THE RELATIONSHIP BETWEEN RELIEF AND GEOLOGICAL STRUCTURE IN THE RIVER BASIN OF SOLINA

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Abstract
The relationship between relief and geological structure in the river basin of Solina
In this paper, within the framework of morphostructural features, relationship between relief and geological structure in the river basin of Solina (north-eastern Bosnia and Herzegovina) is analyzed. Main goal of this study is to investigate causal relationship between complex geological characteristics of the terrain and genesis, morphological evolution and differentiation of three relief units in the river basin of Solina. Relief of river basin of Solina is predominantly non-conformal, tectonically predisposed; its structure is dominated by Cretaceous - Paleogene clastites. In this paper are applied modern geomorphological-geological methods, field work, analysis of topographic and geological maps, as well as satellite images of the studied area. Presentation of data has been realized in the Geographic Information System, and the geospatial data were geo-visualized on two thematic maps.

Key words
Geomorphological-geological analysis, river basin of Solina, morphostructures, relief, Geographic Information System

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1. Introduction

The river basin of Solina covers an area of 47.9 km² and it is determined by orohydrographic surface watershed. In the geographical coordinate system this basin occupies the following position: the ultimate northern point - Velike Njive, 759 m elevation (φ =44°38´01˝ N, λ =18°40´31'' E), the ultimate eastern point - Kapljevac, 745 m elevation (φ =44°36´09˝ N, λ =18°45´01'' E), the ultimate southern point river mouth of Soline, 238 m elevation (φ =44°31´52˝ N, λ =18°41´43'' E), and the ultimate western point is locality Brusnica, 546 m elevation (φ =44°37´01˝ N, λ=18°39´08'' E) (Hadžimustafić, Smajić 2010, 48). The river basin of Solina is formed in the southern sub-basin of the mountain Majevica, which is geotectonically speaking located in the northeastern part of the Inner Dinarides. Broadly speaking, mountain Majevica belongs to morphosystem of the younger western Euroasian extensive chain mountains. It belongs to the Alpine-Himalayan mountain morphosystem. The river basin of Solina is mostly formed in Cenozoic (Neogene) sediments and predominantly has flysch lithological development. Lithological composition include: Neogene limestones, dolomites and clastites (sandstones, sands, marls,clays). The observed area is dominated by the slope fluviodenudation erosion relief and is characterized by a densely developed surface river network (Hadžimustafić, Smajić 2015, 55).

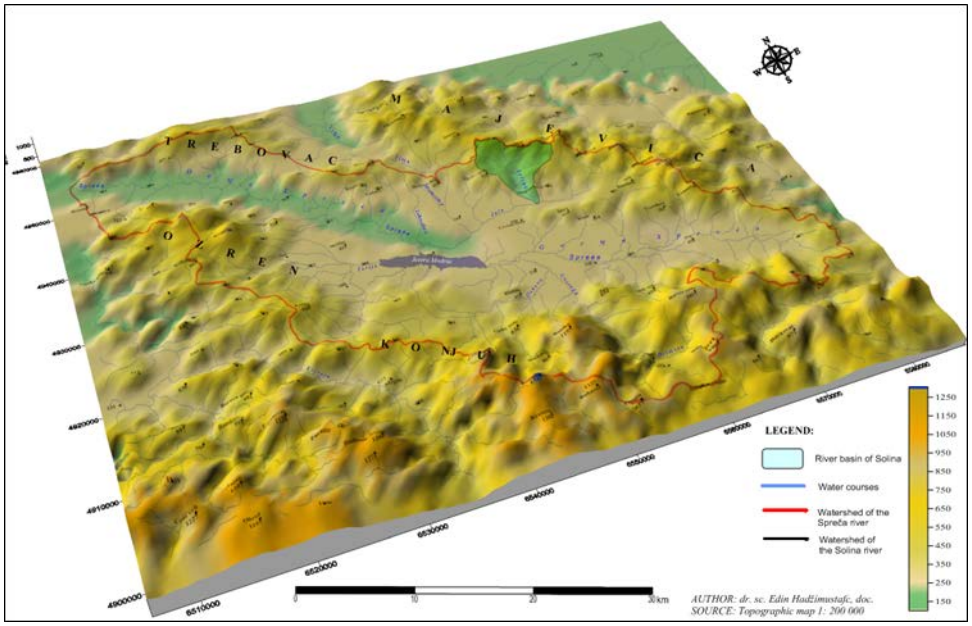

Fig. 1: Geographic-geomorphological position of the river basin of Solina.

According to the structural-genetic, lithological, orographic and morphogenetic homogeneity of the relief units, the river basin of Solina is located in the macro-geomorphological region lowlands, low mountains and hills, valleys and basins of northern Bosnia (Lepirica 2009, 13). From the geomorphological point of view, studied area is part of the meso geomorphological region of Majevica, so that the river basin of Solina in a hierarchical sense represents a micro geomorphological region, which is subunit of the meso geomorphological region of Majevica (Fig. 1.).

