The Sava Plain: Definition, Denomination, Delineation and Subdivision

T. Gaudenyi, and M. Mihajlović

ABSTRACT

The Sava River based its fluvial architecture compromised its upper- and lower courses. The Sava River upper course starts at Radovljica and continues downstream till Krško while from Krško till Belgrade is the Sava lower course. The Sava upper course is positioned in the mountain valley and characterized with headwaters. The Sava lower course positioned in the lowland area of the Pannonian Plain.

The Sava Plain (*Posavina*) is a physico-geographical region, encompass the lowermost, almost flat surface of plain segments of the Sava valley, lower plain segments of its tributaries and adjacent eolian flat landforms. The Sava Plain surface geology composed of Holocene fluvial, as well as Pleistocene alluvial and eolian sediments. According to the Holocene fluvial architecture of the Sava river three significant parts can be defined as the Krško-Samobor Plain, the Upper- and the Lower Sava Plain. The Upper Sava valley represents the Krško-Samobor Basin from Krško downstream till the Podsused Gate. The Upper Sava Plain (*Gornja posavina*) covers the Sava plain in between Podsused Gate downstream to the Slavonski- and Bosanski Brod (or the Brod Gate). The Lower Sava Plain (*Donja posavina*) ascends from Brod Gate downstream till the mouth of the Sava to the Danube in Belgrade.

The Krško-Podsused Plain and the Upper Sava Plain channel planform type characterized with the gentle meandering river architecture its area composed of Holocene fluvial sediments, while the Lower Sava Plain with meandering river architecture of Pleistocene fluvial and eolian sediments and Holocene fluvial.

Keywords: geomorphological subdivision, plain morphometry, Posavina, Sava Plain.

Published Online: February 14, 2022

ISSN: 2684-446X

DOI : 10.24018/ejgeo.2022.3.1.237

T. Gaudenyi*

Geographical Institute "Jovan Cvijić" of the Serbian Academy of Sciences and Arts, Belgrade, Serbia.

(e-mail: t.gaudenyi@gi.sanu.ac.rs)

M. Mihajlović

(e-mail: mihajlovicmilan13@gmail.com)

**Corresponding Author*

I. INTRODUCTION

The Sava River originates from two headwaters Sava Bohinjka and Sava Dolinka which joint at Radovljica (Upper Carniola, Slovenia). It mounts to the Danube in Belgrade (Serbia). The Sava River 990 km length, including the 45 km long course of Sava Dolinka and catchment area of 97,713 km². The Sava River catchment encompasses 12% of the Danube basin, draining into the Black Sea.

To The Sava River represents in terms of water volume the greatest tributary of the Danube and the second-largest tributary of the Danube (after the Tisza) by its length and in terms of catchment area.

The Main geographical studies were focused on the Sava Basin / catchment area (Fig. 1) regarding its hydrological and climatic features, while the Sava valley was not in the focus of the investigations. The definition of plains and their subdivision as physico-geographical units of the Sava River valley were not the objectives (e.g., studies of Cvijić [1], [2] and Dukić, [3] mainly the investigations were related on hydrogeologic, flood and hazards analysis [4]. According to its relief and surficial geology only the segments of the Sava

valley were analyzed regarding its geology, hydrology or geomorphology [5]-[7].

The aim of this paper is to define, delineate, denominate and to propose subdivision of the Sava River plain according to the main landform categories

A. Geographical Setting of the Sava Valley

The the area of investigation of this study is the Sava valley. The upper Sava valley is from the north limited with the Karavanka Mts. and on the south with the Julian Alps. The lower Sava valley bordered on the north with Kalnik, Medvednica, Moslavička Gora, Psunj, Babja Gora, Dilj Gora, Fruška Gora Mts. in the south bordered with Žumberačka Gora, Samoborska Gora, Vukomeričke Gorice, Zrinjska Gora, Kozara, Prosara, Motajnica, Vučjak, Trebava, Majeveca, Cer (*cf.* study of Bertić & Križovan [8]). The Sava valley is a part of four countries (Slovenia; Croatia; Bosnia and Hercegovina; Serbia). The Sava valley relief evolved to its final form in the Holocene due to the neotectonics, fluvial processes (sedimentation and accumulation), eolian processes, slope process and anthropogenic impacts.

