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CONTENT

Prof. Rejhana Dervišević
Editor in Chief

2018 - Year of Anniversaries

60 years	*of Foundation Higher Technical School of Mining that has grown into Faculty of Mining*
45 years	*of Department of Geology*
20 years	*of Department of Civil Engineering*
55 years	*of publishing activities of the Faculty*

In the Year of anniversaries of the Faculty we would like to take opportunity to emphasize decades of work and efforts in which besides education was conducted a research work, achieved numerous significant domestic, European and international projects that contributed to the development of Bosnia and Herzegovina economy, mining, geological and civil engineering profession and science. Today's organization of our Faculty with five departments emerged from all general departments for scientific and non-scientific work and those are: Mining, Geology, Civil Engineering, Bore-hole Exploitation of Mineral resources, Safety Studies as well as 15 scientific fields at which scientific work has been carried out.

Dear readers, it is our great pleasure, in this Jubilee year, to offer to a scientific and professional public insight into "Journal of Faculty of Mining, Geology and Civil Engineering". This issue is available in English as well, in order to make its content available to a wider public that is interested for research in science fields 1.5, 2.1 and 2.7 (Frascati).

We would like to thank to the authors that have chosen our journal for publishing their papers. We expect to continue and extend cooperation in the future, by contributing to the affirmation of the magazine, and promotion of scientific thoughts and scientific results.

Prof. Indira Sijerčić
Vice Dean for teaching and student issues

FACULTY OF MINING, GEOLOGY AND CIVIL ENGINEERING (1958-2018)

The Faculty of Mining in Tuzla was founded in October 1960 as part of the University of Sarajevo, at the request of the mining economy of Bosnia and Herzegovina and the First Mining Congress of Yugoslavia. The Faculty was the fourth mining faculty in the former Federal People's Republic of Yugoslavia (FNRJ) and Socialist Federal Republic of Yugoslavia (SFRJ), and the second one that was opened in Tuzla, after the Faculty of Technology. Prof. Branko Jokanović, a member of the home commission, said that idea about opening of Faculty of Mining in Tuzla dates back to 1921, and this idea was realized in 1958 by opening the Technical School that eventually grew into Faculty.

At the Faculty of Mining in the academic year 1961/62, classes have been achieved at the three departments/courses: Mining and Exploitation, Mining and Measurement, and Mining-Mechanical Department at first degree. During academic 1963/64 Department of Mining and Exploitation and Department of Mining and Measurement began classes at the second degree, and first course of the third degree began at the Departments of the Underground Exploitation of Coal and Mining Geology during academic 1964/66.

The Faculty developed those departments for which there was a mining interest and the corresponding material and professional basis in Bosnia and Herzegovina. Mining-Mechanical Department ceased to exist during academic 1967/68, and there were only two departments left withclasses at the second degree and those were Mining and Exploitation and Mining and Measurement Department.

The significance of the Faculty as a higher education institution for mining personnel in Bosnia and Herzegovina is the fact that at the end of the year 1968 there were about 400 graduated mining engineers in Bosnia and Herzegovina, out of which 182 graduated at the Faculty of Mining in Tuzla. To this number should also be added number of 152 that graduated first degree at this Faculty.

Dr.sc.Ivan Soklić, the first teacher of Geology at the newly established Faculty of Mining, together with geologists who at the time were employees, was engaged at the establishment of Department of Applied Geology. During this period, collections from fundamental geological scientific disciplines have been formed. The Department of Applied Geology has been founded during academic year 1973/74 and Faculty of Mining grew into the Faculty of Mining and Geology. Department was founded during period when geological science reached an enviable level and when Yugoslav geologists achieved great results in the economy. The development and scientific research results in the achieving of scientific heritage in the geology of Bosnia and Herzegovina during that period were much more intense than during period that preceded it.

At the same time, with the affirmation of geological science in the Tuzla basin, and therefore in Bosnia and Herzegovina, have been affirmed modern mining. In the academic year 1974/75 has been founded the Mining and

Final year students of the Faculty of Mining in Tuzla in front of the restaurant at "Slana Banja" in June 1964.

Mechanical Department at the Faculty of Mining, and classes at the Mining and Measurement Department has been completed.

The Faculty of Mining and Geology became a member of the University of Tuzla with its foundation in 1976. In the following year, in 1977, the Faculty became one of the three OOUR's (Basic Organization of joint work) of the Working Organization of the Institute of Mining and Geology and Faculty, within the complex organization of associated labor Tito's Coal Mines - Tuzla. At the Faculty, a teaching-scientific process was carried out, and at the Institute for Mining Research, teachers and associates, through joint teams, engaged in scientific research. This model did not give the expected results, and in January 1990, the Faculty was constituted as an independent organization within the University of Tuzla.

Department for Bore-hole Exploitation of Mineral Resources was established in the academic year 2000/01, while Safety Studies were established in the academic year 2004/05, and today's scientific and teaching activity of the Faculty is organized through five study departments and 15 narrow scientific fields.

After the signing of the Bologna Declaration and General Higher Education Reforms in BiH, classes at the Faculty take place at the first cycle of studies since academic year 2003/04 and at the second cycle of studies since the academic year 2012/13 on all study programs.

Faculty of Mining, Geology and Civil Engineering in Tuzla has, over more than five decades of existence, gave a huge scientific potential to the economy and scientific-research institutions. At the Faculty until today (July, 2018) 3899 diplomas has been obtained: 2702 graduated engineers and 609 bachelors of engineers, 12 specialists, 351 masters of science and 77 MSc, and 148 doctors of science. Three teachers have been selected as regular members of the Academy of Sciences and Arts of Bosnia and Herzegovina: prof.dr.sc. Ivan Soklić, in the field of Geology, prof.dr.sc. Mehmed Ramović, from the field of Geology, and prof.dr.sc. Enver Mandžić from the field of Mining.

STRAW – SUSTAINABLE AND ECOLOGICAL CONSTRUCTION MATERIAL

Krunoslav Ćosić[1], Dubravka Bjegović[2], Ivana Banjad Pečur[3]

SUMMARY

Since the stone age, straw has been used as a building material, but the development of new synthetic materials has completely replaced the natural plant materials. Considering that exploitation of non-renewable resources is increasing, the emission of harmful substances and the negative impact on environment, natural materials are referred as an alternative solution to these problems. Using straw as ecological building material has a positive effect on greenhouse gas,emissions; it is a renewable resource, energy efficient and contains no harmful substances. The main advantages of its use are excellent thermal and sound insulation, high vapor permeability, earthquake and fire resistance, availability and economics. Its use as building material results in economically viable high-performance material instead of burning on the field. Ekopanely, Eco Cocon, ModCell and Durra Panel are companies around the world that have recognized the potential of straw and produce straw materials that enable construction with negative carbon footprint. There is a huge potential for utilization of straw in the construction sector in Croatia, and the future of construction materials will surely focus on ecological materials already recognized by international institutions.

Key words: Straw, sustainability, greenhouse gases, straw panels, insulation

1. INTRODUCTION

Ecological building materials are those that do not affect the health of users and the environment, they minimize the use of non-renewable resources and minimize emission of harmful substances during its whole life cycle. According to the research of Navigant Research company - „The Materials in Green Buildings"- it is anticipated that the global market of green materials will increase from 116 billion dollars (data from 2013) to 254 billion dollars till 2020 (Picture 1). Factors that will affect the growth are the popularity of sustainability measures in building sector, political and regulative support, fall of prices, consumer's demand and economic use which are the result of implementation of green building measures [1].

The process of manufacturing building materials need to be pleasant for humans and the environment, and without harmful effects. While getting raw materials, manufacturing, installation, use and the removal, it is possible that there would be harmful effects on the environment. That is also a possibility when using non-renewable resources of energy and raw materials. In order to reduce the adverse environmental and human impact, natural building materials are increasingly being used. During their production and use phase there are no adverse effects on human health and the environment, they can be re-used, which means that building materials extend life expectancy, reduce raw material consumption, and thus burden the environment. One of the natural materials in addition to wood fibers, hemp, cork, sheep wool and other straw that is increasingly occurring in ecological construction [2]. Herbal materials were one of the first building materials that people used, but the development of synthetic materials in the last century has completely replaced natural plant materials. Given the increasing utilization of resources and the negative impact on the environment, natural materials are increasingly being imposed as an alternative solution to the problem [3]. Straw in the broader sense is the dry stems of all crops, while in the strict sense it only represents dried cereal stems such as wheat, rye, barley and the like (Figure 2). It is mainly used in domestic animals, such as biofuel, building material or as a material for making home decorative items [4].

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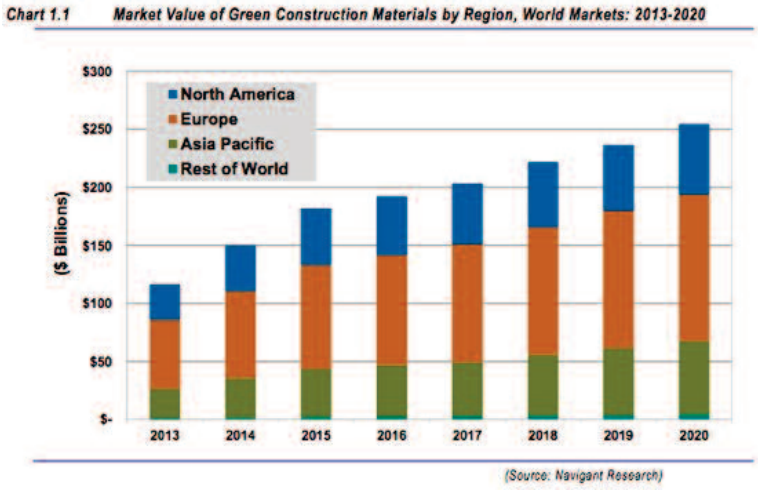

Figure 1. Market value of green building materials according to the regions of the world [1]

Straw is an agricultural surplus but is a valuable combination of insulating and static properties and is an excellent insulating material. In straw houses, the air is far superior to the houses of modern building materials because, unlike concrete, the walls of straw "breathe". Because of this, the air is cooler in them, straw is a natural material that does not contain harmful substances, such as formaldehyde vaporising from modern building materials. Straw is a renewable resource and its use does not disturb the balance of the environment, it is energy efficient, its use reduces the costs of heating and cooling and CO_2 emissions in the atmosphere. In the construction industry, straw has been used since the Stone Age and has recently become increasingly popular because of its good thermal characteristics, availability, low prices and durability. Various forms of traditional architecture used straw, mostly in combination with clay. By discovering and refinement of many new materials, straw has become less and less used, but has recently been used again because of its ecological and financial advantages. The main advantages of straw as building materials are thermal and sound insulation, fire resistance, relatively good strength, earthquake resistance, availability and low price of straw as raw materials and ease of architectural design. All this is why, say, in Great Britain, several hundred thousand such houses were built. Stronger walls are easily achieved by the passive house criterion, and with little heating and cooling needs, it significantly contributes to the reduction of greenhouse gas emissions. Given that more than 50% of all greenhouse gases are generated in construction, including transport related to construction, the challenge of the 21st century is to improve house energy efficiency [5].