2. Material and methods

Complexity of the conducted research works required application of a wide range of methods. Cabinet methods preceded to fieldwork. Topographic and geological maps have been analyzed, as well as satellite images of the studied area. Positioning of the structural and micro geomorphological units was performed through several days of reconnaissance of the terrain. Cartographic, as well as analytical-synthetic method was applied.

Evaluating both cabinet and field data, through software processing and graphical presentation (CorelDraw and Surfer), it is made a 3D model of the river basin of Solina with a characteristic geological cross section. Final 3D model was used to correlate features of relief and geological structure of the observed terrain.

3. Results and discussion

3.1. Geotectonic development of the river basin of Solina

The river basin of Solina has undergone a long and complex geotectonic development which can be in more detail traced from the Paleogene to the Quaternary. In the Cenozoic, picture of the globe as it is known today has taken its final shape. In the area covered by the Tethys, the most significant orogenetic changes took very important place. Changes appeared within Alpine orogenesis, which began much earlier (in the Mesozoic) but culminated in the end of the Paleogene. Orogenetic processes continue in the Neogene, encompassing larger expanses and causing wider tectonic changes. Distribution of land and sea areas in the Quaternary was almost identical to nowadays. Differences are reflected in the hypsometric relations in relief and climatic conditions, where only in the Pleistocene they reach present heights. Tectonic changes in particular occurred during the transition from the Pliocene to the Pleistocene (Wallachian movements) (Herak 1990, 292).

The river basin of Solina in the upper Cretaceous was repeatedly covered by the sea. Regression that occurred in the Paleocene led to the intensification of erosive processes in this area. In the Eocene, as a result of transgression, the Tethys seawater rises. On that occasion was formed sedimentation area whose bottom was intensively sinking and filling with terrigenous sediments. Oligocene is characterized by regression and phase of land formation. In the area of present-day mountain Majevica it was formed lake basin, which in Middle Miocene was filled with water of the Miocene Sea. The middle part of Tuzla basin in the mid-Miocene is beginning to rise. The rise was accompanied by the formation of a number of islands. This kind of Majevica "archipelago" creates a natural barrier, gradually separating the basin into the north and south part. Basin Lopare was formed in the northern part, while Tuzla basin was formed in the southern part. The initial shape of basin Tuzla created during this period had a direction northwest – southeast. This direction basin has maintained to the present day. The elevated island sequence represented the initial ridge of the central Majevica, which in the following geological stages reached the present heights by the action of tectonic movements. The northeastern coasts or border of the Tuzla basin was the mentioned initial ridge. From the south, basin was bounded by Ozren and Konjuh ophiolite complexes, and also with the Đurđevik - Šekovići folded zone. In the west, uplift of the Dobošnica plateau in the Upper Miocene has caused the rise of the Tuzla plateau in the central part of the Tuzla basin. Covered by the sea were Podorašje, Dokanj and Kreka basins. In the Pont, both Podorašje and Dokanj areas

remain uncovered by the sea, while the Kreka basin continues to sink (Soklić 1964, 5 – 15).

In the area of former Tuzla basin, going from the north to the south, seven independent tectonic units with Dinaric direction appear today. These are: Podorašje basin, timor Ljenobud, thrust Kik, Dokanj basin, Tuzla folded platou, Kreka basin i Dobošnica platou (Soklić 1964, 15). In addition to the before mentioned structural - tectonic classification of Soklić (1964, 1986), according to Anđelković (1988), the river basin of Solina belongs to the western zone of the Eurasian morphosystem of younger chain mountains. It represents a segment of Majevica horst – anticlinorium, which originated within the Sava zone of Inner Dinarides (Anđelković 1988, 300-310). The river basin of Solina is mostly part of the structure-tectonic unit of Tuzla basin (as a subpart of the Tuzla trench - synclinorium), and to the smaller it belongs to the northern peripheral part of the horst anticlinorium of Majevica.

From the geological point of view, parts of the Tuzla basin are represented by neotectonic units: Tuzla folded platou in the south part of the basin, in the middle part is located Dokanj sinclyne and on the north is located thrust Kik.

3.2. Structural - tectonic units in the river basin of Solina

In the investigated area, viewed from the south to the north, structural and tectonic units lay in parallel as follows: Tuzla folded plateau, thrust Kik, Dokanj basin and smaller part of the horst-anticlinorium Majevica (Fig. 2).

