HYDROGEOLOGICAL CATEGORISATION OF TERRAIN OF THE SANICA RIVER BASIN

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Considering the material composition of rock masses, the structure of porosity, the mutual spatial relationship of geological units and the water permeability of rocks, the hydrogeological categorization of terrain and rock masses in the basin of Sanica was performed. Three basic hydrogeological units have been identified. The first unit consists of terrain with aquifers of karst porosity, the second unit consists of terrain with aquifers of intergranular, intergranular and/or fracture and fracture porosity, and the third unit consists of terrain without aquifer.

Spatially, the largest part of the basin includes terrain with aquifers of karst and fracture porosity, and the largest part of the researched terrain is characterized by karst hydrography. Consequences of this have been pointed out and also the vulnerability of groundwater to pollution. This, along with the hydrogeological categorization of the terrain, represents an important part of the research, primarily aimed at clarifying the spatial and temporal distribution of waters in the basin, depending on the basic natural conditions. The research is based on the results of previously conducted researches which with the results of original researches and the application of numerous, general and special scientific research procedures, enabled the development of a large-scale hydrogeological map.

Key words*: the Sanica River basin, permeability of rocks, karst, springs, hydromorphological evolution of karst, hydrogeological map*

INTRODUCTION

The Sanica river basin is located in the northwestern Bosnia and Herzegovina in the municipalities of Sanski Most, Kljuc, Bosanski Petrovac and Petrovac. Surrounded by waterfowl, it covers the area between Strazbenica (349 m a.s.l.), Golaja (501 m a.s.l.) and Osljak (666 m a.s.l.) in the northeast and east, followed by Markovo Brdo (411 m a.s.l.) and Cvijica glavica (432 m a.s.l.) and Laniste (717 m a.s.l.) in the southeast and south, Grmec massif with a series of hills - Vrscic (1097 m a.s.l.), Kuresovac (1472 m a.s.l.), Crni Vrh (1605 m a.s.l.), Mala Javornjaca (1432 m a.s.l.), Velika Javornjaca (1456 m a.s.l.) and Dujanovac (1130 m a.s.l.) in the southwest and west, and Metla (743 m a.s.l.), Celic Kosa and Mreznica, Kamenita (441 m a.s.l.) and Begina Glavica (281 m a.s.l.) in the northwest and north. Due to the strong karstification of the terrain there are large discrepancies between surface and underground watershed. Although the position of the underground distribution system is not completely determined, the basin of Sanica belongs to the Bravsko polje, the southeastern part of the Petrovcko polje, the northwestern part of the Srnetica mountain, the eastern part of the Majdanska uvala, and the parts of the Hrustovo and

Krasulje karst plateau which are drained underground under the river Sanica (Fig.1.). Areas with underground drainage comprise about 63% of the total area of the basin, which is about 514 km^2 (Temimović & Džaferagić, 2016).

Water, from an antropogeographic aspect, is the basic natural resource of the researched area. Despite the fact that underground waters are of vital importance for the population settled in the basin and the wider area, due to the increasingly significant anthropogenisation and poor spatial management, they become increasingly vulnerable to pollution. The reason for this is the insufficient knowledge of the way in which they appear and the factors that affect them. In order to clarify the natural factors that influence the distribution of underground and surface waters, complex research has been carried out, the results of which can be of use to preserve the naturalness of water and better management of the entire researched area.