Sava River Basin: Overview

Fig. 1. Sava catchment / Sava Basin. (Source: Secretariat of the International Sava River Basin Commission).

Fig. 2. Classification of structures and faults of the Sava valley (cropped source [8]).

B. Geographical Setting of the Sava Valley

The area of investigation of this study is the Sava valley. The upper Sava valley is from the north limited with the Karavanka Mts. and on the south with the Julian Alps. The lower Sava valley bordered on the north with Kalnik, Medvednica, Moslavička Gora, Psunj, Babja Gora, Dilj Gora, Fruška Gora Mts. in the south bordered with Žumberačka Gora, Samobroška Gora, Vukomeričke Gorice, Zrinjska Gora, Kozara, Prosara, Motajnica, Vučjak, Trebava, Majeveca, Cer (*cf.* study of Bertić & Križovan [9]). The Sava valley is a part of four countries (Slovenia; Croatia; Bosnia and Hercegovina; Serbia). The Sava valley relief get its final form in the Holocene due to the neotectonics, fluvial processes (sedimentation and accumulation), eolian processes, slope process and anthropogenic.

C. The Lower Sava Valley Area in Paleogeographic Context

The results and developments of the geological investigations seems do not follow with further reconstructions of the past environments and the paleogeography. After a very successful petrographic and mineralogical analysis of Quaternary sediments in Eastern Slavonia [10]-[12] and investigations of the Pleistocene glaciations of Julian Alps, Kamnik-Savinja Alps and Karavanke Mountains and its forelands [13] it became evident that some statements regarding the paleogeography of the Sava River should be rewritten.

The kinematics evolutions imply that the late Cretaceous to Eocene collision of the crustal blocks followed by the Miocene uplift and extension of the Pannonian craton. The tectonic extension, accompanied by volcanism, was coeval with the uplift the surrounding Alpine orogenic belts, which largely separated the epicontinental Paratethyan domain from the Mediterranean oceanic Tethyan domain [14], [15]. The early to middle Miocene pre- and syn-rift deposits in the Pannonian Basin System shows a transition from continental alluvial-lacustrine to fully marine environments [16]. The peak of extension was reached in the Badenian-Sarmatian rifting phase (ca. 15-11 Ma) at the eastern part of the Carpathian Basin to the Fruška Gora Mts. [17]. The long-lived Lake Pannon formed at the middle/late Miocene boundary (ca. 11.6 Ma) as a consequence of the tectonic uplift of the Carpathians that separated the basin from marine influences [15]. It took more than 7 Ma for the large Pannonian Basin to be filled with lacustrine and fluvio-deltaic sediments derived by the erosion of the surrounding orogenic belts [18], [19]. At the beginning of the Pliocene the semi-brackish Lake Pannon evolved in the smaller lake denominated Paludina Lake due to the high sediment influx and neotectonics. The significant differences beside its size manifested on water chemistry, the Lake Pannon was semi-brackish while the much smaller Paludina Lake was freshwater [19]. The Paludina Lake existed till the beginning of the Quaternary when it transformed to the Pleistocene river system. The forming of the Pleistocene river system (and vanishing the lake system) in the area of the Carpathian Basin was the beginning of the Quaternary on the stratigraphic scale. The evidence was record in the changes in the *Viviparidae* malacological assemblages VBH. The Pleistocene Paleosava River represents quite different fluvial

system which originated in Bosnia. The Bosnian rivers gave the main water volume, while the enstanite and kaemmerite record show their provenance from central Bosnia [20], [21], [12] confirms the existence of Pleistocene river systems from central Bosnia to the Sava valley. These ultramafic rocks and chromite deposits which found in the Pleistocene Paleosava river sediments in Slavonia their origin confirmed as the area of Konjuh and Duboštica. In the same time the Julian Alps and Karavanke Mts. belonged to the glacial and periglacial realm and rivers such as the Sava River cannot form in the mentioned environmental conditions [13] as it has been identified according to its modern fluvial architecture.

