranjsko** (*Inner Carniola*) belongs to the central highest Dinaric belt and is separated from the Littoral Karst by a narrow belt of impervious Eocene flysch. High, wooded and scarcely populated karst plateaus at an altitude of 800 to 1700 m with intermediate lower valley-like karst depressions at an altitude between 400 and 600 m are predominant in this area. The karst is developed primarily on Triassic, Jurassic and Cretaceous limestones and dolomites but there are also small sections of impervious marls, sandstones and schists that divert the surface waters and dam the underground waters and thus influence the formation and the layout of the through-flow karst. The high out-flow karst can be subdivided in relation to structural tectonic and morphogenetic characteristics into the following more or less coherent hydrogeological units: *Banjsice, Trnovski gozd, Hrusica, Nanos, Javorniki, Sneinik, Krim, Velika gora, Kocevski Rog* and the central part of the Gorjanci mountains. Karst waters flow out from these units to several directions and feed the karst springs in their border zones.

Lying between these high areas of out-flow karst is the central part of the through-flow karst of Notranjsko. Across it the surface and underground waters flow forming intermittently flowing streams that flood the karst poljes. A considerable part of the through-flow karst belongs to the drainage basin of the Ljubljanica river, but some waters drain also towards the rivers *Kolpa* and *Krka*. There is a string of karst poljes in the upper reaches of the Ljubljanica including *the Prezid, the Babno polje, the Rakitna, the Bloke*, as well as better known *the Loz, the Cerknica, the Planina* overflow poljes, *the Logatec* contact polje and *the Pivka basin*. The main springs for these waters are located along the western fringe of *Ljubljana moor* (P. HABIC, 1982). There is the famous *polje of Cerknica* with its periodic lake, numerous springs on the southeastern and ponors in the central part and in the northwest side. In the year 1971 a sluice was built at the entrance of *the ponor*

cave Karlovica which has prolongated the lake phase from 6 to 7 months yearly. The purpose of that is to intensify the lake fishing and tourism. The alternation of the dry and the flood phases, which was in early modern times a matter of admiration for so many scientists still persists (I. GAMS, 1974).

In the Notranjsko podolje only the polje of Postojna - Pivka has bigger flysch area. The rivers draining the flysch have shaped many caves in Cretaceous limestone. The longest is *Postojnska jama* (19,5 km) which is the most visited European cave (since the discovery in 1818 more than 25 million of tourists). Other active caves are situated on the outlet side of the poljes (*Predjama* 7,5 km, *Karlovica* 7,3 km, *Tkalca jama* 2,8 km, *Najdena jama* 5 km, *Logarcek* 2,3 km, *Krizna jama* 8,1 km), rarely on the spring side (*Planina* 6,1 km, *Zelske jame* 3 km). The triangle territory among Postojna, Loz and Logatec on the 30 sq. km has 60 km long cave channels and this is the greatest cave density in Slovenia (I. GAMS, 1974; P. HABIC, 1982a).

The karst of Dolenjsko (Lower Carniola) belongs to the shallow out-flow through-flow karst of the inner Dinaric or Peripannonian belt. The surface is covered with thicker layer of the red karst soil, typical terra rossa, that has made possible denser population in more continuous tracts of agricultural landuse. Gentler forms, dolines, uvala like depressions, even small karst poljes and rounded hills, are predominant in the karst relief. Waters derive from the impervious and dolomitic rims of the karst areas and flow only at small depth under the surface or even in shallow open canyons.

c) **The isolated karst** in sub-Alpine and sub-Dinaric Slovenia is subdivided according to the geological, orographical and hydrographical characteristics into several homogenous isolated units. The hydrological significance of the isolated karst depends on the location and size of carbonate rocks. Both, the shallow and the deep, the out-flow and through-flow karst can be found in this part of Slovenia just as the impounded karst with syphons and the dome karst with the gravitational drainage on the underground waters.

