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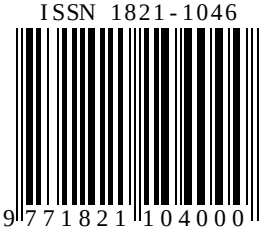

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IMPACT OF THE PARENT ROCK ON EROSION PROCESS DEVELOPMENT IN GRDELICA GORGE AND VRANJE VALLEY

Sonja BRAUNOVIĆ, Mihailo RATKNIĆ, Ljubinko RAKONJAC[1]

Abstract: *In the 1950s Grdelica Gorge and Vranje Valley were subject to erosion processes of all destruction categories, from weak surface erosion on mild slopes to excessive surface erosion and deep erosion in developed configuration terrains. Excessive erosion covered 28% of the total area under review and it made itself manifest in the form of numerous ravines, gullies, landslides and patches of barren parent rock.*

This paper presents analysis of parent rock as one of the natural predispositions for development of intensive erosion processes in this area.

Key words: parent rock, erosion processes, crystalline shales, excessive erosion

UTICAJ GEOLOŠKE PODLOGE NA RAZVOJ EROZIONIH PROCESA U GRDELIČKOJ KLISURI I VRANJSKOJ KOTLINI

Izvod: *Pedesetih godina prošlog veka u Grdeličkoj klisuri i Vranjskoj kotlini bili su zastupljeni erozioni procesi svih kategorija razornosti, počev od slabe površinske erozije na blagim padinama, do ekscesivne površinske i dubinske erozije na terenima razvijene konfiguracije. Ekscesivna erozija zauzimala je 28% ukupne površine područja, a manifestovala se mnogobrojnim jarugama, vododerinama, klizištima, kao i površinama sa ogoljenom geološkom podlogom.*

U radu je prikazana analiza geološke podloge, kao jedne od prirodnih predispozicija za razvoj intenzivnih procesa erozije na ovom području.

Ključne reči: geološka podloga, erozioni procesi, kristalasti škriljci, ekscesivna erozija

[1]mr Sonja Braunović, dr Mihailo Ratknić, dr Ljubinko Rakonjac, Institute of Forestry, Kneza Višeslava 3, Belgrade, Serbia. *sonjabraunovic@yahoo.com*

1. INTRODUCTION

"Terrain parent rock has certain impact on the development of erosion processes. Although it is known that under different climatic conditions on the same parent rock different types of pedological soil layer may be formed, it has been established that velocity and form of erosion processes on soil are predetermined by the parent rock properties to a significant extent. Parent rock affects soil formation and thus its resistance to erosion as well" (Kostadinov, S., 1996).

2. AREA UNDER RESEARCH AND METHODS

The area of Gredelica Gorge and Vranje Valley received its name based on the 1954 Law on Protection from Erosion and Torrent Control and it has been studied as a whole ever since.

The area boundaries defined by the aforesaid Law substantively deviate from the natural gorge and valley borders. They encompass portion of the Južna Morava River drainage basin of the area of 173,260.6 hectares, from Grdelica in the north to above the confluence of the Binačka Morava, not far from Bujanovac in the south. The region is situated between 42°22' and 42°55' of north latitude and between 19°21' and 20°0" of east longitude. It is elongated, stretching in the direction from south-wet to north-east. The area under research is situated in the altitude zone between from 252 to 1,923 meters and features a highly developed hydrographic network.

A digital geologic map was prepared with a 1:100 000 scale ratio and parts of sheets Leskovac, Vlasotince, Trgovište sa Radomirom and Vranje, which belong to the area. The present parent rock types were grouped into igneous, sedimentary and metamorphic rocks.

Parent rock types present were further classified based on the extent of erodibility and percentage shares of very hard, relatively hard, relatively erodible and very erodible rocks (Petrković, S., 1995).

3. RESULTS

Metamorphic rocks. Present crystalline shales, micashists, gniesses, orthogneisses, chloritoshists, quartz shales, amphibolites and amphibolte shales, serpentinites and graphite shales cover 718.85 km^2 or 41.06 % of the total area of the region (Table 1).