TABLE I: EVOLUTION OF THE LOWER SAVA VALLEY AREA DURING THE LAST 12 MILLION YEARS (AFTER ČALIĆ *ET AL.*, [22]; MODIFIED)

Paleogeographic unit	Stratigraphic frame	Numeric age time frame
Lake Pannon	middle Miocene – early Pliocene	~11.6 - ~4.5 Ma
Paludina Lake	early Pliocene - end Pliocene	~4.5 - ~2.6 Ma
Paleosava Sava	Pleistocene Holocene	~2.6 - ~0.1 Ma ~0.1 Ma

The Sava River system was developed in the Holocene with stable climatic and neotectonic conditions recognized by their headwaters (Sava Bohinjka and Sava Dolinka) which were formed in the area of Slovenia.

II. MATERIAL AND METHODS

The analyzed area of the Sava valley 21 DEM-s of 30 m resolution were used from the Earth Explorer DEM collection of the United States Geological Survey (<https://earthexplorer.usgs.gov>) which were merged in the one DEM using QGIS software. The pixel resolution used in our case was 100×100 m.

The surface geology of Quaternary sediments was analyzed by the basic geologic maps of former Yugoslavia at scale 1: 100,000 [23]-[31] and other geologic maps of lower resolution [32], [33]. The main aim was to disseminate the Pleistocene and Holocene sediments which constitutes the Sava River plain. It served as a control mechanism in case of application of the surface roughness.

The study beside the geologic surveying data for the study, on the DEM the roughness tool from QGIS Software used for the delineation of the Sava Plain.

“Tools to analyze and visualize DEMs outputs the single-band raster with values computed from the elevation. Roughness is the degree of irregularity of the surface. It is calculated by the largest inter-cell difference of a central pixel and it surrounding cell. The determination of the roughness plays role in the analysis of terrain elevation data., it is useful for calculation of river morphology and physical geography in general, is derived from the GDAL DEM utility” (QGIS 2.8 User Guide). As it is mentioned the DEM resolution 100×100 m was chosen which enables the good generalization for visualization of spatial objects on this level. With the tool “Roughness” of QGIS software we separate the surface roughness in five classes. The plain terrain of the Sava valley was defined with roughness coefficients of 0-5 (similar as in [22], [34]). Later the generalization and the manual delineation were drawn. The division of the Sava Plain was

based on boundaries was based on tectonic boundaries identified in the Sava River valley. The tectonic bottlenecks identified, and their position shows as the gates on topographical maps.

III. RESULTS

A. Definition and Denomination

If we look back one of the seminal monographs of the North American physical geography published after WWII the major classes of the terrain based upon similarities and differences with respect of main characteristics: relatively amount of gently sloping land, local relief, and generalized profile [40]. Plains were defined as surfaces having a gently sloping land coupled with local relief. Within the broad limits allowed by this definition, however plains exhibit a surprising degree of variety. Some approach as near to perfect flatness as it is possible for a land surface to become, while others are so rolling or dissected as barely to avoid being classed as hills. Some are marshy or seasonally waterlogged, while others are arid sand, gravel or soil. Some are rock-floored; others are surfaced with permanent snow or ice. Some are lie near the sea level while others are thousands meters higher. The only statements that apply to all are that most of their slopes are gentle and that the differences in elevation within limited areas are small.

The Sava Plain limited to the mainly meandering alluvial and fluvial surfaces (and adjacent eolian flat landforms), connected planform lower segments of its tributaries and loess plateaus along the alluvial plain of the lower course of the Sava River, from Krško downstream till Belgrade. Due to mention the alluvial plain of the Sava River cannot be the synonymous to the Sava Plain which is encompass wider area along the lower course of the Sava River.