Figure 2. Balanced straw [4]

2. SUSTAINABILITY

One of the biggest problems humanity faces today is climate change, i.e. carbon dioxide emissions, where construction plays a big role. Short-term goals for gaining a profit have a negative impact and make enormous damage to current, and especially future generations, which will meet their needs through expensive fossil fuels. Resources are limited and only by applying a model of nature (we can visit as many trees as we grow new ones) can create a sustainable, balanced and healthy local community. In addition to manufacturing, energy transformation and road transport, the construction sector occupies a high position on the scale of activities that produce significant CO_2 emissions that go into the atmosphere and stimulate the greenhouse effect [7]. Resources are limited and need to be continually renewed and created so that the negative impact on the environment can be reduced to the smallest possible extent [3]. Using ecological building materials minimizes the use of non-renewable resources and emissions of harmful substances throughout their life cycle and does not affect the health of users. One of the best ecological building materials is straw (Figure 3) for its use of a positive effect on carbon dioxide emissions (negative carbon footprint). Straw grows from the earth, does not require production processes or they are being carried out to a lesser extent, maintains the balance of oxygen and carbon dioxide in the atmosphere in a way that retains (benefits) carbon dioxide and releases oxygen and can be grown every year since the energy required for its production comes from the sun. It is a renewable material, does not contain pollen and does not cause allergies [8].

Figure 3. EXPO 2010 Shangai, China, Vanke pavillon – straw panels [9]

The use of straw is energy efficient, thus achieving the concept of sustainable development and green construction. Green construction does not only apply to energy efficiency, but also to the use of acceptable construction and other materials. In addition to the use of renewable energy sources, we use other "waste" materials that are generated in the industry, which are not harmful to nature [10]. Construction materials prices grow each year, making agricultural waste a challenge for construction, with an emphasis on materials produced from agricultural waste that exhibit characteristics similar to traditional materials but which are much more economical [11]. The basic principle of sustainable construction is the use of local materials of plant, animal or mineral origin with less processing in industrial processes or, on the other hand, the use of recycled materials. Artificial industrial materials emit toxic compounds and cause excess water vapor to fall into excessively sealed spaces can cause moisture and mold. Evaporation of various artificial materials, paints and varnishes has long-term effects on human health, while the production of artificial building materials causes pollution. An example is cement production where huge amounts of energy are consumed using fossil fuels. Figure 4 shows 25 materials with a specific carbon dioxide emission from which it is apparent that the largest metal pollutant is cement while in the middle, although considering the large quantities produced for construction purposes, we can talk about a major pollutant. After water and sand, cement is the most used material that makes it the biggest pollutant in the world.

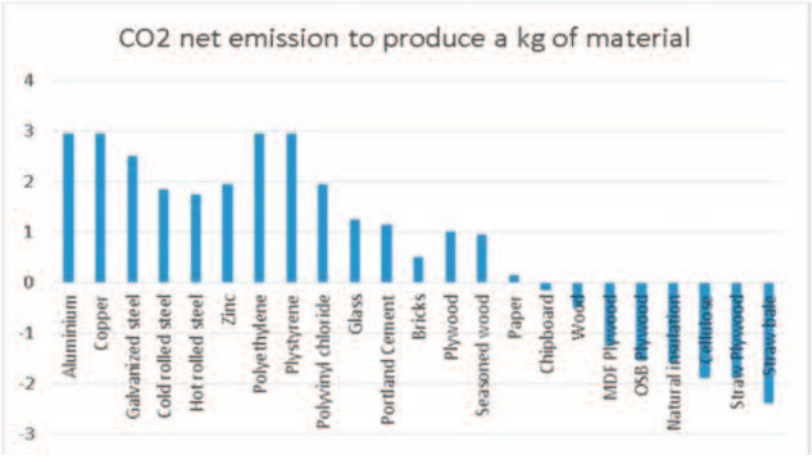

Figure 4. Carbon dioxide emission when producing one kilogram of material [8]

In addition to wood, clay and stone, in our slopes, together with these materials, the best ecological materials are suitable for the construction of houses with low environmental impact [12]. While construction and demolition of buildings in construction generate large amounts of waste, construction of the stalk is environmentally friendly, there is no waste and can be composted upon completion of the construction cycle, which does not lead to carbon dioxide emissions if burned as agricultural waste in the fields. Wihan explored the straw and came to the conclusion that the straw weight of 16 kg holds 32 kg of carbon dioxide, which is about 11 tonnes of carbon dioxide retained during the construction of three typical houses, which require about 350 stems of straw [13]. By using straw as building material, less use of other environmentally-friendly materials leads to socio-economic and environmental benefits, reduces greenhouse gas emissions and the energy required for the construction and exploitation of such buildings.

3. CHARACTERISTICS OF STRAW

It is commonly believed that natural materials are short-lived, unreliable and generally problematic with respect to construction requirements, but much of such misunderstandings on traditional building materials are fueled by a process of rapid industrialization where artificial and industrial materials are favored. Numerous studies on straw houses show that such construction is no more risky than any other form of construction [12]. The straw is completely natural that results in improved air quality in the premises. Thanks to the high level of sound insulation, life in the straw home is quiet, comfortable and quiet. The straw has excellent insulating properties resulting in thermal conductivity between 0.09 and 0.13 W / mK, while straw density ranges from 80 to 140 kg / m^3 depending on the type of cereal, the moisture content and the degree of compression of the baler. This thermal conductivity results in a heat transfer coefficient of U = 0.13 W / m^2K at the stems of the stems of the total thickness of 45 cm corresponding to the passive house criterion [5]. In addition to sound and heat insulation, the straw provides a low risk of fire. Given that the straw in the balm is very dense, there is not enough oxygen to ignite and therefore the stuccoed walls are less prone to fire than the traditional wooden houses [14]. They can withstand half an hour to two hours in the event of a fire, depending on the arrangement and packing of bales. The construction of wooden structures with straw insulation meets all fire requirements (B2 - normal flammability, F90 min - fire resistance) and can be incorporated as a construction element into family houses [2]. Straw straps need to be plastered to protect the straw from external influences while simultaneously reducing the risk of fire to a minimum.

The advantages of straw as a building material in addition to heat and sound insulation are natural origin, high vapor permeability, simple production, transport and installation, biodegradability (ecological care) and price, while straw shades as building material are reflected in the sensitivity to liquefied moisture and possible sensitivity to rodents. Debris moisture is the greatest danger to the straw that later results in the scavenging or degradation of the biological material that is caused by microorganisms. Water is required for rotting and it occurs when water penetrates into the interior of the straw construction as a result of poorly executed detail and surroundings with relative humidity close to 100%. Therefore, special attention should be paid to the design and execution of the roof and floor of the walls, the details about the door

and window, the passage and the air permeability of the structure. The influence of a high relative humidity environment can be a problem only if water vapor diffusion is disrupted through the walls of the structure (moisture buildup) or cold air flows into the structure (condensation in the structure) [15]. Maintaining a low moisture content in the straw is crucial for long-term straw resistance to biological degradation and special attention should be paid to the relationship of straw humidity, relative humidity and ambient temperature [16]. Bale straw mostly contains stems of different types of grain, but the stems themselves do not contain nutrients and are not a suitable insect habitat. During cereal growing, they are often sprayed with pesticides, most commonly in the cereal development stage, so that the amount of pesticides in the straw bales is negligible. The stacks in the bales are interconnected and create a strong connection between the bales, filling the cracks, which is an additional advantage of straw as a thermal insulating material [17]. Sensitivity to rodents may be a potential shortage if straw remains in nutrients. Different types of straw have different chemical composition and strength. According to experience and laboratory tests, the moisture content, density and storage history of bale, and protection from harvest to construction are the main factors affecting the quality of the straw. Moisture content depends on conditions at the time of baling and during storage and transport later. Specifications such as maximum permissible moisture content during construction time and minimum density should be the main criterion for construction of straw facilities [5]. Observing straw microstructure, straw of wheat, for example, has a more complex microstructure than wood. It has more variability with regard to cell types and size, compared to wood straw has shorter fibers and thinner cell walls. The straw of wheat and wood materials contain almost the same amount of cellulose, but the content of hemicellulose is higher in straw (28%), while lignin content is lower (18%) than wood, with hemicellulose content of 23% and lignin content 27% [18]. The straw of wheat has desirable geometric and mechanical characteristics for the production of cement composites, but the use is limited due to the unfavorable influence on the hydration process, which may be due to the higher content of hemicelluloses [19].

4. AVAILABILITY OF STRAW IN CROATIA

The straw is produced by drying stems of various plants such as wheat, barley, rye, oats, rice and others, while the production process itself is very short with very little energy consumption. The most important grain plant used for human consumption is wheat, which is the second in the grain yield range, after corn [20]. After harvesting crops, large amounts of straw remain, which creates a large amount of waste. It is estimated that the straw volume is higher than the crop itself and world annual production is about 709 million tonnes of straw [21]. According to the Statistical Yearbook of the Republic of Croatia for 2015, table 1 shows desirable areas, tuna yields and wheat, barley and soya production from 2010 to 2015 [22].

Year	Reaped surface (ha)	Yield per acre (t)	Manufacture (t)
	Wheat		
2010.	168 507	4,0	681 017
2011.	149 797	5,2	782 499
2012.	186 949	5,3	999 681
2013.	204 506	4,9	998 940
2014.	156 139	4,2	648 917
	Barley		
2010.	52 524	3,3	172 359
2011.	48 318	4,0	193 961
2012.	56 905	4,1	235 778
2013.	53 796	3,7	201 339
2014.	46 160	3,8	175 592
	Soy		
2010.	56 456	2,7	153 580
2011.	58 896	2,5	147 271
2012.	54 109	1,8	96 718
2013.	47 156	2,4	111 316
2014.	47 104	2,8	131 424

Table 1. Reaped Surface and manufacture of wheat, barley and soya [22]

In the intensive cultivation of wheat and barley, it is possible to calculate that one hectare remains 4-5 tons of straw, depending on the variety and year. The ratio between grain yield and straw yield is approximately 50: 50 [5]. The average harvested area of wheat from 2010 to 2015 is about 173,000 ha. If we count on average value, that is, wheat yield per hectare is 4.7 tons (which is equivalent to straw), we reach a figure of 813,000 tons of straw per year. In general, one third of the straw is used as a cattle ranch (straw for cattle), a third is supported (so as not to impoverish the soil if all the harvest remains from the production areas), while one third is available as building material for other purposes. A third of wheat straw in Croatia is available at 271,000 tons. Looking at the refined surface of barley, the average refining area from 2010 to 2015 is 51,500 ha. The average yield of barley per hectare is 3.8 tons per hectare, or the annual available barley yield is about 196.000 tons. If we look at one third, as with wheat, we come to an amount of about 65,000 tons of straw.

According to the study, the amount and calorific value of soyabean biomass, weight of harvested remains or soya straw, ranges from 2.7 to 3.5 tons per hectare [23]. The average yield of soyabeans in Croatia from 2010 to 2015 is about 53,000 ha. Calculating with 3.0 tons per hectare straw, the annual amount of straw soya is about 160,000 tons, or one third of the available quantity is about 53,000 tons.

5. STRAW BUILDING PRODUCTS IN THE WORLD

Straw has been used in construction for thousands of years, and is still used as basic building material such as insulation of finished walls or as a filling in the construction of lightweight wooden structures [6]. Today, there are insulating straw manufactured products on the market, which significantly reduce energy for building performance and energy during building exploitation. Since straw is poorly used today as a building material, it is necessary to ensure the durability of straw so as to reveal its high insulating properties, low carbon contents and the like [16]. There are several stoneware construction products in the world, most notably ModCell from Great Britain, EcoCocon from Lithuania, Durra Panel from Australia and Ekopanely from the Czech Republic.

