TYPES OF THE POLJES IN SLOVENIA, THEIR INUNDATIONS AND LAND USE

TIPI KRAŠKIH POLJ V SLOVENIJI, NJIHOVE POPLAVE IN RABA TAL

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Gams, Ivan: Tipi kraških polj v Sloveniji, njihove poplave in raba tal

Prispevek prinaša nove elementa za klasifikacijo kraških polj, kot dodatno gradivo k avtorjevi zasnovi, objavljeni 1983 (Gams). Predvsem se naslanja na povezavo med tipom kraškega polja, poplavami na njih in izrabo tal. Skupna lastnost polj je aluvijalni pokrov na dnu polja kot posledica odlaganja rečnega transporta v zastajajoči vodi pred ponori. Intenzivno kmetijsko rabo in gosto naseljenost kraških polj v Sloveniji izpričuje gostota naseljenosti z nad 200 prebivalci/km^2, medtem ko je v visokem dinarskem krasu, izven kraških polj, med 10 - 20 prebivalcev/km^2.

Ključne besede: geomorfologija, geomorfogeneza, kraška morfologija, klimatska geomorfologija, kraško polje, raba tal, Dinarski kras, Slovenija, Dinarski visoki kras Slovenije

Abstract UDC 551.44 (234.422.1)(197.12)

Gams, Ivan: Types of the poljes in Slovenia, their inundations and land use

The article contributes new elements to the karst poljes' classification as additional arguments to the one the author published in 1983 (Gams). In the foreground are connections between the polje type, floods and land use. Common characteristic of all the poljes is alluvial cover of the bottom of the polje as the result of fluvial transport sedimentation in the calm water in front of ponors. Intense agricultural land use as well as dense population of Slovene karst poljes are prooved by 200 inhabitants/km^2, while in the high dinaric karst, out of karst poljes, this density is not higher than 10 - 20 inhabitants/km^2.

Key words: geomorphology, geomorphogenesis, karst morphology, climate geomorphology, karst polje, land use, Dinaric karst, Slovenia, high Dinaric karst in Slovenia.

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FOREWORD

The topics dealt with in this paper were suggested by the organizers of the present karst school devoted mainly to the poljes and man's impact on karst. It contains new argumentation for classification of the poljes in Slovenia in respect to the sheme published in 1983 (Gams). In foreground are relations among the polje type, floods and land use. For the more detailed picture see the references cited at the end of this article. The most recent description of the poljes of Notranjsko is published in the Guide-book of the Study group IGU - Man's Impact in Karst (1987).

PIEDMONT POLJES

The Velo polje (= Great Polje) is situated among the peaks Mišelj vrh (2350 m), Vernar (2225 m) and Mali Triglav (2738 m) in the Julian Alps. It is 330 m long and 300 m wide. The local name polje denies the opinion that in the Slavonic languages polje means field only. Its bottom at altitude 1700 m is too high for tillage. In the Slovene popular language it means also larger plain (Badjura, 1953, p. 43). In the Slovenian Dinaric Karst the poljes are called usually "dolina" (= valley) (Loška, Ribniška dolina) or "dol" (Globodol = Globoki dol). Rubble which built the bottom is deposited by the torrent from the Veljska dolina (valley) after snow melting in spring and heavy storm. The surface drainage is there enhanced by the steep slope below the massif of Triglav and inlayers of semipermeable strata. On the polje's bottom the water of torrent penetrates into the rendzina which covers the rubble. The suballuvial corrosion of the limestone basis is proved by collapse alluvial dolines which are often on the margin.

The limestone ridge which divides the two basins - Velo and Malo polje is only few metres high at its lowest point. Both poljes represent the beginning of the dry valley with glacier in the glacial periods of the Pleistocene. In Malo polje the hydrochemical measurements of the water flowing from the spring at one side for a while on the humus black soil mixed with limestone rubble have shown the increase of the total hardness from 100 $CaCO_3$/l to 124 mg $CaCO_3$/l and from 108 mg $CaCO_3$/l to 125 mg $CaCO_3$/l of the carbonate hardness. Higher on the slope at the Vodnik hut where the tree-line is at the altitude of 1850 m (Lovrenčak 1986) the spring water began its running on the humus rendzina of the pasture. Up to Malo polje its carbonate hardness increased from 76 to 113 mg $CaCO_3$/l. This increase is congruent with the similar measurements of the water flowing from bare lime-

