GEOMORPHOLOGICAL CLASSIFICATION OF NW DINARIC KARST

GEOMORFOLOŠKA ČLENITEV NW DINARSKEGA KRASA

P E T E R   H A B I Č

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Abstract UDC 551.44 (234.422.1)

Habič, Peter: Geomorphological classification of NW Dinaric karst

The survey of important geomorphological studies and the situation of NW Dinaric karst is presented, followed by its geomorphological classification and morphological properties of three basic belts: lower Periadriatic, higher central and lower internal or Peripannonian karst. Everywhere different traces of Tertiary tropical planation and dissection and later more arid karst pediplanation are preserved. In the karst relief the features of younger Quaternary corrosional, periglacial and glacial deepening as well as erosional transformation of canyon like fluvial valleys are seen. Morphological differences among the belts are controlled by different geological setting and different intensity of morphogenetical processes.
Key words: karst, geomorphology, relief classification, Dinaric karst, Slovenia

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Habič, Peter: Geomorfološka členitev NW Dinarskega krasa

Podan je pregled pomembnejših geomorfoloških študij in položaj NW Dinarskega krasa, sledi njegova geomorfološka členitev in prikazane so morfološke značilnosti treh temeljnih pasov: nižjega perijadranskega, višjega osrednjega in nižjega notranjega ali peripanonskega krasa. Povsod so ohranjeni različni sledovi terciarnega tropskega uravnavanja in razčlenjevanja ter kasnejše bolj aridne kraške pediplanacije. V kraškem reliefu so vidne poteze mlajšega kvartarnega korozijskega, periglacialnega in glacialnega poglabljanja kraških globeli pa tudi erozijskega oblikovanja kanjonskih rečnih dolin. Morfološke razlike med pasovi so pogojene z različno zgradbo in različno intenzivnostjo morfogenetskih procesov.
Ključne besede: kras, geomorfologija, klasifikacija reliefa, Dinarski kras, Slovenija

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INTRODUCTION

In Slovenia the Dinaric karst passes between the Adriatic and Pannonian basin into Pre-alpine and Alpine mountains. 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 free limestones and dolomites were exposed to further karst transformation.

There are shapes preserved in relief which should originate in different climatic conditions. Differentiated exposure of variously resistant rokcs 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 Middle Pliocene onwards. On small surface, karst in southern Slovenia comprises some thousands of square kilometers only, morphologically extremely heterogeneous surface developed, that deserves a special professional treatment.

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.CVIJIĆ (1893, 1926, 1960). His treatises are essential as numerous younger researchers followed his examples. The CVIJIĆ's scheme of cyclic development of karst surface is known. After him J.ROGLIĆ became famous at home and abroad (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 formerly 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 water retention on the surface. The mentioned three researchers critically summarized older works on karst that is why we shall not mention them in particular.

Interesting data about the intensiveness of recent solute processes in Slovenia were gathered by I. GAMS (1965, 1966, 1980, 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 (1962, 1973, 1978, 1986).

General geomorphological karst development in Slovenia was presented by D. RADINJA (1972), who analysed the karst of Divača (1967) and Doberdob (1965) in detail. The impact of climate on relief formation in Slovenia tried to define M. ŠIFRER (1967, 1972, 1984, 1990). He emphasized the difference between Pliocene tropical and Pleistocene periglacial and glacial formation of the relief. Structurally and tectonically controlled forms in Dinaric karst were beside morphological and hydrographical classifications and regional morphogenetic studies the subject of P. HABIČ researches (1968, 1978, 1980, 1981, 1982, 1986, 1990).

Among the important treatises on karst underground development let us mention the work of S. BRODAR (1952) who tried to enlighten the genesis of caves on Pivka by paleolithic researches. R. GOSPODARIČ (1976, 1982, 1986) widened and deepened the speleogenetical knowledge by chronostratigraphy of cave sediments. Other studies will be mentioned in connection with concrete problematics.

GEOMORPHOLOGICAL SITUATION AND PREVAILING PROCESSES

The Dinaric karst surface reaches its highest peak in Snežnik (1797 m) and its lowest one in Karst of Doberdob (below 100 m) and in Istria, on the sea level even. Lower karst plains are distributed up to 600 m, higher karst plateaus reach the altitudes between 800 and 1400 m, still higher there are some peaks or ridges only.

Between Gorica and Tolmin karstified Mesozoic rocks underlie the Cretaceous and Eocene flysch that is why further towards NW fluvial erosional mountainous relief prevails. Karst plateaus are built by Paleocene, Cretaceous and Jurassic limestones and Upper Triassic dolomites mostly (Fig. 1).

Between the basins of Ljubljana and Krško the karst plateaus pass into pre-alpine hills. The surface lowers in steps, the karstified Mesozoic rocks sink under the Oligo-Miocene marine, lacustrine and fluvial sediments on the east. On the border of Pannonian basin the traces of Pliocene weathering and the remains of former huge Miocene sediments on the karstified limestones are preserved.

The surface among Alps, Panonnian basin and the Adriatic was formed by waters that flew on both sides from the mountains. The waters from Soča river basin are nowadays still oriented towards the

Adriatic Sea from the karst along the Trieste and Kvarner Bay. The waters from Sava river basin flow towards distant Black Sea. In Pliocene between the Posočje and Posavje there was low superficial watershed. Today the underground waters from Dinaric karst flow to both sides at the same time.

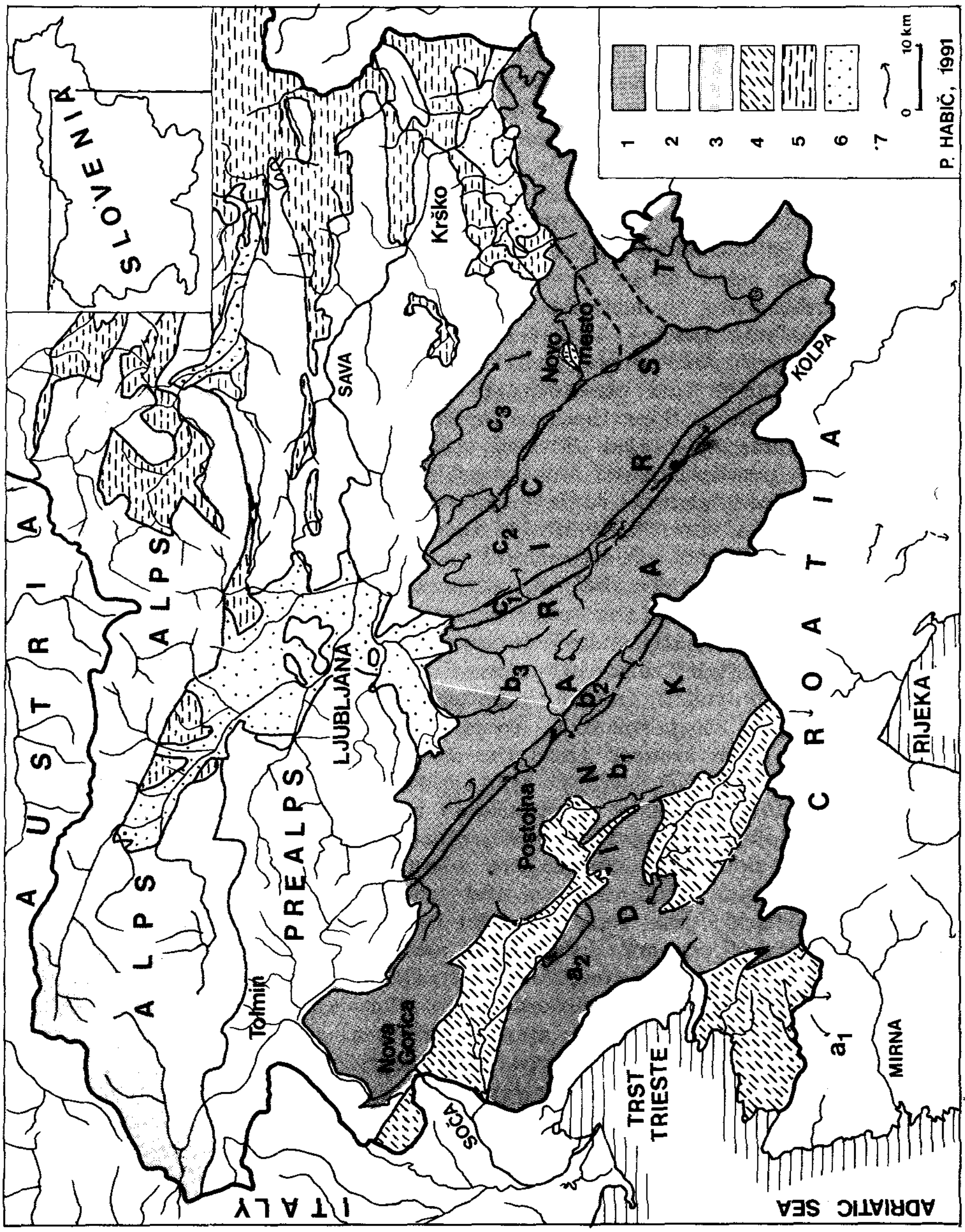
During the geomorphological development the watershed line changed under the influence of erosional processes and tectonical upliftings and subsidences. Older geomorphological studies assigned to this question quite a lot of attention, but the reconstruction of the former fluvial net is not simple and the views of particular researchers differ. What are the relief forms developed by former superficial streams is the question remaining unsolved in particular. Did on carbonate rocks prevailed normal fluvial formation in the first place followed by karst processes later? 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, in Brkini f.e., it is mostly tectonically controlled, as f.e. between Suha krajina and Posavsko hribovje. 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 swallow-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).