B. Delineation and Subdivision

The Sava Plain area shown based on the surface roughness on Fig. 3. It was evident that two fluvial bottlenecks identified. These bottlenecks are the Podsused Gate (in Serbian: *Podsusedska probojnica*) and the Bosanski- and Slavonski Brod transect or the Brod Gate (in Serbian: *Brodaska probojnica*). Both Gates also identified in the fault system of the Sava region [36]-[38], [8] (Fig. 2). The Podsused Gate is genetically connected to the Zagreb fault at Žumberačka Gora – Medvednica Mt. - Križevci contact with the Sava Basin, while the Brod Gate on the Sava faults at the contact of Sava Basin and the Slavonian Mts [8] (Fig. 2). These geodynamic phenomena serve for the subdivision Plains align the lower Sava course. Three plain segments identified the Krško-Samobor Plain, the Upper Sava Plain and the Lower Sava Plain.

The Krško- and Samobor Basins already defined and denominated by Nikolić [5]. The **Krško-Samobor Plain** (in Serbian: *Krško-Samoborska nizija*) encompass the lower plain segment of the Sava River from Krško till Podsused as well as its tributaries: the Krka-, Sutla- and Krapina Rivers (Fig. 3). The meandering character of the river is not visible nowadays clearly on the relief due to river regulation works e.g., in 1775 [39] and later changes [3]. Its surface geology shown only fluvial sediments (*sensu* [28], [25], [23]) (Fig. 3 and 4).

The **Upper Sava Plain** (in Serbian: *Gornja posavina*) encompass the plain segment of the Sava River valley along from Podsused Gate and Brod Gate. Beside the Sava fluvial relief including the lower plain relief of the Kupa-, Una- and Vrbas Rivers (it includes the small landscapes: Lonjsko Polje, Turopolje, Lijevče, Crnac Polje, Jelas Polje). It is surficial geology composed exclusively of fluvial sediments (Fig. 3 and 4).

Fig. 3. Subdivision of the Sava Plain based on the DEM of surface roughness coefficients (NEXT PAGE).

Fig. 4. Subdivision of the Sava Plain on relief model with its topography.

The **Lower Sava Plain** (in Serbian: *Donja posavina*) encompass the plain segment of the Sava River and the lower plain segment of its tributaries Bosna, Drina, Bosut, Kolubara-Tamnava. As well as the whole Semberija Plain, Mačva Plain and south part of the Syrima Loess Plateau. Beside fluvial sediments it encompasses the eolian sediments (loess) (it includes the small landscapes: Županja, Spračva, Semberija, Mačva, Podlužje) (Fig. 3 and 4).

IV. DISCUSSION

The QGIS tool “Roughness” was first time tested for the Western Balkan countries. The DEM resolution 100×100 m shows similar results as used in the paper of studies in [22] [34] which based on the subsequent calculations and analyses were by using the raster-based GIS software Idrisi Andes. In that case the SRTM was resampled from 90×90 m grid cells to 200×200 m grid cells. The 5×5 cells were gathered into a moving window for calculation of average elevation within a window. In our case when have to make a further generalization. The surface roughness coefficients in the also shown the surface roughness coefficient lower than 5 indicated the plain relief (same coefficients as in [22], [34]). However nearly same results got with more simplified method by using QGIS “Roughness” tool. The control checking was don applying the results in the Basic Geologic Map of Yugoslavia at scale 1:100,000 where the Neogene and Quaternary slope sediments must be excluded.

V. CONCLUSIONS

The Sava River Catchment or the Sava Basin represents the catchment area which exceeds 97,713 km² (Fig. 1.)

The Sava valley defined the valley from the confluence of Sava Dolinka and Sava Bohinjka at Radovljica till the mouth of the Sava River mouth to the Danube at Belgrade. The upper Sava valley defied earlier, it ascents till the Podsused Gate, while from Podsused Gate downstream is the lower Sava valley.

The Sava River upper course starts at Radovljica and continues downstream till Krško, from Krško till Belgrade is the Sava lower course.

Along the Sava lower course we define the Sava Plain. The Sava Plain complex has 3 segments. These are: the Krško-Samobor Plain, the Upper Sava Plain and the Lower Sava Plain. The mentioned segments are divided by the Podsused- and the Brod Gate (Fig. 2).