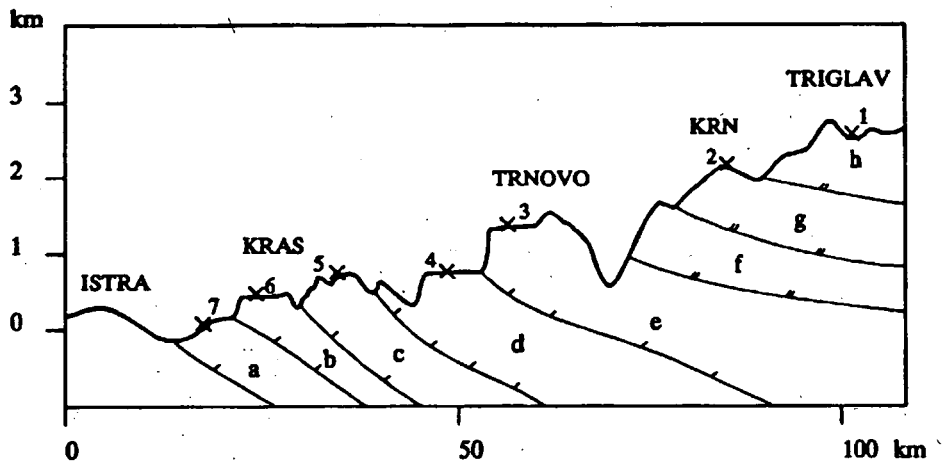
GEOMORPHOLOGICAL DEVELOPMENT OF THE DINARIC KARST

Morphological units accord nearly completely with structure units. In relief the structure got the greatest importance at the contact of permeable and impermeable rocks (contact karst) but also in disposition of singular shapes of relief on the karst surface (structural karst). In Eocene flysch and in Triassic shales and Permian sandstones erosion lowered the surface faster and was generally more efficiate than corrosion on the karstic areas. When calcareous regions were eliminated by tectonic degrees from general fluvial transformation, differences between karst and impervious regions increased. And so the following karstic evolution depended chiefly on different climatic conditions in particular periods.

Cone or stack-shaped karst hills are characteristic for the central highest part and we can range them in singular level with altitudes. Levels of stackshaped hills surprisingly accord also in different structural units, about which older geomorphologists throughout they are unequally dislocated with younger tectonic removals (A. WINKLER, 1957).

Dissection of relief in higher regions call the attention to particular morphogenetic processes, which succeeded in parcelling out the former surface into the relief of stack-shaped hills and closed dry valleys. Disposition of these forms do not accord with normal fluvial transformation, but to a large extent refer to the structure and karst dissection. According to the model and disposition of karst hills we can conclude that karst evolution of the central part of the High Karst began in close connection with climate condition in warm and moisten middle Pliocene or even Miocene era.

In the next phase of morphological evolution, flattenings predominated in border parts of the High Karst and so enormous pediplains sprang up in altitude about 800 and 900 m. On flat surface there are preserved rare isolated hills only, typical hums, which are characteristic also for similar karstic regions in lower Dinaric Karst. Remains of fluvial gravel on border plateaus of the High Karst prove very well that this area originated under the influence of surface running waters, which could periodically transport sand and gravel from impermeable border (P. HABIC, 1992).



Over-thrust units

a - Koper
b - Komen
c - Sneinik
d - Hru"sica
e - Trnovo
f - Kobla-Rut-Podmelec
g - Krn-Savinja
h - Triglav

Paleokarstic

1- Kredarica-Rz-Planika
2- Lanzevica-Gradic-Podrta gora-Krosnja
3- Lokavec
4- Nanos-Hrusica
5- Postojna-Pivka
6- Koblak-Fernetici
7- Crnotici

Figure 3 *Paleokarstic phenomena on the Slovenian karst (P. HABIC, 1992)*

Then followed a new phase in the development of the karst relief. On the borders of High karst intensive deepening of valleys predominated in impermeable areas. Carbonate regions were by degrees completely eliminated from transversal and border fluvial transformation. Karstic dissection did not begin at once in entire actual karst area. The highest karst regions are normally the oldest, and they were exposed to the greatest climatic changes, from wet warm to real mountainous climate.

The highest step formed relief is dissected into stack-shaped summits and into larger, gently or steep sloping dolinas - kontas. They are most frequent in the highest central Dinaric ridge, over 1200 m a.s.l. In the bottom of some kettles or "kontas" there are entrances into ice-caves and deep abysses, some among them surpass direct vertical of 200 m, and total deepness of 50 m.

Among the greatest karstic depressions in the highest part of High Karst belong kotli, doli and drage, depressions with diameter between 0,5 and 1 km, and depth from 100 to 300 m (Table 2). They are disposed at greater fault lines and very often on the limit between limestone and dolomite. In their deepening, accumulation and melting of ice had great importance, because all these depressions began on the limit between glacial and periglacial zone in cold periods of Pleistocene. Accumulation of ice is testified by moraine material that is still preserved in the bottoms and on the borders of mentioned depressions. Characteristic for these depressions is also temperature and vegetation inversion, which is accelerated not only by big altitude of 1250 m a.s.l. but also by karstic cavernosity with comparatively low summer temperatures and winter accumulations of snow.

