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THE ORLJA RIVER – MORPHOLOGICAL AND POTAMOLOGICAL CHARACTERISTICS

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The Orlja river belongs to the hydrographic system of Krivaja River in its upper flow from the left side, in the Crnoriječka plateau and Zvijezda mountain. The rainwaters from mountainous hillsides are mostly surface drained in the Orlja river and, to a lesser extent, infiltrated through carbonate rocks, into a shallow karstic Crnoriječka plateau, where an underground bifurcation of the karstic swalow hole waters is conducted directly in Krivaja, about 4 km downstream of the Olovo and indirectly by the Orlja river, which ends in the Hočevica river, the first rank Krivaja's tributary. Considering the above, Orlja is Krivaja's tributary of the second rank.

The Orlja river belongs to constant flows, whose valley is dissected into very deep carbonate canyon valley, which has all characteristics of the gorge rivers. In some places the deep, convex valley slopes endings are interconnecting, and thus indicates that morphological evolution of underground closed flow; swallow holes, through the collapsed roof opening, in the open, overhead, hydrographic system. The Orlja river valley is unique morphological unit, which, from a normal river valley in the upper flow evolve into the canyon valley and ends with a stepwise riverbed with numerous waterfalls, that local people reffers to as Skokovi.

Key words: Orlja, valley, talweg, profile, morphological evolution, swallow hole, hydrographic system, gorge, bifurcation, waterfalls, evorsion potholes, waterfalls – Skokovi.

INTRODUCTION

The Orlja river belongs to the Krivaja hydrographic system, of the second rank, in its upper flow, about 6 km downstream from confluence of Bioštica and Stupčanica River, where Krivaja River emerges. The morphological-hydrographic system that makes the Orlja river is very unusuall and interesting because of its unconform longitudinal profile, affected by carbonate geological composition, especially in the lower flow. Upper part of the river profile, with relatively higher altitudes, shows tendencies of conformity, wich is a result of verfen geological formations, that defined the surface and widely outspreaded river system in water sources, where belongs the Gnjionica tributary too.

The headwaters of the Orlja river, which is formed in Triassic deposits, primarily Werfenian as well as Anisian and Jurassic, have almost all elements of the normal river valley. The canyon part of the valley is incised in spotted limestones and limestone-chert marls from the Ladinic series. Thanks to this geological spreading of formations and facies, and to a total tectonics, the Orlja valley has a very diversified morphological landscape value.

Morphological diversity is defined by the normal river valley in the upper, and the canyon in the middle and especially in the lower flow. The end of the Orlja valley in front of the mouth in the Očevija (on some topographic maps, besides the mentioned name, the name Očevlja appears, according to the name of the upstream settlement), and in the people known as Hoćevica (which will be used in the text), is characterized by the basin widening of Mehorača (named Meorača on BTM 25, Sheet Olovo North).

The Orlja river is a constant flow with water level fluctuations, where the lowest occurs in summer, where extremely low water levels and flows are occuring. Due to the morphological closure of the river valley, which is at the right angle to the Dinaric directrix and the high level of anthropogenic absences, the river system has preserved the natural state of phyto and zoobenthos with high production of river necton, especially in the Skokova profile.

The river valley has preserved natural features, which is included in the morphological and potamological specificity. Any alteration of the natural regimes by anthropogenic action would endanger its precious natural values, which have not only a landscape but also a scientific value. The morphological and potamological researches in watershed and valley of the Orlja river, document the stated allegations and incorporate this stream and valley into protection priorities from planned concessions for the construction of a mini hydroelectric power plant. These analyzes show that eventual projects in the watershed and the valley of the Orlja river would endanger its original natural diversity.

Morphological and potamological analyzes were realized by modern physical-geographic methodology and methods, including GIS tools. Since there is no installed hydrological monitoring, the river regime has been defined indirectly according to the calculations of precipitation from the isohyet map in 50 mm interpolation.

GEOGRAPHIC POSITION OF THE ORLJA WATERSHED

In the undermountain of the Crnorječka plateau, eroded and segmently karst corroded, on its northeastern end, which is orographically limited by the rounded peak of Mačak (1245 m), the surface and ground waters are drained towards the headwaters of the Orlja river. Its orographic watershed is further aligned on the northeast, with the medium mountain ridges and notches Pogladina (1245 m), Razdolja (1072 m) and Osinjača (1004 m). On the south side, the watershed boundary correspond to the oronymes: Ačkerov grob (1044m), Kremenjača (1069m), Selišta (958m), Orlić (961m) and Jasik (774m) (Fig.1).

