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TERRA ROSSA IN THE KVARNER AREA - GEOMORPHOLOGICAL CONDITIONS OF FORMATION

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Abstract:

Red soil or terra rossa is the most common soil type developed on carbonate rocks in the Kvarner area. In most cases, terra rossa has polygenetic origin. and was formed by mixing of insoluble residue of carbonate rocks with weathered and eroded loess and flysch sediments. Climatic and glacioeustatic changes and tectonic movements during Quaternary have influenced recent position of terra rossa and its mineralogical composition. The recent position of terra rossa is a consequence of erosion. In the areas where tectonic movements were more pronounced, because of slope erosion and resedimentation-colluviation processes terra rossa is found in isolated depressions in the form of thicker deposits. Examples are northern part of Cres island and southern slopes of the Učka mountain. In the areas where tectonic movements were less pronounced terra rossa covers larger areas in the form of thinner deposits. An example is the western part of the island of Krk.

Key words:

Terra rossa; pedogenesis; Quaternary; Kvarner; Adriatic Sea

CRVENICA U PODRUČJU KVARNERA: GEOMORFOLOŠKI UVJETI POSTANKA

Izvadak:

Crvenica ili terra rossa je najzastupljeniji pedološki tip odnosno pokrivač na karbonatnim stijenama kvarnerskog područja. Crvenica je najčešće poligenetske prirode i tada je nastala miješanjem netopljivih ostataka karbonatnih stijena s trošnim i erodiranim naslagama lesa i fliša. Na mineraloški sastav i današnji položaj crvenice utjecale su klimatske i glacioeustatičke promjene, kao i tektonski pokreti tijekom kvartara. Današnji raspored crvenice posljedica je erozije. Tamo gdje su tektonski pokreti bili izraženi, terra rossa se zbog erozije padina i resedimentiranja-koluvijacije nalazi u izoliranim depresijama u obliku debljih nakupina. Primjeri su sjeverni dio otoka Cresa i padine južne Učke. Tamo gdje su tektonski pokreti bili slabo izraženi, terra rossa je male debljine, ali pokriva velike površine. Primjer je zapadni dio otoka Krka.

Ključne riječi:

crvenica; pedogeneza; kvartar; Kvarner; Jadransko more

INTRODUCTION

The Kvarner area consist of the channel part, Cres, Lošinj, Krk and Rab as larger islands as well as a few smaller ones, and the coastal part of the Northern Adriatic including the coast of the Istria peninsula and Vinodol area. The Rijeka Bay, The Kvarner, The Kvarnerić and The Vinodol Channel are situated in the aquatorie between the coast and the islands (fig 1.)

Until today, a numerous fundamental and applied geological investigations have been done in the Kvarner area. Consequently, litostratigrafic characteristics and structural and tectonic fabric of bedrock are well-known. On the other hand, data of genesis, mineralogical and petrological and physical characteristic of covering zone are very inadequate.

The same applies to the red mediterranean soil or terra rossa, which is one of most frequent pedological types in the Kvarner area. The aim of this paper is presenting on new data of the genesis, the spreading and characteristics of terra rossa in the Kvarener area based on investigations. The authors considered the climatic and glacioeustatic changes and tectonic movements during the youngest geological periods.

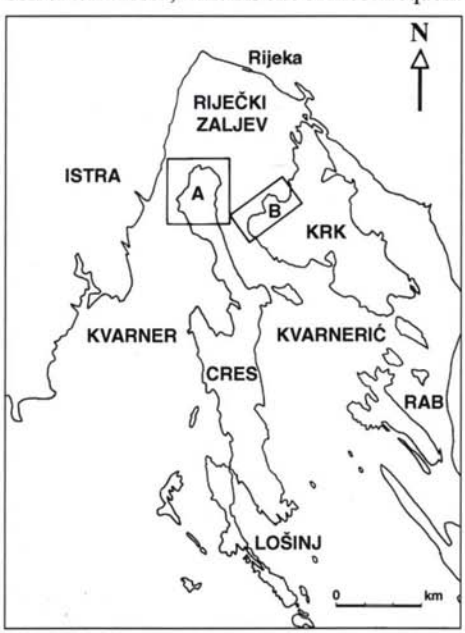

Fig. 1. The Kvarner area
A-area showed in fig. 2.; B-area showed in fig. 3.
Sl.1. Područje Kvarnera
A - područje na sl. 2; B - područje na sl. 3