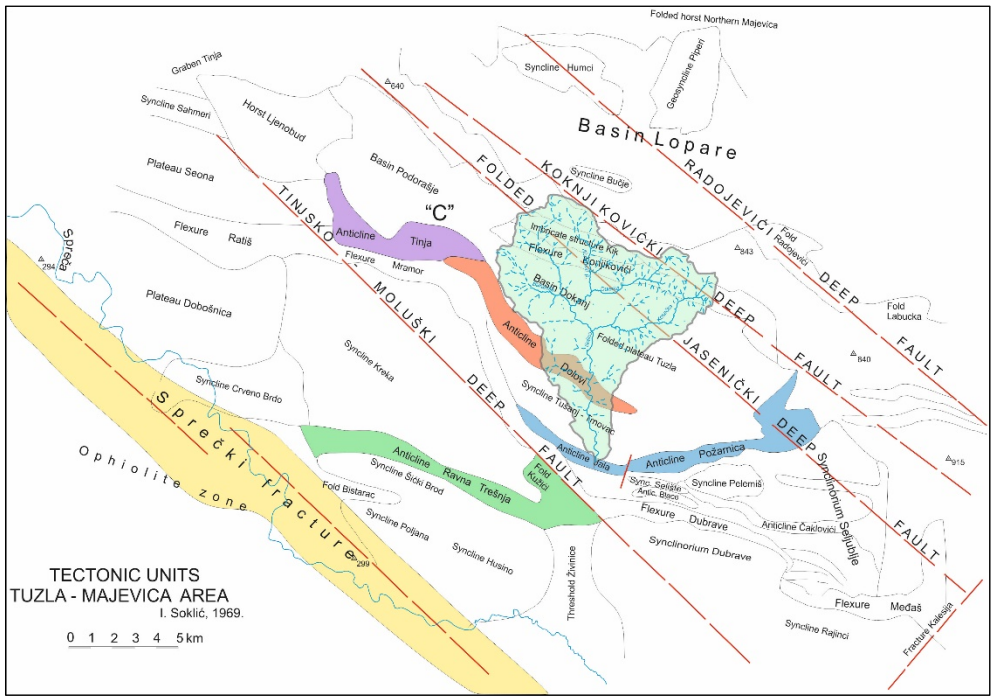

Fig. 2: Tectonic units Tuzla Majevica area

Tuzla folded plateau is affected by strong vertical tectonic movements from the Neogene (Pliocene) to the present day. It stretches on the large area between basin

Dokanj in the north, the southern Majevica in the east and Moluhe fault in the southwest. Western part of the plateau is dominated by the anticline Dolovi, which transversely intersects valley of the Solina. Anticline Dolovi in the area of the river basin of Solina extends from northwest to southeast, from the central part of the left valley side of Solina (wider locality of Gradovrh) to the hanging valley of the Dolovski stream, the right tributary of Solina. As a whole, anticline extends from the Grabovički stream in the east to the Dobrnjska river (locality Previle) in the west, about 12 km in length. North wing of the anticline has a milder slope compared to the south wing. Both wings of the anticline Dolovi are bounded by transverse faults, along which anticline is demoted (Soklić 1986, 41 - 42). In relief, as a one of the micro geomorphological units, valley of Solina has been cut and modeled within this tectonic unit. For the most part of its flow, the valley of the Solina is transverse in relation to the spatial orientation of the strata, showing features of non-conformity.

Basin Dokanj in general extends from the settlement Avdibašići in the west to the Cviljevina on the east, over 15 km in length. It was formed in the Sarmatian Stage as a branch of the Tuzla basin. Northern wing of the Dokanj syncline steeply crosses into Konjiković flexure. Southern wing successively rises to the anticline Dolovi. In the syncline itself, the brachyanthiclines and brachysyneclines appear, as well as several longitudinal and transverse faults. Axis of the syncline, from the Sarmatian to the present, is moved about 800 m to the south. The movement is predisposed by the rise of the horst of Majevica. Basin Dokanj nowadays has a distinctly asymmetrical shape and southern vergence, analogous to the Konjiković flexure, which tends to cover it (Soklić 1986, 40 - 41). Inverse position of the Miocene sediments on the cross section Duboki potok in Gornja Obodnica is a consequence of the Majevica uplift and its displacement to the southwest along the reverse fault, or along the thrust Kik (Vrabac et al. 2008, 60 - 62 and 70). In the river basin of Solina, basin Dokanj extends from Dulerka in the east to Obodnica in the west. In Pannonian, basin Dokanj was in connection with Kreka basin, across the area of present-day settlement Breške. By action of radial tectonic movements and folding of the horst of middle Majevica in Pont, formed are folded structures in the old pre-Majevica basin. Through the action of tangential movements, basin Dokanj is structurally surrounded and enclosed by folds. In addition to the tangential movements that caused appearance of these folds, considerable radial movements along the fault are detected. The effect of radial neo-tectonic movements formed a flexure which in the western part becomes in thrusting encompassing locality Kik. In terms of relief, Dokanj basin genetically predisposed micro geomorphological entirety of Majevica foothills, which by the fluvio - denudation process was dissected and presented with hanging valleys of Kosačka rijeka, Rijeka and Dulerka. Relatively young erosion depressions of previously mentioned hanging creek valleys of the south Majevica hillsides, which are cut into Miocene clastites, generally show features of conformity.