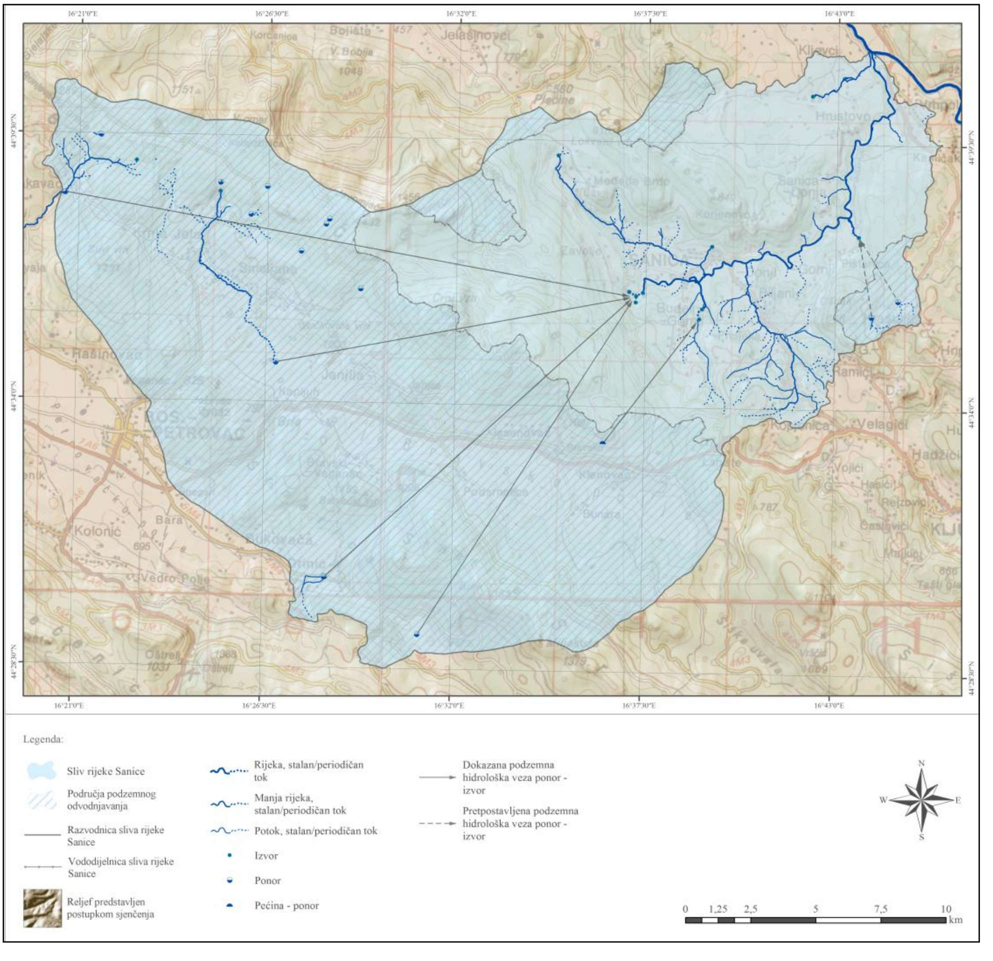


Fig. 1. Sanica river drainage basin

During the determination of the interdependence and legitimacy of the distribution of groundwater and other basic components of the natural environment, the knowledge of general geological, geomorphological and hydrometeorological conditions in the basin has been clarified and presented, which is an important contribution to the understanding of the general geographic features of the Sanica drainage basin. The results obtained, in addition to contributing to the understanding of the researched and wider areas, are particularly important for their practical application.

MATERIAL AND METHODS

The research is based on the results of previous research for different needs and by various researchers. Earlier conducted, although insufficient, the research enabled a fairly good recognition of hydrogeological features in the entire basin.

According to the information available to the authors, the first hydrogeological research in the Sanica drainage basin carried out by the application of reliable scientific procedures was carried out in regional hydrogeological investigations of the Una River basin. The most extensive research was carried out for the needs of the preparation of the Basic Geological Map of the SFR Yugoslavia and the need for the construction of a water supply system in the municipality of Bosanski Petrovac. During the research, for the purpose of determining the capability of capturing and constructing the aforementioned water system, numerous experiments were carried out on the abundance of abysses, the balance of the spring and the analysis of water quality. Over the past several decades, speleological exploration of individual speleological objects and underwater research of the siphons of some of the springs of Sanica have been carried out, which provided a much better understanding of the movement of water in the underground. Smaller research was also carried out in the area of Vrhpolje and Hrustovo settlements with the aim of determining the suitability of the terrain for the construction of hydroelectric facilities on the Sana and Sanica rivers. In recent times, research has also been carried out in the Drinic area with the goal of finding and exploiting groundwater for water supply.

Based on that research, numerous projects, studies and several scientific papers have been done. Among other things, significant projects are to protect the source of Sanica and the Smoljana spring, as well as the potamological study of the Sana River. Some of the important data contained in the original documentation and individual maps were left unavailable to the authors. The obsolescence of previously collected data and the lack of constant observation of the quantity and quality of groundwater has prevented a more correct view of the current hydrogeological conditions which are needed for a more proper way of planning their exploatation.

During the research, several different scientific-research procedures were used, and the research was conducted through several phases. The research began with the collection of documentation originating from earlier research. The collection of work materials simultaneously began with the abstraction of useful information and data, their compilation, comparison, and generalization. Based on the first findings, certain scientific assumptions, objectives and tasks of the research and the content of the work are determined. In further phases of the research, it was confirmed that several factors influence the distribution of water, and the hydrogeological conditions in the investigated area have been roughly clarified.

By using special scientific procedures such as GIS and mapping process, the collected data are presented on several thematic maps, based on which reliable discovery of interconnections and relations between the basic components of the geospatial area, which are reflected in hydrogeological conditions, are possible. At the same time, field research was used to learn about the current hydrogeological conditions. In this way it is possible to more objectively interpret the collected data and finally to determine the degree of influence of certain components of the geographical environment on the distribution of waters.

RESULTS AND DISCUSSION

Hydrogeological conditions in the Sanica River basin reflects the interaction of a number of factors, and are primarily conditioned by the lithological composition and the present structure of the terrain and the distribution of precipitation. The rocks diverse by composition, age and spatial position have reflected on the overall appearance of the terrain and relief and thus hydrometeorological and hydrological conditions differ significantly in certain areas of the basin. The middle and eastern part of the basin is distinguished by a developed and dense hydrographic network of surface watercourses formed mainly on poorly watertight and watertight Perm-triass and Triassic clastics, dolomites, clays, marls and tuffs. The rest of the basin is dominated by highly carved and waterproof carbonates, due to which a deep karst, marked by karst hydrography, has been developed. The deep karst belongs to the southern and western parts of the drainage basin where the annual rainfall is much larger (up to about 1400 mm) compared to the northern and eastern parts of the basin (where it is about 1100 mm). This is particularly favorable for the water supply of large karst aquifers in these areas. The existence of longer dry periods during the year, due to the large thickness of limestone and the possibility of accumulating large quantities of water in the underground, does not significantly reflect the accumulation of steady springs. This is a very simplified explanation of the hydrogeological conditions that are much more complex, and explained in more detail below.

