PEDOGEOGRAPHIC CHARACTERISTICS OF THE RAKOVŠKO-UNŠKO POLJE

PEDOGEOGRAFSKE ZNAČILNOSTI RAKOVŠKO-UNŠKEGA POLJA

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Franc Lovrenčak: Pedogeografske značilnosti Rakovško-Unškega polja

Predstavljene so nekatere značilnosti prsti z Rakovško-Unškega polja na Notranjskem, severozahodno od Cerkniškega polja. Poudarjene so povezave med morfologijo, osnovnim materialom in značilnostjo prsti. Najpomembnejše je vprašanje izvora rdečkastega glinastega horizonta v profilu, zlasti tistega na dnu kraškega polja. Ta plast je ali netopen ostanek preperele matične kamnine ali pa je nastala pri sedimentaciji drobnih delcev na dnu polja. Rezultati terenskih meritev in laboratorijskih analiz vzorcev prsti so prispevek k iskanju odgovora na to vprašanje.

Ključne besede: pedogeografija, prst na krasu, Slovenija, Rakovško-Unško polje

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Franc Lovrenčak: Pedogeographic characteristics of the Rakovško-Unško polje

Some characteristics of soils of the Rakovško-Unško polje in Notranjsko, northwest of the Cerkniško polje, are discussed. The searching for correlations is stressed, between landforms, parent material, and soil characteristics. The primary stress is given to the question of origin of the reddish clay horizon in soil profile, the one from the bottom of the karst polje in particular. It is either a horizon of insoluble residue by parent material weathering, or it was generated by depositing fine particles on the bottom of the polje. The results of fieldwork measurements and lab analyses of soil samples are meant to be a contribution to searching for the answer to this question.

Key words: pedogeography, soil on karst, Slovenija, Rakovško-Unško polje

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INTRODUCTION

Just as the landforms and water on the karst are closely related to carbonate rocks, so are the soils. Therefore, the soil is quite a distinctive and characteristic factor of karst landscape, too. In spite of this fact, karstologists and researchers in other branches pay less attention to soils than, for example to karstic surface and underground forms or water characteristics. In order to become acquainted with the karst as universally as possible, it will be necessary to include investigations on karst soils, too, in further researches of karst.

To become better acquainted with characteristics of karst soils, we have started to investigate them on the Rakovško-Unško polje, between the Cerkniško and Planinsko poljes. We were particularly interested in the relation between landforms and the characteristics of soils on them. The occurrence of the reddish clay horizon in the lower part of deep soil profiles is also interesting. Has this clay, being the residue of parent material weathering, been left over on the site of its origin, or was it transported from some other site? The results of fieldwork measurements and lab analyses of soil samples are meant to be a contribution to searching for answer to this question.