Thrust Kik, as a independent neotectonic unit, enters under the horst of the middle Majevica in direction Gornja Obodnica – Kicelj (673 m elevation). Between thrust of Kik and horst – anticlinorium of Majevica it is formed a syncline with compacted sediments of the Oligo - Miocene, as well as the Lower and Middle Miocene. Towards the south, the thrust is continuously covered by Oligo - Miocene and Miocene deposits of Tuzla-Lopare basin. This cover is Konjikovići flexure (Soklić 1986, 39 - 40). Flexure descends steeply to the south towards the Dokanj syncline. Kik thrust is located in the micro geomorphological unit of the Majevica ridge, the northernmost part of the river basin of Solina.

Majevica ridge is characterized by increased slopes (21° - 26°) caused by tectonic movements of the Majevica horst - anticlinorium uplift, and lithologically is built by to erosion less submissive Eocene clastites. Valley forms in the area of the mountain ridge of Majevica are not developed at all. The hanging valleys of the occasionally active upper flows of Andrić stream, Dulerka, Abramovski stream and Rijeka transversely cross folded structures, so the relief is inverse if we observe relation between relief and geological structure.

3.3. Faults

The river basin of Solina is mostly subjected to radial tectonic movements in the contact zone of horst - anticlinorium Majevica and syncline Dokanj. Majevica horst - anticlinorium, structurally – lithologically, does not represent a single entity.
It is clearly tectonically bounded by the longitudinal southern Majevica fault (Konjikovići fault) from the south and the northern Majevica fault from the north. It consists of mutually parallel units, which all have Dinaric direction: north Majevica anticline, Lopare syncline and south Majevica horst – anticline (Anđelković 1988, 310). Konjikovići fault intersects the northern part of the river basin of Solina about 9 km in length. It does not represent a single entity; it is intermittent, intersected with younger, transcurrent transverse faults.

Final eastern part of the river basin of Solina is disturbed by the faulty tectonics of the south Majevica fault and perpendicular Kapljevac fault, with a block sinking towards the east. Going west, the elevations increase, caused by cascade faulting, culminating in the highest part of the river basin of Solina at the locality Greda (803 m elevation). Greda is bounded on the south by the southwestern fault of Majevica, on the east by the transverse fault Lipik with the northeastern wing which sinks towards the northwest (Fig. 2). From the west, it is bounded by the fault Gavranić, which has meridional direction. Kicelj fault extends in direction northeast - southwest. In the fault zone, there was a local neotectonic sinking of the block to the northwest, which is embossed by the hanging valley of the Abramovski stream left tributary.

In the valley of Solina, there is a northeast-southwest directed fault that intersects the Dolovi anticline and hanging valley of the Dolovi stream. It influenced shape of the valley, with a sharp elbow turn from north-south to west-east.

3.4. Geological composition and relief of Solina river basin

Elevations or recesses in the relief, horizontal and vertical stratification in the river basin of Solina, are primarily conditioned by the resistance of rocks to erosion. Compact and harder rocks, more resistant to the exogenic geomorphologic processes, build up elevations in or positive shapes in relief. Softer rocks, which are less resistant to erosion, embossed relief recesses or negative shapes characterized by small inclination.

The river basin of Solina is geologically built by Cretaceous clastites and limestones, as well as by younger Cenozoic sediments (Fig. 4). Cretaceous - Paleogene clastites are present to a lesser extent, especially in the upper river basin sector, while nearly two thirds of terrain is composed of Neogene - Quaternary sediments. Development of Paleogene in the study area is characterized by Eocene sediments. Eocene clastites lithologically form largest part of Majevica ridge, while to a lesser participate in the structure of the Majevica ridge within the river basin of Solina. Oligocene clastites are fragmentarily located on a smaller area in the northeastern part of the basin, at the contact of two structural units: horst of Majevica and syncline Dokanj.