According to the hydrogeological categorization of rock masses, three bases of hydrogeological unit were isolated in the investigated area (Fig. 2.) The first isolated unit, in which the aquifers are of karst porosity, present the largest part of the basin. In this unit there are water-mass rock masses that are emptied in several powerful karst springs. The second isolated unit consists of rocks of intergranular, intergranular and/or fracture and fracture porosity characterized by good water permeability and the existence of smaller aquifers. The third isolated unit consists of rocks with low permeability in which there are spatially very small and insignificant aquifers. They are emptied of several sources, of small quantities, of which many smaller surface streams are produced which are maintained on a waterproof surface. In deeper parts, the hydrogeological conditions are poorly clarified. However, the mutual spatial relationships of the separated units, or the rock masses different by watertightness, can be somewhat monitored on the basis of the presented hydrogeological profile.

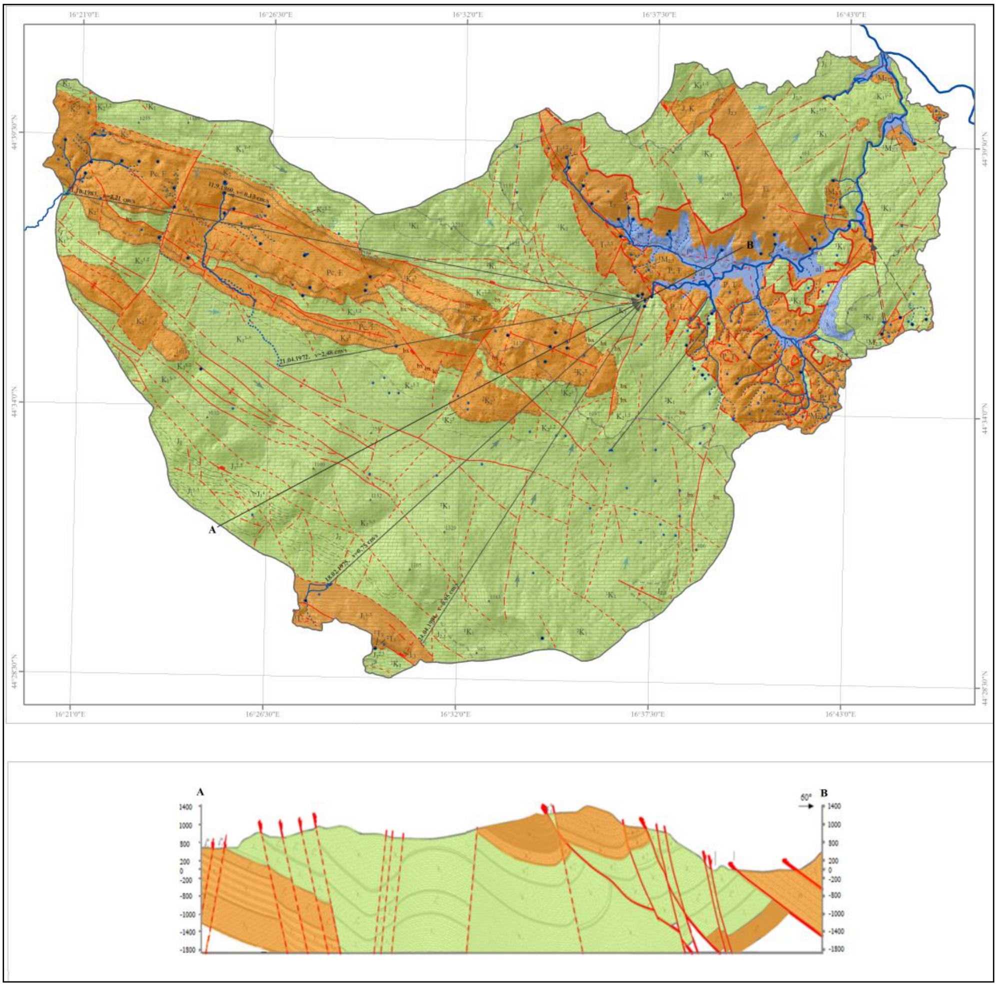
Terrains with aquifers of karst-fracture porosity

The terrain with karstic-fracture porous aquifers comprises about 2/3 of the basin, and they are made of karstified carbonate (limestone, dolomite) and sulphate (gypsum, anhydrite) rocks, and slightly less carstic limestone, cracked breccias, marls, and conglomerates, precipitated mainly during the Jurassic and the Cretaceous (Vrhovčić & Mojićević, 1983). Karstified limestones are large in thickness (at least over 1000 m), very cracked (especially in the ground area of the terrain) and very permeable and play the role of conductors and groundwater collectors. Dolomites have a variable role; are mainly grushed (decayed), play a role of hydrogeological barriers and form (underground) watershed and are generally unfavorable environments for the accumulation and flow of groundwater. Only locally, due to less thickness and cracks, they are permeable and represent pretty good conductors of groundwater. Gypsum and anhydrite have subordinate involvement in Perm-trias terrains, which are generally represented by clastics and clay, which is why they are watertight. Perm-trias clusters limit the karst-fractures aquifers and have great hydrogeological significance as they have caused the appearance of the most extreme springs in the basin.