SOME NOTES ON TERRA ROSSA IN GENERAL

Red soils are one of most widespread soil types in the Mediterranean region and are usually called red Mediterranean soils. Terra rossa is a term used for Mediterranean soils which cover limestones and dolomites. However, some authors use this term for all red Mediterranean soils regardless the underlying rock (e.g. ZAPATA et. al., 1982). The main characteristic of terra rossa is the red colour as the result of rubification, i.e. formation of Fe-oxides (BOERO & SCHWERTMANN, 1989). Terra rossa is usually considered paleosol in the Mediterranean region. However, in some countries (e. g. Lebanon) it is considered recent soil (VERHEYE & STOOPS, 1973). The nature of terra rossa and its relationship to underlying carbonates is a longstanding problem. It has resulted in different opinions with respect to the parent material and origin of terra rossa.

In the 19th century, terra rossa was considered the weathering product of limestone, i. e. insoluble residue (NEUMAYR, 1875).

According to the most widely accepted theory for the origin of terra rosa, it originated from the insoluble residue of carbonate rocks (NEUMAYR, 1875; TUĆAN, 1912; KIŠPATIĆ, 1912; KUBIËNA, 1953; ĆIRIĆ & ALEKSANDRIJEVIĆ, 1959; MARIĆ, 1964; PLASTER & SHARWOOD, 1971; ŠKORIĆ, 1979, 1981 and 1987; BRONGER et al., 1983; MORESSI & MONGELLY, 1988).

However, other authors have indicated that terra rossa could not have been formed entirely from the insoluble residue of limestone and

dolomite. OLSON et al. (1980) emphasised that the terra rossa is mainly debris derived from clastic sedimentary rocks and deposited on limestone. RAPP (1984) proposed that the terra rossa in Southern Europe might be wind-borne material from Africa. Polygenetic origin and external material contribution to the insoluble residue of carbonate rocks were also recognised by GLAZOVSKAYA & PARFENOVA (1974), ŠINKOVEC (1974), DURN et al. (1992), DURN & ALJINOVIĆ (1995), DURN (1996), DURN et al. (1997), BRONGER & SEDOV (1997), BRONGER & BRUHN-LOBIN (1997).

The relation between terra rossa and underlying carbonate rocks points to the specific pedoenvironment of terra rossa formation (BOERO & SCHWERTMANN, 1989). Due to long period of terra rossa formation erosion and deposition processes which are superimposed on karst terrains and induced both by climatic changes and tectonic movements might have considerably affected the terra rossa distribution.

GEOLOGICAL CHARACTERISTICS

In the Kvarner area Cretaceous, Paleogene, Quaternary and recent formation are found (ŠIKIĆ et al., 1969; ŠUŠNJAR et al.; 1970; ŠIKIĆ et al.; 1972; MAGAŠ, 1968; MAMUŽIĆ, 1968; MAMUŽIĆ et al., 1969 ; MAMUŽIĆ et al., 1970; SAVIĆ & DOZET, 1984).

Cretaceous (limestones, dolomites and breccias) and Paleogene carbonate rocks (limestones and breccias) are prevailing in the Kvarner area. Paleogene flysch (siltstone, marl and sandstone) is very restricted. These rocks form the bedrock, partially covered by younger deposits on the land. The zones of terra rossa are common on the carbonate rocks, but flysch rock formations are covered by weathering deposits.

The sea-bottom of the Kvarner area is almost completely covered by Quaternary and recent deposits: near the coast by gravel and sand, and in deeper parts by quick mud (ŠKRIVANIĆ & MAGDALENIĆ, 1979; ALFIREVIĆ, 1980).

The Kvarner area is a part of Adriatic geodynamic unit, which is surrounded by Dinaric unit on the northeast and by Istria unit on the west side (PRELOGOVIĆ et al., 1995). Cretaceous and Paleogene rocks have been folded, and then revers faults and overthrust's have been formed.

Similar structural fabric is visible in the most part of the Kvarner area: relatively of narrow overthrust structures with general strike NW-SE. The boundaries of overthrust's are clearly visible on the contacts between carbonate and flysch rocks. The difference in structural fabric and the general strike are visible in the area of the Učka mountain, between Plomin and Opatija.