METHODS

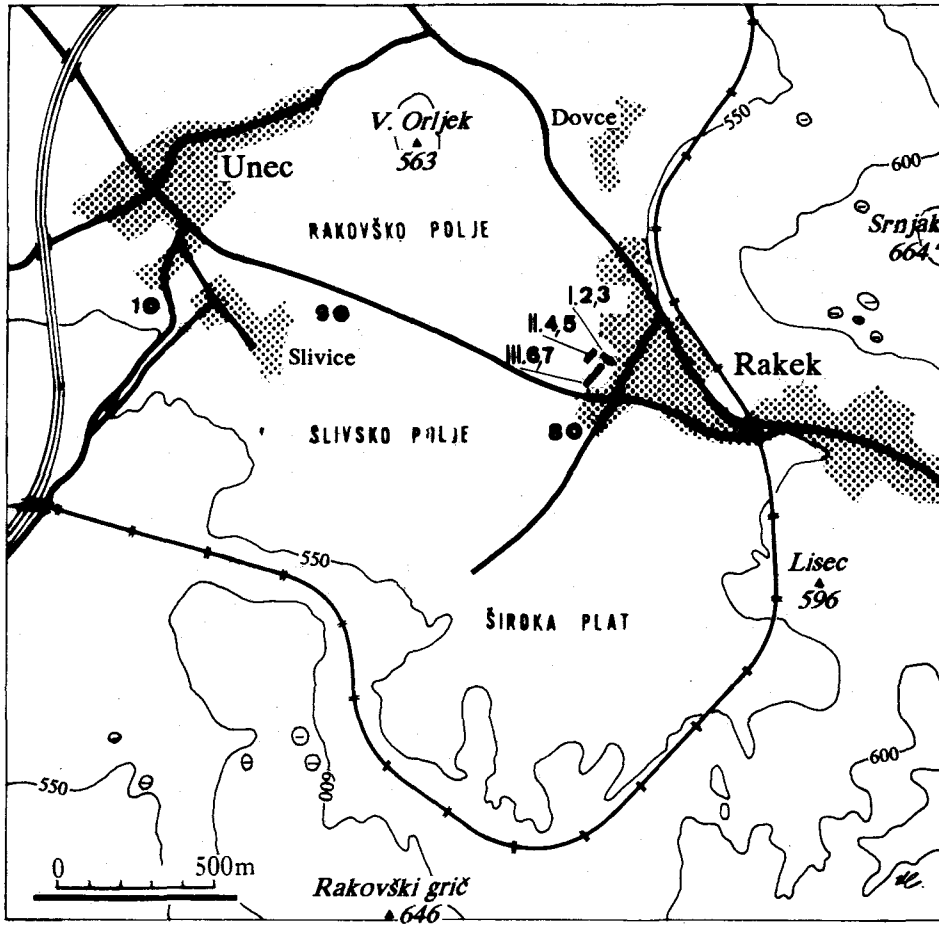
Nine soil profiles were chosen for a detailed presentation, five of which were taken from the border parts of the polje on the northeast and southwest sides, and the other four were taken on the bottom of the polje on its eastern part. (Fig. 1).

Colours of soils were determined according to the Standard Soil Color Chart (1965). Mechanical analysis of soils: samples were prepared with 0.4n $Na_2P_2O_3$ x 10 H_2O; fractions were determined by means of the pipette method, and texture classes according to the international triangular diagram. Soil reaction was measured with the digital pH meter (in KCl). The share of free $CaCO_3$ was determined by means of volumetric method with the Scheibler calcimeter. The share of organic matter was determined by the Walkley-Black method.

SOIL FORMING FACTORS

The Rakovško-Unško polje (the RUP) lies in the Notranjsko valley, northwest of Cerkniško polje. According to Gams (1974) and Habič (1981) it is a karst polje. The polje includes, besides its flat bottom, also the nearby border parts which gently slope towards the bottom. The entire polje lies in the upper Triassic dolomite which has been tectonically broken. The dolomite bedrock on the bottom is covered with a layer of Quaternary sediments, which are most frequently 3-5 m thick. The deepest well drilled in them was 9.45 m deep, and the shallowest one 1.04 m deep (Čadež, 1954). According to

Fig. 1 THE POSITION OF SOIL PROFILES IN THE RAKOVŠKO-UNŠKO POLJE



Čadež (1954), the dolomite bedrock is covered with a layer of dolomite rubble, with pieces no bigger than 8 cm in diameter. In the upward direction this rubble is mixed with loam which is of brownish-red or reddishbrown colour on the bottom and becomes of yellowish-brown and brown colour higher up.

According to Gams (1972) the RUP belongs to the Notranjsko-Kočevsko climate region. Mediterranean climate influence does not reach this part because of the barrier formed by the Dinaric high plateaus. Climatic characteristics are presented by meteorologic data from nearby Planina. The average temperature in January is -1.1 degree C, and in July 18.2 degrees C; the average annual temperature is 9 degrees C. Average precipitations per individual month exceed 100 mm, with the maximum in October and minimum in March; the average annual precipitation quantity amounts to 1821 mm (Pučnik, 1980).