Local 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. On some exposed positions the actual upper forest line is lowered to 1300 m even.

Lower submediterranean areas are warmer and less wet, mean 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 about 5° C with more than 3000 mm of rainfall, snow


AUSTRIA
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PREALPS
DINARIC KARST
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SAVA
Krško
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KOLPA
Postojna
Nova Gorica
Tolmin
SOČA
TRST TRIESTE
MIRNA
RIJEKA
ADRIATIC SEA
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2
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P. HABIČ, 1991

prevails 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, exceptionally 500 mm (J. ROGLIĆ, 1965). All the rainwaters sink directly into karst. Superficial drainage relates to less permeable rocks, distributed among the limestones as partial or complete border or hanging hydrogeological barriers (M. HERAK, 1971).

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.

Table 1: Corrosion intensity

River basin	lowering in mm per 1000 years		
Vipava source	82	*)	- (HABIČ, 1968, 217)
	68	**)	- (GAMS, 1966, 54)
Hotenjka	126	*)	
Idrijca, Idrija	157	*)	
Podroteja	90	**)	
Trebuša	90	*)	
Ljubljanica	65	**)	
Krka, Dvor	33	**)	

Local corrosion effects do not depend on lithological base only but on pedo-cover, vegetation, altitude above the sea level and other

Fig. 1: The situation of Dinaric karst in Slovenia
1 - NW Dinaric karst, Mesozoic carbonate rocks
2 - Pre-alpine mountains with isolated karst, Palezoic, Mesozoic and Cenozoic rocks
3 - Julian and Kamnik Alps with High karst, Mesozoic Cenozoic carbonate and noncarbonate rocks
4 - Eocene flysch
5 - Oligomiocene beds
6 - Plioquaternary sediments in the basins
7 - sinking rivers
a,b,c - explanation in text

Slika 1: Položaj Dinarskega krasa v Sloveniji
1 - NW Dinarski kras, mezozojske karbonatne kamnine
2 - Predalpsko hribovje z osameljenim krasom, paleozojske, mezozojske in kenozojske kamnine
3 - Julijske in Kamniške Alpe z visokogorskim krasom, pretežno mezozojske in kenozojske kamnine
4 - eocenski fliš
5 - oligomiocenske kamnine
6 - pliokvartarne naplavine
7 - ponikalnica
a,b,c - pojasnilo med tekstom

factors (I. GAMS, 1965, 1966) 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. HABIČ & J. KOGOVŠEK, 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 depressions on the chosen morphological unit Planinec south from Snežnik, 3 times 4 km, is presented on the Table 2.

Table 2: The comparison between number and average size of karst depressions on Planinec (Notranjski Snežnik)

type of doline,	number,	diameter, m	depth, m	surface in, $10^3 m^2$	volume in 10^3 m^3
small kettle	124	10	5	0,3	0,5
doline	57	25	10	2	6,5
small kettle	34	50	20	8	50
medium kettle	28	100	30	30	300
big kettle	16	200	50	125	2.000
double kettle	1	400	80	500	13.000
M.Ponikva,Bakar *)	1	1000	150	600	30.000
V.Ponikva,Bakar *)	1	1400	180	1.200	72.000
Prapratna draga *)	1	2000	210	6.000	150.000

*) comparative sizes of the biggest depressions in the high karst

The distribution and size of vertical drainage channels in karst decisively influenced the distribution and shape of karst depressions.

GEOMORPHOLOGICAL CLASSIFICATION OF DINARIC KARST

The author of the first geomorphological classification of Dinaric karst CVIJIĆ (1918) distinguished the virtual karst or holokarst and partial karst or merokarst. In his last, unfinished karst classification (1926) CVIJIĆ divided the morphological types according to landscape: - Tržaški Kras - Karst of Carniola - Karst around Lika and Karlovac - Karst of big karst poljes in western Bosnia - Kistanje karst surface with islands ridge and - karst of Hercegovina and Montenegro.

J. ROGLIĆ (1965) divided the Dinaric karst according to main morphological forms and processes:

- the interior fluviokarst,
- the central, virtual Dinaric karst and
- corrosion plains developed in the altitude of impounded karst.

M. HERAK (1977, 1986) distinguished from geotectonical point of view:
- orogenic folded, dissected and accumulated karst and
- epirogenetic basin and platform tabular karst.

According to this classification in Dinaric karst he differs:
- Adriatic belt with faulted folds of carbonate rocks and flysch, belonging to dissected and accumulated karst,
- High karst belt where overthrust tectonics with neotectonic uplifts and subsidences prevail,
- Interior belt he divided further into two parts:
  a) border low part of the carbonate platform,
  b) karst of the Inner Dinarids.

Our hydrographic and speleological division of the karst follows these structural properties in the landscape units of Slovenia (P. HABIČ, 1969, 1982) as it follows:
a) Littoral Karst or outer Periadriatic karst,
b) Karst of Notranjska or central High karst
c) Karst of Dolenjska or inner Peripannonian karst.

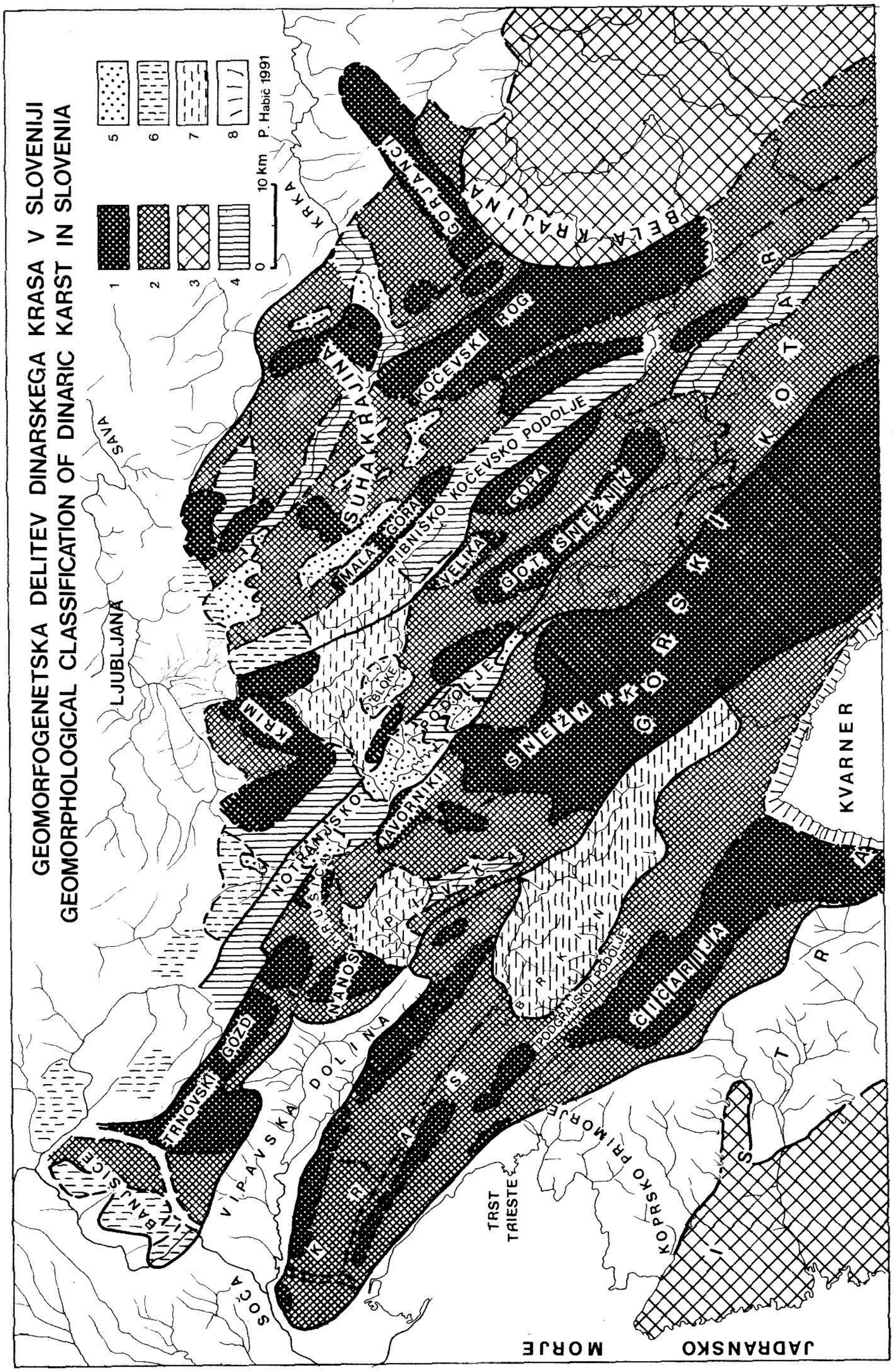
In small scale different morphological units alternate in longitudinal Dinaric zones. Particular zones are dissected in longitudinal and transverse units as the parts were differently uplifted or subsided, they have different lithology or they reflect different morphogenetical influences from the vicinity. Fluvial, fluviokarstic and karstic processes of planation or dissection came into force in particular structural units by various ways either regarding the time or the intensiveness.