The feeding of karst-fractures aquifers is performed collectively and sparsely, by submerging of surface and atmospheric waters through the sinks and along the extended cracks. In the southern and western, and the eastern part of the Sanica basin, there are smaller allogenic watercourses formed on poorly permeable rocks (flysch, dolomites and clastics) and are in contact with karstified carbonates. By the boiling of the rising waters, it was found that the reservoirs of the river Sanica are draining the reservoirs of Smoljana (Kapljuh), Marjanovica do, Drinic and Kozilska Slatina, and towards the springs of the river Korcanica, the sink of Racina cave and several more sinks in the southeastern part of Bravsko polje (Projekat zaštite izvorišta vode za piće Sanice, općine Bosanski Petrovac i Ključ, 2005). It is assumed that the streams of Hladjevac and Bajramovac near the village of Krasulje are being drained underground under the Sikmani spring. Therefore, groundwater by centripetally following the supply of faults, from the karst hinterland, walks towards the hot springs. The data obtained by the diminishing of the abyss indicate the characteristics of the bulk flow, especially along the directions of the transversal to the privileged (along with the dinaric directional dislocations). The groundwater flow rates are different in different directions, but generally in all directions they are high. They, as well as the values of the filtration coefficient, point to the possibility of the existence of almost homogeneous anisotropic aquifers in the area of Grmec Mountain and Bravsko polje. Almost all aquifers are at free level (flysch Grmec plays the role of hanging hydrogeological obstacles and does not significantly affect the role of aquifers in the southern and western parts of the Sanica basin), so the feeding of karst aquifers is quite simple.

The drainage of karstic-fracture aquifers takes place mainly on the strong karst springs located on the edge of the massif and ridge (Projekat zaštite izvorišta vode za piće Sanica, općine Bosanski Petrovac i Ključ, 2005). Because of the poor water retention, the draining in the underground is fast, and the groundwater level fluctuation is pronounced. This reflects on fairly large fluctuations of water runoff and the existence of periodic springs, as well as poor self-purification of contaminated water.

In the border area of the massif Grmec and Gornja Sanica basin, there are four springs of the river Sanica: the cave spring, Varda, Sanicko jezero (Jezero, Jasen) and Jasenak, and the springs form a spring zone and the Sanica river rises. The main cave of Sanica is located at 221 m a.s.l., while the other upstream is at a slightly higher altitude. The small spring Jasenak is located at about 225 m a.s.l. and at the place where the basin is connected by the Varda spring, located at about 235 m a.s.l. and the springs of Sanicko jezero, situated on about 240 m a.s.l.. Unlike the ever-active spring of Sanica, the source of Sanicko jezero is periodic and with watering in the siphon channel. It looks like a well-groomed tower of about 30 m in diameter, as well as the Varda spring, which is more stable and whose cracks and channels are sloping sloping material from the slopes of the spring zone. Underwater research found that Sanica and Sanicko jezero springs are simple and inverse. The springs are fed with water from the Grmec, Srnetica, Bravsko polje and Petrovacko polje and the Kozila uvala.