Crystalline shales are predominant in this area. The north portion of the terrain, up to the Ravnorečka River and Vrla is mostly formed of crystalline shales. Farther to the south, crystalline shales form terrains on the left bank of the Morava River from Plačkovica, and penetrate the granite massif of Vršnika. On the right bank of the Morava, crystalline shales stretch from Masuričko Polje to the sedimentary basins of Buštranja and Marganaca in the south and further on toward Pčinja. Crystalline shales of the lower crystallinity, the so-called "green shales," which are found downstream from Vladičin Han on the right bank of the Južna Morava River caused remarkable erodibility of this portion of the region. Similar

are philites and sericite shales, stretching along the western rim of the area.

Table 1. *Metamorphic rocks*

Bedrock	Map designation	F km^2	%
Feldsparized and granitized shales genetically related to granitoids	Sf	4.42	0.26
Chlorite-sericite shales	Scose	2.82	0.16
Chlorite-muscovite shales	Scom	35.94	2.07
Amphibolic shales	A	3.40	0.19
Quartzites	Q	1.53	0.09
Small-grain biotite and biotite-muscovite gneisses	Gb	180.81	10.44
Chlorite-epidote shales	Scoep	15.16	0.88
Leptinolites and micashists	Sm	151.38	8.74
Muscovite-chlorite shales	Smco	65.93	3.81
Albite-chlorite-muscovite shales	Sabco	178.86	10.32
Migmatites: diffusely migmatized shales	Mi	8.18	0.47
Muscovite-chlorite shales	Sco	24.40	1.41
Albite gneiss with chlorite	Gab	35.03	2.02
Leucogneisses	Gf	1.90	0.11
Sericite-graphite and sericite-chlorite shales	Osse	1.61	0.09
	Total	711.40	41.06

Igneous rocks are also present in the region under research and cover 26.4% of the area. They are represented by granitoid dacite-andesite rocks and their tuffs. Granitoid rocks comprise granites, granodiorites, quartz monconites, etc. (Table 2). The areas of granitoid rock prevalence is to the south and south-east of Surdulica. This igneous massif stretches from Čemernik in the north to Bajčina Čuka and Gizdavac in the south.

Table 2. *Igneous rocks*

Bedrock	Map designation	F km^2	%
Granitoids of Surdulica	γδ	204.45	11.80
Leucogranites, granitoids (Bujanovac pluton)	G"	87.45	5.05
Tuffs	θ	2.10	0.12
Granitoids of Kukavica and Slatinska River	γ	0.94	0.05
Small-grain granitoids of Kukavica	G	3.17	0.18
Small-grain granitoids of Kukavica with quantitatively inferior granitoids of Vlajna	G/G	3.96	0.23
Small-grain granitoids of Kukavica with quantitatively superior granitoids of Vlajna	G/G	13.01	0.75
Tuffs, breccias and rarely tuffs of quartz-latite-dacite composition	ωαq	18.44	1.06
Hybrid rocks of gabbroid and amphibolite composition	Miv	4.09	0.24
Granitoids of Božica	G	23.26	1.34
Quartz latites	αq	17.63	1.02
Biotite dacite	αqb	3.00	0.17
Pyroclasts: agglomerates, breccias and tuffs	$^1E_3$	5.57	0.32
Dacites	xα	70.28	4.06
	Total	457.34	26.40

Sedimentary rocks of different ages cover 32.5% of the area (Table 3). They are comprised of conglomerates, sandstones, claystones, marlstones, bituminous shales, connected or disconnected lake sediments, gravel, sand, clay, alluvial and delluvial deposits, etc.

In studies and analyses of the terrain geologic composition and water flow

deposits, physical and mechanical properties of rocks as sources of deposits are of great importance. Relevant factor of rock erodibility is also the extent of rock fracture; hence even very hard rocks may have low rigidity if tectonically damaged. In the instances of physical rock degradation superiority over chemical degradation, large-grain gravel and sand deposits are formed; if vice-versa, small-grain clay deposits and lesion rocks are created.