METHODS OF INVESTIGATIONS

The degree of investigations of geological fabric in the Kvarner area is quite uneven. For the purpose of this paper all available publications and technical reports located in the archives of companies and institutes were evaluated, and analytical data on terra rossa were systematised.

The results of field investigation performed by the authors during several years were supplemented by the analysis of the monochromatic aerial photographs (scale 1:5,000; 1:10,000 and 1:30,000) and thermosensitive satellite photographs (scale 1:200,000). Based on this approach the areas covered with terra rossa were outlined.

The majority of analytical data for terra rossa are from the samples taken along northern coastal zone of the Rijeka Bay because the major part of the geotechnical investigations in the area were accomplished there. The methods of analysis and equipment are not described in detail in the evaluated papers. However, in majority of cases, the standard methodology and equipment which is in use for soil mechanic

investigations was employed. Particle size analysis was determined on the >0.06 mm fraction by dry or wet sieving. Fractions <0.06 mm were determined using aerometry after treatment with H_2O_2.

Determination of plasticity limits (w_p;w_l) was performed with standard Atteberg apparatus. Semiquantitative mineral composition of the selected terra rossa samples was obtained using x-ray powder diffraction (XRD).

MORPHOLOGICAL EVOLUTION OF THE KVARNER AREA

The recent relief of the area of the Kvarner area is the result of tectonic movements, climatic and sea level changes during the early geological times, and also the exogenetic processes.

Neotectonic movements, (since Lower Pliocene till today), caused by subsidence of the Adriatic plate under the Dinarides had variable intensity and direction (PRELOGOVIĆ et al., 1981). They had the crucial role in the formation of geological structures (PRELOGOVIĆ et al., 1995). Horizontal movements caused the rotation of the northern part of the Kvarner Area and the bending the main orographic axis (MIHLJEVIĆ, 1995). The result of vertical movements was the breaking of the karst plateau, the subsidence of Rijeka Bay and the surrounding channels and significant uplift of the island of Cres, mountain Učka and mountains of the Gorski kotar (BENAC, 1996).

During the Neogene epoch terrigenous conditions and subtropical climate prevailed in the Kvarner area. Intensive karstification processes have occurred on the carbonate plateau (PRELOGOVIĆ & KRANJEC, 1983). The climatic change and glacioeustatic sea level oscillation have been great (BOWEN, 1978) and they have strongly transformed relief, and also destroyed remains of older phases of morphogenesis in the Kvarner area.

The oscillations of the sea level of the Adriatic sea have been more then 100 m during Pleistocene (VAN STRAATEN, 1970). Possibly, there were isolated lakes on the bottom of the depressions of Kvarner at the top of Wuerm regression. The carbonate rock mass is karstified deeply below the recent sea level.

The frequency and the greatness of sinkholes vary greatly on carbonate rocks in the Kvarner area. Their shapes give evidence of tectonic deformations in the rock mass (MIHLJEVIĆ, 1994). Therefore, they are completely or partially destroyed in the zones of active faults.

Mechanical disintegration was much stronger than karstification in the carbonate rocks with more dolomite component. Wide depressions, filled by terra rossa, are noticable in these places. Great karst depressions have been found in the island of Cres, on the eastern slopes of the Učka mountain and around of the Bakar Bay.

The sea-level fall and rise and the tectonic movements have caused increased energy of the relief. Due to these morphogenetic factors and cold climate conditions processes of erosion have been expressed. Therefore, they have caused permanent processes of the denudation and the accumulation of eroded material in the depressions, earlier formed by the tectonic movements.

Great parts of the flysch sediments, products of the kartification and the loess have eroded (BOGNAR & ZAMBO, 1992). Different deposits have mixed during the morphogenesis of Kvarner area. Therefore, the products of weathering, which were formed in different periods of Quaternary are found on the same places.

In most cases, terra rosa has poligenetic origin in the Kvarner area, just like in Istria (DURN, 1996). They have been formed by the process of rubification of insoluble residue of limestones and dolomites, which were mixed with the loess and weathered and eroded flysch. The repeated processes of the rubification on hard, fractured and permeable carbonate bedrock

occurred during periods when the climatic conditions have been favourable.