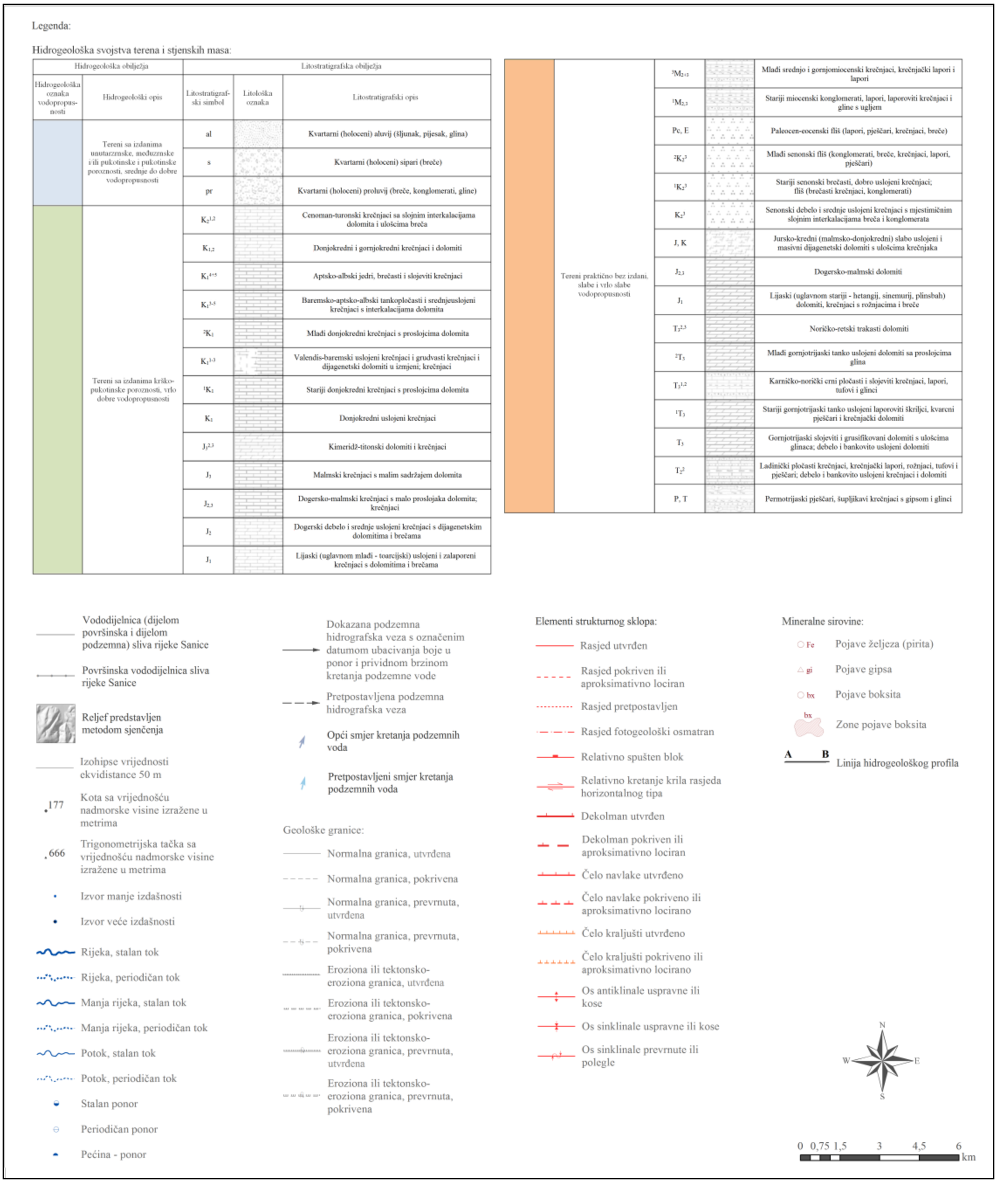


Fig. 2. Hydrogeological map of the Sanica river drainage basin with a hydrogeological profile Petrovacko polje – Gornjosanicka valley

Their emergence is conditioned by a deep denudation-erosion cut in limestone that has reached its waterproofing floor so that the sediments of the Permotrias form a podium and lateral barrier and condition the discharge of groundwater (Temimović, 2009). The springs of the rising leakage mechanism, as indicated, are divided into several height zones and probably connected to each other, suggested by the hydraulic relationships of the springs and the results of the underwater research of the siphon of Sanica spring and the spring of Sanicko jezero.

The location, appearance and hydrological activity indicate that the springs have been caused by lowering of groundwater levels in the neotectonic period, which was generally marked by a significant rise in the terrain. In this rather long period of time, it was likely that in some shorter periods there was more rising, and in other periods less rising or the ground did not rise. This reflected not only the emergence of new caves - springs, but also the emergence of the pediments that are visible on the slopes of Grmec near the spring zone. During the hydromorphological development of karst, the hydrographic zones were transformed from constantly humid areas through periodically moist and periodically dry to constantly dry. The current main spring - the Sanica cave spring signifies a constantly humid or saturated zone. Because of this, it is a source of constant running time, and the springs of Sanicko jezero, Varda and Jasenak are periodic, with very pronounced ranges of fluctuations in flow.

The main spring of Sanica River was captivated in year 1985 and used for water supply of the city and the municipality of Bosanski Petrovac and part of Sanica settlement. For the needs of water supply to certain settlements of Kljuc Municipality, during the dry periods, a decision was made recently on the construction of the water system, which includes the captivation of Varda springs. Such a decision, because of the hydrogeological relations of the Sanica stream, seems unreasonable. Namely, during long dry periods in the hinterland of Varda water, the water is almost fully directed to the main source of water that is at a lower altitude and the flow at Varda is very low. Because of this, besides that its captivation will not meet the needs of water supply, there are also likely to be adverse impacts in the hot zone characterized by a rather high degree of geodiversity.

Based on the data obtained during the three-year period (1978-1981), special values of generosity were determined for all the spring of the Sanica River. The lowest value (Q_{min} = 0,8 m^3/s) and the largest (Q_{max} = 40 m^3/s) determined value of the yield indicates a significant fluctuation of amplitude (high coefficient of unevenness) of yield or leakage (1:50), while the value of average yield (Q_{avg} = 8,9 m^3/s) indicates a great wealth of water (Projekat zaštite izvorišta vode za piće Sanica, općine Bosanski Petrovac i Ključ, 2005).

The springs of the Korcanica River (the spring of Korcanica and the spring of the Korcanicko jezero) are located at a distance of about 2.5 km from the spring zone of Sanica near the village of Budelj Donji. Korcanica spring is a steady hydrological active well, located at about 210 m a.s.l., of broken type since water flows through a multitude of cracks and channels. The Korcanicko jezero is a periodically active siphone spring, located in relation to the main spring about 450 m upstream, at about 215 m a.s.l., below the limestone section about 60 m high. Due to the similarity of the appearance, these and the rivers of the spring of Sanica are also considered as one broader, broken, spring. They are supplied with water by underground drainage from the area of the eastern part of the Grmec massif, the southeastern part of the Bravsko polje and partly from the Srnetica mountain, and the surface inflow of the waters from north-east downhill of the Grmec Mountain. The data obtained by monitoring the method of discharging groundwater in the Sanica springs and hot springs of Korcanica indicate that there are separate aquifers. As with the spring of Sanica, the springs of Korcanica river were formed at the touch of Cretaceous limestone and Perm-trias clastics. The springs formed within the tectonic window in Perm-trias Cretaceous that are gradually eroded, and the hot zone is deepened so that it is significant depth.