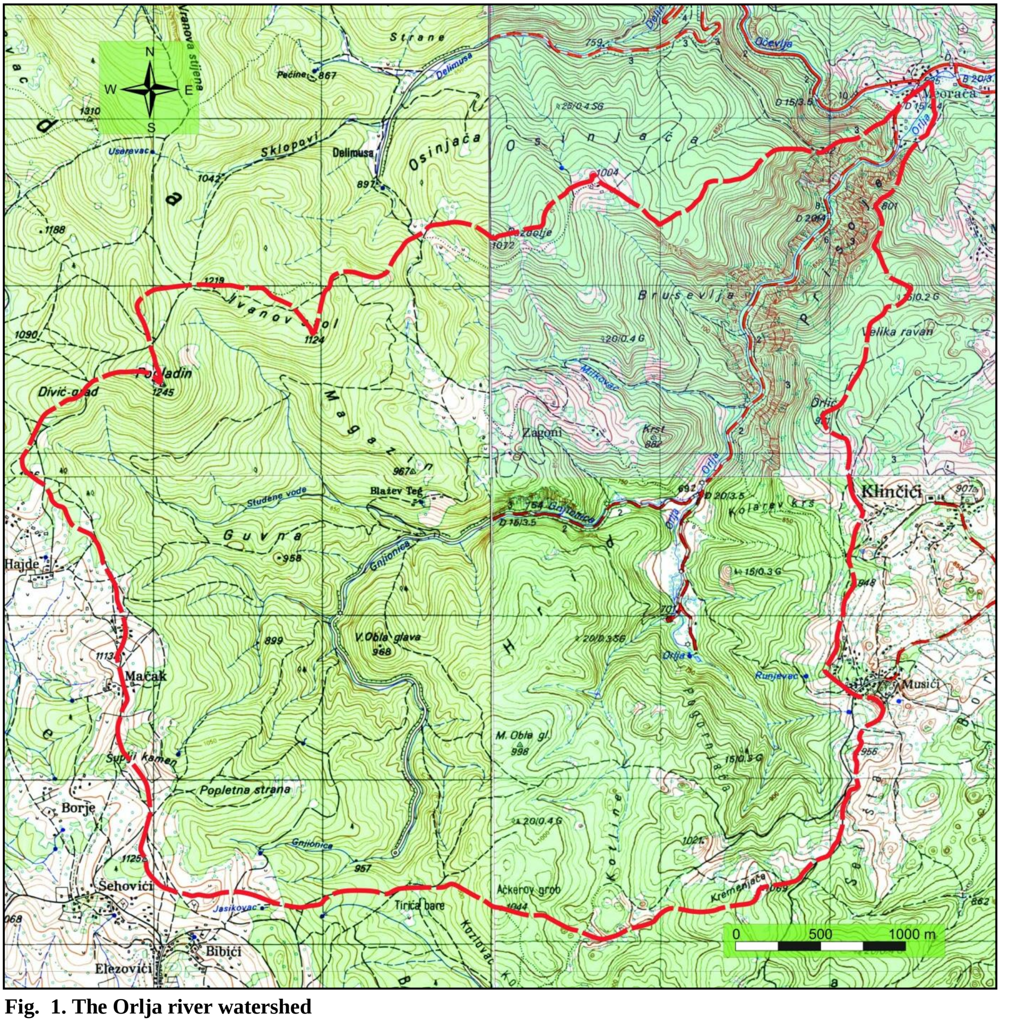

Fig. 1. The Orlja river watershed

The watershed divides are orographic and stable, with the exception of the immediate slopes towards the Mačak, where the underground filtration of the rainwater from the Crnoriječka plateau, where the underground bifurcation occur mainly towards the Bijambare cave and to the other smaller ones, towards the Studene waters of the Gnjionica tributary. The immediate connection of the swallow hole system at the bottom of the Crnoriječka plateau and river system is the vaucluse spring Orlja, whereby the entire hydrographic system was named. Hydronym Orlja can be related to the water gurgling, as a result of the underground ascedent rise in the limestone cracks and its overflow, which forms the main river flow.

The Orlja watershed along with the upper course of Krivaja River and its headwaters is actually the north-eastern border of the sub-region of the Sarajevo-Zenica valley, which further north reaches Karaula; Drina's dividing range to the Bosna river. At this same watershed divide is also the border between the Central and Northern Bosnia region.

Considering this somewhat northerner regional-geographical position, the Orlja river watershed mainly belongs to the orographic unit of the Zvijezda Mt. from the group of ore and flysch mountains of Bosnia and Herzegovina, which also make orographic borders toward the region of northern Bosnia.

The Orlja watershed morphostructurally belongs to the orogenic Dinaride tree, which geotectonically regionalized is part of the inner Dinarides. These are medium high orographic entities, which in the basis have allochthonous paleozoic, which sedimentary prolong in the Triassic, within the most represented werfenian and carbonate deposits.

The orogenously waved morphological structure oriented the slopes of different inclinations toward all horizontal orientation points, which the moderately warm and humid climate modified in somewhat colder climate. Orographic modifications of moderately hot and humid climates into a slightly colder climate of the sub-boreal type are particularly thermally expressed, what is a result of the morphological closure of the main river valley network and its, mainly right-angled orientation to the Dinarides. All other climate elements in the watershed are slightly modified compared to the standard moderately warm and humid climate.

The aforementioned natural-geographic conditions have influenced the genesis of whole mosaic of soils, such as: calcomelanosol-luvisol, complex of rendzinas on limestones and dolomites, and distric cambisol on acidic silicate rocks. Their distribution depends on the altitude and the openness of the morphological habitus.

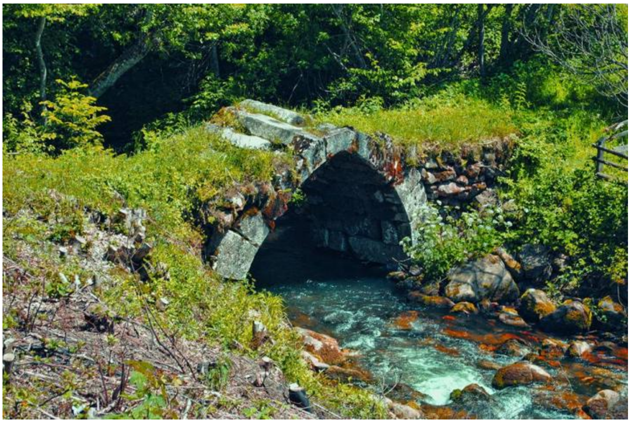

Fig. 2. The Roman bridge on the Orlja river. On the top of the bridge, the „Stećci“ can be seen.

The lowest hipsometric horizons are inhabited by the ecosystems of mesophilic forests of sessile oak and common hornbeam (Carpinion betuli ilyricum). In the higher altitudes, the Orlja watershed is under beech-fir forests (Abieti - Fagetion ilyricum), while the highest altitudes in the watershed and, in particular, the northern exposures are inhabited by the ecosystem of the conifer dark forests (Abieto piceion ilyricum). Considering the fact that light deciduous forests and conifer dark forests, the ground floors are inhabited by low bushes, which makes this watershed a very diverse in vegetation and floristic ecosystems.