There are no permanent streams on the RUP. Water begins to spring after more abundant precipitations, from several springs on the southeastern side of the polje and drains along the artificial ditch to ponors in Bratni dol below Orlek on the northwest side of the polje. While drilling through the sediments on the bottom of the polje, we discovered ground water (January 1951) in the wells, mainly 5 to 205 cm below the surface. In the three wells east from the road to Slivice, water reached up to the brims of the wells (Čadež, 1954). Yet, no traces of excessive humidity in soils were discovered on the bottom of the polje.

Climate conditions are favourable for wood which originally covered the border parts, and most probably the bottom of the polje, too. Nowadays, there are fields with cultivated plants and grass vegetation on the bottom. On the northeast and north borders of the polje, there are meadows with *Arhenatheretalia elatioris*, on the northwest border, there are mesophile grasslands with *Brometalia erecti*. The southwest border of the polje is covered with *Genista triangularis-Pinetum* (Puncer et al., 1976).

SOIL CHARACTERISTICS

As regards parent material and landforms, soils on the borders of the polje differ from soils on its bottom. Shallow soils and deep soils in fissures interchange, mosaic-like, in the border parts, while deep soils prevail on the bottom.

The dolomite bedrock in the borders of the polje, which slope towards its bottom, is corroded and more or less deep fissures filled with deep soils occur there. In between these fissures, bedrock lies shallow under the surface and shallow soils occur there. The profile of these shallow soils consists of Ah horizon which is 20-25 cm deep (Table 1, Profile 1). It lies directly on the parent material or passes over through the transitional AC horizon into the C horizon. The Ah horizon is of dark brown colour and abounds in roots. Its

texture is sandy clay or loam. It contains over 10% of organic matter and over 14% of free $CaCO_3$; its reaction is almost neutral (pH 6.86).

Due to their shallowness, such soils are almost not cultivated at all, and most of them are overgrown with grass vegetation.

On the northeast side of the polje, just below Rakek, where the border gently slopes downwards to the bottom of the polje, different soils were formed. In the upper part of the slope, deep dark brown soils (Profile 2) interchange with deep soils in fissures (Profile 3). In the lower, almost level part of the slope, shallow soils (Profile 4) interchange with deep soils in fissures (Profile 5). As to profile morphology, the soils of the upper part

Table 1: Some characteristics of the soils in the Rakovško-Unško polje

Prof.no.	Place	Horizon	Depth cm	Sand %	Silt %	Clay %	Tex-ture	pH (KCl)	$CaCO_3$ %	Org.mat. %
1	Slivice	A_h	0-20	59	14	27	PG	6,86	14,51	13,4
		C	20-							
2	Rakek	A_{h1}	0-18	33,7	45,2	21,1	MGI	7,12	2,23	7,92
		A_{h2}	18-45	33,1	25,2	31,7	G	7,31	2,98	5,48
		C	45-							
3	Rakek	A_{h1}	0-20	30	48,3	20,7	MGI	7,04	0	9,14
		A_{h2}	20-87	30,4	45,3	21,3	MGI	7,33	4,15	3,05
		(B)rz	87-147	22,5	17,8	59,7	G	7,15	1,36	1,22
4	Rakek	A_h	0-30	60,8	10,8	28,4	PG	7,06	1,42	5,03
		C	30-							
5	Rakek	A_h	0-30	35,7	34,7	29,6	IG	6,96	6,86	6,36
		(B)rz	30-180	22,5	21,6	55,9	G	6,88	1,93	0,34
		C	180-							
6	Rakek	A_h	0-30	29,6	58,6	11,8	MI	6,93	0	6,03
		B_{t1}?	30-70	28,1	42,7	19,2	IG	6,96	2,97	2,85
		B_{t2}?	70-	19,3	49,1	31,6	IG	6,64	0,98	1,34
7	Rakek	A_h	0-30	29,7	45,5	24,8	MGI	6,91	0,68	5,86
		B_{t1}?	30-100	20,4	44,8	34,8	IG	6,90	1,16	2,85
		B_{t2}?	100-	10,8	41,2	48	G	6,68	0	1,34
8	Rakek	A_h	0-15	30,7	42,4	26,9	IG	7,02		4,76
		B_{t1}?	15-45	21	39,4	39,6	IG	6,87		2,99
		B_{t2}?	45-	1,1	22,2	76,7	G	6,68		1,06
9	Slivice	A_h	0-20	32,7	47,7	19,6	MGI	7,62	35,3	6,26
		B_{t1}?	20-70	28,8	35,2	36	IG	7,79	0	
		B_{t2}?	70-	16,2	29,1	54,7	G	7,33		