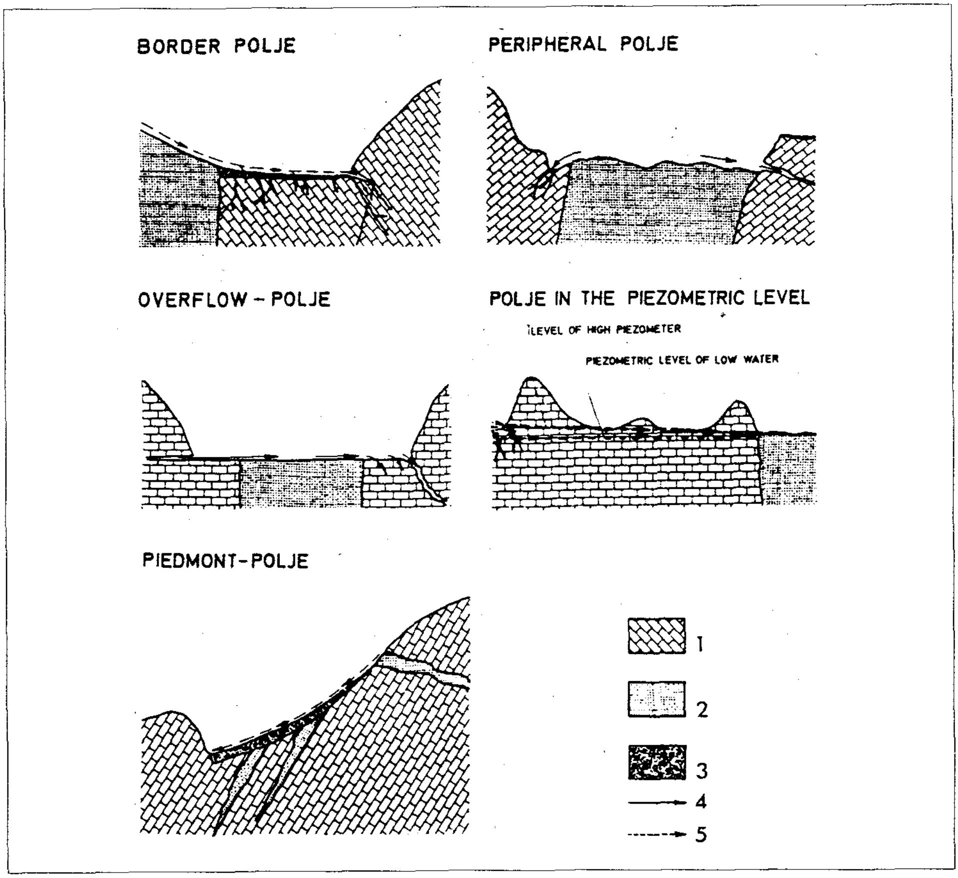
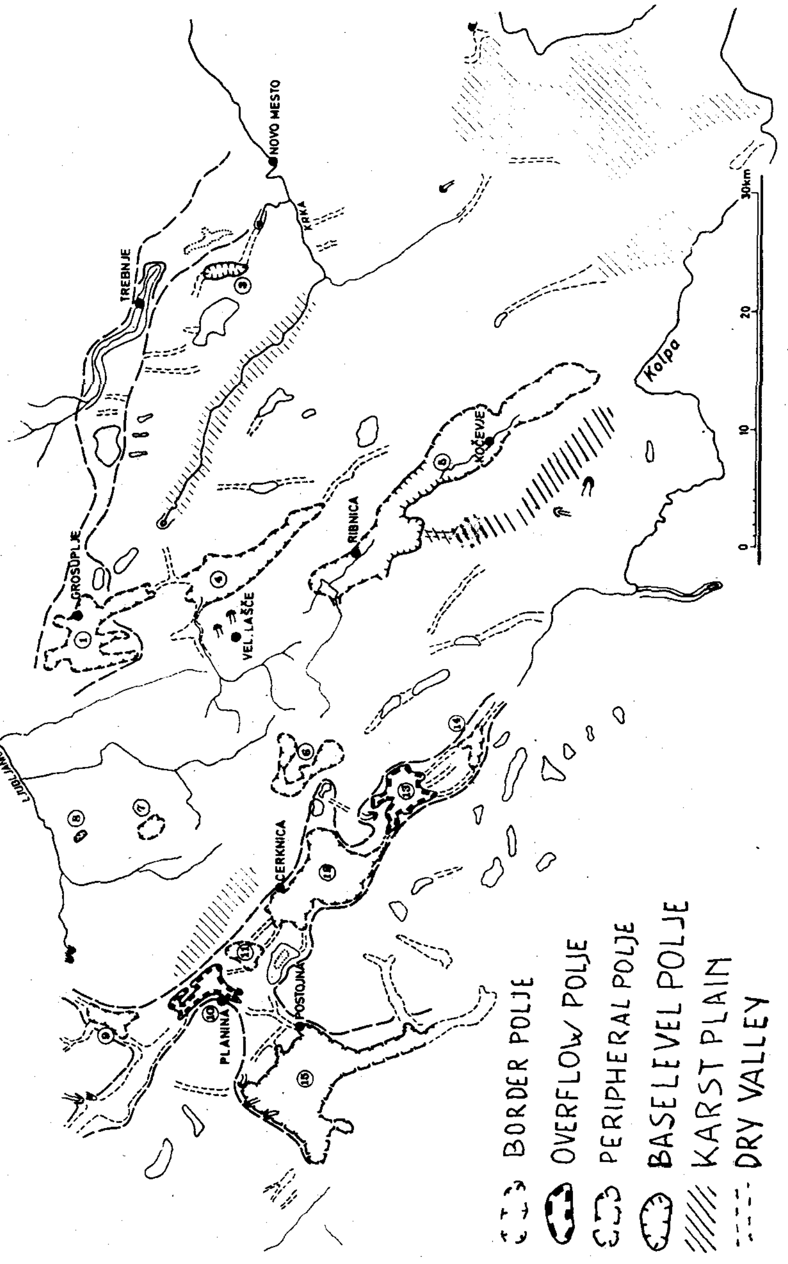


Fig. 1: The types of Karst poljes in Slovenia.
Legend: 1 = Permeable sediments (limestone).
2 = Unpermeable and partially permeable sediments (flysch, dolomite etc.).
3 = Alluvium.
4 = Permanent flow.
5 = Periodic flow.
Sl. 1: Tipi kraških polj v Sloveniji.
Legenda: 1 = prepustni sedimenti (apnenec)
2 = neprepustni in deloma prepustni sedimenti (fliš, dolomit, itd.)
3 = aluvij
4 = stalni tok
5 = občasni tok

Fig. 2: Karst poljes in Slovenia.
Sl. 2: Kraška polja v Sloveniji.