THE CHARACTERISTICS OF TERRA ROSSA

Red soils, usually considered as terra rossa are quite widespread in the Kvarner area. They cover carbonate rocks, especially limestones of Creatceous and Paleogene age in the form of discontinuous surface layer both on land and below recent see level. As the result of erosion processes, accumulations of terra rossa-like material are sporadically found on flysch of Paleogene age.

Terra rossa has dominantly silty clay composition and therefore very low resistance to erosion. Geomorphological evolution was occasionally very dynamic during the Pleistocene in the Kvarner area, accompanied by intense inverse tectonic movements. This caused relatively intense wash-out of soils situated on

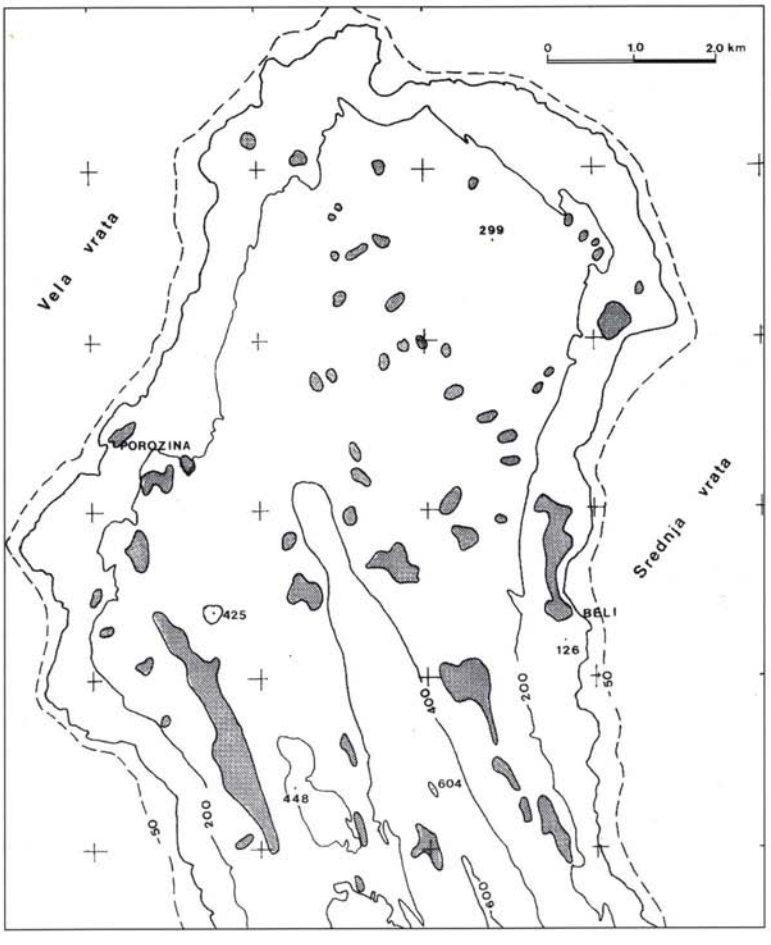

Fig. 2. Terra rossa in the northern part of island of Cres
Sl. 2. Terra rossa na sjevernom dijelu otoka Cresa

the elevated positions and its transport and sedimentation in newly formed depressions, forming soil-sediments. An marked example is the northern part of the island of Cres (Tramunatana) where terra rossa is situated only in sinkholes or other karst depressions forming soil sediments up to several meters thick (fig. 2). On the other hand, distribution of terra rossa in the western part of island of Krk (Šotovento) is different (fig. 3). Terra rossa covers larger areas in the form of thinner deposits whose thickness in most cases doesn't exceed 1 meter. Distribution of terra rossa is certainly caused with less expressed recent tectonic movements in this part of island of Krk.

Erosion of flysch situated in the northeastern part of the island might have increased the amount of material from which red soils on carbonate rocks developed.

In the area of the Kvarner, terra rossa deposits vary in thickness: from very thin discontinuous zones on hills and slopes to deposits in sinkholes and dolinas which are more then several meters thick. Due to polygenetic nature they bear the characteristics of soils, paleosoils and pedo-sedimentary complexes. Their colour varies from yellowish-red to dark red depending on the type and content of Fe-oxides. The upper parts of terra rossa profiles very often are yellowish-brown in colour due to admixtures of Upper Pleistocene loess and subrecent and recent pedogenetic processes respectively. On hills and slopes terra rossa contains fragments of carbonate rocks. These angular to subangular fragments are mainly a few centimetres in size and can constitute up to 50% volume of the soil.