PG - sandy clay, MGI - silty clay loam, G - clay, IG - clay loam, MI - silt loam

Fig. 2 PROFILE THROUGH THE SOIL ON THE EDGE OF THE RAKOVŠKO-UNŠKO POLJE

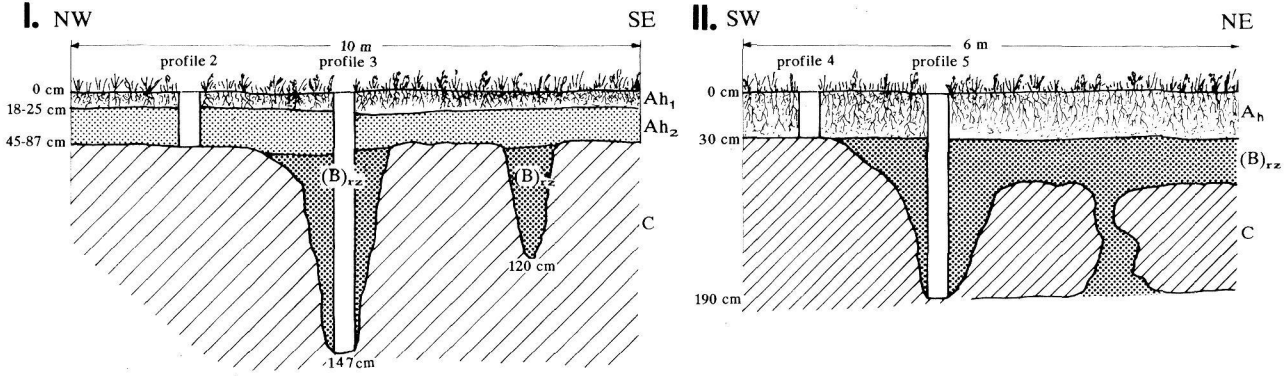
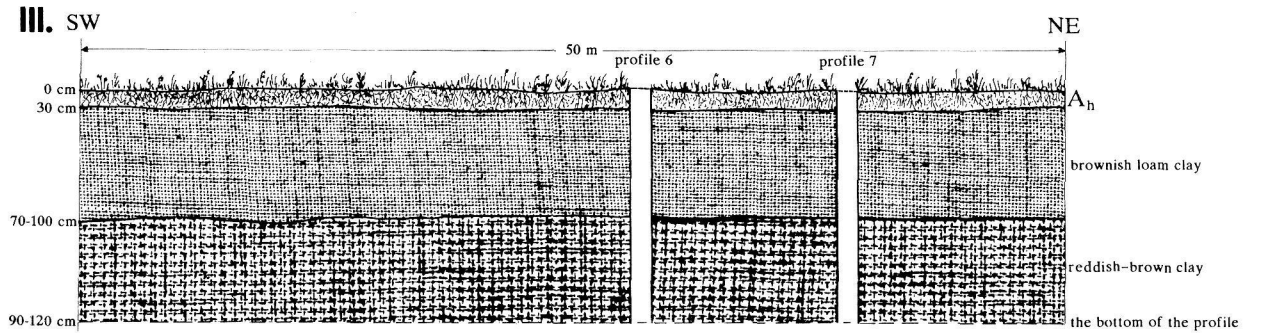


Fig. 3 PROFILE THROUGH THE SOIL ON THE BOTTOM ON THE RAKOVŠKO-UNŠKO POLJE



differ rather greatly from the soils of the lower part.