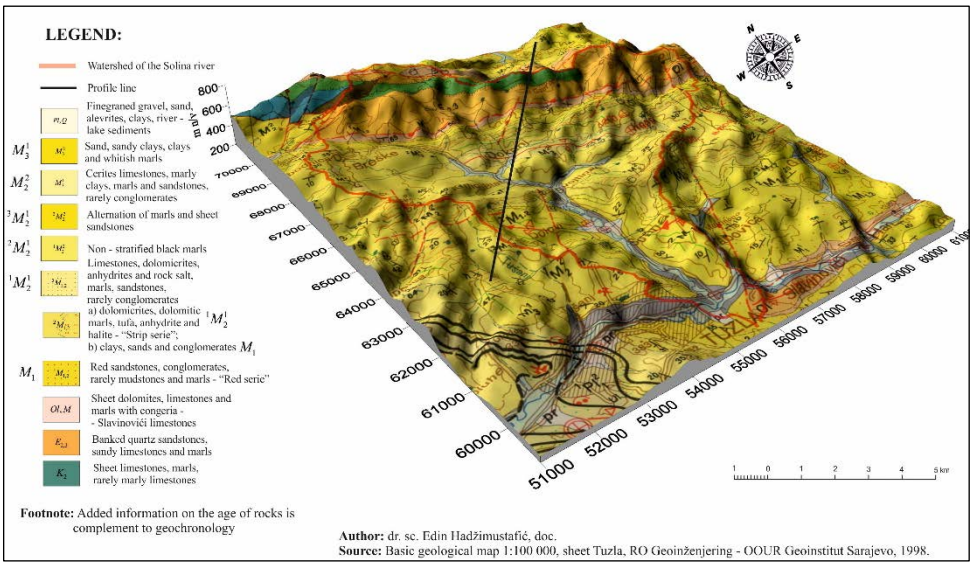

Fig. 3: Geological map of the river basin of Solina.

On the Majevica ridge, in the upper sector of the river basin, clastic sediments of undivided upper Cretaceous appear above the Tertiary sediments. Lithological composition is dominated by light gray to white, more or less crystalline, in places sandy limestones, as well as dolomitic limestones.

Eocene continues on the Cretaceous at the southern slopes of the Majevica horst-anticlinorium morphostructure. The Middle Eocene sediments were developed. Geologically, development of the Middle Eocene in the area of the Majevica ridge is typical. Quartz sandstones, sandy limestones and marls participate in the geological structure. Recent research has found an outcrop of the Lower Eocene sediments on the northwestern wing of the Dokanj syncline, in the Abramovka stream. Sandstone layers appear within marls with micca. The marls contain numulites and rare discocyclines (Pavlovec et al. 2005, 6-7).

According to the Katzer, Oligocene is only continuation of the Eocene, and it is very difficult to separate it. The Oligocene freshwater sedimentary series together with the Lower Miocene in the upper sector of the Solina river basin have a thickness of about 850 m. This unity is divided into 13 strata whose structure is most commonly composed of clays, marls, sandstones (Soklić 1964, 8-9). The Oligocene sediments lie concordantly beneath the Slavinovici limestones in the Tuzla basin. They also participate in the geological structure of the Dolovi anticline, a structural part of the Solina valley. Neogene is characterized by terrestrial and marine sedimentation followed by intense volcanic activity of the Lower Miocene and Middle Miocene ages. Mostly sedimentary structures were formed, where the thickness of accumulated material in the Tuzla basin excides 2500 m.

It should be emphasized that Neogene sediments and neo-tectonic structures mask an earlier highly complex tectonic structure, which makes it difficult to reconstruct the primary relations in the Neogene substrate (Čičić et al. 1991, 33). Miocene development in the study area is complete. Sediments of the Lower, Middle and Upper

Miocene participate in geological structure of the terrain. The freshwater, salt lake water, marine, brackish and caspibrakic formations genetically construct the Soline river basin within the stratigraphic members of: Akvitane, Burdigal - Helvet, Tortonian, Sarmatian, Pannonian.

Recently, a new classification of Miocene sediments in the Tuzla Basin has been given (Vrabac, Ćorić, 2008, 79). The "red" and "colorful" freshwater series are combined into a "clastic - pyroclastic formation" which represents the Lower Miocene bottom of the salt formation. Salt formation has lagoon genesis and it is designated as the Lower Badenian. Over salt formation lie Badenian ("Tortonian"), Sarmatian and Pannonian clastic sediments (Vrabac, Ćorić, 2008, 79).

Lower Miocene (M_1^1) is built of so called „red“ serie and „colorful“ fresh water serie, represented with clastites. Lower Miocene sediments were formed in alluvium and shallow stagnant waters, mainly in lakes. Underneath „red“ series lie „Slavinovići limestones“. Due to their hardness and resistance to fluvio-denudation processes, rocks of this lithological composition and age dominate in the relief. They originated from freshwater lake with varying water levels and low shores. In addition, the Lower Miocene sediments in the river basin of Solina are clays, gravely clays and marls. Lower Miocene is characterized with facies changes caused by strong tectonic movements, accompanied by volcanism. Tectonic movements had tense nature with significant rising and lowering of blocks, some of them were submerged in fresh water and others often remain on the land.
Along the deep faults of southern Majevica smaller volcanoes are formed. These volcanoes cannot be proven with certainty, but their existence is known based on appearance of tuffite rocks and tuffs found in the Lower Miocene and Middle Miocene (Badenian) sediments. Related to the tectonic movements is forming of Tuzla's salt deposit, whose one part is located in the northeastern part of the Solina river basin, on the locality Tetima. Geological structure is dominated by marls, dolomicrites, tuffs, anhydrite, halites – so called "strip series".