LJUBLJANA
LJUBLJANICA
GROSUPLJE
TREBNJE
NOVO MESTO
KRKA
VEL. LAŠČE
RIBNICA
KOČEVJE
Kolpa
CERKNICA
PLANINA
POSTOJNA
0
10
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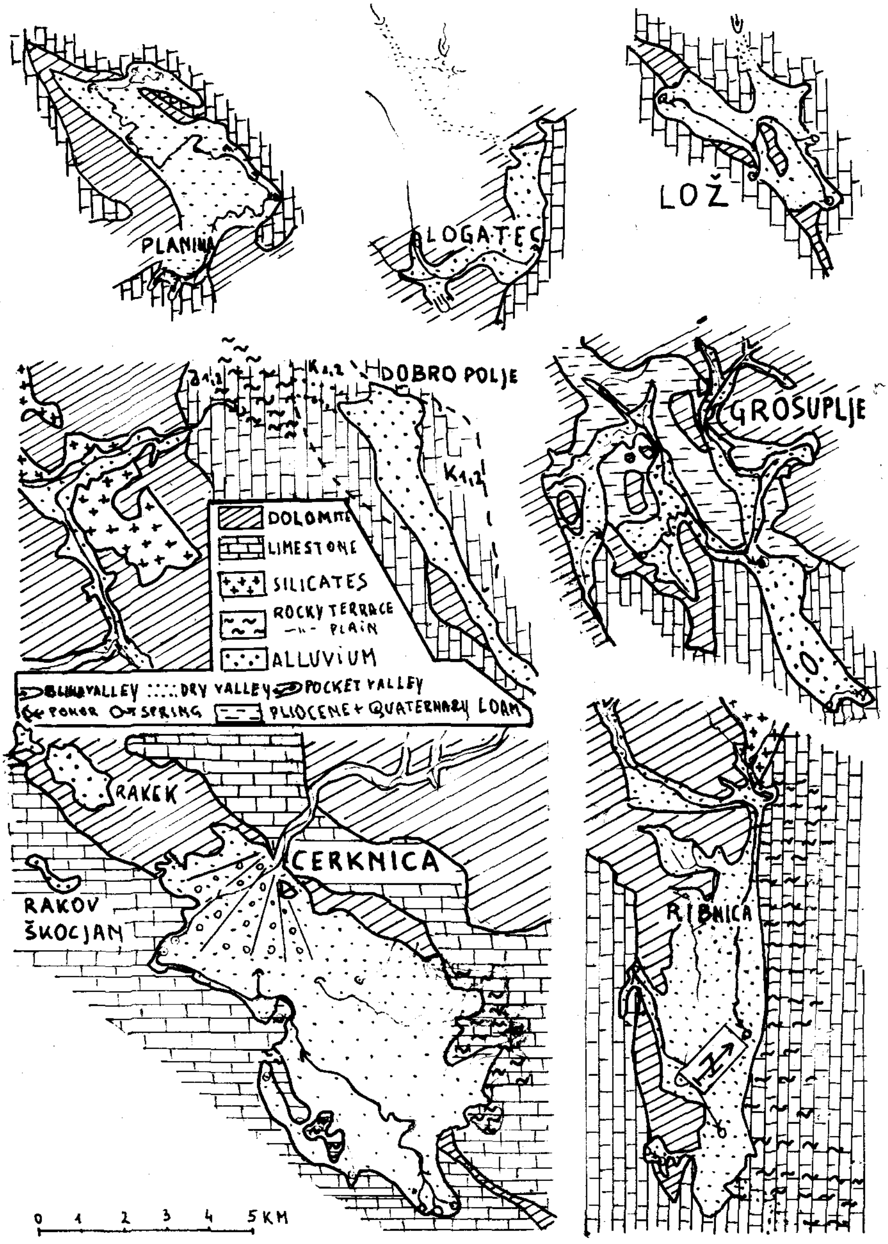
30km
BORDER POLJE
OVERFLOW POLJE
PERIPHERAL POLJE
BASELEVEL POLJE
KARST PLAIN
DRY VALLEY


PLANINA
LOGATEC
LOŽ
DOBRO POLJE
GROSUPLJE
DOLOMITE
LIMESTONE
SILICATES
ROCKY TERRACE
PLAIN
ALLUVIUM
VALLEY
DRY VALLEY
POCKET VALLEY
PONOR
SPRING
PLIOCENE + QUATERNARY LOAM
RAKEK
CERKNICA
RAKOV ŠKOCJAN
RIBNICA
0 1 2 3 4 5 KM

stone of the Julian Alps to the karst covered by soil. The development of the basins of Malo and of Velo polje may be attributed to the suballuvial and to this type of accelerated corrosion. As the vegetational belts in the Pleistocene glacial periods were lower for 800-1300 m, then the similar processes are presumed to be active also in the poljes situated in Dinaric Karst in Carniola in the altitude 400 - 800 m (Gams 1965; 1967).

Since the Middle Ages on Velo polje existed the pasture with the cattle pens. Floods are often but of short duration as the bottom is inclined and the ground permeable. Two concrete dams were built till now to retain the rubble from spreading on the pasture and both are filled already.