The basic three longitudinal zones can be further on divided by common mophogenetical properties (Fig. 2).

Outer Periadriatic karst is divided to:
a_1) Low Istrian karst
a_2) High Trieste-Liburnian karst.

The limit between them is structural along the flysch border of Trieste Bay and Northern Istria. The limit between Periadriatic and central Dinaric karst is Vipava - Brkini - Vinodol flysch belt overthrusted by the High karst. According to Herak's tectonical regionalisation the first Periadriatic zone belongs to Adriatic and the second one to Periadriatic.

The central high Dinaric karst is divided in longitudinal sense along the fault zones to:
b_1) Western High karst, from Banjšice to Snežnik and Gorski Kotar,
b_2) Notranjska, plain and poljes


GEOMORFOGENETSKA DELITEV DINARSKEGA KRASA V SLOVENIJI
GEOMORPHOLOGICAL CLASSIFICATION OF DINARIC KARST IN SLOVENIA
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P. Habič 1991
LJUBLJANA
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SUHA KRAJINA
MALA GORA
RIBNIŠKO KOČEVSKO PODOLJE
VELIKA GORA
KOČEVSKI ROG
GORJANCI
BELA KRAJINA
GOT. SNEŽNIK
SNEŽNIK
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NANOS
TRNOVSKI GOZD
VIPAVSKA DOLINA
BANJŠICE
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TRIESTE
KOPRSKO PRIMORJE
ČIČARIJA
KVARNER
JADRANSKO MORJE

b_3) Eastern High karst, from Krim over Bloke, Potočanska high plateau to Goteniški Snežnik and Velika gora of Ribnica and Kočevje.

The inner Peripannonian karst is divided into three longitudinal zones:
c_1) Western Dolenjska along Mišji dol - Želimlje fault zone including Ribnica and Kočevje basin
c_2) Mala gora of Ribnica and Kočevje, Dobrepolje, western Suha krajina and Kočevski Rog with Poljanska gora belong to the higher western Dolenjska karst
c_3) Eastern Suha krajina with Novo mesto basin, Podgorje and western Gorjanci Mts and Bela krajina belongs to lower eastern part between Žužemberk and Temenica lowered surface.

The width of longitudinal zones varies, in average there are about 15 km across. Within the particular zones there are more narrow or less parallel, from 1 to 5 km wide, belts of higher and lower surface. The ridges and lowered surface and wider belts are tectonically controlled along the longitudinal faults.

The longitudinal dissection is less distinctive on the lowest outer zone of Istria and in the inner karst of Bela krajina. In tectonically active the highest central part the longitudinal belts are more distinctive. Longitudinal ridges and interlying dales are tectonically controlled but morphologically better expressed, as in higher uplifted zone local differentiated erosion and karstification previously prevailed. In lower parts the influences from impermeable vicinity endured longer and contributed to prevalent solution, as it exists on karst poljes still nowadays.

Longitudinal dinaric zone are faulted transversely on several parts, they are variously uplifted and separately morphologically dissected. Transverse faults and relief incision are hydroghraphically important. There the waters from longitudinal zone flew transverselly on both sides. Transverse faults are restricted to particular belts, rarely they cut several belts and exceptionally two parallel zones. The cited structural properties decisively influenced the pattern and distribution of geomorphological units inside the particular zones and belts.

Superficial runoff through the longitudinal lowered surfaces and among higher uplifted ridges was possible, as it exists still nowadays there, where the carbonate rocks are impounded by permeable or badly permeable rocks. On the Adriatic side such barrier is presented by

Fig. 2: Geomorphological classification of NW Dinaric karst
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 - littoral tectonic karst scarp

Slika 2: Geomorfološka delitev NW Dinarskega krasa
1 - višji kopasti kras
2 - robne in pedimentne kraške uravnave
3 - nižji kraški ravniki
4 - podolja s kraškimi ravniki
5 - kraška polja
6 - kontaktni fluviokras
7 - fluvialni relief sredi krasa
8 - obalna tektonska kraška reber

Eocene flysch, in the interior by tectonically crushed dolomites and older Carboniferous, Permian and Triassic as well as younger Neogene clastites.

Formation of surface on carbonate rocks and their karstification conformed to erosional lowering of impermeable barrier and to tectonical uplifting of longitudinal and transverse structural units. Each zone is distinguished for morphogenetical properties connected to geological setting, to relief energy and to consecutive alternating of intensiveness of erosion denudation and karst solution processes.

MORPHOGENETICAL PROPERTIES OF THE BELTS

a_1) ISTRIAN KARST

Istrian karst plain is enclosed from three sides by the sea and from the fourth one by the flysch. The surface on Cretaceous and Jurassic limestones is levelled by corrosional and denudation processes in relatively low position. The contact karst around Buje evidences the former normal superficial drainage from flysch over the limestones (I. GAMS,1986). The karst of Istria is relatively modestly karstly dissected the fact being connected maybe either by arid climate or by slight tectonic uplift.

Relatively thick layer of red soil (L. MARIĆ, 1964, K. URUSHIBARA, 1976) is preserved on the Istrian karst giving to the landscape the character of the Red Istria. Among the karst depression forms bowl-shaped dolines and shallow ouvalas by accumulated loam bottom prevail (P. Habič, 1978). On higher lying areas the dolines are more dense, as obviously these areas were exposed to vertical karst washing off earlier. In central littoral lower belt there are characteristic low hills, residual hills, which are presented along the coast in a form of attractive series of islands (Brioni and Medulin near Pula and the islands between Rovinj and Poreč).

a_2) TRIESTE OR CLASSICAL KARST

Trieste karst among Gorica plain, Vipava valley and flysch Brkini hills belongs to upper Periadriatic karst. The longitudinal ridges on the plateau-like karst surface reach from 100 m a.s.l. near Doberdob to 500 m a.s.l. in Podgrad area. On wide pediplain there are two parallel lowered surfaces bordered on both sides by higher longitudinal, sigmoid ridges. The karst plain was formed by the superficial waters flowing from flysch Brkini hills which later deepened blind valleys into the limestones of Podgrad area and Vreme valley where today the Notranjska Reka sinks into the underground of Škocjanske jame. The Quaternary development of the caves was studied by R. GOSPODARIČ (1984). The remains of sediments from flysch on the karst surface evidence the former superficial flows (D. RADINJA, 1966, 1967, 1969, 1974) (Fig. 3).

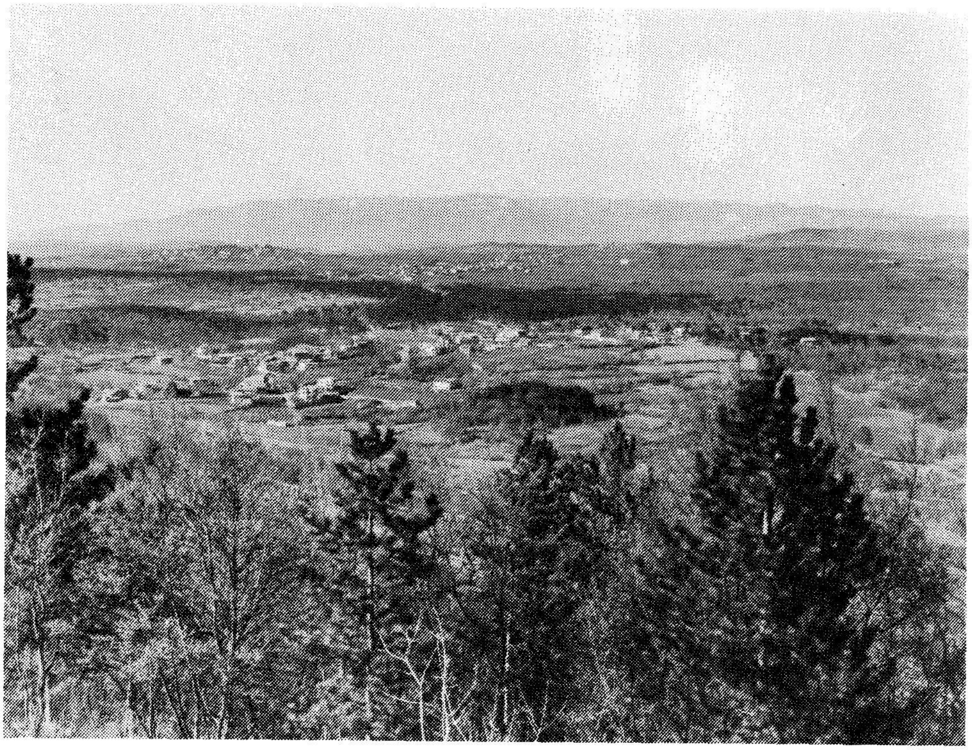

Fig. 3: Classical karst surface (a_2) between Sežana and Tomaj, levelled by erosion -corrosion and pediplanation. In background higher karst plateau Trnovski gozd (b_1).
Slika 3: Erozijsko-korozijsko in pediplanacijsko uravnano površje matičnega Krasa (a_2) med Sežano in Tomajem. V ozadju kraška planota Trnovskega gozda (b_1)

b_1) THE WESTERN HIGH KARST

The Plateau of Banjšice and Trnovski gozd

Banjšice, Trnovski gozd, Nanos with Hrušica, Pivka and Javorniki with Snežnik Mt. belong to the Western High karst. The plateaus are encircled by deeply cut valleys and they reach the altitudes from 600 to almost 1800 m. The western border of Banjšice plateau is morphologically and tectonically dissected. The superficial river net partly remained preserved on the flysch rocks. On the Cretaceous and Jurassic limestones and on the Upper Triassic dolomites the karst prevails absolutely.