The Orlja's watershed has also the meadow-pasture areas, which are anthropogenically adapted for extensive partial cultivation and cattle breeding. For this reason, the map of the catchment area is filled with a numerous toponyms, showing a high level of occasional anthropogenic presence and the centuries of population adaptability in these areas. It is a demo-geographic fluctuating area and has been, since the ancient times, the shortest route between the Central and the North Bosnia. It was a road connection of Sarajevo to the valley of Ljubina through the Crnoriječka plateau, to the Orlja and Hoćevice valley to the Krivaja valley and further through Konjuh to northern Bosnia. This is evidenced by the remains of a caravan road, which in one place overlaid the Orlja river by a Roman bridge. The bridge, actually, is not that old. The walled bridge arc features elements of Ottoman architecture. The crown of the arc ends with the „stećci“, whose angles are incorporated to the convex structure of the bridge. The bridge is named according to the „stećci“ that are from the Roman period. Since 2011. The Roman bridge on the Orlja river was registered in the registry of the historic monuments of Bosnia and Herzegovina. The similar data are also included in the Sarajevo Institute of History proceedings (2014) with very strange semantic title "The Krivaja river trough past". The Proceedings content treats the foremost watershed and valley as the basis for settling, hence, the population that makes the historical past, but not the river and its tributaries, as it is mentioned, which overcomes the historical past and goes to geological chronology.

MORPHOLOGICAL CHARACTERISTICS OF THE WATERSHED AND A VALLEY

Morphostructural relations in the watershed

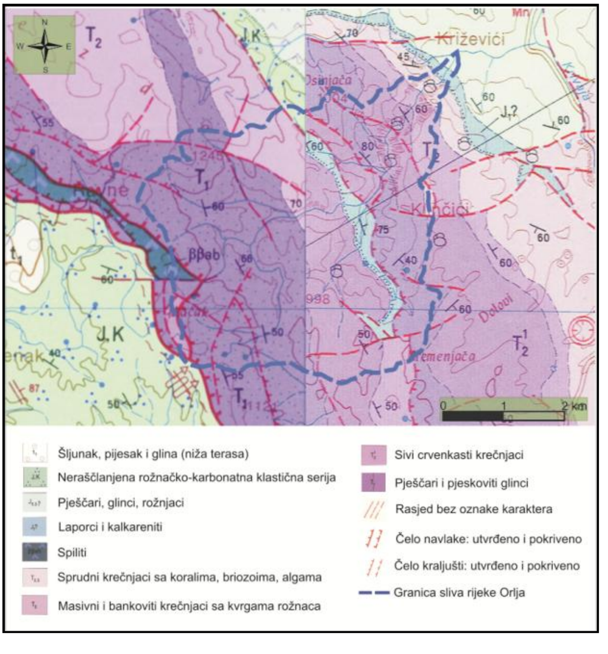

Fig. 3. Geological formations and facies in Orlja watershed

The Orlja catchment area mainly belongs to the far west part of the structural-facial unit of Romanija, defined by the interiormountain fluvial-karstic Crnoriječka plateaus of Mesozoic poorly-folded carbonate layers, which slightly fall in the north-east direction. In this direction, the folds in the watershed is somewhat more pronounced with noticeably compressed folds, in some places overturned,broken and overtrusted.

The canyon-ravine part of the valley and the basin is linked to a part of the tectonic anticline overtrusted on the one part over the Triassic sediments and on the other over the flysch formations. The western boundary of the watershed is faulted and discordant towards the volcanicsedimentary deposits of the central Bosnian ophiolitic zone where the river valley and the Orlja catchment area ends.

The structural-facial units are represented by different formations and facies. The deepest part of the Orlja valley, from the mouth of the left tributary Mikovac to the end of its flow in the Hoćevica river, first crosses the carbonate series of Anisian age, made of gray and redish limestones. This geological formation over the assumed fault, coordinates with the base made of a Werfenian series made of quartz sandstones, conglomerates and claystones. The continuance of the canyon valley towards the northeast is made of Ladinic formations, consisting of limestones, cherts and rarely marls. This part of the canyon valley retains its depth, but is notched to the shape of ravine. After the Ladinic series, the river valley is very narrow and deep, enclosed by fold mirrors created by fluvial carstification from the swallow hole cavern into the open valley formed by banked limestones and subdued dolomitic limestones with paleontological fossil remains, of which, according to the BGM 1: 100 000 sheet Vlasenica, the most significant are: corals, briozoes and algae. This series lies concordantly across the Ladinic series.

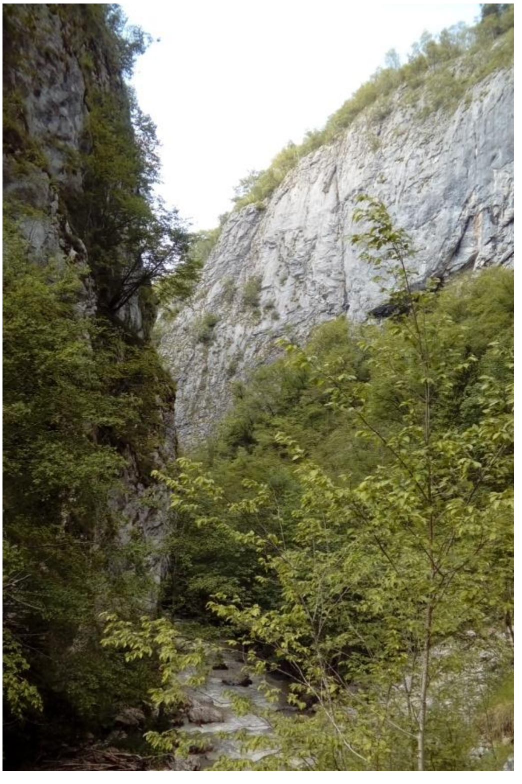

Fig. 4. The Orlja canyon valley in Anisian carbonate rocks

The Orlja canyon valley closes in contact with the Jurassic deposits of marly limestones, marls and calcarenite. On this geological series, the Orlja course reaches the mouth in the Hoćevica river, where the contact with the ophiolitic melange is made, named on the geological maps as a volcanogenic-sediment formation.