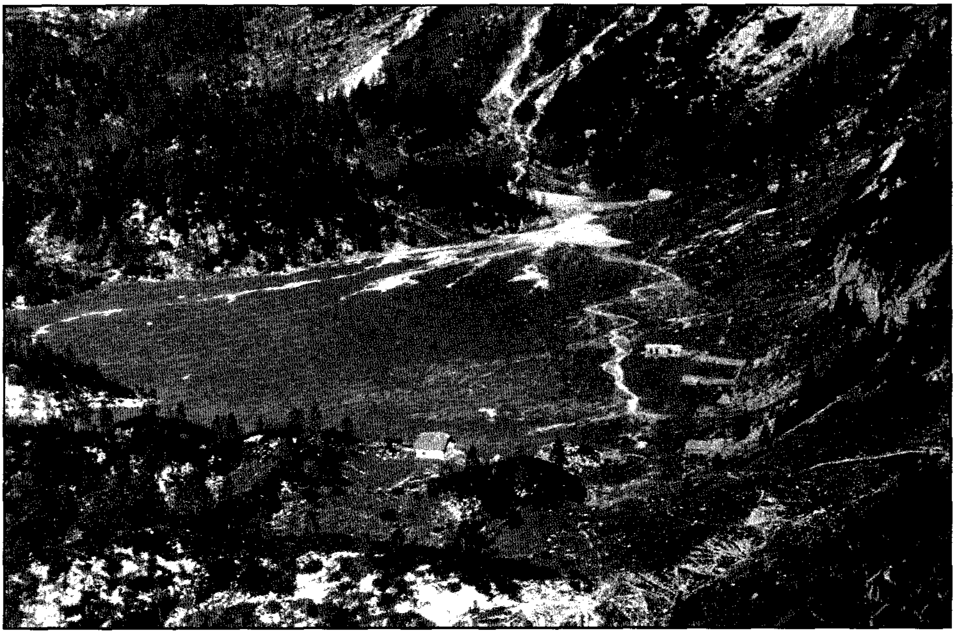


Fig. 4a: The piedmont (foot-hill) polje Velo polje (Julian Alps) is situated on the contact between the forested-grass and stony surface. Belts of rubble, deposited by torrent are shifted in last some tens of years, as they are soon overgrown by grass. In spite there is no sign of the thickening of the alluviation in Holocene. The local accelerated corrosion is proved (photo by I. Gams).
Sl. 4a: Piedmontsko kraško polje Velo polje (Julijske Alpe) ima dno na stiku skalnatega in gozdnato-travniškega površja. Gruščati tokovi (svetle proge) hudournika so se zadnjih nekaj desetletjih večkrat premestili, ker jih kmalu preraste trava. Kljub temu ni znakov, da bi postala gruščnata naplavina na polju v holocenu debelejša. Dokazana je lokalno pospešena korozija (foto I. Gams).

Fig. 3: Some examples of Karst poljes of the Slovene Karst.
Sl. 3: Nekaj primerov kraških polj s slovenskega krasa.

BORDER POLJES

The most impressive border poljes in the world are situated on the contact of impermeable silicious sediments with the limestone (see Lehmann 1959). In Slovenia the water sinking in the border poljes is draining the semipermeable Triassic dolomites and is recently mostly saturated with carbonates. But near to the tree-line, as today lies the Velo polje, in the following border poljes in Slovenia an aggressive sinking water is supposed to exist in the glacial periods of the Pleistocene. As seen on the geomorphological sketch, the bottoms of the border poljes developed mostly inside the dolomite and only at very high level the water reaches the ponors in the border limestone in case of bigger poljes.

The second geomorphological feature is a higher terrace in limestone at the outflow side of the polje. On it remains of the Pleistocene river sediments were found. This is proved for the polje of Logatec (Mihevc 1986. See the sketch!). A similar but narrower

Fig. 4b: In 30 years younger photograph of Velo polje the torrential rubble dams essentially differ from those in the previous photograph. In front the Malo polje border (photo by I. Gams).

Sl. 4b: Na 3 desetletja mlajši fotografiji Velega polja so hudourniški gruščnati nasipi precej drugačni kot na fotografiji iz l. 1994. V ospredju rob Malega polja (foto I. Gams).

1-3 m higher border limestone terraces are on the effluent side of the dolomitic polje at Rakitna and Babno polje. Already Melik (1955) stated the shortening of the river flow on the bottom of the polje as the result of the Holocene removal of the alluvium und unveiling the older sinks. The normal sinks of the water are at present in dolomite far from the end ponors in the limestone. In the polje of Bloke the final ponor of the Bločica under the village Metulje is 5.5 km distant from the ponor at low level. In the Logaško polje, the tributary Petkovški potok in the Pleistocene spreaded on the northern part called Pusto polje a thick cover of gravel and sand. At present its normal ponor is 2 km distant (Mihevc 1986) and it reaches the polje through the dry valley once in many decades.

In the transition belt from northern Triassic dolomite to the southern limestone there is between Ljubljana Moor and Krka basin a series of all sorts of karst basins with sinking rivers. There the largest border polje is the polje of Grosuplje (see the sketch!). Numerous tributaries concentrate in the main river Grosupeljščica. Near the village Boštanj are the main ponors at the contact limestone. Behind these ponors stretches 4 km long and 1 km wide "blind valley" called Radensko polje. The river floods it once in some years. This exceptionally big "blind valley" Melik (1955) explained by the primary flow of the river Raščica through Dobro polje to the Ljubljanica river. Contrary to that, Gams (1986) sees in the "blind valley" Radensko polje the end ponor of the Paleoljubljanica which by Quaternary tectonical subsidence of the Ljubljana Moor was captured by the Sava river. This opinion is based also on the Pliocene-Quaternary clay and loam, thick 1 - 10 m, building a slightly higher polje's bottom without sharp transition. Holocene flooded plain along the tributaries are built of clay and loam and they are according to the pollen analyses of Pleistocene and Holocene age (Buser 1965). On them meadows prevail and settlements on the higher bottom and on the dolomitic ridges are dense (Melik 1955).