ModCell is one of the first straw-based products that enables building with negative ecological printing, quantitative measures that give us information on how much our activities are destroying the Earth [12]. ModCell is a prefabricated system that consists of renewable materials, straw bales and wooden frames, certified by the Passive House Institute in the UK (Figure 5). The ModCell system meets the passive construction standards, saving money and CO_2 emissions, and energy consumption is reduced to a minimum [24].

Figure 5. ModCell System [24]

ModCell panels have heat transfer coefficient U = 0.11 - 0.19 W / m^{2}K. They can be used as bearable or non-supporting elements. All types of ModCell panels can be delivered in a variety of sizes, with excellent sound characteristics (sound attenuation amounts to 50 db for ModCell Traditional) and are fireproof (for

ModCell Traditional burning time is 2 hours and 15 minutes for which it has been certified by Chiltern International Fire). Panels are thickly filled with straw and lined with lime plaster. ModCell panels prevent moisture accumulation resulting in fresh air in the room [24]. The life cycle of the ModCell panel is similar to the traditionally built objects. At the end of the life cycle, they can be reused, as straw and wood are biodegradable and can be used as biomass.

Eco Cocon is a manufacturer of straw-based panels based in Lithuania. Panels are a combination of straw, wood, clay on the inside and lining of wood fibers on the outside which ultimately results in exceptional warmth, high quality and durability [25]. Eco Cocon is a modular panel system that is easy to install, elements are individually made in widths of 40 to 120 cm and height of 40 to 300 cm. Compressed and flexible straps in combination with a wooden construction can withstand heavy loads in extreme cases, such as loss-of-capacity shakes. The heat transfer coefficient is U = 0.107 W / m^2K, including wood fiber lining from the outside of the panel, which is sufficient to achieve the standards for passive buildings. The Eco Cocon system provides thermal bridges, air permeability and panel window connections. In addition to the above mentioned characteristics, the advantage of the Eco Cocon panel is the speed of construction, the panels are relatively lightweight (20 - 200 kg) and all the requirements regarding thermal resistance, strength, fire resistance and durability [25].

Durra Panel is a product of Ortech Industries from Melbourne. The panels have excellent acoustic and insulation properties, proven durability and high fire resistance. They are made of wheat and/or straw rice; during the production process combines high compression temperature, releasing the natural polymer from the straw or natural binder, and forming a solid core of a panel that is coated with a recycled cardboard or a lesion [26]. Durra panels meet specific acoustic needs such as noise reduction making them ideal for airports, hotels, theaters and the like.

The dense compressed core of the Durra panel is resistant to fire for up to 1 hour without releasing dangerous poison gas in combination with a low density smoke index. Durum panels have high thermal insulation properties (thermal resistance, i.e. material resistance to heat transfer at Durra panel is R = 0.62 to 0.72), are vapor permeable, weather-resistant, and termite-resistant. Since straw is not a source of food, it does not contain nutritional value, the termites do not attack the core of the pancake and are not the subject of rodent attacks [26].

Ekopanely is a company from the Czech Republic, which is among the first in Europe to produce strawberry ecopanels as a saving and ecological material, and today's annual production of the company is over 100,000 m^2 of eco panels. The Ekopanely panels are ecological vapor perforated panels made of straw under high pressure and high temperature and are covered with a recycled cardboard (Figure 6). They can be completely recycled and 100% natural, providing excellent sound and thermal insulation, and are installed with dry mounting to save construction time.

Figure 6. Straw Panel of the Ekopanely

The panels are manufactured in a way that the straw is combined under pressure and high temperature, releasing lignin - a natural glue that binds the straw into the hardboard. No additional waste elements are created during the production of the slab, no chemicals are used which makes the production a low-energy process [27]. Panels are vapor permeable and thus regulate moisture in space, do not effect vibration and movement of the basic structure and thus have no surface deformations. The strained strap core pro-

vides the panel with over-sounding and insulating properties making it ideal for low-energy and passive homes. Due to its strongly compressed core, the straw panel is resistant to fire and contains no volatile chemicals [27].

6. CONCLUSION

Straw is a natural material that has a positive effect on carbon dioxide emissions, its energy production comes from the sun, no waste and can be composted upon completion of the building cycle. By using straw as construction material, additional income is generated for farmers, resulting in the generation of economically viable material with high properties instead of the previous burning of straw in the fields. Construction materials prices grow year after year, making straw an agricultural waste and advantageous over conventional materials, especially because the production of straw material does not require expensive and environmentally unsustainable production processes. There are several companies in the world that have recognized the straw potential and are engaged in the production of straw construction materials that allow construction with negative ecological printing. More significant are Eco Cocon, ModCell, Durra Panel and Ekopanely. The aforementioned companies have received certificates for their products that guarantee quality and change the perception of the people that the straw is lightly flammable, rusty or litter of termites, insects and rodents. Much of such misunderstanding stems from the process of rapid industrialization, where artificial and industrial materials are favored. There are numerous examples of constructed objects that point to the success of these companies whose products make it possible to achieve the highest standards of health, comfort and ecological awareness, which ultimately results in a healthy lifestyle, exceptional warmth, high quality and durability. Croatia annually has more than 390,000 tons of straw of wheat, barley and soya, which leads to enormous utilization of this natural material. The foreign markets have already recognized the straw potential as fully ecological material and its properties that fully meet the standards of low-energy construction and healthy living. Given the climate change and the excessive use of resources for the production of construction materials, the future of construction materials will surely focus on ecological materials such as strawberries, which has already been recognized by international institutions that are increasingly fueling ecological construction.

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MIOCENE OF SYNCLINAL SMOLUĆA NEAR LUKAVAC

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SUMMARY

The synclinal Smoluća is located in the Tuzla basin about 15 kilometers northwest of Tuzla. In this synclinal there are clastic sediments and limestones of Miocene. Thickness of these sediments is about 1200 meters. The Lower Miocene is freshwater. The red clays are specific lithological member of the freshwater, clastic formation. The clays represent substratum of the salt formation in the Tuzla basin. Stratigraphic position of these sediments is defined by method of superposition. The Lower Miocene sediments have thickness above 200 meters. Above the Lower Miocene discordantly following the Badenian sediments. The Badenian is divided by foraminifera into the Lower and the Upper Badenian. The Lower Badenian is represented by zone Globigerinoides trilobus and Orbulina suturalis. The Upper Badenian is divided into zone Bolivina-Bulimina, and zone Ammonia viennensis. The Badenian sediments have thickness about 450 meters. Above the Badenian following the Sarmatian sediments which are divided into two foraminiferal zones. The older zone of the Sarmatian is Anomalinoides dividens, and younger zone is Porosononion granosum. The Sarmatian sediments have thickness about 200 meters. The Upper Miocene is represented by the Pannonian sediments. In this sediments have been found molluscs (Congeria and Melanopsis) and ostracods (Candona). The Pannonian clastics sediments have thickness about 300 meters.

Key words: Tuzla basin, Smoluća synclinal, Lower Miocene, Badenian, Sarmatian, Pannonian.

1. INTRODUCTION

Geological investigation of outcrops of sediments and their systematic paleontological and petrographic sampling has been realizationed in the Tuzla basin on the area Smoluća (Fig.1) during 2016. Aim of investigation was determination of stratigraphic belonging of sediments. The macrofossils, foraminifera and ostracods have been analyzed in the paleontological samples. Petrographic analyses of mineral composition, type and intensity mineral alterations, and definition of structural and textural features of rocks. Geochronological belonging of sediments has been determinationed on the basis paleontological characteristics. The biostratigraphic units (zones) have been apart when it was possible. Stratigraphic position of sediments in which fossils have not been found was defined by method of superposition.

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Figure 1. Geographical position of synclinal Smoluća.

2. METHODS

The investigations were realizationed by field and laboratory methods. Field method was geological mapping of outcrops on the characteristic profiles. The best profiles have been chosen. Outcrops on the profiles were investigated in detail. From the most outcrops have been taken samples for macropaleontological, micropaleontological and petrographical laboratory investigations.

3. RESULTS

The oldest sediments determined in the synclinal Smoluća are the Lower Miocene. Transgressively above the freshwater Lower Miocene sediments were deposited the marine Badenian sediments. Above the Badenian there are sediments of Sarmatian and Pannonian (Fig. 2).

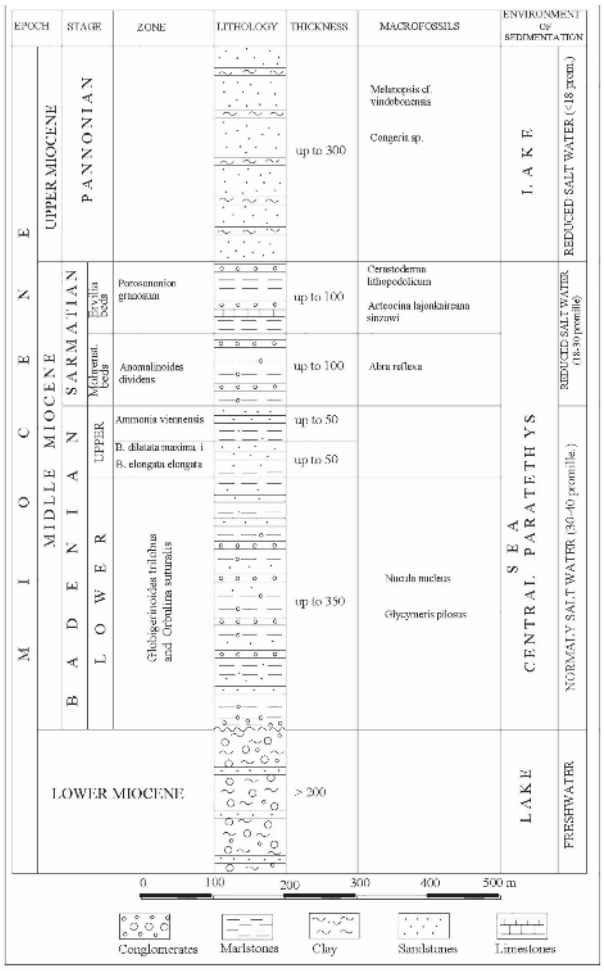


Figure 2. Stratigraphic column of sediments in the synclinal Smoluća near Lukavac.

3.1. LOWER MIOCENE

The Lower Miocene sediments were discovered in the head scarp of landslide to the south of hill Vis (y=6543872, x=4941922) (Fig. 1). These sediments there are on a larger surface to the north of Gornja Smoluća. The Lower Miocene sediments are represented by: conglomerates, sandstones, laminated limestones, marlstones and clay. In these sediments have not been found fossils on the basis of which it can be concluded that they belong to the clastic formation of the Lower Miocene. The thickness of the Lower Miocene is more than 200 meters.

Figure 3. Clayey marlstones and laminated limestones of the freshwater clastic formation of the Lower Miocene.

3.2. BADENIAN

The Badenian sediments there are transgressively above the freshwater Lower Miocene sediments. On the basis of foraminifera the Badenian is divided on the Lower Badenian and the Upper Badenian.