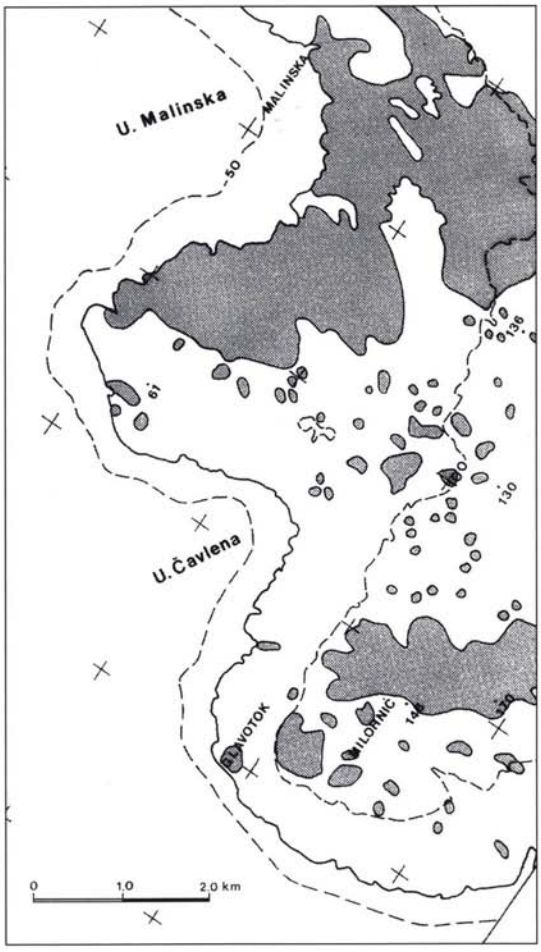

Fig. 3. Terra rossa in the western part of island of Krk
Sl. 3. Terra rossa na zapadnom dijelu otoka Krka

The majority of analysed terra rossa samples is grouped in the area of clayey silt (fig. 4). The content of clay ranges from 18 to 50 wt.% while the content of sand ranges from 3 to 27 wt. %.

On the plasticity diagram most terra rossa samples are plotted above the A-line (fig. 5). The liquid limit (wl) ranges from 33 to 79 % while plasticity index (Ip) ranges from 13 to 47 %. Most of the investigated samples are plotted within the zone of low plasticity (CL) to high plasticity clays (CH). Only few samples are plotted in the zone of low plasticity (ML) to high plasticity silts (MH). Considering Figs. 4 and 5 one could tentatively