In the Dokanj syncline, but also in the top of anticline Dolovi, discovered are sediments of „strip or salt serie“ ($^2M_{1,2}$), according to the new data $^1M_2^1$. It is mainly composed of homogeneous carbonate rocks with a small amount of clay formed by mechanical sedimentation. Evaporite lithological members are rock salt, Glauber's salt and anhydrite. In addition to these members, there are marls, clayly marls, clays, etc. Sheet limestones of Tuzla represent the end of the Tuzla salt formation. Basically, hemogeneous sediments are best developed in the Dolovi anticline with a thickness exceeding 20 m. They are lithologically composed of dolomitic limestones, limestones, and calcrudites (formerly called "poriferous limestones"). In the Dokanj syncline and in the southwestern wing of anticline Dolovi these limestones lateraly cross into anhydrite and rock salt.

Middle Miocene or Tortonian sediments have been deposited discordantly over Cretaceous, Paleogene and freshwater Miocene sediments, and concordantly over the Tuzla Salt formation (Čičić et al. 1991, 41 – 43). Badenian („Tortonian“) sediments, which lay on the salt formation, were created on the deeper sea floor. Facies of marls is developed in the anticline Dolovi, Dokanj syncline and is divided Lower Badenian $^2M_2^1$ „Tortonian“ - ($^1M_2^2$) in a facies of massive marls and Upper Badenian $^3M_2^1$

„Tortonian“ - ($^{2}M_{2}^{2}$) composed of alternating series of marls and sandstones. Lower Badenian „Tortonian“ is built by dark grey and black massive marls. Their thickness is about 120 m. In terms of facial composition and microfauna founds, two levels are distinguished: compact black marls lie concordantly across the strip series, while gray marls and alevritic marls lie across the above black marls.Upper Badenian „Tortonian“ has a great role and importance in the construction of the Dokanj syncline and the Dolovi anticline. In the Tuzla basin, it is being built of alternating series of marls, siltstones and arenites, all together thick about 300 m thick. Thickness of layers varies from 2 to 10 cm with a clear stratification (Fig. 4). The Badenian ("Tortonian") sediments of the Dokanj syncline are divided into the Lower, Middle and Upper Badenian, on the basis of foraminifera findings (Vrabac et al. 2008, 70).

Middle Miocen – Sarmatian (M_{3}^{1}) (according to the new classification M_{2}^{2}) is represented in Kosački stream near Dokanj, at the bottom of the Dokanj syncline and has brakish development. The greatest thickness of the Sarmatian over of 300 m was recorded in the Kosački stream. This sedimentary complex is composed of calclutites, chert arenites and phylarenites, clays, marly clays, marls, marly limestones, etc. Evidented are also and special sort of biogenic limestones- oolitic limestones, whose thicness is abot 7-10 m thick. These limestones are also used as building material. Many borrow pits used to be present in the Dokanj basin, where the beautifully layered carbonate sandstone of the older Sarmatian was extracted. In the central part of the river basin is positioned locality Majdan, whose name means borrow pit.

For the Upper Miocene – Pannonian (M_{3}^{2}) (according to the new classification M_{3}^{1}) is characteristic deposition of sediments in the brackwater depositional environment, and consequently, the caspibrack sediments are deposited. It builds the central part of the Dokanj syncline with a thickness of sediments of about 120 m. Lithologic composition includes: clayly marls, clays and less frequently gravely sandstones, sands and marly limestones. Similar Pannonian sediments are also found in the southwestern wing of the anticline Dolovi.

There is no Pont in the river basin of Solina. Below the Salt formation of Lower Baden, deposits are represented by freshwater clastic sediments of "red" and "colorful" series, whose thickness is about 300 m. Due to their great similarity, these series have been merged into a clastic - pyroclastic formation (Vrabac, Ćorić, 2008, 79).

At the end of the Pannonian, the Paratetis sea is completely receded, at that time terrestrial sediments are formed in the Solina basin. Deposition of terrigenous material produces thick deposits of clastic rocks. Clay - sand sediments: siltstone, marl and marl - sandy clays, sand and gravel participate in the formation of Plio-Quaternary sediments.