In lower border plateaus and pediplains karstic transformation began later than in central part of High Karst. At first karstification advanced under fluvial sediments, progressively sand, gravels and also clays were eliminated and processes that are characteristic for bare karst predominated. In drought and warm periods, when calcareous surface was still covered by sands and clays, shallow and broad piedmont uvalas arose. After removal of sediments, especially in cold and wet periods of Pleistocene, local deepening of karst relief predominated. In uvalas and on the flat surface dolines began to rise, which are younger than uvalas and they do not follow evolutive form, originating on the junction with dolines, according to J. CVIJIC (1960).

In Periglacial zone fine formation of surface was important under the influence of frost and corrosion of bare rock. By formation of limestone pavement in this phase of karstic transformation also differentiation in relief is important, first of all owing to petrographic differences among limestones and especially among dolomites. Development of structural karst forms was accelerated in cold humid periods.

Post glacial corrosion transformation of karstic area covered with vegetation did not completely succeed in eliminating the traces of Würm high mountainous karst. Essential traces of former surface are preserved either in big, with periglacial and glacial material filled karstic depressions, where only smaller alluvial dolines are formed now, or in differently preserved limestone pavements where we can study the entire evolution of their destruction.

Consequently, relief of high Dinaric karst is the result of different transformation processes which made their influence felt from time in the Mio-Pliocene to geological present. Singular relief properties are due to climatic conditions. In warmer subtropical

Pliocene climate mostly plains, cone-shaped surface and karst poljes could originate. Cooler Pleistocene climate contributes to karst dissection by kettles, dolines, limestone pavements and thin superficial down cuttings. But only fluvial erosion-corrosional and climatically conditioned processes cannot explain all the relief properties of Dinaric Karst. Geostructural conditions and differentiated tectonic movements of particular geoblocks have to be considered too, forming particular morphotectonic units.

GEOMORPHOGENETICAL INTERPRETATIONS

Geomorphogenetical studies accentuated the successive development phases and prevailing processes as they could be noticed on the karst surface. Superficial transformation elapsed in relatively long post Eocene orogene period. Several epirogenetic phases followed when the rate between permeable and impermeable rocks changed considerably.

Post-over-thrust radial tectonics cut folded and thrusted rocks into big blocks and differently uplifted them. Erosion, that followed, removed thick layers of softer and more resistant rocks as well as the actual surface comprises different structural units and rarely corresponds to them. In general the surface on the impermeable rocks is more lowered and erosionally more dissected than on limestones or dolomites. The inverse altitude ratio is extraordinary. The impermeable areas controlled by normal superficial drainage are more lowered than the ones draining through the karstified borders.

In the inliers of impermeable rocks in the middle of the karst normal fluvial relief with local erosional base in the altitude of shallow-holes developed. Somewhere along them either smaller or bigger karst depressions, blind valleys and poljes appear, or the allochthonous superficial rivers cut their canyon-like beds in the karst surface. Different types of contact fluvio-karst were formed (I. GAMS, 1986).

Recent regional climatic conditions importantly controlled the genesis of the surface. They are evidenced in locations exposed to sun or sunless and in different altitudes above the sea, on the passage among mediterranean, submediterranean and continental mountain climate in particular. Morphological differences were carried into effect in cool Pleistocene conditions mostly, when the areas above 1300 m were permanently covered by snow and ice, and the surface above 600 m was bare as it is today above the upper forest line in the altitudes between 1600 and 1800 m.

Lower submediterranean areas are warmer and less wet, mean annual temperature above 10 °C, 500 to 1000 mm of rainfall, seldom in form of snow. On the highest ridges of Dinaric karst the mean annual temperatures are 5 °C with more than 3000 mm of rainfall, snow prevail in cooler half of the year, it can last from October to May, the blanket of snow is 1 to 2 m thick. High intensiveness of rainfall is morphologically important as more than 300 mm could fall in one day even. All the rainwater sink directly into karst. Superficial drainage relates to less permeable rocks, distributed among the limestones as partial or complete border or hanging hydrogeological barriers.