The Krško-Samobor Plain formed in the Krško- and Samobor microbasins (defined after Nikolić, 1985) and represents the lower plain relief of the Sava river alluvial plain and the plain segments of its tributaries (Krka, Sutla, Krapina). The surface geology of Krško-Samobor Plain shown only fluvial sediments.

The Upper Sava Plain formed on fluvial sediments of the Sava River and its tributaries from Bosnia, Zagorje and Slavonia.

The Lower Sava Plain formed on the fluvial sediments of the Sava River its tributaries in Slavonia, Syrima, Semberija, Mačva and Šumadija as well as eolian sediments of the south parts of the Srem Loess Plateau.

ACKNOWLEDGMENT

The Authors are grateful to Predrag Vulić (University of Belgrade) and Petar Stejić (Geological Survey of Serbia) for consultation and scientific literature supply.

FUNDING

The investigations of Tivadar Gaudenyi were supported by the Bolyai János Research Grant of the Hungarian Academy of Sciences.

REFERENCES

- [1] Cvijić J. *Morphologie Terrestre. Vol. 1.* Belgrade: Državna štamparija Kraljevine Srba, Hrvata i Slovenaca; 1924. Serbian.
- [2] Cvijić J. *Morphologie Terrestre. Vol. 2.* Belgrade: Državna štamparija Kraljevine Srba, Hrvata i Slovenaca; 1926. Serbian.
- [3] Dukić D. *La Save – étude potamologique.* Belgrade: Académie Serbe de Science; Monographies CCLXXV, Institut de Géographie 12; 1957. Serbian with French summary.
- [4] Bačani A, Šparica M, Velić J. Quaternary Deposits as Hydrogeological System of Eastern Slavonia. *Geologia Croatica* 1999; 52 (2): 141-152.
- [5] Nikolić B. Geomorphological characteristics of the River Sava valley between Krško and Podsused. *Geographical Papers* 1985; 6: 61-77.
- [6] Gaudenyi T, Nenadić D, Stejić P, Jovanović M, Bogičević K. Stratigraphic revision of the Quaternary material from the vicinity of Belgrade and the Serbian segment of the Tisza valley analysed by V.D. Laskarev. *Quaternary International* 2015; 357: 93-109.
- [7] Brkić Ž. The relationship of geological framework to the Quaternary aquifer system in the Sava river valley (Croatia). *Geologia Croatica*, 2017; 70 (3): 201-213.
- [8] Prelogović E, Saftić B, Kuk V, Velić J, Dragaš M, Lučić D. Tectonic activity in the Croatian part of the Pannonian basin. *Tectonophysics* 1998; 297: 283-293.
- [9] Bertić I, Križovan Z. Veliki geografski atlas Jugoslavije. Zagreb: Sveučilišna naklada Liber; 1987. Serbo-Croatian.
- [10] Mutić R. Correlation of the East Slavonian Quaternary deposits based on mineralogical-petrological analyses (Eastern Croatia, Yugoslavia) Part I. The Drava Depression. *Acta Geologica* 1989; 19 (1): 1-60.
- [11] Mutić R. Correlation of the Quaternary sediments in the Eastern Slavonia on the basis of mineralogical and petrographic data (Eastern Croatia, Yugoslavia) Part II. Loess Plateau. *Acta Geologica*, 1990; 20 (2): 29-80.
- [12] Mutić R. Correlation of the Eastern Slavonian Quaternary deposits based on the Mineralogical and Petrological Analyses (Eastern Croatia) Part III: Slavonia-Srijem Depression. *Acta Geologica* 1993; 23 (1): 1-37.
- [13] Bavec M, Verbič T. Chapter 29: Glacial History of Slovenia. In: *Quaternary Glaciations Extent and Chronology*. Ehlers J, Gibbard PL, Hughes PD. Eds. Elsevier, Netherlands: Developments in Quaternary Science 15, 2011, pp. 385-392.
- [14] Rögl F. Mediterranean and Paratethys: facts and hypotheses of an Oligocene to Miocene paleogeography. *Geological Carpathica*, 1999; 50: 339-349.
- [15] Rundić Lj, Vasić N, Životić D., Becthel A, Knežević S, Cvetkov V. The Pliocene Paludina Lake of Pannonian Basin: New evidence from northern Serbia. *Annales Societas Geologorum Poloniae* 2016; 86: 185-205. doi.org/10.14241/agsp.2016.003
- [16] Ter Borgh M, Vasiliev I, Stoica M, Knežević S, Matenco L, Krijgsman W, Rundić Lj, Cloetingh S. The isolation of the Pannonian Basin (Central Paratethys): New constraints from magneto- and biostratigraphy. *Global and Planetary Change* 2013; 103: 149-167. doi.org/10.1016/j.gloplacha.2012.10.001
- [17] Fodor L, Csontos L, Bada G, Györfi I, Benkovics L. Tertiary tectonic evolution of the Pannonian Basin System and neighboring orogens: a new synthesis of paleostress data. In: *The Mediterranean Basins: Tertiary Extension within the Alpine Orogen*. Durand B, Joivet L, Horvath F, Seranne M. Eds. London: Geological Society of London Special Publication 156; 1999, pp. 295-334.