The Anisian stage is quite karstified, what is indicated by the general morphography of rock masses intersected by numerous diaclasis and brahioclasis and tectonic mirrors (Fig. 4). The fissure porosity indicates the occurrence of karstic springs and wells, especially those in the Orlja headwaters. They are of a contact type, created within the Anisian stage and above the marly limestones, marls, and calcarenites of the Jurassic formation. In the same zone on the tectonic contact of massive limestones and volcanogenic-sediment formation, the thermomineral waters, similar to those on other localities of the Olovo can be found.

The headwaters, especially the tributary of Gnjionica, has a drainage basin in a Anisian series limestones, which overlap on Werfenian deposits and form an aquatic hydrological zone. The fluvial process is established by a series of contact springs of lesser ambundance, defined by the hydronym of „Studena voda“, the tributary of Gnjionica, and the direct formation of surface flows from the precipitation. The tributary of Studena voda originates from a series of less generous permanent sources, which show the intermitent source traits.

Morphographic-morphometric characteristics of the basin and valley

The Orlja drainage basin (watershed) is situated in the south-south-eastern slopes of the Zvijezda Mt. In fact, it represents the border of this mountain toward the fluvio-karstic Crnoriječka plateau in the east and the utter slopes of the Konjuh Mt in the north. Accordingly, the Orlja river basin belongs to some of the ore and flysch mountains that are part of the outer Dinarides. This is, towards the north, a falling morphological vault, that is by Hoćevica River valley and its tributaries, and especially by the Orlja river, vertically dissected the streching of the Dinaric morphostructure. Morphostructural relations, as stated, have defined its contact with fluvio-corrosional plains, such as Crnoriječka plateau, Velika Ravan, Klinčićko-bakićki corrosion plateau and other smaller ones, that do not belong to the Zvijezda Mt. morphostructure.

The Orlja drainage basin is located in mountainous morphostructures, which is documented by the altitudes of orographic division range, which are mostly watershed divisions because of the geological water bearing formations and facies. The orographic division ranges in the north are following the heighest points and trigonometers: Osinjača (1004 m), Razdolja (1072 m), Ivanova stola (1218 m) and Pogladina (1245 m). From the west, the orographic boundary, which is not a watershed division i one part due to the karstic corrosion drainage basin on the border with the Crnoriječka plateau, coincides with Mačak (1113 m) and Šehović peak (1125 m). From the south, the orographic boundary of the Orlja basin, are defined by the oronyms Akčerov grob (1044 m) and Kremenjača (1069 m). From the east, the orographic basin is determined by somewhat lower morphostructures, where the most prominent are: Selišta (956 m), Orlić (961 m), Velika Ravan (1510 m) and Prisoje (801 m).

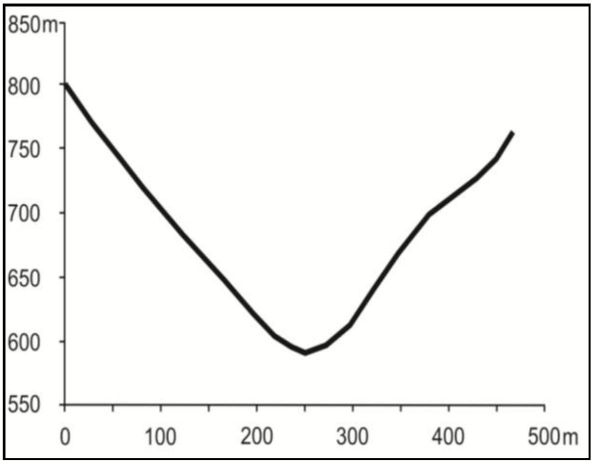

Fig. 5. The cross-section profile of the Orlja in the canyon valley „Skokovi“

Thus defined orographic watershed of the Orlja basin has the altitude of 1093 m, which includes it in high division ranges. The total length of orographic watershed is 19.6 km, and the coefficient of watershed development is 1.1 and shows that watershed and basin, especially in the central part, have an approximate oval shape. This data suggests that the precipitous waters flow very quickly and without losing trough the tributary system from the catchment area to the main stream. The predominantly oval form of the basin is also indicated by the basin fullness coefficient of 0.41. This also suggests that high water waves are fast and rush through the main stream.

The Orlja valley base and its most significant tributary Gnjionica have an average altitude of 722 m and the average relief energy of the basin is 371 m. Generally, this data is not a special feature, but considering that the change of the relative height of 371 m appears in the range of all 5.2 km, it represents a high degree of relief energy. The relief energy of the basin is very pronounced in its lower part, at the location of Skokovi, at the place where the river was cut into Anisian limestones and, inferiorly, to the Ladinic stage on the transversal profile where on only 500 m, the difference in the relative height from the base to the valley shoulders, is 266 m.

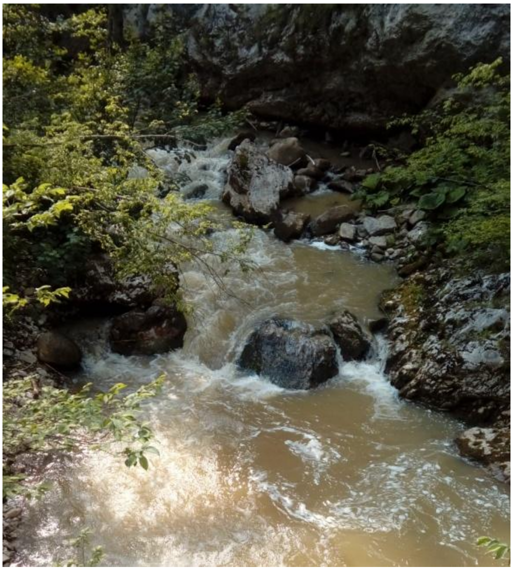

Fig. 6. The Orlja's talweg is mostly unconform. The riverbed is inherited and adapted by a finished genetical processes. That's why the riverbed is breached with overflows and waterfalls.