Profile 2 consists of the humose Ah horizon which is 45 cm deep and lies on the dolomite parent material. The upper part of the horizon, which could be defined as Ah1 subhorizon, is of dark brown colour, of crumb structure, and abounds in roots; it reaches down to the depth of 18 cm. (Fig. 2, I). Its texture is silty clay loam with 21.1% of clay and contains 7.92% of organic matter. The lower part which could be defined as Ah2 subhorizon, is of lighter colour than the upper part; it lies at a depth between 18 and 45 cm, its texture is clay loam with 31.7% of clay and contains 5.48% of organic matter. The entire Ah horizon contains about 2% of free $CaCO_3$, and its reaction is neutral. As to these two characteristics, almost no difference occurs between the two subhorizons. Small stones are present in the whole of the horizon.

About three meters east of the above mentioned profile, very deep soil was formed in the 147 cm deep fissure in dolomite (Table 1, Profile 3). (Fig.2, I). Profile morphology of the upper part is similar to that of the neighbouring profile (Profile 2). The Ah horizon reaches down to 87 cm, Here as well, it is divided into the upper Ah1 subhorizon which reaches down to the depth of 20 cm, its texture is silty clay loam with 20.7% of clay and 9.14% of organic matter. The lower Ah2 subhorizon lies at a depth between 20 and 87 cm, its texture, too, is silty clay loam with 21.3% of clay and 3.05% of organic matter. As to the reaction and share of free $CaCO_3$, only slight differences occur between the two subhorizons.

Under the Ah horizon, reddish clay lies which reaches down to the bottom of the fissure. The horizon of this clay could be defined as (B)rz, since this is the transformed insoluble residue of dolomite weathering. As to the texture of this horizon, it is clay with about 60% of clay; it contains only little organic matter and no free $CaCO_3$; its reaction is neutral.

Similar profile morphology is found with soil lying east and west of the two profiles described above. The clay horizon in one of the fissures which is 3 m deep and 2 m wide, contains 57.7% of clay, thus resembling greatly, so in this characteristic as well as in others, the (B)rz horizon in the profile 3. Peds in it are angular blocky and they have dark coats.

The shallower soil at the foot of the slope which passes over to the bottom of the polje (Table 1, Profile 4) consists of 30 cm deep Ah horizon that lies on the dolomite parent material. (Fig. 2,II). This horizon is of dark reddish colour (5 YR 3/2), abundant in roots, of crumb structure, sandy clay texture with 28.4% of clay - similar to the shallow soil on the higher southwest border of the polje. There is about 5% of organic matter in this horizon and a little more than one per cent of free $CaCO_3$; its reaction is neutral.

An interesting phenomenon has been discovered in this profile: about a 20 cm thick layer of yellowish clay (65.1% of clay) occurs at a depth of about 80 cm under the dolomite, and further down, below it, dolomite parent

material is found again. This clay layer is about 1 m long and lies already out of soil forming process; it does not contain organic matter and almost no $CaCO_3$, and its reaction is neutral (pH 6.91).

Two meters from the profile 4, on the slope away from the bottom of the polje, there lies deep soil in a 180 cm deep fissure (Table 1, Profile 5). (Fig. 2, II). The profile consists of a 30 cm thick Ah horizon, in the same way as in the profile 4. The texture is clay loam with 29.6% of clay and 5.36% of organic matter; its reaction is neutral and there is about 1% of free calcium carbonate. Below it, the reddish orange (10 YR 5/6) horizon lies, with a large share of clay (53.7%) almost without organic matter and free $CaCO_3$; its reaction is neutral. This horizon can be defined as (B)rz. Peds are angular blocky.