CORROSION INTENSITY

A lot of water contributes to intensive solution, lowering the karst surface from 30 to 150 mm in thousand years in average. In spite of different methods defining the corrosion intensiveness the values presented on the following table correspond well.

region	river basin	denudation rate (mm/1000 years)
Litoral karst	Vipava source	82 * 68 **
High karst	Hotenjka Idrijca, Idrija Podroteja Trebusa Ljubljanica	126 * 157 * 90 ** 90 * 65 *
Lower karst	Krka, Dvor	33 **

* - HABIC, 1968, pg. 21 ** - GAMS, 1966, pg. 54

Table 1 *Corrosion intensity in Slovenia*

Local corrosion effects do not depend on lithological base only but on pedo-cover, vegetation, altitude above the sea level and other factors (I. GAMS, 1992) among which the way of vertical percolation too. Infiltrated water joins into trickles and flows through crushed or less impermeable zones. The trickles are either permanent or periodical of various discharge. The rate between low and high discharge and between small and big trickles is 1:10.000 and more (P. HABIC & JANJA KOGOVSEK, 1979). The consequences of different washing off reflect in intensive karst dissection on the surface. In climatical and energy sense it is more intensive in higher than in lower positions. The dissection of higher karst is not due to solute processes only, but to mechanical weathering of limestones and dolomites in particular as well as to sheet erosion of the scree from the slopes into closed karst depressions or into hanging gullies.

The size of karst dolines on the chosen morphological unit from Sneinik, 3 times 4 km, is presented on the table 2.

type of doline	number	diameter (m)	depth (m)	surface in 10^3 m^2	volume in 10^3 m^3
A snow doline	124	10	5	0,3	0.5
B doline	57	25	10	2	6.5
C small kettle	34	50	20	8	50
D medium kettle	28	100	30	30	300
E big kettle	16	200	50	125	2000
F double kettle	1	400	80	500	13000
M.Ponikva, Bakar*	1	1000	150	600	30000
V.Ponikva, Bakar*	1	1400	180	1200	72000
Praprotna draga*	1	2000	210	6000	150000

* comparative size of the biggest depressions in the high karst

Table 2 *Number and size of karst dolines on Sneinik mountain*

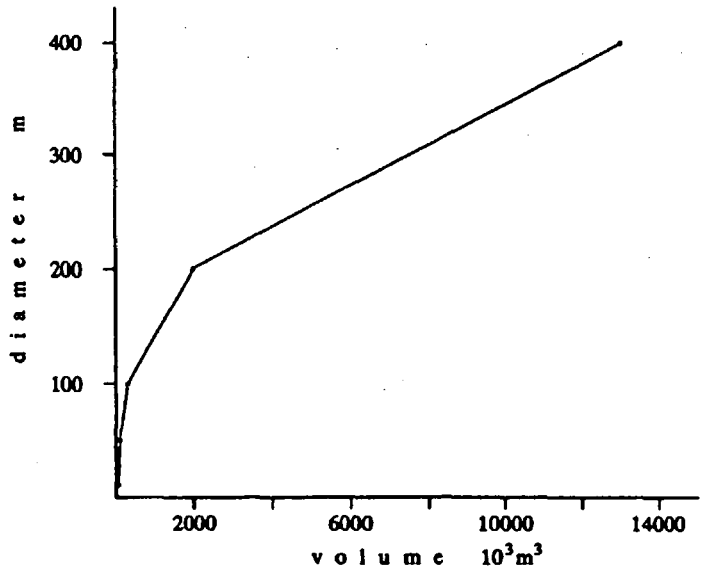


Figure 4 *Karst dolines in High karst (Sneinik mountain): relation between diameter and volume*

CONCLUSION

The geomorphogenesis of the Dinaric karst in Slovenia is based on previous knowledge about the origin and development of Classical Karst. According to relief, hydrographic and speleological properties the area became famous in past century. Geomorphologists J. CVIJIC, A. MELIK, J. ROGLIC and I. GAMS studied it among the others. They were followed by younger researches who deepened their knowledge by new results.

Today we think that he surface among Tertiary Pannonian basin, Alps and Adriatic Sea was formed some time about the Pliocene onwards. First deciding factors were morphogenetical influences from the impermeable vicinity when the waters ran off superficially over the impounded carbonate rocks. Later tectonical movements contributed to surface transformation and to karst dissection, dismembering and differently uplifting the particular carbonate blocks. geological basement including differently resistant lithological links and tectonically broken rocks played an important role while shaping their corrosional and erosional relief. Beside the above mentioned factors, climatically controlled processes in Tertiary and Quaternary transformed the karst relief significantly. Their influences are seen in the distribution of conical-shaped hills, wide pediments, karst peneplains, poljes and uvalas, deep dales, kettle-funnelor dish dolines and thinly corroded surface. Geomorphological influences from the impermeable vicinity are preserved in forms of contact fluviokarst, in canyon, steep-head and blind dolines and in the remains of fluvial or marine sediments, loam, sand and gravel which are preserved on the karst surface and its underground.

According to the predominating relief properties the NW Dinaric karst is divided to three basic morphogenetical units and the division continues to smaller parallel dinarically oriented stripes which are mainly tectonically conceived. Each unit distinguishes by singular complex of karst forms.

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