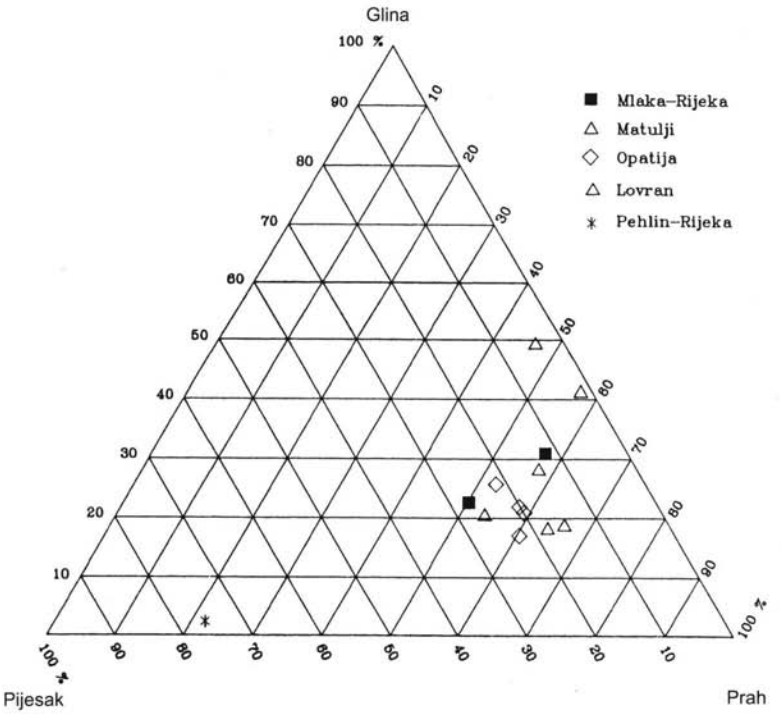

Fig.4. Particle size analysis of terra rossa
Sl. 4. Trokomponentni dijagram

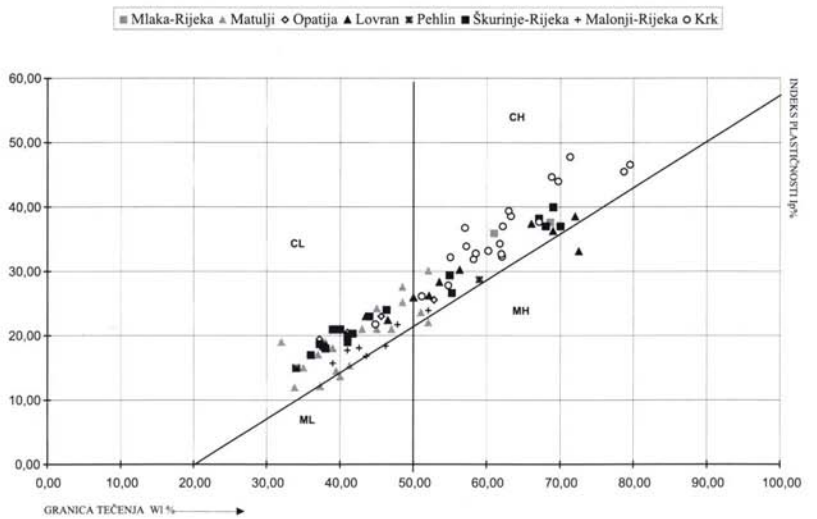

Fig. 5. Plasticity diagram
Sl. 5. Dijagram plastičnosti

Sample Uzorak	Micaceous minerals and kaolinite Tinjčasti minerali i kaolinit	Quartz Kvarc	Fe-oxides and hydroxides Fe-oksidi i hidroksidi
1	55	30	15
2	45	45	10
3	40	45	10

Table 1. Mineral composition of samples of terra rossa (wt. %)
Tablica 1. Mineralni sastav uzoraka terra rosse (tež.%).

suppose that relatively slight addition of clay increases plasticity of terra rossa much more than it can be predicted from particle-size analysis.

Compared to terra rossa in Istria (DURN, 1996) terra rossa from the Kvarner area are enriched in silt and clay. However, JASNIĆ (1992) and DURN (1996) showed that due to the method of particle-size analysis employed, the content of clay, silt and sand in terra rossa may significantly vary. Dissimilarity between the particle-size distribution and plasticity might be the consequence of agglomeration of clay particles in terra rossa. The result of inadequate deagglomeration is a higher content of both silt and sand particles in terra rossa. Namely, agglomeration of clay particles and stickiness of mineral particles coated with iron and manganese oxides is a common feature especially widespread in soils. Scattering of samples on plasticity diagram may also be an indication of polygenetic origin of terra rossa.

Mineral investigation of terra rossa was performed only on three samples from the Matulji locality. Analysed samples contain 40 to 55 wt.% micaceous minerals (illitic material and muscovite) and kaolinite, 30 to 45 wt.% quartz and 10 to 15 wt.% Fe-oxides (Table 1). Mineral composition of samples from the Matulji locality is similar to the mineral composition of terra rossa from Istria determined by ŠKORIĆ (1987). Based on detail analysis of terra rossa in Istria DURN (1996) shows that main crystallised clay mineral phases in fraction <2mm are kaolinites and illitic material while chlorite, vermiculite and mixed-layer clay minerals represent subordinate mineral phases. The same author found amorphous inorganic compounds in terra rossa from Istria.

CONCLUSION

The Kvarner area is mainly built up by carbonate rocks of Cretaceous and Paleogene age (limestones, dolomites, dolomitic limestones and breccia). Terra rossa is the most common soil type developed on carbonate rocks in the Kvarner Area.