Observations in the three-year period (1978-1981) found that the yield of the springs varies from $Q_{min} = 0.3\ m^3/s$ to $Q_{max} > 20\ m^3/s$, which indicates large amplitudes of fluctuation of yield (about 1:66 and more) (Karakterizacija podzemnih voda sliva rijeke Save na teritoriji Federacije BiH: knjiga I - Tijela podzemnih voda podsliva rijeke Une na teritoriji Federacije Bosne i Hercegovine, 2009).

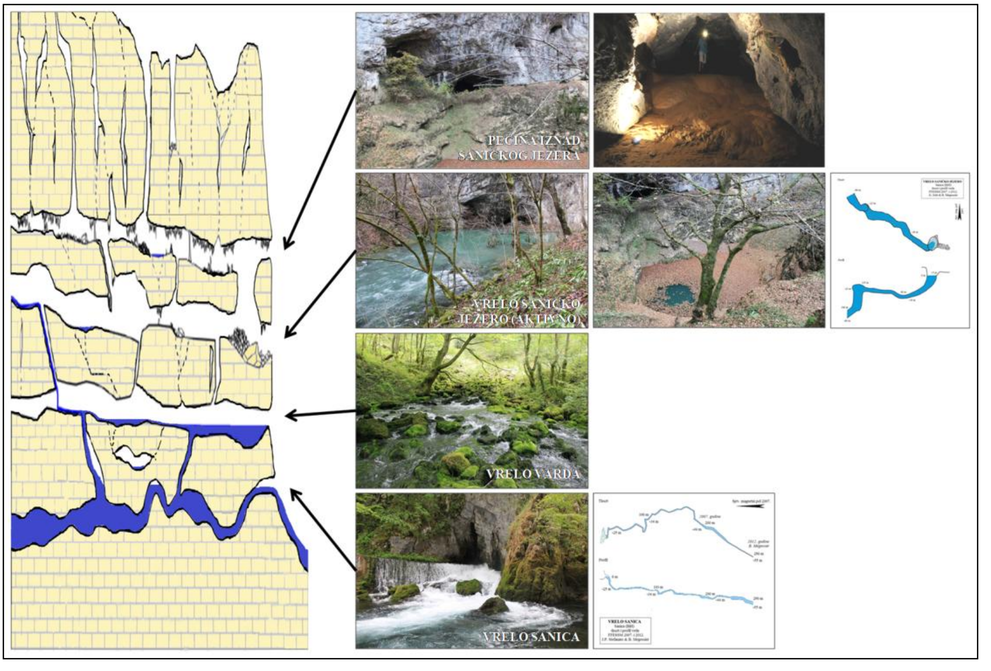


Fig. 3. Simplified presentation of the probable mutual relationship between the spring of the river Sanica deriving from the position and appearance of the hydrological characteristics of the investigated springs

At the Trebunj (near the village of Sanica), located at about 225 m a.s.l. empty groundwater from the karstic underground Celic Kosa and a part of Hrustovo karst plateaus. The spring is of cave type, probably of ascending mechanism of leakage since it, as well as the springs of Sanica and Korcanica rivers, was created in the contact of the Perm-trias watertight creations and the Triassic and Cretaceous carbonates. Release data is unknown, but according to the estimation it can be included in the medium-generating springs. It is captivated and used for water supply in one part of the Sanica settlement.

The area of Hrustovo karst plateau is drained, in addition to the Trebunj springs, to the wells of Glibaja. The main spring of Glibaja is Kljevacko spring, located about 210 m a.s.l. and about 300 m north of the Hrustovaca cave. The Glibaja Valley is a prerequisite for a fault that separates the clay lichens in this area. The same defect was also a precondition for the Hrustovacka cave. Between the springs and the caves are observed forms of valley relief formed by the action of the former watercourse, which likely flowed from the cave (Temimović, 2009). These fossil fluvial relief forms, and the present spatial relations of springs and caves indicate the possibility that the spring was generated after the cave has lost its permanent hydrographic role. Kljevacko spring belongs to low-generating springs.

In the Sikmansko spring by the abandoned settlement of Sikmani, the groundwater of aquifers is discharged, located in the area of the ridge of Osljak and the western part of the Krasuljska karst plateau. As well as the above-mentioned larger springs in the Gornjosanicka valley, it is formed on the touch of the roofs of heavily cracked Cretaceous limestone and floor Perm-trias clastics, and according to the mechanism of leakage, it is similar to Trebunj Spring. The flow rate fluctuations are very pronounced, and during the long dry periods, the boil almost dries. Generation data are unknown, but according to the estimation, this spring belongs to medium-generating springs.