Table 3. *Sedimentary rocks*

Bedrock	Map designation	F km^2	%
Classic base of the series: conglomerates, colored and red sandstones	^{1}Ol, M	23.62	1.36
Conglomerates and sandstones with coal lenses in the upper part	$^{1}_{2}K^{3}_{2}$	6.52	0.38
Mid-part of the series: limestone's with charts, sandstones and marlstones	^{2}Ol, M	5.71	0.33
Small-grain sandstones, claystones and marlstones	$^{2}_{2}K^{3}_{2}$	7.89	0.46
Volcanogenic-sedimentary horizon: conglomerates, sandstones and tuffs	$^{2}E_3$	3.62	0.21
Sandy claystones and marlstones	$^{2}M_2$	8.98	0.52
Uppermost part of the series: bituminous claystones, sandstones and marlstones	^{3}Ol, M	3.98	0.23
Shallow-water chastises: conglomerates, sandstones and claystones	$^{3}E_3$	19.26	1.11
Marlstones	$^{4}E_3$	14.95	0.86
Sub water sliding horizon: marlstones, claystones and sandstones	$^{5}E_3$	93.46	5.39
Turbidity horizon: marlstones, aerolite's and sandstones	$^{6}E_3$	0.92	0.05
Alluvium	al	102.62	5.92
Diluvium	d	5.37	0.31
Prolluvium – face of the delta	pr	0.72	0.04
Fluvial terrace	t	12.03	0.69
Lowest terrace	t_1	9.74	0.56
Mid-terrace	t_2	8.99	0.52
Highest terrace	t_3	2.17	0.13
Prolluvium – face of the subaerial delta sediment	prQ_1	55.80	3.22
Marginal face: conglomerates and breccias	E_3	3.62	0.21
Sedimentary-volcanogenic unit: conglomerates, sandstones, greywacke, marlstones and tuffs	$^{3}M_2$	13.55	0.78
Loose sandstones and conglomerates	M,pl	70.94	4.09
Pellet marlstone limestones	$_{3}K^{3}_{2}$	7.13	0.41
Conglomerates, gravels, sandstones, sands, clays	$^{1}M_2$	0.73	0.04
Sands, clays, marlstones, bentonite clays, lignite	pl	40.38	2.33
Colored sandstones, conglomerates and sandy marlstones	M_2	12.29	0.71
Grus horizon: conglomerates, sandstones and claystones	$^{3\text{-}5}E_3$	22.06	1.27
Mixed horizon of shallow-water clastites and limestones	$^{3\text{-}4}E_3$	3.64	0.21
Marlstones and marlstone limestones (santonite)	$^{3}_{2}K^{3}_{2}$	0.89	0.05
Neogene of Vranje Valley	N	2.29	0.12
	Total	563.87	32.54

3.1 Rock erodibility in the area under research

Due to complex geologic composition and varying conditions for deposit production, the rocks were classified according to the degree of erodibility, which was determined based on the geologic morphology, structure and physical and chemical parameters of the rocks. According to their resistance to erosion devastation of the geologic formations within the drainage basin area, 4 categories were identified (Figure 2):

Very hard rocks. Granites; Granitoids (Bujanovac – Vranje); Andesites (to the left of the Južna Morava River); Dacites (to the left of the Južna Morava

River) cover 24.81% of the total area of the region.

Deposit: rock blocks, gavel, grus of igneous and limestone origin.

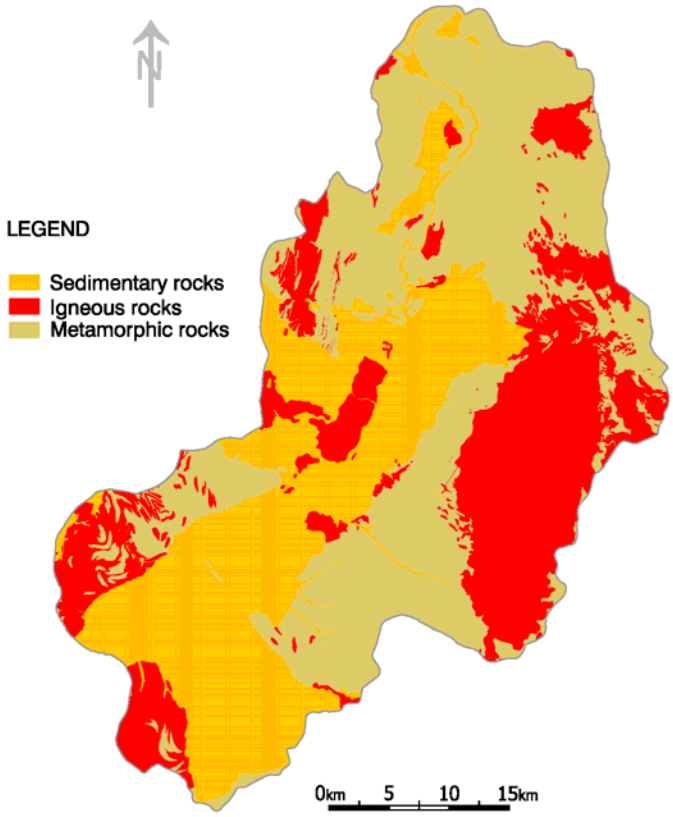

Figure 1. *Presence of sedimentary, igneous and metamorphic rocks*

Relatively hard rocks. Gneiss (crystalline shales of higher crystallinity present to the left of the Južna Morava River; sources); Granites metamorphed; Diabase philites in the Vlasina basin; Limestones with sandstones and shales.