On the eastern side the fluviokarstic flysch Banjšice pass into the karst surface of Lokovec between 800 to 1000 m a.s.l. Dry Čepovan valley, about 300 m deep, is downcut into this surface. Eastwards the

Fig. 4: Dry Čepovan valley, cut down into Trnovsko Banjšice karst plateau (b_1) at the foot of Julian Alps, remained hung above the Idrijca valley on the north and Vipava on the south.
Slika 4: Suha Čepovanska dolina, zarezana v Trnovsko-banjško kraško planoto (b_1) ob vznožju Julijskih Alp, je obvisela nad dolino Idrijce na severu in Vipave na jugu.

Voglarji plateau, ressembling Lokovec, continues by steep flank into flysch Vipava valley. Among the sigmoid summits of Lokovec the fluvial sands and gravels deposited by the former flows from the Julian Pre-Alps, are preserved (Fig. 4).

The central ridge of Trnovski gozd is the highest in conical-shaped peaks of Golaki (1495 m) lowering in steps to the border treads on the Idrija and Vipava sides. Conical-shaped summits and intermediary ouvalas developed by limestone weathering and by superficial and karst debris washing off. In cooler Pleistocene periods the waters deepened karst depressions mostly. In the central ridge there are in kettle-shaped dolines, more than 100 m deep, remains of glacial scree. Similar forms are found elsewhere in the high karst. In lower positions the characteristical forms of subglacial nival forms are found. On corroded limestone pavements there are deep rounded solution runnels passing to the roche moutonées surface. The debris of weathered cherts among the limestones is morphologically important (P. HABIČ, 1968). More soil and agricultural surfaces are preserved there.

Pivka and the border

Pivka is transitive region between the Trieste karst and Notranjska lowered surface and an important gap in the ridge of the High karst. Around the flysch bottom, lying from 510 to 560 m a.s.l., different morphological units are distributed (Fig. 5). On the flysch smaller independent lost river basins developed. In the valleys there are several generations of quaternary sediments, in denudation ridges among the valleys the erosional relief corresponds to the structure of the flysch base.

Morhological development is connected to the underground runoff through the karst border (P. HABIČ, 1989). Cave sediments in the border limestones were studied in detail by I. GAMS (1965a), R.GOSPODARIČ (1976, 1986) and F. HABE (1970, 1976), the development of the surface on

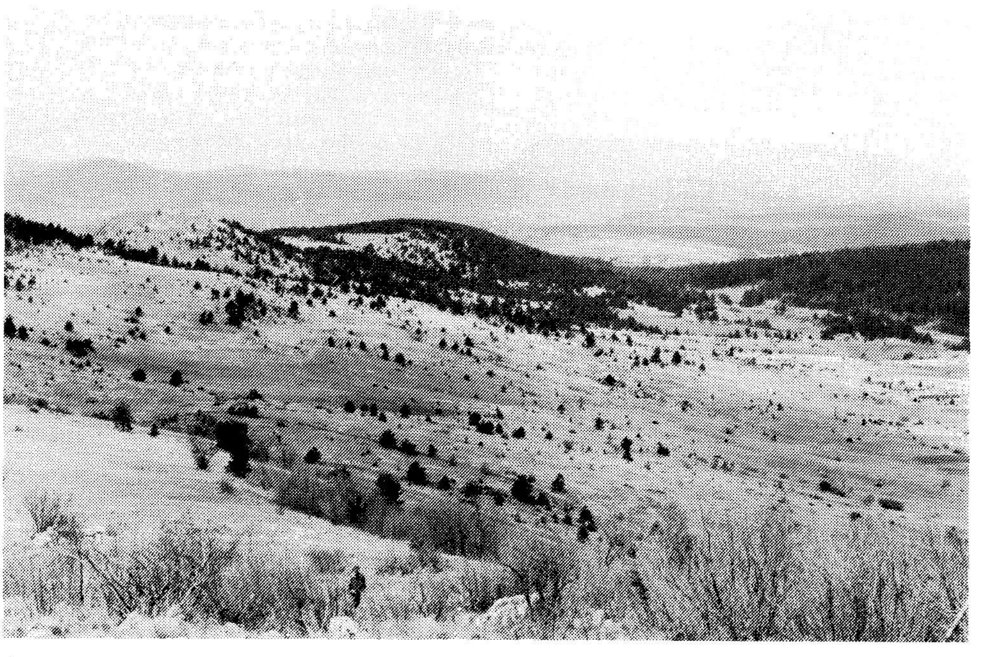

Fig. 5: Along the karst Pivka valley and Postojna valley (in the center) the pediment plains are distributed in the steps, passing in steep flanks into higher conical karst plateau of Javorniki. In the background Nanos karst plateau.

Slika 5: Ob kraški dolini Pivke in ob Postojnski kotlini(v sredini) so stopnjasto razporejene pedimentne ravnice, ki s strmimi rebrmi prehajajo v višje kopasto kraško planoto Javornikov. V ozadju kraška planota Nanos.

the outflow side of Pivka and on the border of Planinsko polje was studied by F. ŠUŠTERŠIČ (1978).

The impermeable flysch impounded the waters and influenced the formation of karst on the inflow Pivka side. In pediment plain there are periodically flooded ouvalas, up to 50 m deep, with flat rocky bottom in the altitude of high karst waters runoff (P. HABIČ, 1987). In higher border there are older pediments. Above the Pivka basin the pediment lies on the altitude of 590 m. It is not yet clear where Pivka sank in upper level of Postojnska jama at that time or did it flow on the surface over the Postojna gap. On the karst plain along Pivka there are ouvalas, up to 50 m deep, periodically flooded. In karst incisions lacustrine carbonate loams are preserved which were ranged to the transition from Pliocene to Pleistocene according to palinology. According to these data the old Pivka bottom is Quaternary. Higher pediments along the western foot of Javorniki Mt. are consequently older. Above them karst surface of Javorniki and Snežnik with traces of dissection in three phases lie (P. HABIČ, 1980). According to morphological properties they are considered to have Pliocene or even older origin (Figs. 6, 7).

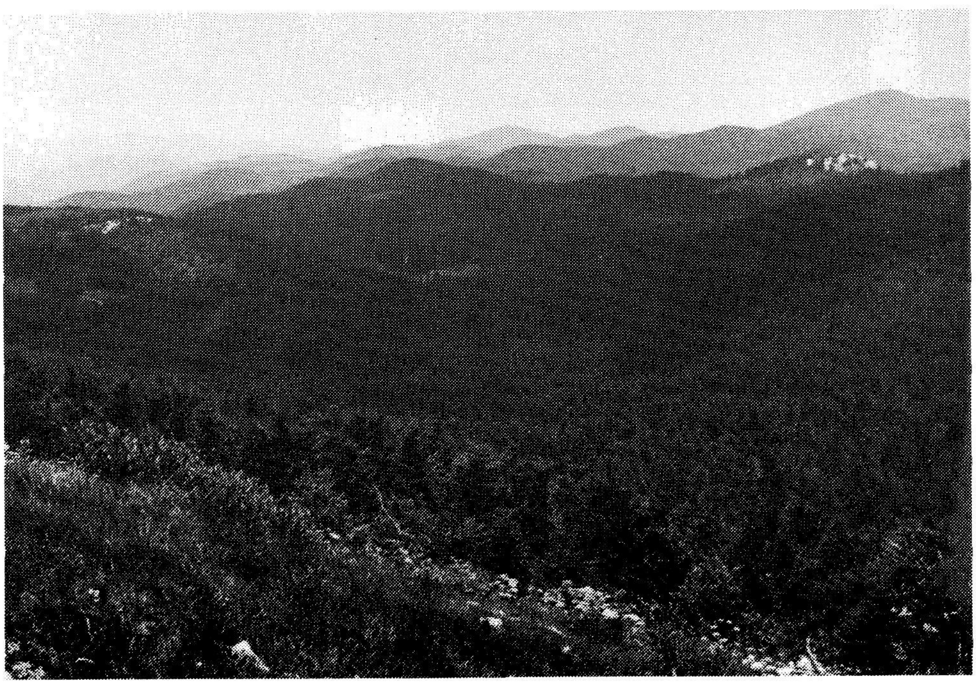

Fig. 6: Karst Javorniki (b_1) with typically distributed conical summits, interjacent dry valleys and ouvalas on the western border of Pivka

Slika 6: Kraški Javorniki (b_1) z značilno razporejenimi kopastimi vrhovi, vmesnimi suhimi dolinami in uvalami na zahodnem obrobju Pivke.