The Orlja river drainage basin has an area of 18.3 km^2, the length of 7.7 km and an average width of 2.8 km. The maximum width of the basin occurs in its central part and is 5.2 km. The basin is asymmetrical as indicated by a coefficient of asymmetry of 1.75. The average height of the basin is 907 m and shows a fairly uniform height on almost all orographic elevations.

Within a basin, bordered by orographic watershed divide, there are orographic morphostructures that have oriented the Orlja river system on the main course and its tributaries, especially in the headwaters. All mountain morphostructures with their altitudes are not significantly behind the watershed divide, with the altitudes: Magazine 967 m, Guvna 958 m, Obla Glava 968 m, Hrid 945 m, Mala Obla Glava 998 m, etc. Within the watershed morphologic unit, through its spreading, the streams were engulfed by meanders, and especially the Gnjionica around the Obla Glava and Hrid. In this sector, river valleys are normal and have convex slopes. Subsequently, due to the change of the geological structure from the Werfenian to the Anisinian and the Ladinic, the morphological habitus is changed into smaller, ravine and canyon valley. The valley of this form is particularly illustrative after the mouth of the left tributary of Milkovac, to the mouth of Orlja in Hoćevica. On this profile, the riverbed has an unconform talweg, which is why smaller sections occur, through which the river water flows over, known to the locals as Skokovi (Fig. 6).

POTAMOLOGICAL CHARACTERISTICS

Orlja's river system

Hydronym Orlja is the main potamological backbone and refers to a stream that originates from the vaucluse springs beneath the limestone section of the Pogornjača at a height of 710 m. The source is well-shaped form, from which water is ascendingly pruned and overflows over a low limestone girder, from which a smaller stream evolve and has the hydronym Orlja, which etymologically translates as the mountain stream. As the water is ascending, it is quite certain that the karstification system is lower than the recent topographic surface. Given the water temperature of avg. 8.0°C, it can be assumed that it is a deeper karstic aquifer. Analyzing the topographic and geological maps as well as the fragmentary field researches above the Orlja springs towards the south-southeast in the direction of Selište, the dry valley is recognized on the surface. Her former hydrographic function was transferred to the karst underground.

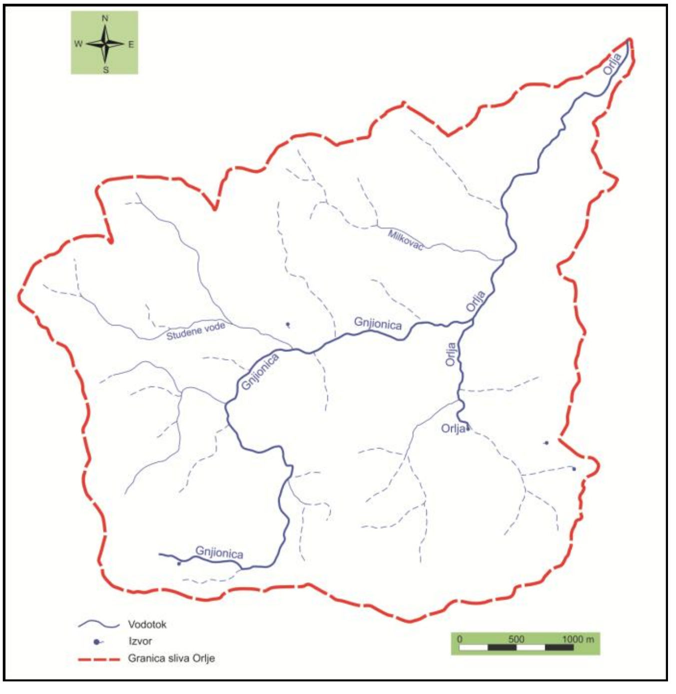

Fig. 7. Hydrographic system of the Orlja river

In the same geological substrate, the juvenile hypothermal waters occur with a temperature of 26°C at the source. The sources are of an faulted type and point to their tectonic origin. The difference in the temperatures of thermal and normal waters in proximity, indicates the existence of separate underground independent hydrographic systems. The Orlja thermal waters are valorized for tourist purposes.

If the Orlja source is treated at its beginning, then the headwaters of this river are replaced by its direct source. Thus treated Orlja has a length of 4 km. If the hydrographic system includes the tributaries, which is necessary, then its longest tributary Gnjionica is treated as the extension of the total length of the Orlja course for another 5.2 km as its length is. Therefore, the total length of the Orlja river, with its longest tributary is 9.2 km.

The Gnjionica has a branched hydrographic network. The total length of all permanent streams in the Orla river basin is 20.72 km. If this data is placed in the ratio of the total drainage area (18.3 km²), then the average density of the surface river network is 1.13 km/km². The river network is more dense on the left catchment area, which can also be seen on the hydrographic map (Fig. 7), due to the unpermeable hydrogeological composition in relation to the right, which is made of massive limestones, highly karstified from the surface and hydrogeologically water-permeable. The Orlja river network is more dense than other smaller river basins in the hydrographic network of Bosnia and Herzegovina, because the average rainfalls on each km² of the catchment area has 880 m of surface flows. In this way, the precipitate waters infiltrates faster without loss on evaporation, evapotranspiration and absorption in the pedological substrate and fissure filtrations.