Tectonic movements and sea-level changes during the Pleistocene induced relief of high energy. This enabled intense erosion and mixing of older terra rossa soils, weathered flysch and loess which was repeatedly blown to the Kvarner area during the colder periods of the Pleistocene. Because of these processes, products of pedogenesis and weathering formed in different periods of the Quaternary under similar or distinct conditions may be closely associated.

In most cases, terra rossa in the Kvarner area has polygenetic origin and was formed by mixing of insoluble residue of carbonate rocks with weathered and eroded loess and flysch. Process of rubification repeatedly occurred on hard, fractured and permeable carbonate rocks in Quaternary during periods with favourable climatic conditions.

Climatic and glacioeustatic changes and tectonic movements during Quaternary have influenced the recent position of terra rossa and its mineralogical composition. The recent position of terra rossa is a consequence of erosion. In the areas where tectonic movements were

more pronounced, because of slope erosion and resedimentation-colluviation processes terra rossa is found in isolated depressions in the form of thicker deposits. Examples are northern part of The Cres island and southern slopes of the Učka mountain. In the areas where tectonic movements were less pronounced terra rossa covers larger areas in the form of thinner deposits. An example is the western part of the island of Krk.

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Sažetak

CRVENICA U PODRUČJU KVARNERA: GEOMORFOLOŠKI UVJETI POSTANKA

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Tla crvene boje javljaju se u mnogim mediteranskim zemljama kao jedan od najzastupljenijih pedoloških tipova i općenito se nazivaju crvena mediteranska tla (eng. red mediterranean soils). Terra rossa (ili zemlja crvenica u našim krajevima) je sinonim koji se najčešće upotrebljava za crvena mediteranska tla razvijena na vapnencima i dolomitima. Povijesno je stariji, a koristili su ga i prvi istraživači tih tala. Temeljna značajka terra rosse, iz koje i proističe njen naziv, je crvena boja. Ona je posljedica rubifikacije, procesa peptizacije amorfnih željeznih oksida i formiranja kristalića getita i hematita u gustoj osnovi tla. Većina autora danas smatra da su terra rosse paleotla. Je li terra rossa nastala iz netopljivog ostatka vapnenca i dolomita, ili njezin glavni ishodišni materijal predstavljaju neke druge stijene, pitanje je koje i danas privlači pozornost istraživača.

Autore koji se bave istraživanjem tala na karbonatnim stijenama, možemo s obzirom na tumačenje postanka terra rosse, podijeliti u tri grupe. U prvoj grupi su autori koji smatraju da su terra rosse nastale iz netopljivog ostatka vapnenca i dolomita, u drugoj oni koji smatraju da su terra rosse nastale iz materijala nanesenog na vapnenačko-dolomitnu podlogu, a u trećoj grupi, autori koji terra rossu smatraju poligenetskom tvorevinom. Bez ulaženja u kritičku analizu dosad iznešenih ideja o matičnim stijenama za nastanak terra rosse, može se zaključiti da su razlike u tumačenju vjerojatno posljedica geološke i pedološke građe područja na kojima se nalazi istraživana terra rossa, kao i različitih analitičkih metoda koje su autori primijenili na svojim istraživanjima.

Veza terra rosse s vapnencima i dolomitima u podlozi, kao i njezina karakteristična crvena boja ukazuju na specifični pedookoliš njezinog postanka. Proces formiranja terra rosse na karbonatnoj podlozi vjerojatno se odvijao kroz duže vremensko razdoblje. Zbog procesa erozije i taloženja, u osnovi je teško naći neporemećeni (cjelovit) profil terra rosse u prvobitnom položaju. Formiranje kroz dulje vremensko razdoblje povezano je s klimatskim varijacijama. Unosi drugih materijala, također su mogli bitno utjecati na izvorne komponente terra rosse.

Kvarnersko područje, kako obale tako i otoci, najvećim dijelom su oblikovani u karbonatnim stijenama kredne i paleogenske starosti (vapnenci, dolomitični vapnenci, dolomiti i breče). Crvenica je najzastupljeniji pedološki tip odnosno pokrivač na njima. Također su, u obliku pretaloženih materijala, ustanovljene i na paleogenskom flišu.