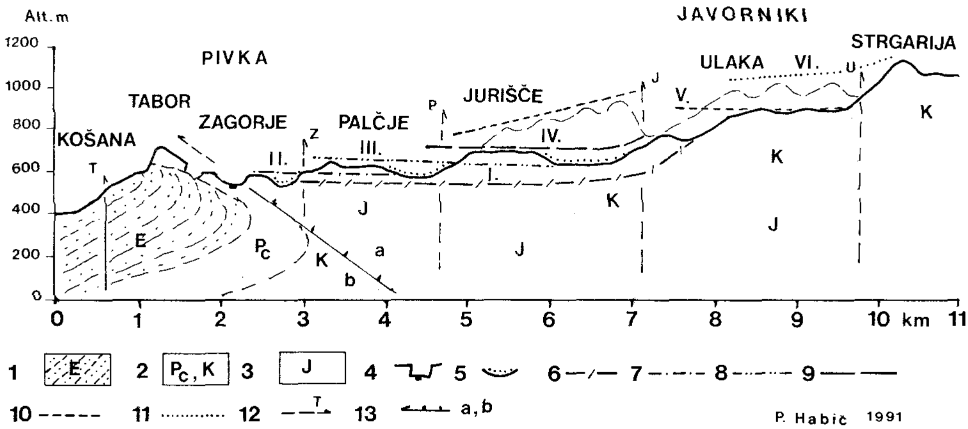

Fig. 7: Morphological cross-section of Upper Pivka and western Javorniki
1 - Eocene flysch
2 - Paleocene and Cretaceous limestones
3 - Cretaceous and Jurassic limestones
4 - karstified Pivka valley
5 - lacustrine and pediment ouvalas
6 - alluvial fan of Koritnica, Quaternary glacis (I)
7 - pediment of Zagorje (II)
8 - Palčje pediment (III)
9 - Rožanec pediment (IV)
10 -Jerusi conical-shaped surface (V)
11 -Javorniki conical-shaped surface (VI)
12 - fault: T - Tabor, Z - Zagorje, P - Palčje, J - Jurišče, U - Ulaka
13 - over-thrust, nappe: a - Javornik - Snežnik, b - Komen

Slika 7: Morfološki prerez Zgornje Pivke in zahodnih Javornikov
1- eocenski fliš
2- paleocenski in kredni apnenci
3- kredni in jurski apnenci
4- zakrasela dolina Pivke
5- jezerske in pedimentne uvale
6- Koritniški vršaj, kvartarni glacis (I)
7- Zagorski pediment (II)
8- Palški pediment (III)
9- Rožanski pediment (IV)
10- Jeruško kopasto površje (V)
11- Javorniško kopasto površje (VI)
12- prelom: T- taborski, Z-zagorski, P-palški, J-juriški, U-ulaški
13- nariv, pokrov: a -javorniško snežniški, b - komenski

Javorniki and Snežnik

Javorniki and Snežnik Mt. are composed by several conical elevations cut by steep flanks, dolines and ouvalas. Southwards the Snežnik is cut by steep edge along the flysch Bistrica basin and the valley of Notranjska Reka and on the eastern side by steep flank along the Notranjska plain and poljes.

Javorniki and Snežnik had similar development as Trnovsko-Banjška plateau which could be deduced after fine dissection and formation of particular morphogenetical units. The karst depressions reflect long lasting karstification. The effects of glacial and periglacial transformations are expressed. At surface dissection tectonic ruptures are seen and along them particular structural units are either uplifted or subsided.

b_2) THE NOTRANJSKA PLAIN AND POLJES

The longitudinal belt of lower karst surface in the central high karst is connected to regional Idrija fault zone according to geological setting. L. PLACER (1982) wrote about the form and genesis of this zone around Idrija. In the area karst plains prevail, and karst poljes, Planinsko polje, Cerkniško, Loško and Babno polje near Prezid are deepened in them. Karst poljes are tectonical and erosion-corrosional depressions. The last segments of former flows which had formed the whole plain, are preserved in them (Fig. 8).

Karst dissected polje's bottom is covered by Quaternary sediments, they are found in the outflow cave channels even (A. MELIK,

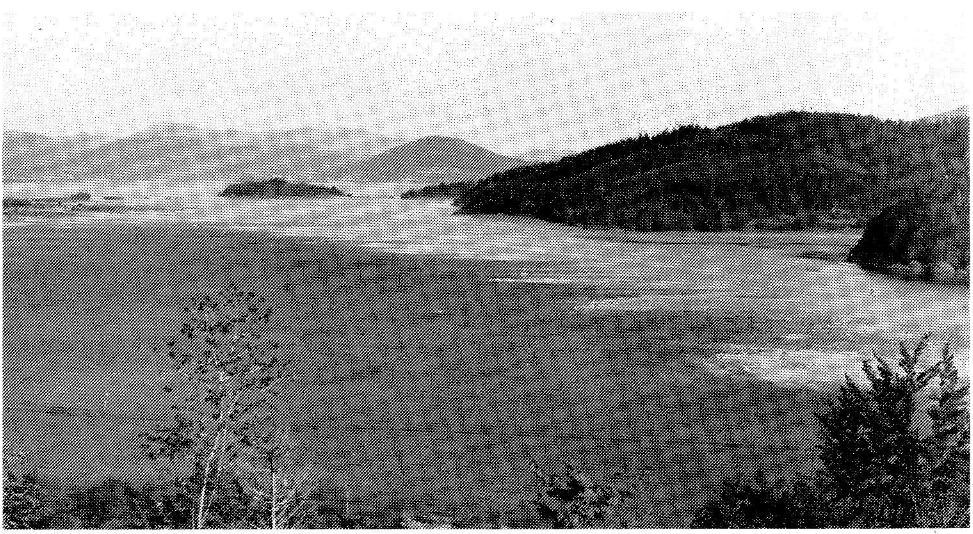

Fig. 8: The intermitten Cerknica lake on Notranjska karst polje (b_2)
Slika 8: Presihajoče Cerkniško jezero na kraškem polju v Notranjskem podolju(b_2).

1955, R. GOSPODARIČ, 1970). On Cerkniško and Planinsko polje there were several phases of deepening and accumulation phases evidenced connected to Pleistocene climatical oscillations and tectonical subsidences. Till now in the bottom of the poljes no traces of Pre-Quaternary sediments were found. By pediment plains on the border one can conclude that the planations belong to Upper Pliocene at least and not to Quaternary as it was meant by I. GAMS (1973).

The former fluvial transformation of the peneplain did not leave distinctive traces in the form of typical fluvial terraces or uninterrupted valley's bottom. The old surface is tectonically, erosionally and karstly dissected and it is extremely difficult to reconstruct the uniform levelled surface. The former superficial streams on the plain are more reliably indicated by the remains of fluvial allochthonous sediments.

b_3) THE EASTERN HIGH KARST

The outset of this zone is for some ten kilometers displaced towards southeast owing to the right wrench-fault along the Idrija fault. The karst surface reaches the altitudes from 600 to 1200 m. From the both longitudinal sides it is tectonically cut. In inliers of impermeable rocks the fluvial relief prevails. With exception of Iška and Kolpa, the water flows from it through the karst border. On the contact characteristic forms of contact fluviokarst developed.

In well karstified limestones the relief ressembles to the one in the Western High karst. In predominantly dolomitic areas typical fluviokarstic relief prevails with longitudinal ridges and shallow wide depressions.

c) PERIPANNONIAN KARST

Compared to the High karst the plateau like surface is 300 to 400 m lower, the ridges only reach the altitudes between 800 to 1000 m, the majority of low karst plain lies between 150 to 400 m. With exception of Kočevski Rog, the higher ridges are limited to narrow longitudinal zones, as is Mala gora between Ribnica and Dobrepolje plain. The alternation of longitudinal ridges and interlying narrow valleys is characteristic for the whole Suha krajina (P. HABIČ, 1988). Morphological curiosity of this zone presents the transverse ridge of Gorjanci between Novo mesto basin and Bela krajina.

c_1) THE WESTERN DOLENJSKA PLAIN

Ribnica and Kočevje plains are deepened along the Želimlje - Mišji dol fault zone. The difference in lithological structure and lower, more opened vicinity on the eastern side facilitated the underground runoff in the transverse direction. That is why in this area no bigger karst poljes developed. A wide karst plain spreads out from impermeable rocks near Velike Lašče towards Kolpa. Among the longitudinal belts a narrow ridge of Mala gora, more than 900 m high (A. KRANJC, 1981) is well seen and on the other side lies low Dobrepolje karst plain. The superficial Rašica contributed to its development (M. ŠIFRER, 1969) while the form and situation are tectonically conceived.

c_2) THE WESTERN SUHA KRAJINA AND KOČEVSKI ROG

The area starts on the north-west by the contact karst polje of Grosuplje and continues towards concave Western Suha krajina and Kočevski Rog up to Karlovac karst plain on the other side of the Kolpa river in the altitudes between 150 to 200 m. The whole zone is tectonically bordered, evidenced in longitudinal and transverse flanks. Big number of karst ouvalas morphologically distinguishes it from other karst belts of the Dinaric karst (P. HABIČ, 1988). The underground waters between Ribnica polje and Krka valley contributed to their origin (Fig. 9).