Smaller periodical flows, associated with surface flushing of terrigenous material, are the most significant factors in the formation of proluvial, delevial, and proluvial - deluvial Holocene (Quaternary) deposits in the Solina basin. Quaternary sediments of the Holocene age include deposits formed by sliding of the terrain.

The inundation terraces (alluvium of riverbed) are constructed by river sediments, whose composition is dominated by fine-grained sediments with clayey and sandy composition over gravelly-sandy deposits (facies of riverbed). Two levels are

distinguished in the sediments of the first and second floodplains. They build river terraces of the Soline valley, as well as the lower course of the hanging stream valleys in the river basin of Solina.

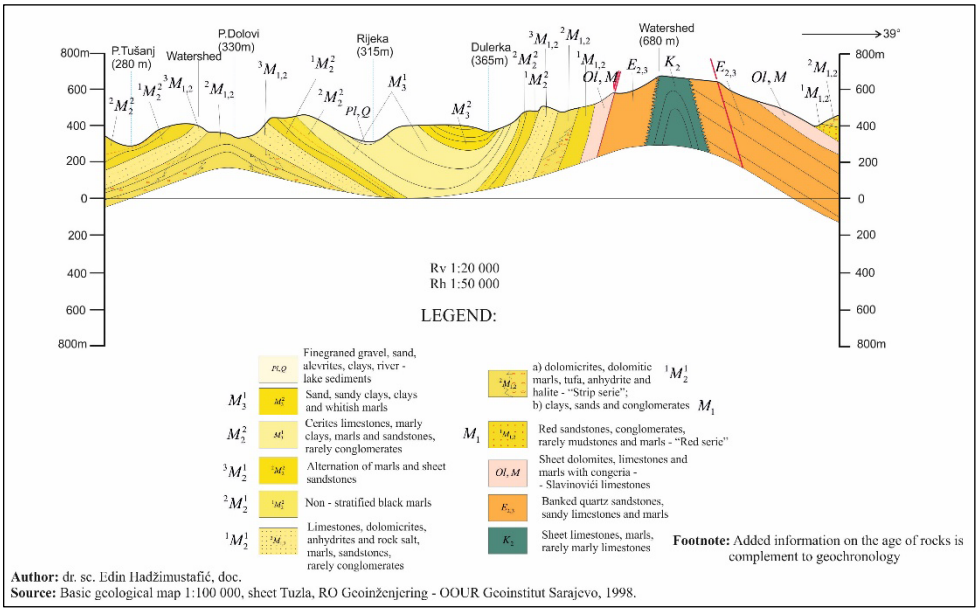

Fig. 4: Geological cross section: direction Tušanj stream - Majevica ridge.

In the study area, the relief of the northern microgeomorphological unit, the mountain ridge of Majevica and its southern slopes, is mostly non-conformal. This situation was conditioned, mostly by the neotectonic activity - raising of the horst - anticlinorium Majevica, which also caused appearance of layers from the central part of the river basin whose lithological composition is dominated by Cretaceous - Paleogene clastites. The central part of the river basin, structurally the Dokanj syncline, micro geomorphologically the foothills of the southern slopes of Majevica, in northern part at the contact of the Dokanj syncline with the horst anticlinorium of Majevica, has an inverse relief which gradually harmonize in the central and southern parts, what is especially evident in the hanging valley of Kosačka rijeka. Valley of Dulerka, where gravity folds also are displayed, shows some features of non-conformity.

The Solina valley in the upper part is nonconform, predisposed by the transversal extension of the Dolovi anticline, from east to west, dividing the valley into two units. In the central and lower part, it becoming a longitudinal conform valley.

4. Conclusion

The analysis shows that the river basin of Solina is mostly part of the structure-tectonic unit of the Tuzla basin, while in the north structurally and lithologically it belongs to the Majevica horst-anticlinorium.

Parts of the Tuzla basin are represented by neotectonic units: Tuzla plateau in the southern part of the Solina river basin, the central part is represented with Dokanj syncline and in the north by the thrust Kik. Based on the conducted geological-

geomorphological research works in the river basin of Solina, three relief units were separated. These units from the Solina river mouth to the ridge of Majevica extending from Solina valley, across the Dokanj syncline to the microgeomorphological unit of the ridge of Majevica. In the area of the river mouth of Solina and central part of the Solina valley, the relief is conformal. The unconformity of relief is caused by the tectonic movements which conditioned uplift of the anticline Dolovi. Dokanj syncline is microgeomorphologically foothill of the southern slopes of Majevica, where the inverse relief in its northern part alternates, which gradually converges towards the Soline valley. The relief of the mountain ridge of Majevica is predominantly non-conformal, tectonically predisposed; its structure is dominated by Cretaceous - Paleogene clastites.

References

Anđelković, M. 1988: Geologija Jugoslavije. Građevinska knjiga. Beograd. 310 – 320.