- [18] Magyar I. Paleogeographic evolution of the Late Miocene Lake Pannon in central Europe. *Palaeogeography, Palaeoclimatology, Palaeoecology* 1999; 147 (3-4): 151-167.
- [19] Radivojević D, Magyar I, Ter Borgh M, Rundić Lj. The Lake Pannon – Serbian side of the story. In: *Proceedings of the XVI Serbian Geological Congress*. Serbian Geological Society: 2014, pp. 54-60.
- [20] Pamić J. Osnovne petrološke karakteristike kromitnog područja Duboštice u Bosni. *Geološki Glasnik*, 1979; 14: 135-148. Croatian.
- [21] Grafenauer, S. Rudna petrologija ultramafičnih kamnih Jugoslavije. Ljubljana: Dela 22, SAZU 152. Slovenian Academy of Sciences and Arts, 1975. Slovenian.
- [22] Čalić J, Milošević MV, Gaudenyi T, Štrbac D, Milivojević M. Pannonian Plain as a morphostrucural unit of Serbia. *Bulletin of the Serbian Geographical Society*, 2012; 92 (1): 47-69.
- [23] Buser S. *Basic Geological Map of Yugoslavia 1: 100 000 Sheet Celje L33-67.* Belgrade: Federal Geological Institute; 1977. Serbo-Croatian.
- [24] Buzaljko R, Marinković S. *Basic Geological Map of Yugoslavia 1: 100 000 Sheet Brčko L34-110.* Belgrade: Federal Geological Institute, 1986. Serbo-Croatian.
- [25] Cajhen J, Ferjančić L, Grad P, Mić D, Novak D, Štribar L, Turnšek D, Volk J, Vujić D. *Basic Geological Map of Yugoslavia 1: 100 000 Sheet Novo Mesto L33-79.* Belgrade: Federal Geological Institute, 1970. Serbo-Croatian.
- [26] Galović I, Brkić M, Buzaljko R. *Basic Geological Map of Yugoslavia 1: 100 000 Sheet Vinkovci L34-98.* Belgrade: Federal Geological Institute, 1989. Serbo-Croatian.
- [27] Jovanović Č, Magaš N. *Basic Geological Map of Yugoslavia 1: 100 000 Sheet Kostajnica L33-106.* Belgrade: Federal Geological Institute, 1986. Serbo-Croatian.
- [28] Šikić K, Basch O, Šimunić A. *Basic Geological Map of Yugoslavia 1: 100 000 Sheet Zagreb L33-80.* Belgrade: Federal Geological Institute, 1971. Serbo-Croatian.
- [29] Šparica M, Buzaljko R. *Basic Geological Map of Yugoslavia 1: 100 000 Sheet Nova Gradiška L33-106.* Belgrade: Federal Geological Institute, 1984. Serbo-Croatian.
- [30] Šparica M, Juriša M, Crnko J. et al.. *Basic Geological Map of Yugoslavia 1: 100 000 Sheet Nova Kapela L33-108.* Belgrade: Federal Geological Institute, 1980. Serbo-Croatian.
- [31] Šparica M, Buzaljko R, Pavelić, D. (1987). *Basic Geological Map of Yugoslavia 1: 100 000 Sheet Slavonski Brod L34-97.* Belgrade: Federal Geological Institute, 1987. Serbo-Croatian.
- [32] Čičić S. *Geološka karta Bosne i Hercegovine R 1:300.000.* Sarajevo: Faculty of Civil Engineering, 2002. Serbo-Croatian.
- [33] Croatian Geological Survey. *Geološka karta Republike Hrvatske izrađena na temelju osnovne geološke karte m 1:100.000, područje Republike Hrvatske.* Zagreb: Croatian Geological Survey, 2009.
- [34] QGIS 2.8 User Guide [Internet] (http://docs.qgis.org/2.8/en/user_manual/processing_algorithms/gdalogr/gdal_analysis/roughness.html derived on March 1st, 2020)
- [35] Čalić J, Gaudenyi T, Milošević MV, Štrbac D, Milivojević M. Geomorphological method for delineation of plains - case study of the south-eastern (Serbian) segment of Pannonian Plain. *Carpathian Journal of Earth and Environmental Sciences*, 2012; 7 (2): 239-248.
- [36] Vukašinović S. The need for accordance of geomorphological subdivision of Yugoslavia with the new data on its structural composition. *Bulletin of the Serbian Geographical Society*, 1973; 53 (2), 15-25. Serbian with English summary.
- [37] Vukašinović, S. Contribution to the geotectonic distinction of interboundary space of the Dinaride, Pannonide and Serbo-macedonian Mass. *Zapiski Srpskog geološkog društva za 1972. godinu.* 1973; 9-19. Serbian with English summary.
- [38] Vukašinović S. A view on the neotectonic and metalogic subdivision of Yugoslavia. *Zapiski Srpskog geološkog društva za 1974, 1975:* 21-34. Serbian with English summary.
- [39] Pick K. Die Schiffbaren Flüsse in Krain. *Sonderabdruck aus der Österreichischen Wochenschrift für die öffentlichen Baudienst*, 1910; 29-30: p. 18. German
- [40] Finch VC, Trewartha GL, Robinson AH, Hammond EH. *Physical Elements of Geography.* New York – Toronto – London: McGraw – Hill Book Company Inc.; 1957.