More marked Holocene shortening of the main river occured at the river Raščica. In Pleistocene it has spread over the northern, larger part of the Dobro polje (19.5 km^2) accumulation terraces and also gravel (Šifrer, 1967). The rivers draining the Triassic dolomite usually transported no gravel or it was soon chemically and mechanically weathered. But in the river basin in the region Velike Lašče patches of the Permian schists and sandstone enabled the river to transport the silicious gravel from the region. But today the river sinks 3 km from the polje and only once in many years its flood reaches through the dry valley the NW, lower part of the polje (Kranjc 1980; Melik 1955) and endangers the settlements in the south-eastern narrower continuation of the polje called Struge (see the sketch!). It does not deposit at the normal ponor near the village Ponikve (=ponor) before Dobro polje (=good field) any gravel.

At the village Ponikve (=ponor) is 2 km wide and 3 km long karst plain without considerable alluvium. The difference of the Pleistocene gravel deposits in the Dobro polje and the absence of it in the present river can be explained by the climatical geomorphology. In this sense the karst plain at Ponikve may be explained as the result of the flooding in the warm periods of the Pleistocene. Now the final part of the river is regulated.

In the east of the Grosuplje polje geomophological evidence of the historical man made reverse transformation of a periodical border polje (or large blind valley) into normal river valley exists. Once the river Višnjica normaly disappeared in the ponors near the village

Muljava in the southern end of the 1,3 km wide plain and only at high level continued its surface course to the head of the river Krka. As this head tectonically subsided, the denivelation enabled the tributary to sink at low and middle level in the border limestone around Muljava. To avoid inundations and for the drive of the mills the surface river bed was regulated and collapse dolines as new swallow holes were artificially filled. So the sinking river became a steady surface flow and thus the development of the rudimental semipolje stoped (Gams 1986).

OVERFLOW POLJES

The dam which forces the underground water on the inflow side of the polje to flow on the surface toward the ponors on the outflow side in limestone is in Slovenia built of Triassic dolomite only. The classical form of the overflow polje in Slovenia is the polje of Planina (9 km^2, see sketch!). On this polje the project was prepared for the water storage for HP by blocking cca 120 ponors on the NE side (Jenko 1959). The project was refused for the sake of natural conservation of the typical Slovenian polje.

In the Slovenian karst geomorphology the factors of poljes development are a matter of discussion between the advocates of tectonics (Habič 1982, and some geologists) and of suballuvium solution (Gams 1980). In this regard is to mention that along the main, Idrija fault, the contact of the Cretaceous limestone and Triassic dolomite transverses the top of the Jakovica ridge. It divides the main polje bottom from the bay Babni dol where around the numerous ponors and ponor caves behind them the basin is at most enlarged on the border limestone.

The predominant dolomitic bottom and its enlargement on the limestone are covered by in average 2-5 m thick loam and sand of Holocene age. Locally up to 20 m deep swallow holes were found beneath (Jenko 1962; Melik 1955). The Holocene alluviation was explained by the trees fall. As the roots retaining the soil rotted the flood water blocks with loam the entrances to the stony ponors. Thus floods lasted longer, now about 3-5 weeks in the year. Although the ammelioration of ponors shortened the time of flood the bottom is in spite of the fertile soil still without fields and settlements and used only for meadows (Gams 1980). So the polje of Planina is an example in this regard.

The dolomitic belt stretches through the whole Notranjsko podolje and is a dam also for the Veliki Obrh in the polje of Lož (12 km^2). Contrary to the Planina polje here the floods are restricted to the two valleys of the Veliki and Mali Obrh and the settlements are dense on the higher dolomitic terrace where once fields prevailed (Gams 1973b).

NW of the Lož polje the same dolomitic belt is enlarged in the bottom of the most famous Slovenian polje Cerkniško polje (45 km^2). The river takes rise at the SE and E border limestone created in Pliocene parallel valleys which rested only some metres above the bottom between the poljes of Cerknica and Rakek (see the sketch! The geology is taken from the geological maps in the scale 1 : 100.000). Probably due to the tectonical sinking which is proved also for the Holocene time (Gospodarič & Habič 1979; Habič 1980) the main ponors near the recent settlement Cerknica developed. With them the basin began to form. Before the Würmian these ponors were blocked by gravel and sand of the river

Cerkniščica which drains the predominant Triassic dolomite. But there are also patches of silicious inlayers which provide together with steep dolomitic slopes the gravel. Before capturing and diverting into the polje the river has flown on the surface to Ljubljana Moor (Melik 1955). The fan at the Cerknica which is now used for fields of the settlements has blocked the ponors and so prolongated the floods in the seasonal lake which lasts 285 days in average per year (Kranjc 1981). The fan shifted the border corrosion to the NW edge thus enlarging the bottom on the limestone. Recently the ponors in dolomite renewed but only on the rim of the fan. From them the water flows directly to the Bistra river on Ljubljana Moor.

The water from the Cerknica polje ponoring in the border limestone rises again in the spring on the SE side of the little polje in dolomite - polje of Rakek. It is seldom flooded and then the water is sinking in dolomite on the N side - the same as it was in the Cerknica polje before the fan the ponors were blocked (Gams 1965).

Later the near basin composed of a pocket and blind valleys, called Rakov Škocjan developed as a consequence of the shifting the outlet from the Cerknica polje to the south. We may consider its 1.3 km long and narrow belt of alluvium as the beginning of the development of a new polje in the rocky bottom of the 4 km long and 40 m deep wooded uvala. This has to be explained as a result of tectonical subsidence. No other reliable reason of the uvala origin is known.