From the spring of Smoljana and several smaller springs, Smoljana River is formed, which represents the most important watercourse in the wider area of Bosanski Petrovac. The spring is fed by underground watering from the middle part of the Grmec Massif. Smoljana spring is located at the settlement Krnja Jela, at about 930 m a.s.l., at the bottom of a semicircular denudation-erosion depression that is covered with thick deposits of regolith. It emerged in the syncline along the wrinkles lithologically made of flysch creations. The formation of the springs was primarily influenced by the molars of molasses within the limestone, which are less watertight and cause the leakage of groundwater. The spring belongs to the overflowing type of springs, and it is probably hydrologically connected with other springs and it is of broken type. Since it is the most extraordinary, it is presumed to be located in the most conducting zone, that is, the water permeability of the cracks and channels of the Smoljana spring is higher. In relation to the other springs found in the hot zone of fluctuation, the generosity is much higher. They are located at a lower altitude and have less generosity, but the fluctuations in volume are much lower. The total volume of the spring of the Smoljana River (Smoljana - the main spring, Sedra, Pecina I, Pecina II and Crno Spring without Luka Spring) is about Q_{min} = 5 l/s to Q_{max} > 100 l/s. According to the data of periodic observations of the abundance, it is noted that the flow of water in the main spring, in periods of smaller flows, corresponds approximately to the value of 50% of the flow of all springs (Projekat zaštite izvorišta vode za piće Sanica, općine Bosanski Petrovac i Ključ, 2005).

Terrains with aquifers of intragranular, intergranular and/or fracture and fracture porosities

They include mainly aquifers in the alluvial deposits of the laid parts of the river and river valleys of Sanica and its tributaries, as well as with thicker layers of proluvial and eluvial deposits at the foot of steep slopes Celic Kosa and Osljak. Alluvial, proluvial and talus sediments are rocks of quaternary, predominantly holocene, ages litologically represented by gravel, sand, breccias, conglomerates, rubble and clay (Vrhovčić & Mojićević, 1983). The share of certain rocks in the aqueduct material is very variable, which directly reflects on their watertightness and wateriness.

The aquifers in alluvial deposits are fed by the infiltration of atmospheric waters, water from other aquifers (karst-fracture, proluvial and eluvial) and the waters of surface watercourses during their spill-over of alluvium. Aquifers in proluvial and eluvial deposits are also accumulated by the infiltration of atmospheric waters, and by pouring water from the trough, mostly periodic streams. In addition, they are also being fed in the waters of karst-fractured aquifers, and the talus cones and avalanches often cover the sources that drain the mentioned aquifers. According to the above, all aquifers are mainly associated with the atmosphere through the aeration zone, and therefore they are of free level. Due to the significant thickness of alluvial deposits (over 5 m a.s.l.) and filtration possibilities, there are significant but not reliable amounts of groundwater. Alluvial aquifers are spatially limited and mainly located in larger alluvial (floating) plains and represent aquifers of compact type. Alluvial aquifers are characterized by good hydraulic connection with surface watercourses. In addition to being watered by surface watercourses, they are mainly scattered through the porous environment and are drained towards the surface water courses at a time when the water level in the troughs is reduced. In this way, they are to a lesser extent equalizing the regime of surface watercourses and contributing to its persistence (Spahić, 2013).

Terrains without aquifers

Areas which practically have no aquifiers account for almost one third (around 28%) of the basin and the same for the categorized hydrogeological unit in the river basin of the Sanica River. They are presented mainly by watertight and predominantly watertight hydrogeological complexes of the so-called "Paleozoic of Kljuc area" and "flyche of Grmec Mountain" in which there is a greater share of watertight rocks. More precisely, terrains without aquifiers are represented by Perm-trias sand, marls, and marble limestone, breccias, conglomerates and clays, then triassic tufts, sandstones, corneas, shingles, clays and crushed dolomites, Jurassic dolomites and breccias, upper and paleocene eocene flysch and flysch sediments (marls, sandstones, breccias, conglomerates and limestones) and miocene marls, marlstone limestone, limestone, sandstone, conglomerates, breccias and clays (Vrhovčić & Mojićević, 1983; Šušnjar & Bukovac, 1979; Jurić, 1977).

The predominantly waterproof hydrogeological complex of Perm-trias sediments has enabled the formation of a dense network of surface watercourses in the basins of the Biljanska River and the Sanica River, and with its role of underground and lateral hydrogeological obstacles, the water leakage from the karst aquifers was caused. Triassic deposits in the Biljanska River basin also play an important role in maintaining surface watercourses, and in the Bosanski Petrovac area they play a role of hydrogeological obstacles and build a drainage basin of the Sanica River. Dolomites, which are the most represented lithological member of Triassic deposits in the investigated area, have two roules, one of which is the role of waterproofing rocks. Namely, they are mostly crushed, partially frozen and glazed, and very poorly karsted and thus poorly or by no means permeable. They were somewhat more cracked and karsted in the terrain parts of the terrain, which makes it possible to drain - the flow of water through larger cracks and channels to the source. In addition to the aforementioned Upper-Trias dolomites and the water-permeability of the anticline in Bosanski Petrovac, Lower-Jurassic dolomites also significantly contribute.