Tivadar Gaudenyi was born in 1975 in Novi Sad (Serbia). He got PhD of Geographical Sciences (2010) at Faculty of Sciences, University of Novi Sad. His major field of study was physical geography. During studies, he attended fellowships at Department of Geology and Paleontology University of Szeged (Hungary), Geological Institute of Hungary (Budapest, Hungary), Department of Quaternary Paleontology, University of Vienna (Austria), Department of Geography, University of Bayreuth (Germany), EM-MIC Lab, University of Bergen (Norway), short courses at RHUL and UCL (London, UK) and University of Oxford (UK).

His research focus is Quaternary environments reconstructions of Central- and SE Europe, Quaternary geology, Quaternary stratigraphy, Quaternary malacology and geomorphology.

Mr Gaudenyi has been employed since 2010 at Geographical Institute "Jovan Cvijić" of the Serbian Academy of Sciences and Arts at the Department of Physical Geography. Mr Gaudenyi has an active role in the Serbian Geological Society and the Serbian Society of Geomorphologists.

Milan Mihajlović was born in 1994 in Sremska Mitrovica (Serbia). Mr Mihajlović got BSc in Geography at Faculty of Geography, University of Belgrade in 2018 and MSc at Faculty of Forestry, University of Belgrade, Department of Ecological Engineering for Soil and Water Resources Protection in 2019.

Mr Mihajlović research focuses are studies in physical geography and practical application of GIS software for analysis and mapping.