After the shifting of the outlet from the Cerknica polje to the Rakov Škocjan the high water from there invaded the Rak channel of the Planina Cave which was previously used for the outflow of the Postojna polje (Gospodarič 1976). This water sinks on the effluent side of the dolomite dam of Planinsko polje after flowing over the same dolomitic belt where before the fan the Cerkniščica accumulated sand near the bordering limestone.

For the same reason that the project for water storage in the Planina polje was abondoned also the experiment of making the Cerknica lake permanent by means of the dam on the ponor caves, this time for development of tourism, was given up. The dam only slightly prolongated the lake stage (20,3 km^2 or 53 % of the polje's bottom) and the dry season still remained. The lake bottom is useless for agriculture which centered the fields in the higher dolomitic and limestone terraces on NE and SE border. There the settlements are dense (Kranjc 1985).

PERIPHERAL POLJES

The centrifugal drainage of the larger patch of the Eocene flysch of the Mt. Brkini allowed on its border on the southern and northern side development of the blind valleys only. The area of Eocene flysch near the Postojna town and in the drainage basin of the Pivka river is drained mostly in one river - that of the Pivka. It was therefore able to create with its tributaries the belts of alluvial plains. South of the Postojna town the plain at the confluence with the Nanoščica is 2-3 km wide, enough to determine the basin, 90 m deep with karst drainage as the (peripheral) polje. The northern plains mostly developed in the flysch. In SE they stretch also on border limestone. Between the villages Slavina and Pivka the Pivka river receives some torrents from the western side draining the Eocene flysch belt, which is now reduced. Originally longer brooks presumably sank on the eastern border limestone. Thus developed dry valley Vlačno, 4 km long which generated probably as a blind valley, as well the bay of plain at the village Trnje. The estavellas in the periodical lakes of Petelinje and Palčje probably originated as ponors of the brooks from flysch. The bottoms of the basins with periodical lakes are at the same level as the river bed of the Pivka.

The land surface in flysch was in the Quaternary lowered more than the limestones in the surroundings (Radinja 1972). This occured also with the flysch in the drainage basin of the Notranjska Reka bordering to the upper Pivka basin between the Pivka and Knežak settlements. There the plain of the Pivka consists of numerous open basins which are flooded at high water. Their origin may be considered as the effect of the ancient drainage from the higher surface built of flysch. Now it is separated by a crest built mostly of the Paleogene limestone. Later lowering of basins to the present level can be explained by the suballluvial corrosion in the piezometric water level maintained by the flysch inliers below the marginal limestone.

To the north and east of the Postojna polje there is 10 to 80 m higher hilly terrace, many hundred metres wide. Till now only the northern terrace ("Postojna step") is attributed to the fluvial processes of the Pliocene Pivka. According to the sheme of the polje development and of the border solution also the eastern hilly terrace may be explained by the primary border corrosion of the river sinking below the Mt Javorniki.

With more intense Pleistocene lowering of the surface in flysch the bottom plain of the peripheral polje was essentially reduced and thus the flooded area also. The deepest floods occur in front of the ponor of the Pivka in the Postojna Cave. The flooded plains are used for meadows, which predominate over the fields around the dense villages on the flysch hills. Limestone border terrace is overgrown by forest.

BASELEVEL POLJE

The Ponikve polje with its 450 m wide bottom is on the limit for a polje recognition (Gams 1973). Its often floods are caused by the fact that the outlet of the polje is rising on the border of the 1,2 km distant Ljubljana Moor about 4 m lower than the polje's bottom. The origin of the basin cannot be explained by lithological differences - it is in the Triassic dolomite - nor by fault line. The only fault line is acc. to the geological map higher on the NE slope on the contact with the Jurassic limestone. The basin can be explained mostly with the suballuvial corrosion and areal tectonical subsidence of the wider surroundings of Ljubljana Moor. This is proved also with the pothole, 47 m deep in the lake at the near village Jezero, both situated in a similar oval depression as Ponikve.

Entirely in the same carbonate rock (limestone) is also the deepest polje in Slovenia, the polje Globodol. Its bottom is flooded mostly in the lower edge dotted with dolines. The central bottom is higher, with deep loam and gley soil. There are three settlements which are isles of densely populated area in the wooded surroundings. The floods occur in the level of the high piezometric level maintained by the spring of the Prečna in the near pocket valley Luknja (Gams 1959). Ford and Williams (1989) called this type baselevel polje.

Three kilometres eastwards of Globodol is a basin with many similarities with Globodol - that of Mirna peč: a similar size, a similar direction towards Luknja and in the same Jurassic limestone. But in the basin of Mirna peč which is combined pocket and blind valley, the river flows with spring at one and sinks at the opposite end. The primary flow of the Paleo-Temenica through Globodol is therefore presumed. In it the NW corner where the river takes its spring is narrower and the southern end wider and there begins the dry valley stretching toward the Luknja. In it more than 100 m high mountain ridge is lowered to 50 m.