In the Grmec Massif there is a spatially large and predominantly waterproof flysch hydrogeological complex. Flysch is a carbonate composition and is characterized by a mixed type of porosity. Sandstones, limestone, breccias and conglomerates in this complex have enabled the formation of sparsely smaller aquifers that are emptied on sources of small to medium-sized types. In parts of the terrain where marls, clays (ie clay component) and non-classified limestones prevail, short, periodically hydrologically active, ponderous watercourses which sink in contact with karstified limestone. Since the flysch complex is located in the roof of permeable carbonates, it plays the role of hanging hydrogeological barriers. Miocene sediments have a similar role in several isolated and spatially very small areas. They are characterized by mixed - intergranular and cracked type of porosity, and spatially small and intermittent aquifers of low coefficient of transmissibility (permeability) and low water mobility.

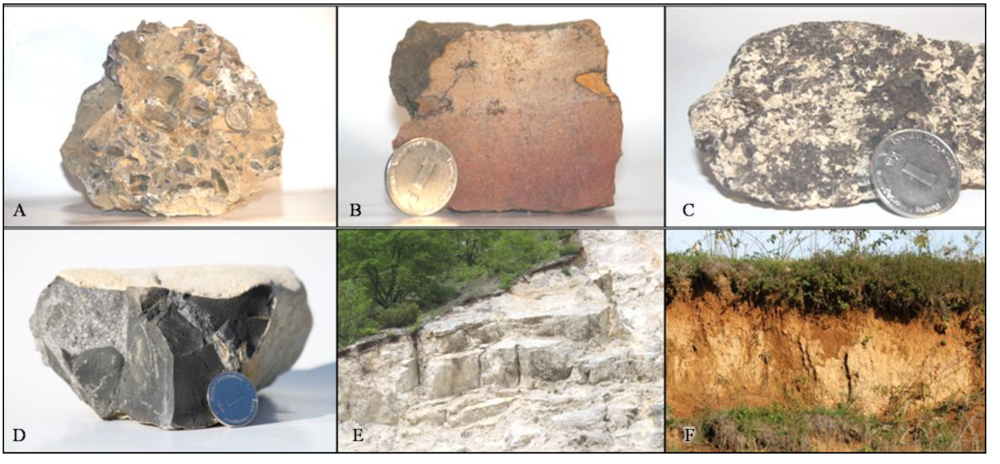


Fig. 4. Permotrias conglobreccia (Budelj Donji) – A, Sandstone (Biljani Gornji) – B, Karnik-norik tuff - C, Marl (Prisjeka Gornja) - D, Upper-Triassic dolomite (Kordici) – E and Miocene clay (Jezerci) - F in the study area

In general, in the described terrains, are spatially very small and, from the aspect of water-mobility and aquifers, insignificant aquifers that are emptied on very low-flow springs (mostly from 0.5 l/s to 3 l/s), some of which are used for water supply of smaller settlements. Although the springs of the Smoljana River are somewhat more generous, the aquifer from which it is saved is spatially small and there is no possibility of storing more water. This reflects on a great reduction in the yield of the spring during longer drought periods. Their yield basically depends on the meteorological conditions (the amount of precipitation and the speed of their filtration, evapotranspiration, the length of the dry periods, etc.), since they are mainly harvested by atmospheric waters. According to the above, the basic hydrogeological role of rock masses in the described terrain is the spatial limitation of karst-cracking aquifers and directing the flow of groundwater towards the discharge bases.

CONCLUSION

The research was carried out with the aim of clarifying the basic hydrogeological characteristics of the river basin of the Sanica River, ie understanding of the spatial and temporal distribution of waters in that basin, depending on the most important natural factors. It was found that the distribution of water in the underground and on the surface of the terrain is primarily conditioned by its lithological composition and tectonic relations, and the distribution of precipitation. The plains are mostly abundant with limestone, which are highly karstified and thick, making them a holokarst. In the area of the holokarst, there are the largest quantities of groundwater that flows out into several strong karst springs, whose occurrence is conditioned in most cases by the position of waterproof Perm-trias clastics to carbonates. Watertight clusters, crushed dolomites, marbles and clays, deposited in different periods of time, apart from spatial limitation of karst-fracture aquifers, also prevent the formation of larger aquifers and cause the surface runoff of the waters in the areas of their distribution. As such rocks often alternate with watertight, they build hydrogeological complexes, but in general the terrains that they build can be considered watertight. A smaller part of the terrain also applies to alluvial, proluvial and eluvial aquifers that constitute a unique third categorized hydrogeological unit in the investigated area.

The distribution of groundwater in relation to the above is much more complex. The hydrogeological categorization of terrain and rock masses, in which three basic hydrogeological units are separated, provides a fairly good understanding of the basic legitimacy of the distribution of groundwater. However, for a more precise classification of hydrogeological conditions in the future, it is necessary to undertake extensive research. This work, resulting from the compression of a multitude of data collected during previous research, and a specially designed hydrogeological map and the presented hydrogeological profile, in the absence of precise data, can be a fundamental basis for more accurate water management and generally the entire area in the basin of the Sanica River. The hydrogeological map presented, although it only contains basic information, can be especially useful for the production of precise maps where the areas of greatest danger from pollution of water will be shown and act according to them in order to preserve the naturalness of underground and surface waters. Preserving the naturalness of groundwater, or timely prevention of their pollution, requires continuous observation, in several springs and percolating wells, basic physical-chemical and biological indicators of water quality, and therefore it is necessary to pay more attention to this. Due to their regional importance, special attention should be paid to the study of the protection and sustainable use of the waters of the Sanica River drainage basin.

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