The Lower Badenian is representad by: thin-stratified and stratified marlstones, sandstones, conglomerates and limestones. From makrofossils have been found taxsodont bivalves *Nucula nucleus* (LINNE) and *Glycymeris pilosus* (LINNE), (Fig. 4) (y=6540308, x=4941321).

a) b) c)

Figure 4. Marlstones (a), Nucula nucleus (b) and Glycymeris pilosus (c).

In the samples collected from outcrops of Gornja Smoluća (y=6540387, x=4941293) were found predominantly planktonic foraminifera. The following foraminifera have been determined: *Globigerinoides trilobus* (REUSS), Orbulina suturalis BRÖNNIMANN, *Globigerina bulloides* d' ORBIGNY, *Lenticulina inornata* (d' ORBIGNY), *Pullenia bulloides* (d' ORBIGNY), *Praeglobobulimina pupoides* (d' ORBIGNY), *Bulimina* sp., *Bolivina antiqua* d' ORBIGNY, *Bolivina* sp., *Valvulineria complanata* (d' ORBIGNY), *Elphidium* sp., *Pullenia quinqueloba* (REUSS), *Laevidentalina* sp., *Asterigerinata planorbis* (d' ORBIGNY), *Hansenisca soldanii* (d' ORBIGNY), *Ammonia viennensis* (d' ORBIGNY), *Spirorutilus carinatus* (d' ORBIGNY), *Nonion commune* (d' ORBIGNY), *Cibicidoides ungerianus ungerianus* (d' ORBIGNY), *Bulimina subulata* CUSHMAN & PARKER and *Pappina cf. parkeri* (KARRER). The rare fragments of echinoids spine and ostracods have been found. This association of foraminifera belongs to the Lower Badenian zone *Globigerinoides trilobus* and *Orbulina suturalis* (Fig. 5). The thickness of the Lower Badenian can be up to 350 meters.

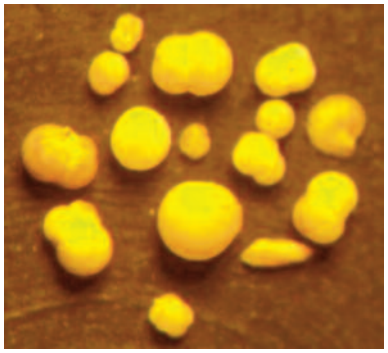


Figure 5. The association of foraminifera from the Lower Badenian zone G. trilobus and O. suturalis.

The Upper Badenian is represented by: thin-stratified and laminated marlstones, sandstones and polymictic conglomerates. These sediments have been found in the Lukavački stream. The Upper Badenian is divided on the older and the younger part. The older part contains the association predominantly of benthic foraminifera: *Bolivina dilatata maxima* CICHA & ZAPLETALOVA, *Bulimina elongata elongata* d' ORBIGNY, *Bulimina* sp., *Nonion commune* (d' ORBIGNY) and *Fursenkoina acuta* (d' ORBIGNY) (Fig. 6) (y=6541009, x=4942510, Agići).

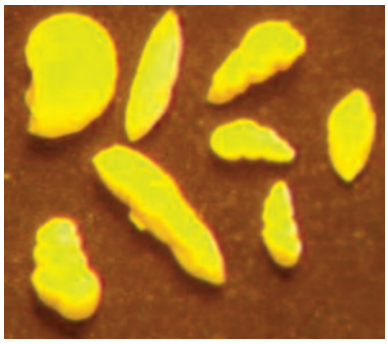


Figure 6. Foraminifera from the older part of the Upper Badenian.

On the basis of this association is determined that above mentioned sediments belonging to zone *Bolivina dilatata maxima and Bulimina elongata elongata.* The younger part of the Upper Badenian is represented by: laminated and thin-stratified marlstones, sandstones and subordinate conglomerates. From the macrofossils one gastropod has been found. Microfossils are represented by relatively frequent species of foraminifera *Ammonia viennensis* (d' ORBIGNY) (Fig.7) and rare ostracods. These sediments belonging to the younger part of the Upper Badenian, that is zone *Ammonia viennensis.* Thickness of the Upper Badenian is probably up to 100 meters.

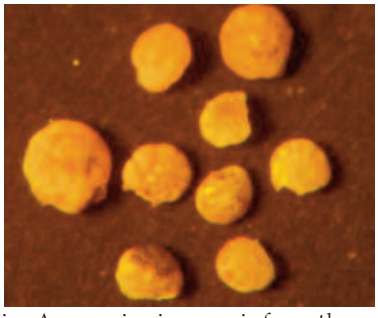
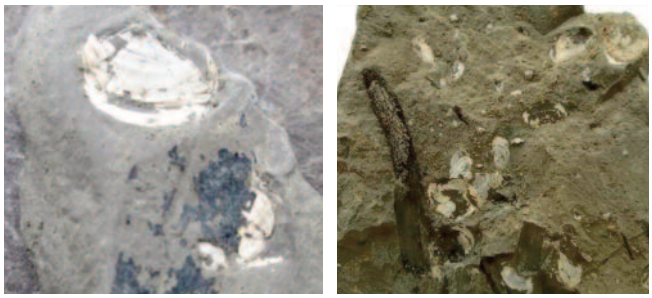


Figure 7. Foraminifera of the species Ammonia viennensis from the younger part of the Upper Badenian (Lukavački stream, y=6543696, x=4941871).

3.3. SARMATIAN

The Sarmatian sediments have been determinated on the basis of macro and microfauna from Lukavački stream. The sediments are divided on the older and the younger part of the Lower Sarmatian. The Sarmatian is represented by: laminated and thin-stratified marlstones, sandstones and subordinate strata of limestones. The older part of the Lower Sarmatian contains sediments with frequent bivalv *Abra reflexa* (EICHWALD) (Fig. 8) (y=6543705, x=4941910). These sediments belonging to Mohrensternia beds.



a) b)

Figure 8. Bivalva Abra reflexa with print of leaf (a) and carbonificationed fragments of macroflora (b).

Foraminifera are relatively rare, among whose dominated the benthic forms: *Anomalinoides dividens* LUCZKOWSKA, *Globigerina praebulloides* BLOW, (Fig. 9), *Articulina sarmatica* (KARRER), *Quinqueloculina* sp. and *Globigerina* sp.. Ostracods are represented with different genera and species. Analyzed sediments belonging to zone *Anomalinoides dividens*.

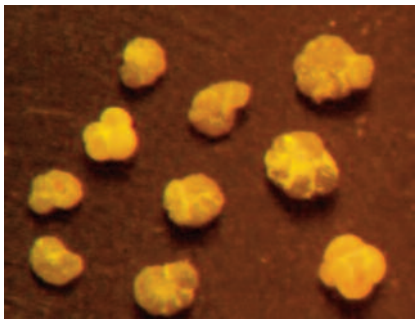


Figure 9. The association of foraminifera from the Lower Sarmatian zone Anomalinoides dividens.

The younger part of the Lower Sarmatian sediments have been found in the trough of Mala river west of village Agići (y=6540465, x=4942352). These sediments contain bivalv Cerastoderma lithopodolicum (DUBOIS) (Fig. 10-a) and gastropod *Acteocina lajonkaireana sinzowi* (KOLESNIKOV) (Fig. 10-b). These fossils are characteristic for *Ervilia* beds that is zone *Porosononion granosum*.

a) b)

Figure 10. Cerastoderma lithopodolicum (a) and Acteocina lajonkaireana sinzowi (b).

In this part of the Lower Sarmatian foraminifera are relatively rare. Next foraminifera are determinated: *Porosononion granosum* (d' ORBIGNY), *Ammonia viennensis* (d' ORBIGNY), *Elphidium* sp. and *Bolivina* sp. Parts of fish as fragments of teeth and otoliths have been found. The thickness of the Sarmatian sediments is probably up to 200 meters.

3.4. PANNONIAN

The Pannonian contains: sandstones, sandy clay, calcareus clay, laminated and stratified marlstones and conglomerates. From the samples collected south of hill Vis, valley Mala river, Lukavački stream and south of village Agići, the gastropod *Melanopsis* cf. *vindobonensis* FUCHS (Fig. 11) and bivalva *Congeria* sp. have been determined. The thickness of the Pannonian is up to 300 meters.

Figure 11. Melanopsis cf. vindobonensis (y=6541671, x=4941366).

Among microfauna have been found ostracods *Candona* sp. div. (Fig. 12).

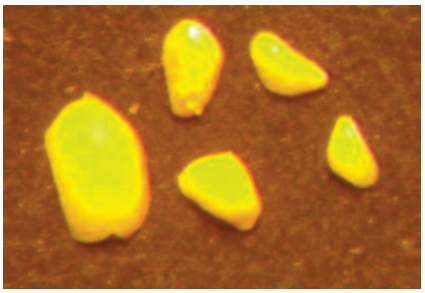


Figure 12. Candona sp. div. (y=6543643, x=4941602).

4. DISCUSSION

The investigated sediments of synclinal Smoluća on the published geological maps of Tuzla basin were differently petrographic and stratigraphic classified. Katzer (1909) [3] in the synclinal Smoluća determinated clastic sediments of the Miocene and Pliocene. Kranjec (1965) [4] on the area of synclinal Smoluća defined: the Helvetian (red and gray clay, sandstones and conglomerates) which considered as lateral equivalent of the salt formation, next the Younger Tortonian (marlstones, sandstones, conglomerates and rare limestones), the Lower Sarmatian (marlstones, limestones, sandstones, conglomerates and clay), and the Pannonian (clay, sands, marlstones and conglomerates- gravels). Soklić (1986) [8] on the investigated area of Smoluća determinated sediments of: the Lower Miocene, the Helvetian, the Tortonian (the Badenian), the Sarmatian and the Pannonian. On the OGK sheet Tuzla (Čičić et al., 1991) [1] in the area Smoluća defined sediments of: the Lower-Middle Miocene, the Younger Tortonian, the Sarmatian and the Pannonian. It is important that stratigraphic units of the Middle Miocene (the Badenian and Sarmatian) on the above mentioned geological maps were not biostragraphicaly divided, and treatment of the freshwater Lower Miocene sediments was different. The former researchers the Lower Miocene sediments most often denominated as „multicolor series", and they considered it as lateral equivalent of the salt formation or its substratum in the Tuzla basin. Katzer (1909) [3] classified these sediments in the Aquitanian, Stevanović and Eremija (1960) [9] in the Younger Burdigalian and Helvetian, Kranjec (1965) [4] in the Middle Miocene, Soklić (1986) [8] in the Helvetian, Čičić et al. (1991) [1] in the final part of the Lower Miocene and the beginning of the Middle Miocene. Vrabac and Ćorić (2008) [10] these freshwater sediments classified in the Lower Miocene, considered that they represent substratum of the salt formation, and not its lateral equivalent, which most of the researches thought. On the all former geological maps of the Tuzla basin, which included this area, the border between the Lower and Middle Miocene was presented as normal. However, the results of these investigations testimony that above the freshwater Lower Miocene sediments discordantly follow marine sediments of the Lower Badenian, and the border between these stratigraphic units is tectonic-erosional. Petrović (1979) [6] on the basis of foraminifera the Badenian of Tuzla basin divided into the Lower,

the Middle and the Upper. Soklić et al. (1980) [7] defined zone *Orbulina universa* and *Globigerinoides* in the Lower „Tortonian". Ćorić at al. (2007) [2] and Vrabac and Ćorić (2008) [10] the Lower Badenian classified on the older zone *Ammonia viennensis* and *Nonion commune,* and younger zone *Globigerinoides trilobus* and O*rbulina suturalis*, whose equivalent is nannoplankton zone NN5 (Martini, 1971). [5]. On the area Smoluća have been defined association of foraminifera which belongs to the Lower Badenian zone *Globigerinoides trilobus* and *Orbulina suturalis.* In the sediments of the Upper Badenian have been defined the older zone *Bolivina dilatata maxima* and *Bulimina elongata elongata,* and the younger zone *Ammonia viennensis.* Above the Badenian sediments there are the older Sarmatian sediments which belonging to zone *Anomalinoides dividens*. Over, follow sediments of the younger part of the Sarmatian, which bellonging to zone *Porosononion granosum*. Above the Sarmatian there are the Pannonian sediments with characteristic as sociation of molluscs.