COMBINED TYPE OF POLJE

The Ribnica polje (see the sketch!) is a combination of the border and overflow type. The Triassic dolomite predominates in the alluvial bottom where in NW thick gley loam predominates (Rus 1925) considered by Melik (1955) to be of lacustrine origin . The NW dolomitic belt which reaches the spring Rakitnica, forces the underground water from the limestone mountain to rise also in the main spring Ribnica. These two rivers contribute to the border polje the additional overflow polje as they sink on the polje (Melik 1955). The border polje's type is represented by the river Sodraška Bistrica which drains mostly the dolomitic hills on the NW side. It sinks near to the limestone border S of the Ribnica town. When turning to south the river bed is connected by the artificial ditch with the ponor cave Tentera to avoide the flood on the polje's bottom at high water level or to prolongate the river flow on the polje at the drought (Rus 1925). The Ribnica town is not called according to the Bistrica which flows through it but according to the 2 km distant smaller river Ribnica. In respect to the medieval finding of the settlement the swallow hole of the Bistrica was presumably the Tentera cave.

The polje's bottom is in Slovenia exceptional regarding the rocky plain on the NE side, mostly 2 km wide. It begins behind the ponor of the river Tržiščica (or Žlebiščica) in form of some metres higher rocky terrace. Its first part in the northern edge of the polje, has considerable inclination which corresponds to the gravel transport of the Tržiščica which drains not only dolomite but also silicate-Permian sandstone, schistes and conglomerates. The rest of gravel built of these sediments can still be found on the northern part of the terrace. Later the rocky terrace gets a similar inclination as the alluvial plain of the Bistrica. The common flow of the Bistrica and Tržiščica over the rocky terrace ended when the Bistrica eroded in the 10 - 25 m high ridge a through valley near the contact of dolomite and limestone of the rocky terrace and invaded the dolomitic part of the polje.

An even older change is recognizable. The dolomitic surface NW of Ribnica is levelled near the village Dane with terrace of 620 m of the altitude. Its continuation is between the ridge Bukovica and Mt. Mala Gora. South of Rakitnica begins in the mountainous relief in the altitude of 510-520 m a large karst plain. South of Grčarice and at Gotenica it is tectonically uplifted to 600 m and later lowered to 550 m at the village Morava. No other river can form this karstic plain as the combined rivers Sodraška Bistrica, Ribnica and Rakitnica, the last two ones before they were captured by the dolomite belt in the polje.

At high water level the joint water from the Ribnica polje flows through the dry valley which divided two hills Jasnica and Svinjski grič towards the polje of Kočevje.

The dense settlements on the polje of Ribnica are situated on the dolomitic elevations and on the higher rim of the alluvial polje's bottom. It was used mostly for the fields and recently mostly for meadows and on the rocky terrace for forest. The floods have been diminished with ammelioration of river beds and ponors.

The polje of Kočevje is a combination of peripheral and border type. The underground water from the limestone mountains is forced by the Jurassic dolomite to spring as the Rinža. After flow in the limestone it sinks in the final ponors in the isolated Triassic dolomite near the village Črni potok.The peripheral character is given to the polje by the patch of the Tertiary sediments N of the town. It is built at the base of Miocene sediments. Upwards follow Pliocene schists, sandstone, marls and clay (Savić & Dozet 1985). The 100 m deep sediments are the rest of the largelly sized impermeable sediments with centrifugal drainage. On the NE side the rocky terrace continues from the Ribnica polje along the abondoned railway. The terrace is about 10 m higher than the surface of the Pliocene sediments and polje bottom along the Rinža. For the not yet explained reason the rocky terrace has no inclination toward SE. According to the geological map Delnice the lower surface is covered by lacustrine sediments.

The Rinža flooded at very high level the whole alluvial plain and partially also the town. At low water its superficial flow is for 5 km shorter. The final ponors near the village Črni potok are ammeliorated (Kranjc 1972, 1982). As the alluvial plain covers less than one half of the bottom, the polje settlements are recently less dense than usually in the Slovene poljes and forests on the limestone terrace cover greater percentage. As towards SE the basin is open and because of the large rocky terraces the size of polje is discutable (from 100 km^2 - Kranjc 1972 - to 72 km^2 - Gams 1978).

CONCLUSIONS

The review of the polje types in Slovenia and their mutual comparison resulted in the priorities of the geomorphological processes for their development.

Tectonics as the initial state of the formation of the polje basin is obvious in the case of the uvala Rakov Škocjan. Due to the tectonic subsidence the cave ceilings are thin and liable to collapse. So the cave channels opened on air and in the narrow river basin floods began with deposition of the loam.

The second case, the tectonical subsidence of the valley head with spring of the Krka created the vertical difference between it and the tributary Višnjica which began to sink in the border limestone near Muljava. The seasonal dry-up of the last river section and also the forming of the rudimentary polje were interrupted by man blocking the ponors and ammeliorating the river bed for drive of mills and to avoid the floods.

Besides of the baselevel poljes which are related to the tectonics, the poljes in Slovenia are developed by other processes too. All are situated in front of the ponors near to the petrological contact of impermeable or semipermeable sediments with permeable limestone. Sinking of the river brings about the floods and sedimentation of the river load. Its accumulation is resulting in two morphological processes - border corrosion and suballuvial corrosion. The first one was in Slovenia measured by means of hydrochemical analyses in the blind valleys with sinking water from less carbonate flysch (Gams 1962). These basins have similar origin as the border polje. Technically is nearly impossible to measure the suballuvial corrosion, but it is consistent from the geomorphological point of view. The impermeable alluvial cover would make the underground rock higher than the karst surroundings where the corrosion of the precipitation water steady lowers the surface. This would lead to the disappearing of the basin. Prove of the suballuvial corrosion are the numerous collapse dolines encountered on the polje's bottom.