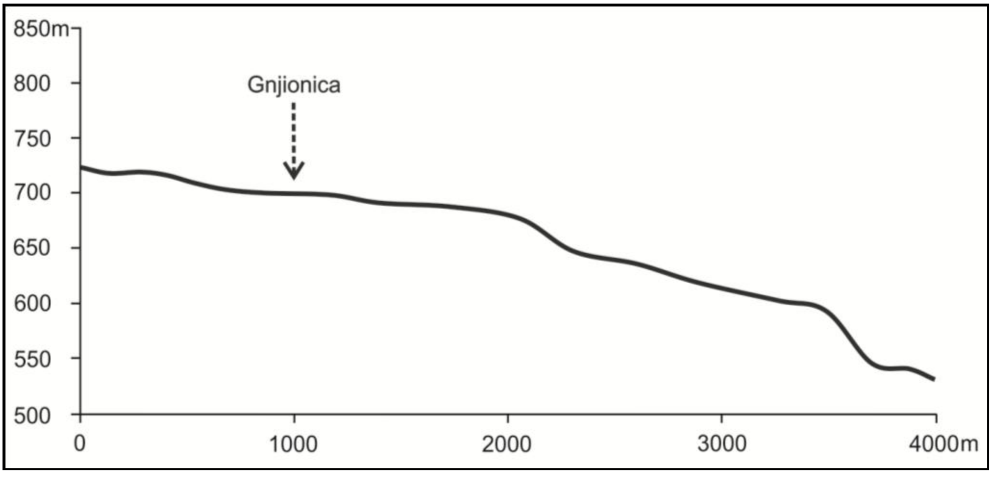

Fig. 8. Longitudinal profile of the Orlja river

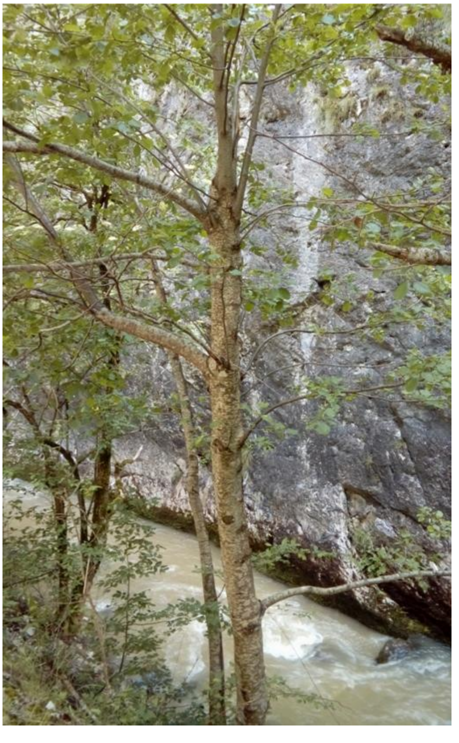

Fig. 9. Fault mirror that makes a riverbed and also a river valley.

In the hydrographic system of Orlja, except for Gnjionica, the most important tributary is Studene vode, named after a cold, weakly abundant strams, which, apart from the rainfall, also receive water from the less abundant karst springs and wells. They increase their abundance, twice a day by about ¼ of water. The fact that daytime capacities on sources increase during the day, it indisputably point to their intermittent genesis. Further increasing of the Orlja water to the mouth, has a left tributary Milkovac, periodically tributaries and weakly abundant springs in the level of the riverbed.

The coefficient of the development of the river is 1.1 which shows that the river system allows, lossless and fast inflow of precipitation waters in some of the streams.

The hydrographic system of Orlja ends in the village of Mehorača, at an altitude of 535 m, so the overall decline of the Orlja is 175 m. If in the hydrographic system of Orlja is imputed the elevation of the Gnjionice source, as the longest tributary, then Orlja has a total drop of 510 m. Average fall of the Orlja river per talweg is 46.25‰. The biggest declines are in the lower flow (fig. 8).

The longitudinal profile of Orlja is gradual. In addition it is inverse, because it has a larger declines at the mouth than at the source. From the source, in the length of 2 km, the longitudinal profile is a lot more balanced, and then there are a uniform declines about 1.2 km, and up to the mouth there are cascades, which is why this part of the talweg is named „Skokovi“.

When the longitudinal profile is brought into correlation with the geological substrate, then equilibric downfalls are achieved in the series of Werfenian quartz sandstones, claystones and conglomerates. The equilibric canyon shaped valley downfall was formed in Anisian carbonate rocks, and stepwise profile in canyon valley originated in Ladinic series of reef limestones. The cascades affected the emergence of smaller waterfalls and overflows - leaps. The cascades are not tectonically predisposed, but made from collapsed rock blocks dispersed and chaotically stacked, over and around which flows the river water. These cascades are numerous, more than 50 in lengths of 250 m. Behind them, the falls were created in the pockets of the riverbed bottom. They are the erosion forms created in the river detritus or in polished rock masses in the shape of a pot, earning the name of evorsion pots. On the overall longitudinal profile, the rich zoo and fito benthos is present, that enable life to a variety of nectonic organisms; predominantly to the river trout.

Such an unregular and unnatural longitudinal profile points to the unusual genesis of the river valley in which it is located. The lower, atypical, longitudinal profile can be genetically linked to the tectonic dislocation which has created such a deep valley (Fig. 9). In this segment of the longitudinal profile, the vertical fault mirrors are visible, which arise from the bottom of the riverbed towards the end of the valley sides. Given that at the base of the riverbed, in more places, form an angle of more than 90°, we are inclined to explain that this part of the valley was formed on a tectonic dislocation, where the underground cave stream (swallow hole) was metamorphized, and whose cave roof is colapsed because of suffossional sinking, so a former swallow hole is transformed into today's surface flow.

River regime

Considering the water regime in the Orlja water system was considered from the context of the climate regime, predominantly pluviometric, and the river system is fed with the rainwaters. In addition to the rainwaters, there are also the underground springs, most often karstic, followed by floodplain springs that participate in the stable flow of the Orlja river. And these waters are vadose.

In addition to rainwater and groundwater, in the flow regime, the thermomineral waters have been included, which are formed in proximity to the main source of the Orlja. These waters are considered to be hypothermic with water temperature at the source of 27°C. They belong to the juvenile genesis and by the mineral composition they're similar to those in the Olovo and Solun in the Krivaja valley. The thermomineral sources of Orlja were created in contact of the tuffs and carbonates.