5. CONCLUSION

On the area Smoluća are defined freswater sediments of the Lower Miocene, marine sediments of the Badenian and Sarmatian, and lake sediments of the Pannonian. On the published geological maps of the Tuzla basin the sediments of Smoluća have been classificationed in the different stratigraphic units, with concordant borders. Big lithological differences between the freshwater and the marine sediments, different dip angles, and absens of the salt formation, are arguments of the tectonic-erosional unconformity between the Lower Miocene and the Lower Badenian. Borders between the Badenian, the Sarmatian and the Pannonian are possibly normal. Petrographical and paleontological characteristics of the Lower Miocene sediments indicated their origin from shallow freshwater lake. The Badenian and the Sarmatian sediments have been deposited on the south margin of the Centarl Paratethys. The Pannonian sediments have been deposited in the freshwater lake. During the Badenian salinity was normal, and during the Sarmatian and especially the Pannonian, salinity was significantly reduced. The results of this investigations will be used for construction of detailed geological maps of the Tuzla basin and neighbouring basins on the North Bosnia.

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DEFINING QUALITY PARAMETERS OF LIMESTONE DEPOSIT APPLICATION OF BLOCK MODEL

Dean Osmanović[1], Akif Ibrišimović[2], Benjamin Brašnjić[3]

SUMMARY

Using limestone as mineral raw materials in the portland cement production industry it is necessary to pay more attention to the chemical composition than physical-mechanical properties. In Bosnia and Herzegovina, quarries which supply cement factories are relatively small, there fore, there is a deficit in the experience of planning and designing such quarries. The chemical composition in the deposit was expressed through a mean weighted value that is not satisfactory for more serious production planning. In order to solve this is sue for quarry "Ribnica", a block model of limestone reserves was created in the licensed GEOVIA Surpac™ software. By using this block model it is possible to predict the chemical composition of the limestone for each open pit level (bench) partially, as well as for the periods of exploitation. The block model was created based on the designed contours of the quarry, the up-to-date state of mining works and the database of research works. This paper describes determination of the chemical composition of limestone for $CaCO_3$ component, which has significant importance in the portland cement production. The analysis found that the upper benches (E-650, E-630, E-610 and E-590) have $CaCO_3$ content below the required average (86%) of total $8{,}78 \times 10^6$ banck cubic metre (bcm) of limestone it is estimated that there is $7{,}36 \times 10^6$ bcm of limestone with $CaCO_3$ content greater than 86%.

Key words: limestone, portland cement, block model, GEOVIA Surpac™, $CaCO_3$

INTRODUCTION

The importance of limestone in relation to other rocks of any origin is shown by the fact that the application of limestone exceeds the total application of all other rocks together. Its properties are of crucial importance for its application, that is, application limestone in certain branches is conditioned by its chemical and physical-mechanical properties. The use of limestone in the lime production industry, Portland cement as well as in the desulphurization process in thermal power plants is specific. Limestone for these purposes is a strictly defined chemical compositions [2].

For example, for the flue gas desulphurization process of the new block 7 in TE "Tuzla" requires a limestone with a minimum content of $CaCO_3$ 96%, while for desulphurization of the flue gas of the new block 8 in TPP "Kakanj" requires a limestone with a minimum content of $CaCO_3$ 92% (fluidized-bed combustion technology), and the option of applying conventional technology which requires a limestone with a minimum content of $CaCO_3$ 96%. For the production of lime the content of $CaCO_3 + MgCO_3$ should be to be at least 95% [2, 5, 6]. Specifically for Kakanj cement factory it is claimed that the limestone from quarry "Ribnica" on average contains 86% of $CaCO_3$, which is a basic problem. When designing and planning a quarry that requires a certain quality of mineral raw materials (chemical composition) it is necessary to fulfill two basic objectives [13]:

- satisfy the requirements related to quality (chemical composition) and
- meet quantitative requirements.

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These goals are the most significant for design and planning because the absence of one or the other has a negative effect. Specifically for the quarry "Ribnica" requirements related to quantities are not at risk by any means.

So far, the traditional way of interpretation has been used in the "Ribnica" quarry, the quality of the mineral raw material in the entire deposit, which is represented by the mean weighted value and the insulins of the contents of certain components for the entire thickness of the deposit, which is not enough for the management of mineral [7, 13].

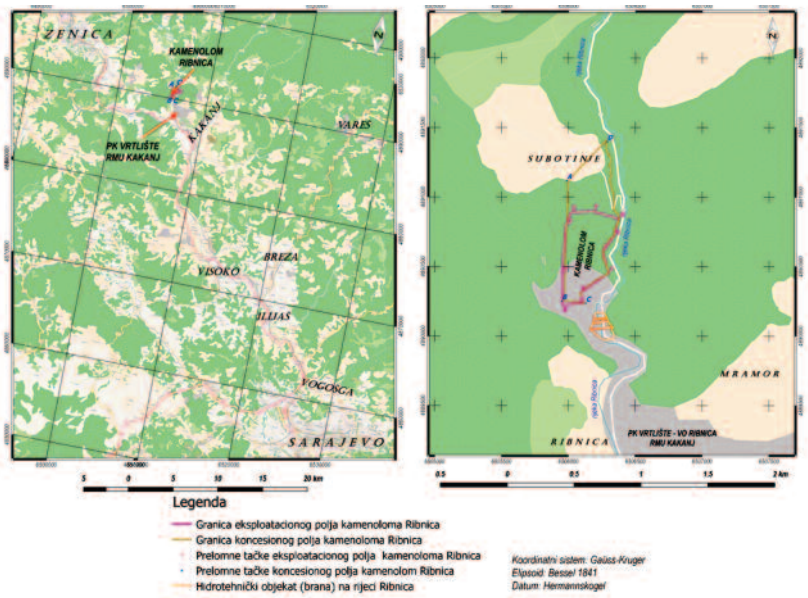
To meet these requirements (on average content of $CaCO_3$= 86%) block model of limestone deposit was created defined by content of calcium carbonate. The bay model was created in licensed GEOVIA Surpac™ software, allowing statistical analysis of $CaCO_3$ prognosis per floor level to the details of quality at the level of daily production. By updating the exploration database, a block model will also be updated to increase the reliability of the model in the future. Updating is also possible with data obtained from composite analysis from mining drill holes that are carried out in the Kakanj cement factory.

The mines in Bosnia and Herzegovina are beginning to apply modern software tools intended for designing and planning open pit mine, and in most cases this is the software used by Geovia - Dassault Systèmes® Surpac™, Minex™ and Whittle™. Some of the mines used in the project documentation and research works are: Coal deposit "Kongora" [9], open pit mine of coal "Delići" near Ugljevik [21], open pit mine of coal "Bogutovo Selo" and "Ugljevik Istok 1" in Ugljevik [12], open pit mine of coal "Gračanica" in Gacko [3], open pit mine of coal "Mošćanica" near Zenica [11] as well as the metal deposit "Buvač" mine Omarska near Banja Luka [19].

2. LOCATION AND GEOLOGICAL CHARACTERISTICS OF QUARRY "RIBNICA"

2.1. LOCATION

The "Ribnica" quarry is located northwest of Kakanj (Bosnia and Herzegovina) at the distance of about 6 km. The deposit is reached by the macadam route through Ribnica - Subotina, which in the Donji Kakanj passes to the old asphalt road Sarajevo - Zenica. In this way, the quarry has a connection with Kakanj and the highway Sarajevo - Zenica. Picture 1 shows the location of the "Ribnica" quarry [4].



Picture 1. Location of quarry „Ribnica"

2.2. GEOLOGICAL CHARACTERISTICS

In the geological structure of limestone deposit, which are formed from Jurassic-Cretaceous sandy clay sediments, upper Cretaceous-clastic carbonate sediments and Oligomiocene sediments. Jurassic-cretaceous, sandy clay sediments are bedrock of the Ribnica deposit and as they do not represent raw materials for cement production [7].

Upper cretaceous sediments or Turonian-Santonian sediments represent a bedrock of Oligo-Miocene sediments and the toprock of the jurassic-cretaceous sandy clay sediments. Upper Cretaceous carbonate flysch by its chemical and mineralogical-petrographic composition, is a suitable raw material for cement production.

Geological mapping and laboratory examinations revealed the presence of breccia layered limestones, chalkrudites, limestones, marly limestones, lime horn. The limestones in quarry are usually gray, light-gray to reddish brown, resulting from a slightly increased content of limonite iron oxide. Also, on certain layers there is a noticeable appearance of red brown marley clay or red brown clayey marl, which in many ways affects the quality of limestone as a raw material. Based on the previous chemical analyzes taken from the exploratory drillholes and excavations, it is evident that the carbonate flywheel contains over 90.00% of $CaCO_3$ [7].

Basal zone or Oligo-micene sediments were developed in the north and west (marginal) parts of the deposit along the western boundary of the exploitation field. Oligo-miocene sediments represent a direct top rock with upper middle carbonate flysch [7].

The lowest level of oligo-miocene sediments are represented by basal conglomerates, while higher levels are represented by red sand, yellowish sand and clay.According to the validated Elaborate [7] and the Decision of the Ministry of Economy of the Zenica-Doboj Canton as of February 2017, the balance sheet of the reserves of limestone is as shown in Table 1.

Category	Amount ($x10^6$ t)
A+B+C1	53,687
The average content $CaCO_3$ is 90,21 %	

Table 1. Overview of limestone reserves at Ribnica-Subotinje

3. SYSTEM OF EXPLOITATION AND EXISTING STATE OF MINING WORKS IN QUARRY „RIBNICA"

3.1. SYSTEM OF EXPLOITATION

The quarry development of the Main Mining Project [10] takes place in a particular excavation boundary corresponding to the boundary of the exploitation field (area of exploitation field about 19.4 ha). The exploitation system has been designed to provide detecting, obtaining limestone and auxiliary works that provide the planned quarry capacity and a lot of utilization of the equipment.

The basic indicators of the exploitation system are the direction and intensity of the advancement of mining works in plan and depth, which is realized with two production processes: the overburden and obtaining limestone, which consist of mining operations drilling, blasting, dozer pushing of the material to the basic loading-transport plateau, loading and limestone transport to the Kakanj cement factory. The primary technological scheme for obtaining limestone at the "Ribnica" quarry is shown in Figure 2. Overall slope angel of completion of the slope of the quarry is approx. 53 ° [4, 10, 16, 17].