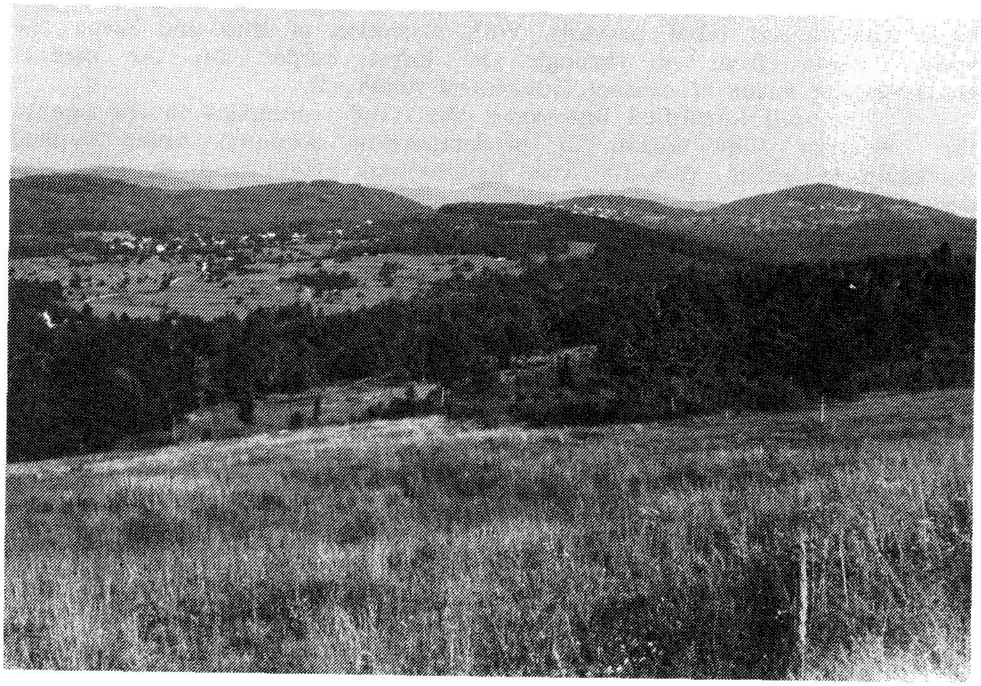

Fig. 9: Karst surface of western Suha krajina with conical ridges and interjacent dales and ouvalas (c_2)
Slika 9: Kraško površje zahodne Suhe krajine s kopastimi hrbti in vmesnimi doli ter uvalami (c_2).

Pleistocene sediments in karst depressions and on higher benches indicate the transformation of the karst surface in several phases. Miocene and Pliocene layers with inliers of coal among sands and loams around Kočevje show abundant local tectonic subsidences inside the karst plain. The mentioned sediments present an important chronological indicator of tectonic movements and morphological development.

In Kočevski Rog the altitude differences between the ridges and depressions are smaller, karst depressions do not have flat bottom as corrosional formation did not reach the karst water table. According to the altitudes Kočevski Rog can be compared with western Gorjanci on the other side of Žužemberk fault zone.

c_3) THE KARST OF LOWER DOLENJSKA AND BELA KRAJINA

The eastern Suha krajina is low karst landscape on the passage to tertiary hills on the border of Pannonian basin. The units of partial or complete and contact fluviokarst alternate in the relief, between 200 to 600 m high (I.GAMS,1984). The lowest depressions lie in the zone of permanent flow, in the zone of flood karst water or just a little above it. Karst ridges and interlying depressions are oriented in north south direction. The plateaus on NW side are more uplifted, the central part is lower, in the altitudes between 200 to 350 m, SE part is higher again, 300 to 500 m and subsided along the transverse Straža fault. In the continuation towards SE the surface is upraised up to transverse fault near Semič where it lowers to the karst plain of Bela krajina, 150 to 300 m high (Fig. 10).

The low karst plain of Bela krajina presents a special unit on the border of wider Karlovac basin beacuse of its extension and morphological properties. It is dissected to smaller structural units rather similar according to altitudes and geomorphological properties. Because of low altitude of the surface it was not karstically dissected as it was the case on higher karst. Karst surface is thickly covered by terra rossa giving the landscape the appearance of mild karst. The remains of Pliocene chert sands, covering once the limestones entirely, are not rare.

Thick blocks of Miopliocene loams and marls with inliers of coal in Kanižarica demonstrate abundant local subsidence within the fault zone on the border between lower peneplain and higher karst ridges. This surface is geomorphologically much more heterogeneous (P. HABIČ et al., 1990) and could be compared to other areas in the similar fault zones.

CONCLUSION

The geomorphological classification of the NW Dinaric karst is based on previous knowledge about the origin and development of karst

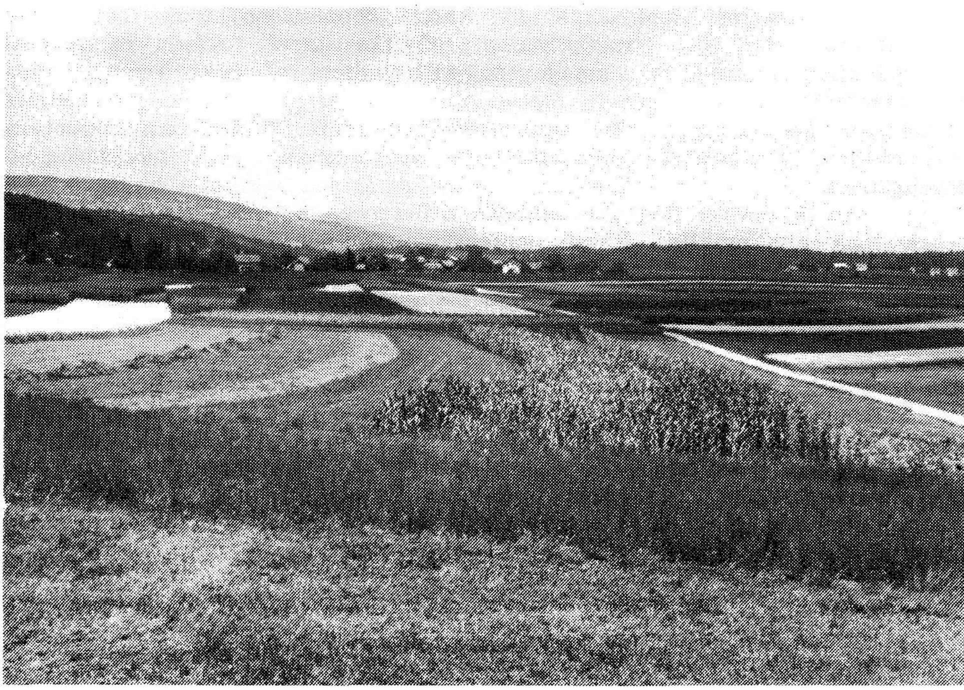

Fig. 10: Low karst peneplain of Bela krajina (c_3) at the foot of Poljanska gora (on the left) and Gorjanci (in background) covered by terra rossa and well cultivated.

Slika 10: Nizek belokrajnski kraški ravnik (c_3)ob vznožju Poljanske gore (levo) in Gorjancev (v ozadju) je pokrit s terra rosso in lepo obdelan.

in the area of southern Slovenia. According to relief, hydrographic and speleological properties the area became famous in past century as Classical Karst. Our classical geomorphologists J. CVIJIĆ, A. MELIK AND J. ROGLIĆ studied it among the others. They were followed by younger researchers who deepened their knowledge by new results.

Today we think that the surface among Tertiary Pannonian basin, Alps and Adriatic Sea was formed some time about the Middle 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 ouvalas, deep dales, kettle- funnel- or dish-shaped 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 in its underground.

According to 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. These units could be genetically compared to the neighbourhood on the base of detailed geomorphological studies only.

Translated by Maja Kranjc

GEOMORFOLOŠKA ČLENITEV NW DINARSKEGA KRASA

Dinarski kras v Sloveniji prehaja med Jadransko in Panonsko kotlino v predalpski in alpski gorski svet. Kraško površje sestavljajo podedovane in recentne oblike, ki so rezultat večfaznega geomorfološkega razvoja. Ohranjeni so sledovi starega fluvialnega, fluviokraškega in kraškega uravnavanja iz časov, ko so bile karbonatne kamnine z vseh strani obložene in zajezene z neprepustnimi kamninami. Po splošni, a nepopolni izravnavi razgibane postoorogene geološke podlage je sledila doba erozijskega in korozijskega poglabljanja in razčlenjevanja, ko so bili posamezni predeli z zaporednimi tektonskimi premiki različno dvignjeni ali pogreznjeni. Razkriti in nezajezeni apnenci ter dolomiti so bili izpostavljeni nadaljnjemu fluvialnemu in kraškemu preoblikovanju.