The slope with interchanging shallow soils and deep soils in fissures slants down to the bottom of the polje. The dolomite bedrock on the bottom lies, for the greater part, more than 1 m below the surface. Thus, deep soils prevail on the bottom of the polje. Besides the depth, profile morphology is also characteristic of these soils. The profile mainly consists of three horizons. Typical characteristics of these soils are seen in profile 7 (Table 1, Profile 7). (Fig. 3, III).

The profile consists of the light Ah horizon which abounds in roots, it is of dark reddish brown colour, 30 cm deep, and has silty loam texture with 24.8% of clay; it contains about 5% of organic matter and very little free $CaCO_3$; its reaction is neutral.

Below it, there lies a black brown horizon which reaches down to 100 cm; it is of clay texture with an even larger share of clay than the upper horizon (34.8%), smaller share of organic matter (2.85%), and about 1% of free $CaCO_3$; its reaction is neutral. Individual peds also occur in it. This horizon lies on a reddish brown horizon of clay texture with the largest share of clay (48%) in the entire profile. It still contains a little bit of organic matter (1.34%), but no free $CaCO_3$; pH 6.68.

Below the humose A horizon of the soils, and also in other parts of the bottom of the polje, there is a clay loam horizon which mainly lies on the reddish clay horizon. The latter everywhere contains a large share of clay (48-76%).

A comparison between the characteristics of the soils on the borders of the polje and those on its bottom shows that they were formed and developed in different soil forming processes. The differences are evident in their thickness and profile morphology. Shallow soils occur on the border parts with the A-C or A-AC-C profiles, and can be ranked among rendzinas which were formed on the dolomite parent material where weathered dolomite had mixed with organic matter which resulted in the humose horizon. Rendzina interchanges with deep soil in fissures, that can be ranked among chromic cambisols with the A-(B)rz-C profile. Stritar (1990) calls them 'fissure-filling

chromic cambisols'. A more detailed definition has to be postponed until thorough pedologic investigations, being performed by pedologists within the scope of elaborating a pedologic map on the scale of 1:50000, have been finished for this area, which has not been the case so far.

Soils which can be found on the north border of the polje below Rakek settlement differ from rendzinas and chromic cambisols, especially in profile morphology. They consist of a rather deep humose horizon which is divided into two parts by several characteristics. This thick upper horizon can lie directly on dolomite. Under a fissure, there lies a reddish insoluble clay residue of dolomite weathering. To a certain extent (as to texture) the lower part of the A horizon resembles the second horizon in the soils on the bottom of the polje. Yet, it is difficult to define it more distinctly without detailed pedologic investigations. Possibly, it could be the result of human activities, i.e. the growing of cultivated plants here, in the vicinity of the settlement. It could also be formed in a natural process of transporting and depositing tiny soil particles on the slope.

Soils on the bottom of the polje differ from those in the border parts by their greater depth and the profile which is mainly composed of three horizons. (Fig. 2, III). There are no distinctive and deep fissures on the bottom of the polje. Investigations of soils (Lovrenčak, 1989) and deposits on the bottom of the RUP (Čadež, 1954) have shown that the tectonically broken dolomite bedrock is covered with a more or less thick layer of reddish clay. It occurs at different depths. At the border parts of the bottom of the polje on the southeast and north sides, as well as in one part of the south side, it is 20-90 cm deep. In the central part of the bottom, on the west side, on both sides of the road between Unec and Rakek, it lies at the depth of 100-120 cm. Deeper down, reddish clay occurs in the east part of the bottom, i.e. on the site where clay was dug for the former brick factory (280 cm deep). It is even 400 cm deep near the clay pit. The deepest (500 cm) is the reddish clay near Slivice (Čadež, 1954).