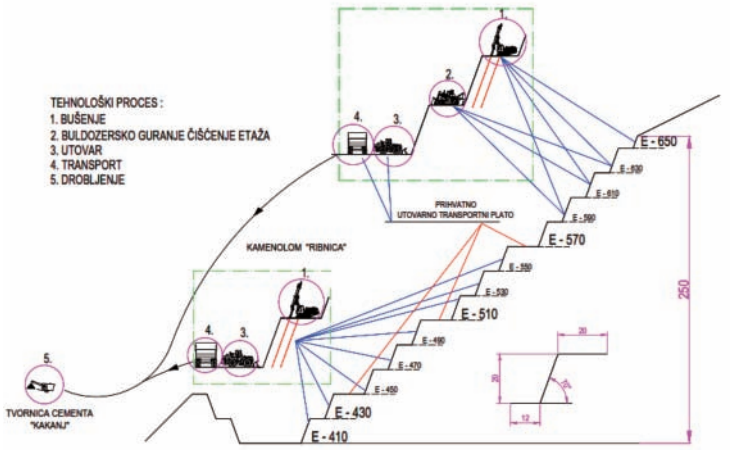


Figure 2. The primary technological scheme for obtaining limestones at the "Ribnica" quarry

3.2. DESCRIPTION OF THE EXISTING STATUS OF MINING WORKS

The existing status of mining works on the "Ribnica" quarry is defined by the situation map of the scale 1: 1000 with the state of December 2017. Based on the situation map in the Surpac™ 6.0 software the digital model of the quarry (DTM or boss DMT - digital terrain model describes the three-dimensional shape of the Earth's surface or topography, without vegetation and artificially constructed objects. The model is numerically defined by a series of three coordinates X, Y and Z in digital form). Figure 3 shows the digital model of the current state of mining works on the "Ribnica" quarry.

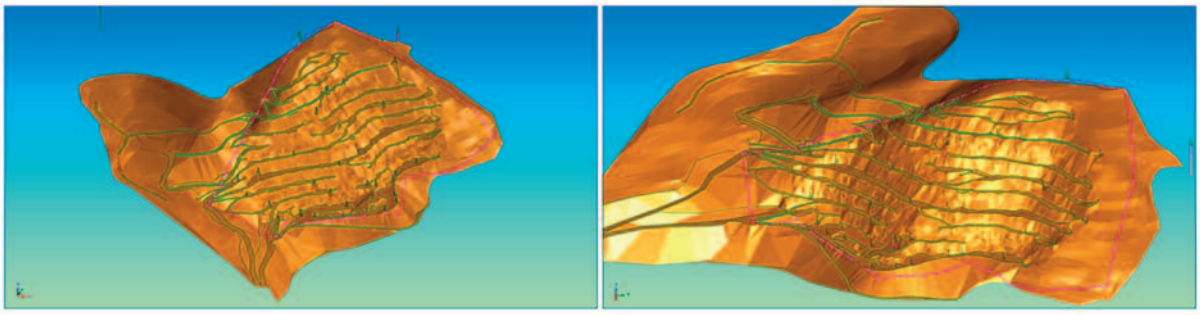


Figure 3. Current state of mining works on the "Ribnica" quarry (picture left - southeast view, picture to the right - view from northeast)

In the "Ribnica" quarry currently working floors are 450 to 650 meter above mean sea level (mMSL), with slight deviations from the level of the floors which can be considered practically correct in the mining industry. From the base plateau to E-450 mMSL started with the opening of the deep part of the quarry, and is currently the lowest angle approx. 441 mMSL while the highest approx. 650 mMSL which makes the total altitude difference around 210 m. On the south-west side of the quarry there is a secured access to each floor. The bench 450, 510 and 570 are basic for loading and transport. The upright working slope is somewhat milder than the projected one. The mining works are generally moving from east to west.

4. BLOCK MODEL OF THE EXPLOITATION LIMESTONE RESERVES AND THE EVALUATION OF THE QUALITY OF LIMESTONE BY THE CACO3 COMPONENT

4.1. BLOCK MODEL OF LIMESTONE RESERVES EXPLOITATION

In order to carry out a complex planning and design process in a mining project, it is necessary to have accurate and precise representation of the geological characteristics of the analyzed site. For this reason it is necessary to develop a geological model that actually represents a sufficiently credible simulation of the actual geological characteristics of the deposit. The significance of the geological model for the success of the mining project is crucial, and it is clear that any mistakes made in the model are transmitted to the further stages of the project. By the middle of the seventies of the last century, under the geological model, a large amount of geological documents (maps, profiles, textual documents) were defined, based on the material background, defining the deposit. With the development of IT support conditions have been created for the development of digital geological models. By moving from material to digital models, geological interpretation is significantly faster for numerous analyzes and thus on the design quality.

Basically, digital geological models can be divided into:

- geological models based on mini blocks, and
- grid based geological models.

Geological models based on mini blocks (block models) are characterized by deposits with a very complex shape (metal deposits). The basic principle in this model is the discretization of the mining body on a large number of mini blocks. The block is a unique volume information carrier that includes three-dimensional (3D) area. This means that each block has its own location, size, and qualitative attributes in 3D space. Blocks within the model have the basic size (standard dimensions) but because of better interpretation in geologically complex zones can be smaller (sub blocks). Most of the leading commercial software, specialized for mining, are based on block modeling (Dassault Systèmes® Surpac™, Gems™, Whittle™) [15].

Based on exploratory geological works, a geological database was created (37 wells with technical analyzes) in Surpac™ 6.0 software. Based on the map of current works and final contours of the surface, a block model of limestone exploitation reserves was created. The block model is calculated by interpolation methods, deterministic or geostatistical methods (the deterministic method of inverse distance with the value of step 2 was applied).

The Blok model offers the greatest features of all types of models and therefore has the widest application in modeling the base and surface kits. It can be used for all types of inserts that are determined by block dimensions. The used dimensions of blocks and subblocks are X=20 (2,5), Y=20 (2,5) Z=10 (2,5) [20].

4.2. THE EVALUATION OF THE QUALITY OF LIMESTONE BY THE $CACO_3$ COMPONENT

The attributes used in the block model are calcium carbonate content (%), specific gravity of limestone and exploitation stage. The digital model of the final contour of the quarry is shown in Figure 4.

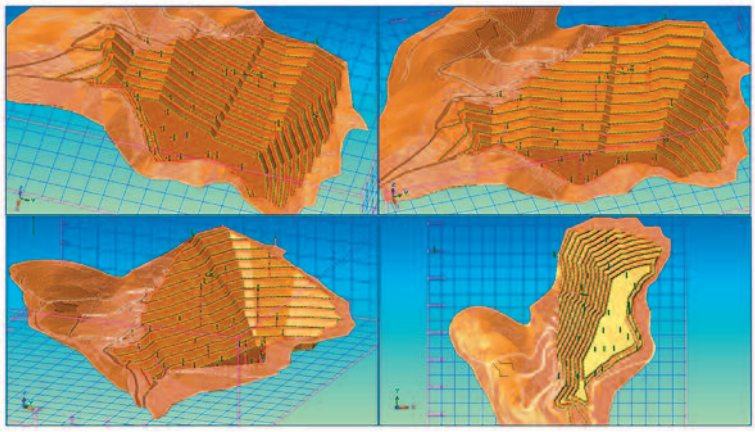


Figure 4. The final contour of the "Ribnica" quarry

The digital model of the quarry and the limestone block model by the content of $CaCO_3$ (%) in the first and second stage of exploitation is shown in Figure 5, while Figure 6 shows the vertical and horizontal cross section through the block model. The limestone quality estimate for the exploitation phases is shown on graphs, Figure 7 as well as the histograms given in Figure 8.

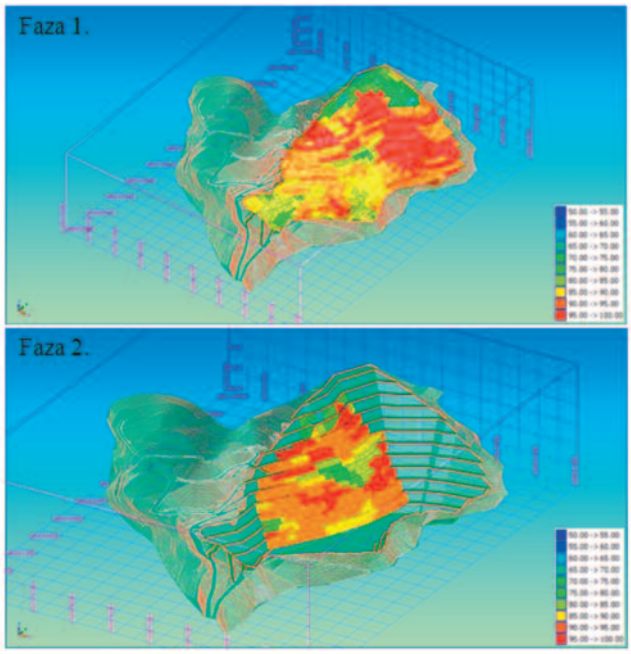


Figure 5. Block model of the content pattern of $CaCO_3$ in the first and second stage of exploitation

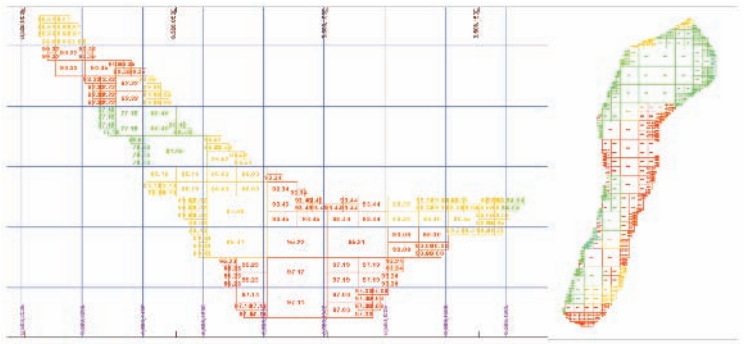


Figure 6. Vertical and Horizontal cross-section through block model with $CaCO_3$ content