In the altitude of climatic tree-line on the contact of covered and bare karst surface in the Alps the measurements proved the special type of the locally accelerated corrosion. During the flow on the Malo polje (1670 m) draining the higher bare surface, the water hardness considerably increased. In the cold Pleistocene periods the similar processes contributed to the deepening of the poljes in the Dinaric karst being situated at the altitude of 400-800 m. Then on the dolomitic surface and on the alluvial fan seasonal permafrost prolongated the surface rivers from dolomite to the ponor in the limestone border. But coarser river load was consequently favourable for the suballuvial solution.

In the border poljes in Slovenia the rivers, draining the semipermeable dolomite sink. Their basins are shallow and presumably young. Before the basin fomation the surface rivers lowered the dolomite with erosional and solutional processes. After they lowered the dolomite surface below the surrounding limestone karst water from limestone began to spring on the contact with dolomite and invaded the initial polje (case of Ribnica and Cerknica). So the overflow poljes developed. The alluvium cover also in them enhanced the suballuvial solution based on the higher biological activity in the moist soil. Erosional widening of the rocky ponors is of second importance. By this process originated rubble is absent in the springs and must have been dissolved in the underground channels or transformed in sand (Kranjc 1989).

The geomorhological study of the poljes in Slovenia revealed changes in the polje type in the geological past. The overflow polje of Rakek is now a dry polje in the dolomite. In the geological past it developed as the overflow polje so as the near Planina and Cerknica poljes are. The border polje of Ribnica was later combined with the overflow type. The role of the peripheral polje at Kočevje is diminished together with the diminishing size of the isle of the Neogene impermeable sediments. The centrigufal drainage in the peripheral polje at Postojna is now reduced and with it also the peripheral type of the polje.

Due to the diminishing river load in Holocene the water streams on the bottoms of border and peripheral poljes are shortening but the exceptional floods rest although they are more seldom. The longest floods are in the baselevel polje. The periodical lake in the overflow polje of Cerknica is a consequence of the accidental piracy of the neighbouring river. Its gravels in form of a fan blocked the ponors near Cerknica. The flooding of the total bottom of the Planina overflow polje is attributed to the man's activity in Holocene where once grove and now only meadows are, and despite of the fertile soil the fields and settlements are absent.

The plain bottoms of the poljes in the Dinaric karst are isles of the intensive land use and dense settled similar to the intramountainous basin in the nonkarstic Slovenia. In them the population density is more than 200 inhabitants/sq km, and outside them in the karst is in average 30 inh./sq km. In the so called high Dinaric Karst the communal seats are all in the poljes.

TIPI KRAŠKIH POLJ V SLOVENIJI, NJIHOVE POPLAVE IN RABA TAL

Povzetek

Tematiko tega članka so predlagali organizatorji kraške šole v Postojni 1994, namenjeni predvsem kraškim poljem v Sloveniji in človekovemu posegu v kras.

Nova argumentacija za tipe kraških polj v Sloveniji in njihovo medsebojno iskanje skupnih pogojev in razlik po tipih sta dala nove poglede na razvoj več kraških polj. Skupna lastnost polj je aluvialni pokrov na dnu kotanje kot posledica odlaganja rečnega transporta v zastajajoči poplavni vodi pred ponori rek. Ti so locirani na stiku vodoneprepustnih flišev ali polprepustnih dolomitov z apnenci. Drobnozrnati aluvialni pokrov pospešuje robno in grobozrnati, kot je bilo v hladnih pleistocenskih razdobjih, podaluvialno (podnaplavinsko) korozijo. Tektonsko grezanje uvale Rakovega Škocjana je omogočilo začetek nastajaja novega kraška polja vzdolž rečnega toka Raka. Grezanje izvirnega območja Krke je zaradi nastale denivelacije omogočilo ponore Višnjice pri Muljavi, kjer pa je nastajajoče rudimentarno kraško polje preprečil človek z regulacijo reke in zamašitvijo nastajajočih novih ponorov za za odpravo poplav in pogon mlinov.

Dna robnih polj so v Slovenija razvita predvsem na robnem dolomitu in tam so razdalje med ponori nizke in visoke vode dolge do več kilometrov. Kraški ravnik pri vasi Ponikve je pripisan toplodobnemu kvartarnemu naplavljanju Raščice, ki je v ledenih dobah nasula prodno teraso v 3 km oddaljenem Dobrepolju. Robna polja so plitve in mlade kotanje, nastale v območju predhodnega znižanja dolomita s skoncentriranimi rečnimi dolinami. Po nastanku kotanje je pričela pritekati voda iz robnih apnencev, kjer je podzemno vodo prisilila k dvigu dolomitna pregrada. Ribniško in Cerkniško polje sta s tem dobila kombinirani tip robnega in prelivnega polja. Reke Sodraška Bistrica, Ribnica in Rakitnica so pred spremembo skupno odtekale proti JV in izdelale kraški ravnik, ki ga je med Grčaricami, Gotenico in pol poti do Kočevske Reke tektonika dvignila na ok. 600 m, nakar se zniža do Morave na 540 m. V naslednji fazi sta Sodraška Bistrica in Tržiščica, slednja z bolj agresivno vodo, izravnali na apnencu kraški ravnik, ki sega mimo Ribniškega še v Kočevsko polje, tu pa iz neznanih razlogov nima strmca. Kočevsko polje je kombiniran tip robnega in perifernega polja; slednji je nastal zaradi nekoč obsežnejšega otoka noegenih sedimentov pri Šalki vasi.

Intenzivno kmetijsko rabo in gosto naseljenost kraških polj v Sloveniji izpričuje prebivalstvena gostota z nad 200 ljudi na km^2. Izven polj je v visokem Dinarskem krasu v

povprečju med 10 in 20 preb./km^2. Tam so na poljih, po stanju 1994, vsa občinska središča te regije.

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