Deposit: large-grain gravel, medium-grain deposits, grus, sands, small quantities of small-grain deposits.

Relatively erodible rocks. Sericite-chlorite shales (crystalline shales of lower crystallinity present at Vlasina Complex, to the east of the Južna Morava River); perm red sandstones; Micashists (to the right of the Južna Morava River); Volcanic tuffs accompanying andesites and dacites.

Deposit: leafy large and medium-grain gravel, cobbles, sand, some clay.

Very erodible rocks. Lake sediment of neogene age – in Leskovac and Vranje-Bujanovac basins; conglomerates, sandstones, marlstones; Fluvial terrace deposits: gravels, sands, clays along the lower course of the Južna Morava River and its widened valleys; Contemporary deposits: elluvium, delluvium, alluvium and prolluvium in the drainage basin of the Južna Morava and its tributaries, comprised of gravel-sand and clay sediments, with larger gravel contained in both elluvium and delluvium.

Deposit: gravel, sand, clay, with sand-clay deposit prevailing.

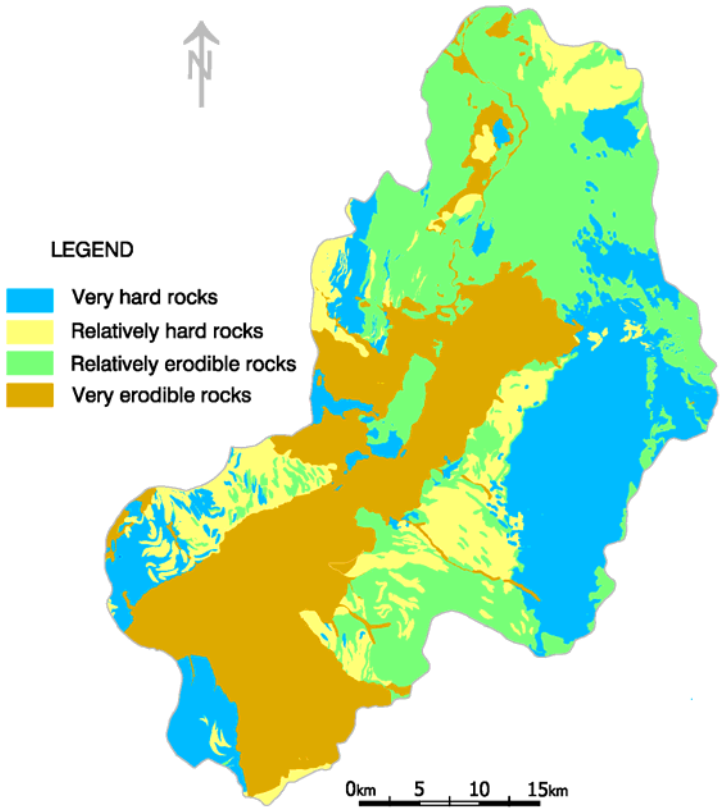

Figure 2. *Map of rock erodibility in the area under research*

For deposit formation within the investigated region, tectonic versatility of the terrain is significant as well, which is a distinctive property of the entire region and results in a number of fractures, which, in turn, intensify rock degradation process even when very hard rocks such as igneous rocks are at issue.

4. DISCUSSION AND CONCLUSION

Very hard rocks cover 24.81%, relatively hard rocks account for 13.78 %, relatively erodible rocks 29.18% and very erodible rocks 32.23% of the total area.

In the territory of Grdelica Gorge and Vranje Valley, areas potentially threatened by erosion cover over 60%, i.e. they are superior to the stable areas.