V reliefu so ohranjene oblike, ki naj bi nastale v različnih klimatskih razmerah. S klimo je povezano diferencirano razgaljanje za erozijo ali korozijo različno odporne geološke podlage. V nepropustnih kamninah se je zlasti v hladnejših kvartarnih obdobjih površje hitreje zniževalo kot v zakraselih karbonatnih kamninah, ki so manj odporne v toplih in vlažnih klimatskih obdobjih.

Poglavitne kraške oblike se v obravnavanem predelu razvijajo nekako od srednjega pliocena do danes. Na majhnem prostoru, saj zajema kras v južni Sloveniji le nekaj tisoč kvadratnih kilometrov, se je izoblikovalo morfološko izredno pestro površje, ki je še vedno deležno posebne strokovne obravnave.

PREGLED POMEMBNEJŠIH GEOMORFOLOŠKIH RAZPRAV

V celoti je o Dinarskem krasu precej napisanega. Prvi sintetični prikaz je podal J. CVIJIĆ (1893, 1926, 1960). Njegove razprave so temeljnega pomena, saj so se mnogi mlajši raziskovalci zgledovali po njih. Znana je Cvijićeva shema cikličnega razvoja kraškega površja. Za njim se je doma in v svetu uveljavil J. ROGLIĆ (1957,1960,1965) z izvirnimi pogledi na globinsko cirkulacijo, robno korozijo, fluviokraško in povsem korozijsko kraško preoblikovanje.

Prvotno fluvialno zasnovo površja Dinarskega krasa v Sloveniji je vztrajno zagovarjal A. MELIK (1935, 1961, 1963). Zakrasevanje naj bi se začelo šele z epirogenetskim dviganjem prvotnega uravnanega površja. V hladnih pleistocenskih obdobjih so se po njegovih ugotovitvah fluvialni procesi znova okrepili, še posebno na kraških poljih, kamor so vode nasule mehanski drobir in z njim zapolnile tudi podzemeljske rove, kar je vplivalo na trajnejše zastajanje vode na površju. Omenjeni trije raziskovalci so v svojih delih kritično povzeli starejše vire, ki jih tu ne kaže posebej omenjati.

Zanimive podatke o intenzivnosti recentne korozije v Sloveniji je zbral I. GAMS (1965,1967,1980,1985), ki je podal tudi monografski pregled novejših krasoslovnih dognanj(1974). Preučeval je učinke pospešene korozije, razvoj polj in slepih dolin ter druge oblike kontaktnega fluviokrasa (1962, 1973, 1978,1986).

Splošni geomorfološki razvoj krasa v Sloveniji je predstavil D.RADINJA (1972), ki je bolj podrobno analiziral morfogenezo Divaškega (1967)in Doberdobskega Krasa (1969) Vpliv klime na oblikovanje reliefa v Sloveniji je skušal oceniti M. ŠIFRER (1967, 1972, 1984, 1990). Posebej je podčrtal razlike med pliocenskim tropskim in pleistocenskim periglacialnim in glacialnim oblikovanjem reliefa. Strukturne in tektonsko zasnovane oblike v Dinarskem krasu so bile poleg morfoloških in hidrografskih členitev ter regionalnih morfogenetskih študij predmet naših raziskav (P. HABIČ, 1968,1978, 1981,1982,1984, 1986, 1990).

Med vidnejšimi razpravami o razvoju kraškega podzemlja naj na tem mestu omenim delo S. BRODARJA (1952), ki je ob paleolitskih raziskavah v jamah na Pivki skušal osvetliti njihov razvoj. V tej smeri je s kronostratigrafijo jamskih sedimentov razširil in poglobil speleogenetska spoznanja R. GOSPODARIČ (1976, 1982, 1986). Druge razprave bodo omenjene v zvezi s konkretno problematiko.

GEOMORFOLOŠKI POLOŽAJ IN PREVLADUJOČI PROCESI

Dinarsko kraško površje v Sloveniji sega najvišje v Snežniku (1797m), najnižje na Doberdobskem krasu pod 100 m in v Istri celo do morja. Nižji kraški ravniki so stopnjasto razporejeni do višin okrog 600 m, višje kraške planote segajo v višine med 800 in 1400 m, iznad njih se dvigajo le posamezni vrhovi ali hrbti.

Velika namočenost prispeva k izdatni koroziji, s katero se kraško površje povprečno zniža od 30 do 150 mm na tisoč let. Vkljub različnim metodam določanja korozijske intenzitete so vrednosti prikazane v naslednji tabeli precej podobne.

Tabela 1: Korozijska intenziteta v NW Dinarskem krasu

Porečje-zaledje izvira	znižanje v mm na 1000 let		
Izvir Vipave	82	*)	- (HABIČ, 1968, 217)
	68	**)	- (GAMS, 1966, 54)
Hotenjka	126	*)	
Idrijca, Idrija	157	*)	
Podroteja	90	**)	
Trebuša	90	*)	
Ljubljanica	65	**)	
Krka, Dvor	33	**)	

Prenikajoče vode se združujejo v curke, ki odtekajo po bolj prepokanih in prepustnih conah. Curki so stalni ali občasni in različno veliki. Razmerje med nizkimi in visokimi pretoki ter majhnimi in velikimi curki znaša 1:10.000 in več (P.HABIČ, J.KOGOVŠEK, 1979). Posledice točkovno različnega spiranja se kažejo v veliki kraški razčlenjenosti površja. Ta je v klimatskem in v energetskem pogledu večja v višjih predelih kot v nižjih. K razčlenjevanju višjega krasa poleg korozije odločilno prispeva mehansko razpadanje apnencev in zlasti dolomitov ter površinsko bolj ploskovno spiranje drobirja po pobočjih v zaprte kraške kotanje, v viseče dole in žlebove.

Velikost kraških globeli na izbrani morfološki enoti Planinca južno od Snežnika v velikosti 3 krat 4 km je prikazana v tabeli 2.

Tabela 2: Primerjava števila in povprečne velikosti kraških globeli na Planincu (Notranjski Snežnik)

tip vrtače	število	premer m	globina m	ploščina $10^3 m^2$	prostornina $10^3 m^3$
kotlič	124	10	5	0,3	0,5
vrtača	57	25	10	2	6,5
mali kotel	34	50	20	8	50
srednji kotel	28	100	30	30	300
velik kotel	16	200	50	125	2.000
dvojni kotel	1	400	80	500	13.000
M.Ponikva,Bakar *)	1	1000	150	600	30.000
V.Ponikva,Bakar *)	1	1400	180	1.200	72.000
Prapratna draga *)	1	2000	210	6.000	150.000

*) primerjalne velikosti večjih globeli v višjem krasu

Na razpored in obliko kraških globeli odločilno vplivajo navpični odvodniki, ki so vezani na prelome ter razpoke in so litološko tektonsko pogojeni. Pomembno vlogo ima tudi izpostavljena lega višjih kraških planot. Tam že dolgo prevladuje kraško razčlenjevanje, ki se je v pleistocenu okrepilo z izdatnimi glacionivalnimi procesi.

GEOMORFOLOŠKA ČLENITEV NW DINARSKEGA KRASA

K prvi geomorfološki klasifikaciji spada Cvijićeva(1918) delitev Dinarskega krasa na pravi kras ali holokarst ter delni kras ali merokarst. V zadnjem nedokončanem pregledu krasa je CVIJIĆ (1926) bolj pokrajinsko opredelil različne morfološke tipe kot so:

- Tržaški kras
- Kranjski kras
- Ličko-karlovški kras
- Kras velikih kraških polj zahodne Bosne
- Kistanjska kraška zaravan z otoško verigo ter
- Hercegovsko-črnogorski kras

J.ROGLIĆ (1965) je Dinarski kras delil po poglavitnih morfoloških oblikah in procesih na:

- notranji fluviokras
- osrednji pravi dinarski kras in na
- korozijske uravnave, nastale v višini zajezene kraške vode.

M.HERAK(1977,1986) je z geotektonskega vidika ločil:

- orogenski nagubani, disecirani in akumulirani kras ter
- epiorogenski bazenski in platformski tabularni kras

Po tem načelu je razdelil Dinarski kras na:

a) Jadranski pas s prelomljenimi gubami karbonatnih kamnin in fliša, ki pripada diseciranemu in akumuliranemu krasu.
b) Visokokraški pas, v katerem prevladuje narivna tektonika z neotektonskimi dviganji in grezanji.
c) Notranji pas, ki ga dalje deli v dva dela
   c_1) robni nizki kras dinarske karbonatne platforme
   c_2) kras Notranjih Dinaridov

S temi strukturnimi potezami se sklada naša hidrografska in speleološka delitev krasa Slovenije (P.HABIČ, 1969, 1982) na:

a) Primorski ali perijadranski kras
b) Notranjski ali osrednji dinarski kras
c) Dolenjski ali peripanonski kras

V vzdolžnih dinarskih pasovih se v drobnem prepletajo različne morfološke enote. Posamezni pasovi so vzdolžno in prečno razčlenjeni, ker so deli različno dvignjeni ali pogreznjeni, so drugačne litološke sestave, ali so se v njih drugače uveljavili morfogenetski vplivi iz sosedstva. Po posameznih strukturnih enotah so se različno uveljavili fluvialni, fluviokraški in kraški procesi uravnavanja ali razčlenjevanja.