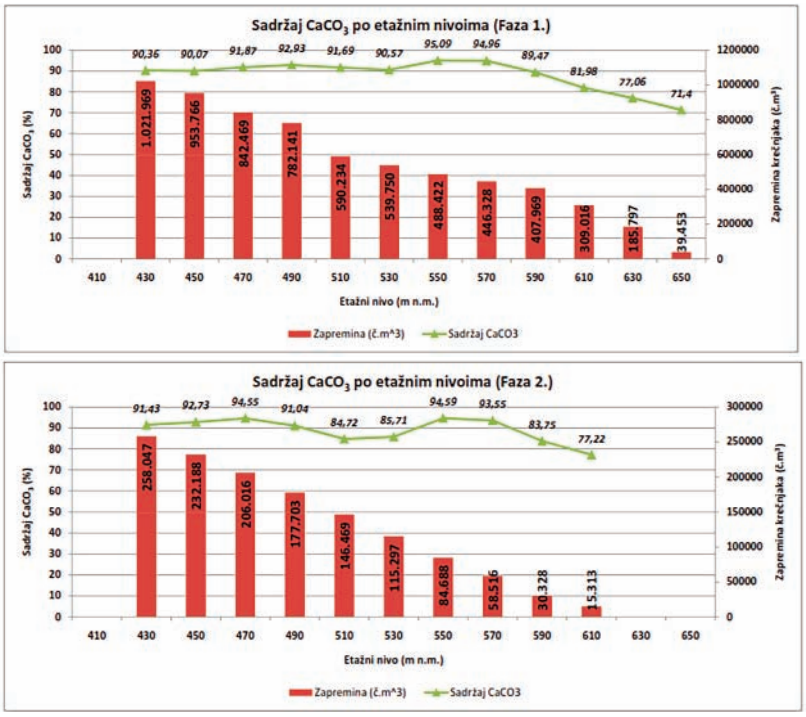


Figure 7. Content of $CaCO_3$ in limestone per bench

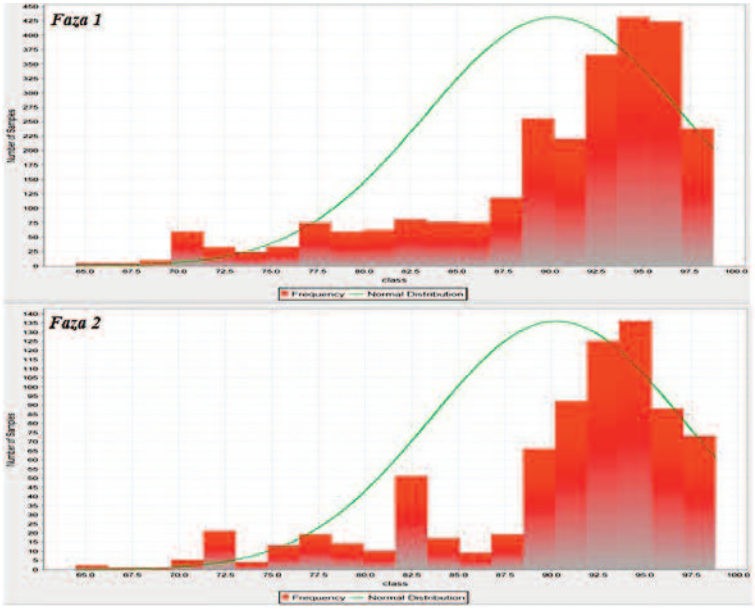


Figure 8. Histogram of $CaCO_3$ content in limestone by stage of exploitation

Stage of exploitation	Volume of limestone x10^6 (bcm)	Average content $CaCO_3$ (%) $\bar{\chi}$	Standard deviation of content $CaCO_3$ (%) σ
1.	6,61	90,68	6,94
2.	1,32	90,81	6,76
3.	0,85	92,51	3,49
Σ	8,78	90,87	6,72

Table 2. Overview of $CaCO_3$ contentby exploitation stage

Analyzing the $CaCO_3$ content in limestone it was noted that the top bench (650, 630, 610 and 590 mMSL have a poorer quality, Figure 8. In the first stage of exploitation of a total of 6.61 x 10^6 bcm of limestone it is estimated that about 5.44 x 10^6 bcm has $CaCO_3$ content greater than 86%. In the second stage of exploitation from 1.32 x 10^6 bcm of limestone, about 1.08 x 10^6 bcm limestone has $CaCO_3$ content greater than 86%, while in the third stage of exploitation of total 0.85 x 10^6 bcm of limestone about 0.84 x 10^6 bcm has a $CaCO_3$ content greater than 86%.

The results show that from the total exploitation volume of limestone, which is about 8.78 x 10^6 bcm, the $CaCO_3$ content is greater than or equal to 86% with 7.36 x 10^6 bcm of limestone. The remaining limestone reserves in the amount of about 1.42 x 10^6 bcm have a $CaCO_3$ content of less than 86% and they are necessary in the exploitation process to homogenise in order to meet the required limestone quality.

5. CONCLUSIONS

Exploitation of limestone at quarry „Ribnica" started in 2005 and the quarry is open for Kakanj cement factory needs. From the end of 2005 till end of 2017 quarry delivered average 120 x 10^3 bcm/year of limestone ore with average quality of 88% of $CaCO_3$, in this period quarry excavated about 1,56 x 10^6bcm of ore.

Limestone from "Ribnica" quarry is used as a mineral raw material in the cement production industry and the quality requirement for the delivered ore is such that the $CaCO_3$ content is average 86%.

In order to fulfil the mentioned demand of the Kakanj Cement Factory, the block model was developed for the limestone reserves on the quarry "Ribnica" with the licence software Surpac™ so the $CaCO_3$ content could be defined by quarry benches and exploitation periods, which can be a daily or after several decades with the significance of achieving the required quality and developing the mining works in the quarry. In the future, the database of research works will be updated and therefore a block model will be updated and it will provide greater reliability of the model and analysis performed. There will also be added other attributes to a block model that will contribute to a greater or lesser extent to the planning and design of exploitation in this quarry.

Based on the analysis with the block model, it was estimated that there is a total of 8.78 x 10^6 bcm of limestone located, there is about 7.36 x 10^6 bcm of limestone with content of $CaCO_3$ greater than 86%. Also, about 1.42 x 10^6 bcm of limestone has a lower than 86% content of $CaCO_3$, so the quantities stated in the exploitation process need to be homogenized in order to satisfy the quality of total reserves.

Such approach to planning and designing projects in mining and geology is also applicable to other types of deposits with different attributes in a three-dimensional space, and the block model of the deposit is the most suitable solution.

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DEVELOPMENT OF NEW EDUCATION PROGRAMS IN THE FIELD OF SPATIAL DATA INFRASTRUCTURE (IPP) IN BOSNIA AND HERZEGOVINA (BESTSDI PROJECT)

Mirza Ponjavić[1], Indira Sijerčić[2], Rejhana Dervišević[3], Kemal Gutić[4], Elvir Ferhatbegović[5]

SUMMARY:

Project application "Western Balkans Academic Education Evolution and Professional's Sustainable Training for Spatial Data Infrastructures" – BESTSDI has been selected for funding in frame of ERASMUS+KA2 Capacity Building in Higher Education call 2015. Project is worth 978.166,66 € and is one of 147 selected among 736 submitted applications. Project applicant is Faculty of Geodesy at University of Zagreb and project partners are Catholic University Leuven (B), University of Split (HR), Ss. Cyril and Methodius University Skopje (MK), Bochum University of Applied Sciences (D), Polytechnic University of Tirana (AL), Agricultural University of Tirana (AL), University of Banja Luka (BiH), University of Mostar (BiH), University of Sarajevo (BiH), University of Tuzla (BiH), University for Business and Technology Prishtina (XK), University of Montenegro (MN), University of Belgrade (RS), University of Novi Sad (RS) and University of Prizren „Ukshin Hoti" (XK), as well as associated partners Federal Administration for Geodetic and Real Property Affairs of FBiH (BiH), Republic Administration for Geodetic and Real Property Affairs of RS (BiH) and Real Estate Cadastre Agency of Republic of Macedonia (MK).

Objective of BESTSDI project is to improve the curricula at the partner universities by introducing the concepts of spatial data infrastructures (IPP) and e-government as well as extended concepts like smart cities, smart environment, digital single market, etc. based on IPP. The project courses will address two types of students, namely students having a specialisation on fundamental geospatial data management (for instance in geodesy, geoinformatics etc.) and students at other faculties utilizing the IPP concepts, for instance urban planners, environmental engineers and students in forestry, geography or agriculture. Project duration is three years and project start is foreseen for October 15th 2016.

The paper includes IPP Status in Bosnia and Herzegovina, IPP in High education of Bosnia and Herzegovina, and BESTSDI Requirement Analysis. IPP Status considers legislative, organizational (bodies, responsible authorities) and technical organization (web, geoportal, newsletter) of NIPP in the country including NIPP stakeholders ando other governmental bodies, business sector, educational institutions and end users: municipalities, public enterprises, citizens, as well as role of Universities in NIPP as NIPP development from academic aspect. Status IPP in High education is described in sense of the presence of IPP in high education studies on universities.

Keywords: spatial data infrastructures, curricula, high education

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1. IPP STATUS IN BOSNIA AND HERZEGOVINA

1.1. NIPP IN BOSNIA AND HERZEGOVINA

There is a large number of laws and legal acts related to the use of spatial data and are committed to IPP development and strengthening. First and foremost, there are a number of documents and acts of the European Union, state-level laws (related to authorship and access to information), and the laws in FBiH and RS, which define the way of spatial data collecting, storing, processing and presenting. This includes general regulations, geodesy regulations and real estate cadastre with accompanying regulations, the IPP Regulation, regulations in the field of spatial planning, regulations regulating access to public sector information in FBiH and RS, environmental regulations, regulations on waters, agricultural land regulations, forestry regulations, statistics regulations, regulations and acts related to sharing and exchange of data at entities and cantonal levels, and many others. Most of these legal acts are accessible and can be found on the websites of FBiH Government, RS Government, and some ministries..

There are also a large number of cantonal laws in the FBiH that are largely in accordance with federal laws or are fully taken over. It can be concluded that there is a legal regulation that needs to be taken into account and which is important for creating the legal framework necessary for the development and establishment of the IPP in BiH. Within the IMPULS project [7], a review of the NIPP status in BIH is provided, both in legal and technical terms. The objective of this project is to establish a modern and functional framework for spatial data sharing in accordance with regional and international standards [4]. Shorty it can be described by the following facts:

- In BiH, there are some specific laws and legislation that regulate the IPP (autonomous) regulation (in RS, the law regulates IPP issues in a single chapter, which is not a separate act [8], and in the FBiH there is a Regulation on IPP that has the weight of the legal act [5], to the adoption of a law, and could be considered as autonomous act)
- There are strategic documents: FBiH has adopted the IPP Development Strategy and the IPP Council of the FBiH adopted a 3-year plan that relies on this strategy in the part of its short, medium and long term goals; the RS is drafting this strategy and establishing the IPP Council.
- There are appointed coordinators for the establishment, implementation and maintenance of the IPP at the level of both entities: FGU has been recognized as a contact point for the FBiH, according to the adopted strategy.
- Since there are no separate laws pertaining to this area, legal mechanisms between the contact points of individual participants / stakeholders and all other entities involved in the development and use of IPP have not yet been defined.
- In FBiH and RS, there are data sets that are harmonized with the INSPIRE rules (administrative units, altitude, geographic names, orthophoto footages).
- There is a metadata directory catalog: on the IPP Council website for FBiH there is a directory developed in accordance with the regional IMPULS project.
- Metadata for harmonized data sets (overview and download) are published at the regional level through the IMPULS project [1].

1.2. INSTITUTIONS PARTICIPATING IN THE DEVELOPMENT OF NIPP

In Bosnia and Herzegovina, there is a legally prescribed obligation at the entity level in order to establish records of certain data affecting the space in various sectors (spatial planning, geodesy, agriculture, forestry, water management etc.). However, the establishment of these data often does not follow the actual needs and prescribed obligations, so that it is very heterogeneous and usually closed within individual sectors. At the same time, the information collecting, processing and making this data available through various information systems is under the constitutional competence within the sphere of all levels of government. Cantons and local self-government units (municipalities/cities) did not have enough funds to complete the projects, so they were implemented sporadically based on the available donor funds.

Very few projects were systematically set up, such as a cadastral records inventory project conducted by entity management for geodetic and property-legal affairs based on a unique methodology and technology. For the collection and maintenance of spatial data sets at the entity level, the competent ministries or institutions are responsible for submitting the official spatial data sources according to the annexes to the INSPIRE Directive [6].