The river regime is defined by the pluviometric and thermal indicators derived from the isohyet and isothermal maps of the first and second climatological period. According to the data of the pluviometric regime, the Orlja drainage basin belongs to the group of watersheds in the Krivaja river system, which have an increased amount of rainfalls and is 1329.5 mm/m² during the average year. An increased rainfalls with an average maximum occurs during the spring and the minimum during the hydrological summer (Fig. 10). The maximum amount of rainfall in the spring period is often combined with snow and karstic

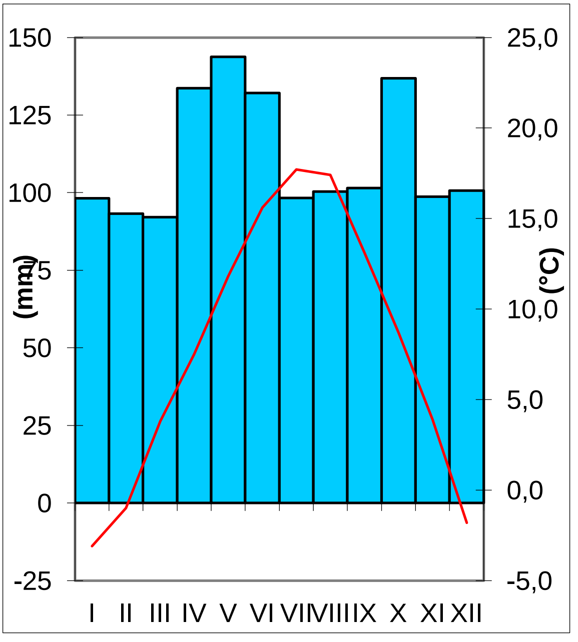

Fig. 10. Isohyet and isothermic regime in Orlja watershed

retention, which increases the water inflow from the catchment area into the main flow of Orlja.

In the precipitation regime, the predominant part is the rain, and during the colder period of the year, snowfall prevails. The snow winter begins in mid-November, and its end averagely falls in the second half of February.

The average annual amount of precipitation in the drainage basin is 1,330 million m³ of water per km². The Orlja catchment area receives about 24,330 million m³ of precipitation annually. The loss of the rainfall waters in the Orlja basin, which is hydrologically waterbearing, is 20%, which practically means, that in the main watercourse inflows annually, approximately about 1.1 million m³/km² or about 19.5 million m³ of precipitation from the whole Orlja basin. According to this data, from every km² in every second, the surface water inflow in Orlja is averagely 34 liters. If rainfall data and specific water flow are converted into flows, then on the transversal profile at the mouth to the Hoćevica, average annual flow rate is 0.62 m³/s of water.

Fig. 11. Hypothermal spring with constant flow about 10l/sec.

During the aridic years, the water flow rate is reduced by ½ m³, and at extremely high water levels, the flow is increased to over 15 m³ of water. The maximum water level and flows occur during the spring months, and the minimum during the colder period of the year, when the rainfalls are replaced by snowfall. Consequently, in the spring falls, the retentive snow falls are included. In addition, in the carbonate deposits of the Anisian and Ladinic stages, a karstic aquifer is formed, which is part of a constant flow of the headwaters in the basin of Studene vode. Karst springs have a intermittent character, and during the day they increase the abundance for a two times, which is visible on the water level of the mentioned course.

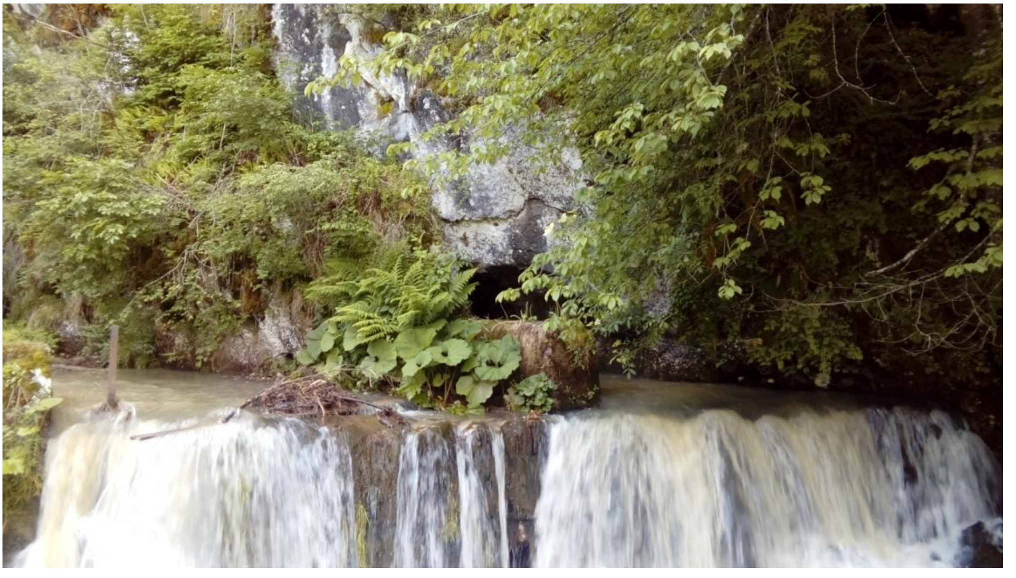

Fig. 12. Karts spring of Orlja. The spring is vaucluse, of a cave type. The water arise on the end of the carbonate section. The water level on the springs in the time of the photographing (26.05.2018.) was high. The water was turbid, which implies on the connection of the spring of Orlja with karstic hinterland at Crnoriječka plateau.

INSTEAD OF CONCLUSION

The presented physical-geographic elements, predominantly morphologically and potamologically, incorporate the Orlja river into a very diverse hydrographic system and make it unique in the Krivaja river basin and beyond. The small watersheds and river systems, such as the Orlja river are quite rare, which are networked by extremely diversified hydro-morphological elements which, within only a few hundred meters of longitudinal and transversal profiles, change drastically. This position refers to some hydro-morphological elements, which should obviously be supplemented by others, including zoogeographic and phytogeographic, although these studies fragmentally defined the biogeographic habitus in the watershed of the Orlja river and preliminary showed very diverse features. Based on these studies, a SWOT analysis was made, which disputes any anthropogenic interventions, such as the intent of constructing of a mini hydroelectric power plant, which would alter the existing natural landscape. The landscape is the basic element from which, according to the Europe directive, begin the elaboration of environmental impacts.