The reddish clay horizon in the lower part of the profile has also been discovered in soils on dolomite and limestone elsewhere in Slovenia. Gregorič (1969) states that the (B) horizon of reddish brown soils (shallow to medium deep) on Triassic dolomite contains 25.2-60.2% of clay, and the B horizon of leached reddish brown soils contains from 37.4% to 43.9% of clay. Sušin (1968) also discovered similar proportions of clay in terra rossa on limestone in the lower part of the profile, e.g. in the B horizon of ilovka (medium leached terra rossa) there is 51.6-80% of clay. Stepančič (1975) states that luvo chromic cambisols on reddish brown clay on dolomite at Stehovec in Dolenjsko, north of Žalna, contain 67.3% of clay in the B1t horizon and 91.7% of clay in B2t horizon. Both horizons are of reddish brown colour. If compared to the proportion of clay in the horizon at the bottom of the RUP where it amounts to 48-77.6%, this percentage resembles the one in ilovka on

limestone and the one in the soil on dolomite at Stehovec. In this connection a question occurs about the origin of this clay, as well as the question of how to define systematically the soils on the bottom of the polje.

Reddish clay particles are a transformed insoluble residue of dolomite weathering. They can be autochthonous or allochthonous particles in soil. Gregorič (1969) came to the conclusion that deep leached soils are partly autochthonous and partly allochthonous. They were formed on the wide bottom of the Šmarska dolina valley near Grosuplje and on the levelled ridges which slope gently southwards. Precipitation water transported clay particles from higher areas.

Considering the fact that the RUP is also the bottom of a karst depression, it is supposed that clay particles here could also have been transported from border parts where clay horizons occur in fissures. The conclusion (Lovrenčak, 1989) that the reddish clay (B)rz horizon is autochthonous can only remain a hypothesis. The idea of allochthonous origin of clay is also supported by the conclusion by Čadež (1954); she states that this clay belongs to a group of separate deposits covering the dolomite parent material.

The answer to the question about systematic ranking of soils on the bottom of the RUP can also be just a hypothesis for now. As to their physical and chemical characteristics, they could be ranked among chromic cambisols. While investigating chromic cambisols on dolomite in Dolenjsko, Stepančič (1975) discovered three soil system units:

- luvo chromic cambisols on reddish brown clay;
- acro chromic luvisols with complex profile;
- acro chromic luvisols on silty loam.

It is typical of all units that the profile consists of two strata: the stratum of reddish brown clay lying immediately on dolomite and the stratum of yellowish brown silty clay loam of various depths covering the reddish brown clay.

If soils from the bottom of the RUP are compared with these units it becomes evident that the former also consist of two strata; the lower one of reddish clay and the upper one of brown clay loam. The texture of the lower part resembles the reddish horizon of the soils on dolomite in Dolenjsko (Table 2).

Table 2: Shares of clay and silt in lower soil horizons

	Clay	Silt
On dolomite in Dolenjsko	50-90%	maximum 30%
On the bottom of the RUP	48-77.6%	22.2-29.1%*

* *There is 41.2% of silt in Profile 7 and 49.1% of silt in Profile 6.*

The upper horizon differs in its texture from the lower. Therefore, we can only partly conclude that also the RUP soils have a bi-stratum profile. Even if physical and chemical characteristics of the soils from the bottom of the RUP are compared with the first type of soil on Stehovec, certain similarities can be observed (e.g. the reaction, the proportion of clay in A horizon). In view of these similarities, soils on the bottom of the RUP can be defined as chromic cambisols. A more detailed systematic ranking can supposedly be defined as leached chromic cambisols which developed on the relict layer of red clay.

CONCLUSION

In the RUP, which is divided into two parts regarding the landforms, i.e. the border part and the bottom of the polje, differences in soils are evident between the two parts. In border parts, two soil types interchange in the soil cover, i.e. rendzina and chromic cambisol which repeatedly occurs in fissures in the dolomite bedrock. On gentle slopes, both types of soils are deeper, and fields also occur there, but for the most part they are overgrown with meadows. On steeper slopes only grass vegetation grows.