According to the values of the average erosion index Z_{sr} = 0.78, in the period reviewed (1953), the area subject to research was jeopardized by the strong surface erosion processes (Braunović et al, 2010). Excessive erosion affected 28 % of the region (drainage basins of the Jastrebačka, Letoviška, Sejanička, Radovska, Palojska, Ličindolska, Predejanska, Džepska, Jovačka, Korbevačka and Banjska rivers and numerous torrential streams: Krpejski Stream, Mlakačka Valley, Zla Valley, Repinska and Kalimanska rivers, Lještarska Valley etc.). In respect of the

parent rock, the aforestated drainage basins mostly lie on the crystalline shales (Braunović, Ratknić. 2010/a, 2012), which is, together with the other factors (relief, climate, vegetation, deforestation, etc.) contributing to the intensive development of erosion processes.

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IMPACT OF THE PARENT ROCK ON EROSION PROCESS DEVELOPMENT IN GRDELICA GORGE AND VRANJE VALLEY

Sonja BRAUNOVIĆ, Mihailo RATKNIĆ, Ljubinko RAKONJAC

Summary

The paper presents and determines the geologic composition of the parent rock of the region of Grdelica gorge and Vranje Valley. Sedimentary rocks of different ages (conglomerates, sandstones, claystones, marlstones, bituminous shales, connected or disconnected lake sediments, gravel, sand, clay, alluvial and delluvial deposits, etc. . .) cover 32.5% of the area.

Igneous rocks (granitoid rocks - granites, granodiorites, quartz monconites and dacite-andesite rocks and their tuffs, etc.) cover 26.4% of the area.

Metamorphic rocks (crystalline shales, micashists, gniesses, orthogneisses, chloritoshists, quartz shales, amphibolites and amphibolte shales, serpentinites and graphite

shales) cover 718.85 km^2 or 41.06 % of the total area of the region.

Crystalline shales of the lower crystallinity, the so-called "green shales," which are found downstream from Vladičin Han on the right bank of the Južna Morava River caused remarkable erodibility of this portion of the region (Krpejski Stream, Mlakačka Valley, Predejanska River, Palojska River, Džepska River, the so-called Džepske torrents, etc.).

Very hard rocks cover 24.81%, relatively hard rocks account for 13.78 %, relatively erodible rocks 29.18% and very erodible rocks 32.23% of the total area, which means that over 60% of the region is potentially, i.e. depending on other factors, is susceptible to erosion.

Given the fact that the areas which in the 1950s were endangered by the processes of excessive and strong erosion mostly correspond to the areas formed from erodible rocks, parent rock is one of the significant causes of intensive erosion process development.

UTICAJ GEOLOŠKE PODLOGE NA RAZVOJ EROZIONIH PROCESA U GRDELIČKOJ KLISURI I VRANJSKOJ KOTLINI

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Rezime

U radu je definisan sastav geološke podloge područja Grdeličke klisure i Vranjske kotline.

Sedimentne stene različite starosti (konglomerati, peščari, glinci, laporci, bitumenozni škriljci, vezani ili nevezani jezerski sedimenti, šljunkovi, peskovi, gline, aluvijalni i deluvijalni nanosi itd.) zauzimaju 32,5% površine.

Magmatske stene (granitoidne stene: graniti, granodioriti, kvarcmonconiti i dacitsko-andezitske stene i njihovi tufovi, itd.) zauzimaju 26,4% površine.

Metamorfne stene (kristalasti škriljci, mikašisti, gnajsevi, ortognajsevi, hloritošisti, kvarcni škriljci, amfiboliti i amfibolitski škriljci, serpentiniti i grafitski škriljci) pokrivaju 718,85 km^2 ili 41,06 % ukupne površine područja.

Kristalasti škriljci nižeg stepena kristaliniteta "zeleni škriljci", koji se pružaju nizvodno od Vladičinog Hana (desna strana toka Južne Morave), doprineli su veoma izraženoj erodibilnosti područja (Krpejski potok, Mlakačka dolina, Predejanska reka, Palojska reka, Džepska reka, tzv. Džepske bujice itd).

Veoma čvrste stene zauzimaju 24,81%, uslovno čvrste 13,78 %, uslovno erodibilne 29,18%, dok veoma erodibilne stene zauzimaju 32,23% ukupne površine, što znači da je preko 60% područja potencijalno tj. u zavisnosti od drugih faktora, podložno eroziji.

Obzirom da se područja koja su pedesetih godina bila ugrožene procesima ekscesivne i jake erozije uglavnom poklapaju sa površinama koje su izgrađene od erodibilnih stena, geološka podloga je jedan od značajnih uzroka razvoja intenzivnih procesa erozije.