The natural landscape, as a complete system of diverse natural elements linked to mutual and causal connections and relations protected by self-regulatory natural processes, determines different natural indicative-attributive elements. Differences between natural landscapes are more evident if the indicative-attributive elements, which are also their prefixes (plain, valley, ravine, hilly-mountain, river, lake, coastal, forests, etc.) more numerous. Thus, the landscape is far broader concept in relation to elaborate understanding of environmental impacts. If the anthropogenic actions eliminate the basic indicative-attributive element, in our case the Orlja course, then the hydrographic natural system, defined by the drainage basin and bounded by orographic watershed divide, loses the meaning of the river landscape designation.

When evaluating the existing natural system, it is necessary to proceed from the landscape morphological and morphogenetic diversity, from which, the first is defined by morphographic plasticity, which is quantitatively expressed by morphometry, and the other by its genesis. The watershed is very diverse in morphology, so on a small area, of only 18.3 km² wich is an area of the Orlja drainage basin, it varies considerably. This certainly contributes to the vertical dissection, whose base is represented with a very deep river valley, regardless of whether it is morphogenetically-tectonically predisposed or karst-corrosive and suffossion-collapsed.

The morphological reality is named by the river system of surface streams with numerous springs and wells. Hydronym Orlja includes a drainage basin and a river valley, where the numerous morphosculptural elements created by the fluvial erosion are arranged, which is treated as a natural agens and modificator. Precipitation waters denudate the basin and fluvially destroy its substrate and sides. Downstream of the destructed detritus, the succession of the accumulative barriers begins, through which the water is poured. This process is particularly pronounced on the unconform longitudinal profile of Skokova, where on and below the polished rock masses, the evorsion pots emergs, and underneath the accumulated beams, the falls occur. This part of river talweg is unstable especially on the accumulated beams and changes under the flow regime influence.

On the valley slopes, which are formed in the Werfenian mass, the rainwaters flow on the surface up to the main stream. If they are anthropogenically destructed, for example, by logging, gullies are forming, which start to cause guding of a rainfalls, which makes it deeper. Denudation and erosion is particularly pronounced in the Werfenian series whose detritus is introduced into the river, at the bottom of which, in the areas of a conform profile, the deposit waves are accumulating, which regressively balance the river talweg. In this way, in the upper flow of the Orlja and especially in the Gnjionica naturally, and 4 decades ago, by intensive exploitation of forest resources, the longitudinal profile changed due to changes in the lower erosion bases. Recently, since the exploitation of forest resources has been diminished, the Orlja upper flow riverbed has stabilized and has a natural features. Each subsequent intentional impact would have a continuation of the unnatural morphological development of the riverbed and the riverbed aluvium.

The river slopes from the Skokova and the middle flow of Orlja and its tributaries from the headwaters are slope, dilluvial, proluvial, eluvial and colluvial. They are quite unstable and any anthropogenic interference without previous protection, which would not be in harmony with the natural environment, would cause their displacement and sliding towards the riverbed, which is very narrow and closed. These interventions, on labile slopes, would initiated enormous landslides, which would baffle the present river valley.

The variable river regime has its own natural fluctuation according to which, all other natural processes, as well as the life cycles of flora and fauna in the valley and the riverbed of Orlja have been adapted. The Orlja river regime is in the line with the isohyet spread of precipitation, morphological relationships, especially the morphometric characteristics of the river basin and the geological substrate. Oval-shaped drainage basin with predominantly hydrological isolators, caused a constant flow throughout the year. In addition, the watershed at the time of the inundation, allows rapid inflow of the rainfalls to the main watercourse, where the water height is rapidly growing. The high water level does not last long; as long as the extremely high amount of rainfall is present.

During the summer period, the inflow and the water level decrease, and in period of drought, the decrease of the flow is drastic, though the river flow never dry out. From the absolutely lowest water level and flow, any anthropogenic subtraction of even the smallest amount of water, would endanger the life of benthic and nectonic organisms and thus cause the death of the river.

The anthropogenic interventions in concession actions for the construction of mini hydroelectric power plants are unacceptable, because of the total change of natural landscape from the phase of the fluvial natural system into the anthropogenic piping system. This would permanently affect the natural course, through which this natural landscape is named a river. So, the concepts of: drainage basin, orographic divide, watershed divide, river valley, riverbed, spring, headwaters, overflow, evorsion pots, dragged deposit waves, cascades, intermittent springs, vaucluse springs and many others, would loose the total elements of natural, whole and system landscape, and without them, there would be no other elements such as biological diversity.

Therefore, in the case of environmental impact studies, it is necessary to proceed from a basic indicating element, that changes naturally to anthropogenic, to understand the essence of their changes. Thus, from the hydrological minimum it can not be a biological minimum (this issue will be considered at some other occasion) because it means a dry riverbed, and that loose every sense of the natural landscape expressed by hydro-morphological and then any other, especially biological, diversity. In addition to this reflection are the principles of the Decree on Strategic Environmental Impact Assessment in the Federation of Bosnia and Herzegovina where "... *the conservation of natural treasures is carried out in such a way that the level of consumption of renewable resources*, in our case waters, *does not exceed the limits in which natural systems can replace them ...* "

Literature:

Spahić, M, (1990): Rijeka Krivaja – potamološka razmatranja. Geografski pregled br. 33-34. Sarajevo

Spahić M. (2013): Hidrologija kopna. Sarajevo Publishing. Sarajevo

Spahić, M. (2017): Vjetrenice. Acta geographica Bosniae et Herzeovinae, vol. 4., no.8. Association of Geographers in Bosnia and Herzegovina, Sarajevo

Uredbu o strategijskoj procjeni uticaja planova i programa na okoliš Kantona Sarajevo, (2011)

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