Čičić S. et al.: Osnovna geološka karta 1:100.000, list Tuzla. SFRJ, RO Geoinžinjering - OOUR Geoinstitut, Sarajevo, 1988.

Čičić, S., Jovanovič, Č., Mojićević, M., Tokić, S. 1991: Tumač za list OGK Tuzla 1:100000. Savezni geološki zavod Beograd. 1-72.

Hadžimustafić, E., Smajić, S. 2010: Orografska struktura poriječja Soline. Zbornik radova Prirodno-matematičkog fakulteta, Svezak Geografija, Godina VII, Broj 7. Univerzitet u Tuzli, PMF. Tuzla. 47-56.

Hadžimustafić, E., Smajić S. 2015: Morfostrukturna analiza tipova dolinske mreže poriječja Soline. Zbornik radova Prirodno-matematičkog fakulteta, Svezak Geografija, Godina XII, Broj 11. Univerzitet u Tuzli, PMF. Tuzla. 49-57.

Herak, M. 1990: Geologija. Školska knjiga. Zagreb. 292.

Lepirica, A. 2009: Reljef geomorfoloških makroregija Bosne i Hercegovine. Zbornik radova Prirodno-matematičkog fakulteta, Svezak Geografija, Godina VI, Broj 6, Univerzitet u Tuzli, PMF. Tuzla. 7-52.

Pavlovec, R., Pavšić, J., Vrabac, S. 2005: Spodnji eocen na Majevici severno od Tuzle (severovozhodna Bosna). Geologija, 48/1. Geološki zavod Slovenije. Ljubljana. 5 -12.

Soklić, I. 1964: Postanak i struktura tuzlanskog bazena. Sarajevo, 1964. 5 - 25.

Soklić, I. 1986.: Tektonsko – strukturni oblici tuzlanskog bazena i Majevice. Akademija nauka i umjetnosti BiH, Odjeljenje tehničkih nauka, Knj 10. Sarajevo 1986. 23-55.

Vrabac, S., Ćorić, S. 2008: Revizija „karpata" Tuzlanskog bazena sa osvrtom na stratigrafski položaj sone formacije. Geološki glasnik, Broj 37. Sarajevo. 71 – 81.

Vrabac, S., Ferahatbegović, Z., Đulović, I., Bijedić Dž. 2008: Asocijacije mikroforaminifera u krovinskim sedimentima sone formacije i njihova primjena pri izradi istražno – eksploatacione bušotine B – 84 na ležištu kamene soli Tetima. Geološki glasnik, Broj 37. Sarajevo. 59 – 70.

THE RELATIONSHIP BETWEEN RELIEF AND GEOLOGICAL STRUCTURE IN THE RIVER BASIN OF SOLINA
Summary

In this paper has been analyzed the relationship of relief and geologic structure in the Solina river basin, located in the northeastern part of Bosnia and Herzegovina. The aim of the study was to investigate and determine the cause and effect of relationships of geological characteristics of the terrain to the genesis, morphological evolution, and ultimately differentiation of the relief units. Modern geomorphological-geological methods, fieldwork, analysis of topographic and geological maps, as well as satellite images of the studied area were applied in the paper. The presentation of data was realized in the Geographic Information System, and the geospatial data were geo-visualized on two thematic maps.

The geotectonic development of the Solina river basin was analyzed, where it was determined that it had undergone a long and complex genesis and its structural-tectonic units were separated. The Solina river basin is mostly part of the structure-tectonic unit of the Tuzla basin (as a subdivision of the Tuzla trench - synclinorium), and to the smaller northern peripheral part it belongs to the Majevica horst anticlinorium.

Structural and tectonic units, stretching from south to north of the basin, lay in parallel as follows: Tuzla folded platou, thrust Kik, Dokanj basin and smaller part of the horst-anticlinorium Majevica. Each of the units is analyzed in detail.

The river basin of Solina is mostly subjected to radial tectonic movements in the contact zone of horst - anticlinorium Majevica and syncline Dokanj. Majevica horst - anticlinorium, structurally – lithologically, does not represent a single entity.

The river basin of Solina is geologically built by Cretaceous clastites and limestones, as well as by younger Cenozoic sediments. Cretaceous - Paleogene clastites are present to a lesser extent, especially in the upper river basin sector, while nearly two thirds of terrain is composed of Neogene - Quaternary sediments.

In the Solina river basin, three geomorphological units are separated, going from north to south. The relief of the mountain ridge of Majevica is predominantly non-conformal, excepting the anticline Dolovi. Dokanj syncline is microgeomorphologically foothill of the southern slopes of Majevica, where the inverse relief in its northern part alternates, which gradually converges towards the Soline valley. In the area of the river mouth of Solina and central part of the Solina valley, the relief is conformal.