Geološki razvoj bio je tijekom pleistocena na području Kvarnera povremeno vrlo dinamičan. Tektonskim pokretima tijekom pleistocena stvoren je reljef visoke energije. To je omogućilo jako erodiranje starijih naslaga terra rosse, zatim kore fizičko-kemijskog raspadanja na paleogenskom flišu i lesa, istaloženog u hladnijim razdobljima pleistocena te njihovo taloženje u novonastalim udubljenjima. Zato se na istim ili bliskim mjestima nalaze produkti razgradnje stijena, nastali u različitim razdobljima kvartara kao i u različitim fizikalno-kemijskim uvjetima.

Vjerojatno je da su crvena tla na području Kvarnera prvenstveno poligenetske prirode. Nastala su rubifikacijom (ocrvenjivanjem)

netopljivih ostataka vapnenaca i dolomita koji su pomiješani s lesom i materijalom ispranim s flišnih terena. Procesi ocrvenjivanja opetovano su se odvijali na tvrdoj, raspucaloj i permeabilnoj karbonatnoj podlozi tijekom razdoblja s povoljnim klimatskim uvjetima.

Raspored crvenice na području Kvarnera vrlo je nejednolik. Tamo gdje su tektonski pokreti bili izraženi terra rossa se nalazi u depresijama u obliku izoliranih nakupina veće debljine. Izraziti primjer je sjeverni dio otoka Cresa (Tramuntana). Tamo se terra rossa nalazi jedino u ponikvama ili u krškim uvalama. Naslage su često višemetarskih debljina (sl.2). Nasuprot tomu, raspored crvenice na zapadnom dijelu otoka Krka (Šotovento), posve je drugačiji (sl.3). Tamo terra rossa pokriva razmjerno široka područja u obliku relativno tankog pokrivača, čija debljina najčešće ne premašuje 1 m. Razlog tomu su svakako mirniji recentni tektonski pokreti ovog dijela otoka Krka.

Terra rosse u području Kvarnera, zbog poligenetske prirode, imaju karakteristike tala, paleotala i pedo-sedimentnih kompleksa. Njihova boja može varirati od žutocrvene do tamno crvene boje, ovisno od udjela Fe-oksida i hidroksida. Gornji dijelovi profila često imaju svijetlosmeđu boju zbog pomiješanog gornjopleistocenskog lesnog materijala i djelovanja subrecentnih i recentnih pedogenetskih procesa. U ponikvama se obično nalaze naslage crvenice bez krupnijih frakcija. Na uzvišenjima i padinama crvenica sadrži odlomke podrijetlom iz stjenovite podloge. Ti odlomci su najčešće uglasti do poluuglasti i centimetarskih dimenzija. Njihov udio u ukupnom volumenu može doseći 50 %.

Većina ispitanih uzoraka terra rosse je grupirana u području glinovitog praha, tj. u njima prevladava prašinasta komponenta (sl.4). Udio glinovite komponente je 18 do 50 %, a pijeska od 3 do 27 %. Na dijagramu plastičnosti većina uzoraka grupirana je iznad A-linije. Raspon granice tečenja (wl) je 33 do 79 %, a indeksa plastičnosti (Ip) je 13 do 47 % (sl.5). Većina ispitanih uzoraka nalazi se u području niskoplastičnih (CL) do visokoplastičnih glina (CH). Neki uzorci nalaze se u području praha niske (ML) do visoke plastičnosti (MH). Na temelju navedenih dijagrama može se pretpostaviti da i razmjerno mali udio glinovite komponente povećava plastičnost materijala više nego što se može očekivati s obzirom na granulometrijski sastav.

U usporedbi s terra rossama Istre, terra rosse Kvarnera bogatije su siltnom i pjeskovitom komponentom. Međutim, ovisno od primjenjene granulometrijske metode analize iskazani udjeli čestica glina, silta i pijeska u terra rossi mogu bitno varirati. Nepodudarnost rezultata granulometrijskih analiza i mjerenja granica plastičnosti može, prema tome, biti i posljedica aglomeracije glinovitih čestica u terra rossi pa su iskazani viši udjeli čestica silta i pijeska od stvarnog. Naime, aglomeriranje minerala glina i ljepljenje mineralnih čestica presvučenih željeznim i manganskim oksidima uobičajena je pojava naročito raširena u tlu. Raspršenost uzoraka na dijagramu plastičnosti može biti i indikacija poligenetske prirode terra rosse.

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