On the northern border of the polje, below Rakek, a deeper A horizon occurs in the soil; it is present in both soil types. As an assumption, it is explained as the result of human activities, i.e. land cultivation. The reddish clay (B)rz horizon in chromic cambisols could be autochthonous; it was formed through dolomite weathering.

Deep chromic cambisols are stretched over the bottom of the polje. They are supposed to rank among leached chromic cambisols which might have a bi-stratum profile; such a profile is the result of ancient pedogenesis. There are certain indications that the lower horizon of red clay could be the deposit of fine particles transported from border parts of the polje onto its bottom. The thesis that fine particles were transported from the slopes and deposited on the bottom of the polje is also supported by its rather flat and level bottom. A better defined answer to the question about autochthonous or allochthonous origin of this clay and reddish horizon, as well as of clay loam horizon above, should be given by further investigations of these soils.

Because of the flat bottom and the depth of these soils, they are cultivated on almost the entire bottom. It is the location of the major fields of farmers from Rakek and Unec, who grow corn, wheat, potato, turnip, and fodder plants.

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PEDOGEOGRAFSKE ZNAČILNOSTI RAKOVSKO-UNŠKEGA POLJA

Povzetek

Rakovško-Unško polje lahko reliefno delimo na dva dela: robni del in dno polja. Na vsakem od teh delov se kažejo razlike v lastnostih prsti. Na robnih delih se v odeji prsti prepletata dva tipa prsti: rendzina in rjava pokarbonatna prst, ki se često nahaja v žepih v dolomitni matični osnovi. Tako prepletanje obeh tipov prsti je opazno tudi na kraškem površju, vzhodno od Rakeka, v podolju proti Cerknici. Na položnejšem površju sta oba tipa prsti globlja in so na njih njive, večinoma pa ju poraščajo travniki. Na strmejših pobočjih ju porašča le travniška vegetacija.

Na severnem robu polja pod Rakekom se v prsti pojavlja globlji A horizont, ki se nahaja v obeh tipičnih prsteh. Domnevno ga razlagamo z delovanejm človeka, kot posledica obdelovanja. Rdečkast glinast (B)rz horizont

v rjavih pokarbonatnih prsteh naj bi bil avtohton, nastal s preperevanjem dolomita.

Na dnu polja se razprostirajo globoke rjave pokarbonatne prsti. Domnevno jih uvrščamo med izprane rjave pokarbontane prsti, ki imajo verjetno dvoslojen profil, ki je razultat policikličnega pedogenetskega razvoja starejše pedogeneze. Za spodnji horizont rdeče gline nekateri znaki kažejo, da bi bil lahko nanos drobnih delcev iz robnih delov polja na njegovo dno. Tezo o nanosu drobno zrnatih delcev iz pobočij na dno polja lahko podpremo tudi z reliefno oblikovanostjo. Dokaj plosko in ravno dno polja kaže na to, da je nastalo s sedimentacijo.

Primerjava prsti na dnu Rakovsko-Unškega polja s prstmi na dolomitu na Dolenjskem pokaže, da je spodnji horizont prsti na dnu polja po teksturi podoben rdečkastemu horizontu v prsteh na Dolenjskem. To kaže na sorodno pedogenezo.

	glina	melj
Na dolomitu Dolenjske(Stepančič, 1975)	50-90%	največ 30%
Na dnu Rakovsko-Unškega polja	48-77,6%	22,2-29,1%*

* v 7. profilu je 41,2% in v 6. profilu 49,1% melja

Bolj jasen odgovor na vprašanja o avtohtonosti ali alohtonosti glinastega in rdečkastega horizonta ter tudi ilovnato glinastega horizonta nad njim naj bi dala nadaljna proučevanja teh prsti.

Zaradi ravnega dna in globine teh prsti so skoraj na celotnem dnu obdelane. Tu so poglavitne njivske površine kmetovalcev iz Rakeka in Unca, ki pridelujejo koruzo, krompir, repo in krmne rastline.