Po skupnih morfogenetskih značilnostih delimo osnovne tri vzdolžne pasove na ožje proge (Slika 2).
V zunanjem perijadranskem krasu ločimo:

a_1) nižji Istrski kras
a_2) višji Tržaško-liburnijski kras
Meja med njima je strukturna in poteka ob flišnem obrobju Tržaškega zaliva in Severne Istre. Mejo med perijadranskim in osrednjim Dinarskim krasom predstavlja vipavsko - brkinsko - vinodolski flišni pas, na katerega je narinjen Visoki kras. Po Herakovi tektonski rajonizaciji pripada prvi perijadranski pas Adriatiku, drugi pa Periadriatiku.
Osrednji visoki Dinarski kras je po dolgem razdeljen ob prelomnih conah na:
b_1) zahodni Visoki kras, od Banjšic do Snežnika
b_2) Notranjsko podolje v idrijski prelomni coni
b_3) vzhodni Visoki kras, od Krima do Goteniškega Snežnika
Notranji, peripanonski kras delimo v tri podolžne pasove:
c_1) Ribniško-kočevsko podolje v mišjedolsko želimeljski prelomni coni
c_2) višji Dolenjski kras z Ribniško in Kočevsko Malo goro, Dobrepoljem, zahodno Suho krajino in Kočevskim Rogom s Poljansko goro.
c_3) nižji Dolenjski kras med žužemberškim in temeniškim podoljem z vzhodno Suho krajino, Novomeško kotlino, in Belo krajino. V tem pasu izstopa višje dvignjen kras Gorjancev s specifičnimi morfološkimi potezami.

Širina vzdolžnih pasov je različna, povprečno znaša okrog 15 km. Znotraj posameznih pasov so še ožje bolj ali manj vzporedne, od 1 do 5 km široke proge višjega in nižjega površja. Hrbti in podolja so tako kot širši pasovi tektonsko zasnovani ob vzdolžnih prelomih.

Vzdolžna razčlenjenost je manj izražena na najnižjem zunanjem istrskem in notranjem belokrajnskem krasu. Vzdolžne proge so bolj izrazite v tektonsko razgibanem najvišjem osrednjem pasu. Vzdolžni hrbti in vmesni doli so sicer tektonsko zasnovani, vendar morfološko bolj izraženi, ker je v više dvignjenih pasovih najprej prevladalo lokalno diferencirano erozijsko in korozijsko razčlenjevanje. V nižjih predelih so dalj vztrajali vplivi iz nepropustnega sosedstva ter prispevali k prevladi korozijskega uravnavanja, kakršno je še danes na kraških poljih.

Vzdolžne dinarske proge so na več mestih prečno prelomljene, različno dvignjene in ločeno morfološko razčlenjene. Prečne poči in reliefne zajede so bile hidrografsko pomembne. Ob njih so se vode iz vzdolžnih pasov prečno odtekale na obe strani. Prečni lomi so omejeni na posamezne proge , redko sekajo več prog in le izjemno dva sosednja pasova. Navedne strukturne poteze so odločilno vplivale na zasnovo in razporeditev geomorfoloških sklopov znotraj posameznih pasov in prog. Ti sklopi se odlikujejo z individualno razporeditvijo kraških reliefnih oblik.

V skrajenm severozahodnem delu Dinarskega krasa so k prečni razčlenjenosti pripomogli nekdanji, k jadranski kotlini konvergentno usmerjeni površinski tokovi, ki so tekli iz pregorja Julijskih Alp čez Trnovsko in Banjško planoto ter Tržaški kras. Takšni so še danes tokovi s fliša Goriških Brd in Beneške Slovenije. S fliša teče čez Istrski kras Mirna s pritoki. Suha Limska draga je delo nekdanje Pazinske reke , ki sedaj ponika ob stiku fliša in apnencev sredi Istre.

Nedvoumno sled takšnega konvergentnega toka predstavlja viseča suha Čepovanska dolina in njen domnevni podaljšek v Devetaškem dolu na Doberdobskem krasu (A.MELIK,1963, D.RADINJA,1969). MELIK(1956) je v hidrografski mreži današnjega Posočja in ob pritokih Nadiže našel še več odsekov prvotnih konvergentnih tokov.

Na nižjih zunanjih in notranjih pasovih ni alohtonih prečnih suhih dolin, saj za takšne tokove ni bilo ustreznega hidrografskega zaledja. Vode so z osrednjega najvišjega pasu odtekale po nižjih vzdolžnih progah in podoljih do izrazitejših prečnih lomov. V zunanjem pasu so tokovi s primorskega krasa tekli k morju proti NW in proti SE. V porečju Ljubljanice je prečni tok voda med Pivko in Ljubljanskim barjem vezan na prečni reliefni lom, v porečju Krke na lom med Dolenjskimi Toplicami in Novim mestom. Kolpa si je med Gorskim Kotarjem in Karlovško kotlino izdolbla kolenasto zavito antecedentno kanjonsko dolino prek več pasov, ker so nepropustne kamnine v povirju prispevale plavje, s katerim je dolbla strugo v dvigajoče se kraške planote.

V porečju Ljubljanice so se tokovi ohranili na površju v vzdolžnem podolju le v območju kraških polj, sicer pa so se prestavili v podzemlje (A.MELIK,1952). Podobno velja tudi za zahodni del porečja Krke s prečnim podzemeljskim odtokom iz Ribniško kočevskega podolja v kanjonsko strugo Krke. Ta se je ohranila na površju v nizkem vzdolžnem žužemberškem podolju, ki je odprto v prečno Novomeško kotlino, po kateri se Krka lahko podobno kot Kolpa v Karlovški in Ljubljanica v Ljubljanski kotlini površinsko odteka v Savo. Poleg Krke so si v najnižje kraško površje na obrobju Panonske kotline zarezali kanjonske doline tudi pritoki Kolpe kot so Lahinja z Dobličico in Krupo na levem delu (P. HABIČ et.al, 1990) ter Dobra, Mrežnica in Korana na desnem delu porečja (I.GAMS,1986).

Površinski odtok po vzdolžnih podoljih in med višje dvignjenimi hrbti je bil in je še možen, kjer so karbonatne kamnine zajezene z nepropustnimi ali slabo prepustnimi kamninami. Na jadranski strani pomeni takšem jez eocenski fliš, v notranjosti pa tektonsko zdrobljeni dolomiti ter starejši, karbonski, permski in triasni pa tudi mlajši neogenski klastiti.

Oblikovanje površja v karbonatnih kamninah in njihovo zakrasevanje se je potemtakem prilagajalo erozijskemu zniževanju nepropustnega jezu in tektonskemu dviganju vzdolžnih ter prečnih strukturnih enot. Vsak pas se odlikuje z morfogenetskimi posebnostmi, povezanimi z geološko zgradbo, z dvignjenostjo in z različno intenzivnostjo erozijsko denudacijskih ter kraško korozijskih procesov.

SKLEP

Geomorfološka klasifikacija NW Dinarskega krasa je oprta na dosedanje znanje o nastanku in razvoju krasa na območju južne Slovenije. Ta predel je po svojih reliefnih, hidrografskih in speleoloških posebnostih zaslovel v prejšnjem stoletju kot klasični kras. Med drugimi so ga preučevali naši klasični geomorfologi J.CVIJIĆ, A. MELIK in J. ROGLIĆ. Sledili so jim mlajši raziskovalci, ki so poglobili njihova spoznanja z novimi dognanji.

Danes sodimo, da se je površje med terciarno Panonsko kotlino, Alpami in Jadranskim morjem oblikovalo nekako od srednjega pliocena dalje. Sprva so bili odločilni morfogenetski vplivi z nepropustnega sosedstva, ko so vode še površinsko odtekale čez zajezene karbonatne kamnine. Kasneje so k oblikovanju površja in h kraškemu razčlenjevanju pripomogli tektonski premiki, ki so razkosali in različno dvignili posamezne karbonatne bloke. Pri oblikovanju njihovega erozijskega in korozijskega reliefa je imela pomembno vlogo geološka podlaga z različno odpornimi litološkimi členi in s tektonsko razlomljenostjo kamnin. Poleg tega so k oblikovanju kraškega reliefa pomembno prispevali klimatsko pogojeni procesi v terciarju in kvartarju. Njihovi vplivi se kažejo v razporeditvi kopastih vzpetin, širokih pedimentov, ravnikov, polj in uval, globokih drag, kotlastih, lijakastih in skledastih vrtač ter drobnega korozijsko razjedenga površja. Geomorfološki vplivi z nepropustnega sosedstva so ohranjeni v oblikah kontaktnega fluviokrasa, v kanjonskih, zatrepnih in slepih dolinah ter v ostankih rečnih in morskih naplavin, ilovic, peska in proda, ki so ohranjeni na kraškem površju in v podzemlju.

Po prevladujočih reliefnih značilnostih je NW Dinarski kras razdeljen v tri osnovne morfogenetske enote, te pa še v manjše vzdolžne dinarsko usmerjene proge, ki so pretežno tektonsko zasnovane. Vsaka enota se odlikuje s svojevrstnim sklopom kraških oblik. Te enote je mogoče genetsko primerjati s sosedstvom le na podlagi podrobnih geomorfoloških preučevanj.

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