In a number of institutions, projects to establish spatial data bases have been initiated or initiated, but none of them has developed spatial data infrastructure that could be directly used for IPP. By the level of availability of spatial data and readiness for customer service capacity in accordance with the INSPIRE directive, ie the readiness to implement the IPP, these institutions can be categorized into 4 categories:

- Institutions that publish and maintain spatial data services
- Institutions that have capacities for servicing spatial data
- Institutions using spatial data services from other institutions and
- Institutions that do not use web services.

Based on the general assessment, there are very few institutions in BiH that could be ranked in first or second in the level of readiness for the implementation of the IPP. A slightly larger number of institutions are in the third category, although the number of institutions in the fourth category is dominant. They lack the necessary capacity to organize and establish spatial data infrastructures [9].

The situation regarding the availability of capacity to establish IPPs at lower administrative levels is also very heterogeneous. Institutions that are responsible for collecting and maintaining spatial data sets at the level of local governments are mostly institutes for spatial planning, various directorates and public companies for power supply, water supply, telecommunications, road maintenance and municipal services. There is great contrast and dispersion in terms of capacity for IPP development, so that some institutions in the larger urban centers (Sarajevo, Banja Luka, Tuzla, Mostar) have functional spatial information systems and a significant spatial data base, while for most institutions this is not the case.

1.3. THE ROLE OF THE UNIVERSITIES IN THE NIPP

As in other areas as well as in the development of the IPP in BiH, universities should have a research and educational role. In this sense, the academic community is involved through the following higher education institutions that actively participate in international research projects for the development of IPP:

- Faculty of Civil Engineering in Sarajevo,
- Architectural Civil Engineering Faculty in Banja Luka,
- Faculty of Agriculture in Sarajevo,
- Faculty of Mining, Geology and Civil Engineering in Tuzla
- Faculty of Natural Sciences, Mathematics and Education in Mostar, as well as other higher education institutions.

Although B&H universities are involved in these projects, it can be concluded that they do not participate enough and that their potential is not used in terms of cooperation with domestic institutions currently in charge of developing IPP in BiH. In addition, the curricula do not contain subjects or curricula relevant to the development and application of the IPP. Their improvement (which is the goal of the BESTSDI project) would create the prerequisites for launching new research projects and intensifying cooperation between the public and private sector in this area. By expanding the program with subjects in this area, the teaching process would be more appropriate and in line with market needs, and educated experts would be more prepared for the challenges of applying new geoinformation technologies and concepts.

1.4. DEVELOPMENT OF NIPP

IPP building is a process that can greatly enhance the modernization and efficiency of state administration and provide the basis for economic development. Sharing and applying spatial data could be used by a large number of users, especially administrative bodies at all levels of government. These data should also be available to private companies for commercial purposes, universities and research centers for education and research, a non-governmental sector for more active participation in democratic processes, and citizens who will benefit from a large number of services derived from well-planned spatial data infrastructures.

The current situation of the IPP in BiH is characterized by spatial data services that are either not in function, or are connected. One part of the infrastructure related to spatial databases in individual institutions is at various stages of development, whereby unified standards are not always applied. Data exchange modes are different and generally unordered, suggesting that spatial data exchange is at a low level.

Laws and other legal acts relevant to spatial data should pay attention to their compliance with the provisions of the INSPIRE Directive, thereby contributing to easier access to the European Union. The INSPIRE directive and IPP development in BiH should be seen as an opportunity to create a more efficient system of providing services, better informing citizens and creating new jobs in the IT sector. For a successful development of the IPP, it should have a clear vision and goal, and take into account the positive experiences in the EU and in the region. Significant investments are needed to realize well-planned IPP development, but the results related to more efficient management and greater transparency in the entire society will be justified [9].

Within the framework of IPP development, the academic community has for the moment been engaged in an institutional sense, which is associated with the lack of curricula in this field. The requirements of the BESTSDI project are well recognized and addressed by these shortcomings and its results are expected to directly strengthen the role of higher education in this domain and to increase the engagement of the academic community in the further implementation of the IPP in Bosnia and Herzegovina.

2. STATE OF IPP AND HIGHER EDUCATION IN BOSNIA AND HERZEGOVINA

The question of the current state of IPP presence in the teaching activities conducted by higher education institutions was dealt with by representatives of partner universities from BiH within the framework of a special working group. For the needs of the BESTSDI project, this group has analyzed the current situation in the context of the development of new and supplementary curricula with subjects and topics in the IPP field. The analysis was preceded by an exhaustive collection of data on existing programs whose purpose is to identify existing teaching content that can be used for new objects in the project and to define guidelines for further design of new plans. The approach to defining the guidelines is generally described by the relatin between activities and tasks as shown in Figure 1.

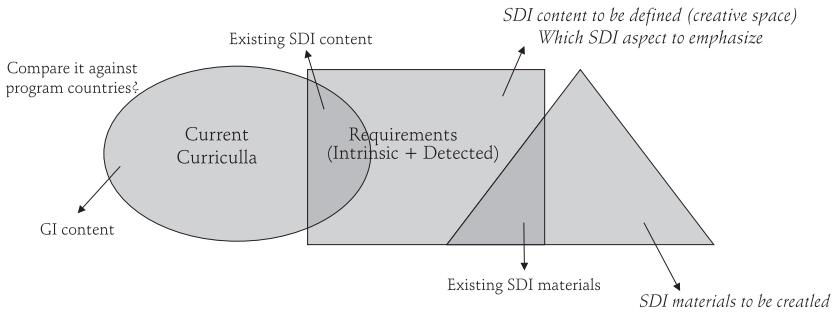

Figure 1. Relation of taks that should result with guidelines for new curricula design

Based on this preliminary metadata analysis of existing IPP and geoinformation courses at BESTSDI project, a number of conclusions and recommendations have been made for existing plans and for building a new specific IPP program for partner countries, including B&H:

- Spatial data is present in curricula, but spatial data infrastructure is often not recognized as a curriculum
- It is necessary to identify and promote IPP aspects that are recognizable by users or communities
- The Master's degree can be the main target level for the new BESTSDI curriculum
- New IPP courses could be initially offered as elective courses because of administrative processes related to updating existing ones or creating new accredited curricula
- Course descriptions (abstract and learning outcomes) must be re-written in order to better illustrate what is being done on courses
- Current programs offer a solid foundation for geoinformation topics
- The IPP is currently covered in basic form (mostly at the electoral level)
- There are lack of benefits, examples of use and application of IPP in geodisciplines
- There is a need to put GIS technology in a broader context in order to fulfill its intentional use in decision-making at all levels.
- The following questions could also be raised about existing curricula and programs, which could be the driver of the necessary changes:

- whether the existing study programs fulfilled their purpose?
- are students sufficiently educated to participate in IPP development in the coming years?
- is it what the existing programs provide enough to meet their future needs?

Generally, a large number of existing courses have been identified that could be reused in some form for new courses to be defined within the BESTSDI project such as Geospatial Data Infrastructure, Geoinformation Infrastructure, Topographic Models, Real Estate Valuation, Geoinformation Systems, Geoecology and Geospatial Database, Physical Planning and Urban Planning, Sustainable Use of Natural Resources and Environmental Protection System, Land Consolidation, Cadastre, Detection of Subterranean Infrastructure, Fundamentals of Remote Detection and Surveying, Active Geodetic Surveying, Reference Networks, Basics of Mathematical Cartography, Structural Geomorphology, Geodiversity and Geoinheritance etc.

For broader use of existing courses, project partners need to agree on their usage and licensing permissions, which will relate to metadata, structure and course materials. Collected metadata, despite some disparities in consistency and use of multiple languages, provide the basis for more detailed analysis and research. A complete collection of metadata metadata is available on the work platform of the Project on the website [3].

It could be concluded that in BiH there is experience and knowledge gained through the introduction and realization of existing geoinformatics subjects and topics which could serve as a good heritage for a good starting point when introducing changes and creating new curricula adapted to the development trends of the IPP [2].

3. ANALYSIS NEEDS FOR THE BESTSDI PROJECT

In order to analyze the needs for the BESTSDI project in BiH, a survey was conducted (addressed to 250 institutions with 12% of responses), which showed the lack of educated persons with knowledge in the area relevant to IPP development. Public sector organizations (local government - 40%, universities - 17%), research institutes and private companies (10%) and the non-governmental sector (3%) participated in the survey.

The largest number of organizations concerned the spatial data users (56%), then producers and experts in this field (17%), while others were system suppliers. These organizations come from spatial planning (34), agriculture (20), environmental protection (13), property cadastre (10), architecture and forestry (7) and civil engineering (3%).

- In terms of competence needs, most think that through their work it is necessary:
- understanding the basic elements of geoinformation (70%)
- use of geospatial data (80%)
- field data collection and digitization (66%)
- land recording and GPS use, application of satellite and photogrammetric images (55%)
- mapping and visualization (53%)
- spatial data analysis (43%).

In answers to geoinformation and IPP language lessons, most agree that they should be native language (87%), as well as that there is a need for distance learning with access to educational materials (73%).

Knowledge and understanding of the aspects of INSPIRE (objectives, conceptual framework, EU directives) is mainly at a lower level, and the main disadvantages and obstacles are lack of resources, lack of qualified staff and so on.

Conclusions of this survey:

- this study (survey) helps in further activities on the development of IPP in BiH,
- such an analysis is very important for understanding the actual situation and needs in B&H,
- there is a need for educational materials related to INSPIRE and
- this project is very important for popularizing and developing the user's awareness of accessibility of spatial information and their exchange in a legally and standardized manner.

The results of the survey show that there is a real need for a certain level of knowledge in geoinformation management in the public as well as in other institutions, as defined by INSPIRE, and further indicates the need for adaptation of curricula for the establishment and development of IPPs [2].

4. CONCLUSIONS

This paper provides a brief description of the current state of the Spatial Data Infrastructure (IPP) in B&H with reference to IPP in Higher Education and Analysis of BESTSDI Project Requirements. The role of the universities in NIPP is related to its development from the academic aspect in terms of the presence of IPP in study programs.

In general it can be concluded that universities in BiH do not participate enough in IPP development and that their potential is not used in terms of cooperation with domestic institutions currently in charge of IPP development in BiH. Also, curricula and university programs do not contain subjects or teaching topics relevant to the development and application of IPPs. Their improvement (the goal of the BESTSDI project) would create the prerequisites for launching new research projects and intensifying cooperation between the public and private sector in this area.

Concerning the current status of higher education regarding the presence of the IPP in the curricula, it can be concluded that in BiH there is experience and knowledge gained through the introduction and realization of existing geoinformatic subjects and topics, which could serve as a good heritage for a good starting point at introducing changes and creating new curricula adapted to the trends of IPP development.

The survey conducted in the framework of the project with the aim of request analysis has shown that there is a real need for a certain level of knowledge in the field of geoinformation management as defined by INSPIRE, further pointing to the need for adaptation of curricula for the establishment and development of IPPs.

The results of the project will certainly impact on changes in the development of a common approach for the development of new or updated existing curricula in the field of IPP in BiH. The implementation of these programs and plans, as well as the changes in practice that will occur through the application of acquired knowledge through academic education, remain the long-term challenge of this project, as actual results will only be visible years after its implementation.

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APPLICATION OF GPR OR DUCTILE WATER PIPES ON THE EXAMPLE OF REGIONAL WATER SUPPLY SYSTEM "PLAVA VODA"

Nedim Suljić[1]

SUMMARY

The route of the main water transport line of the regional water supply system "Plava voda" begins at the water spring "Plava voda" in the municipality of Travnik, and then passes through parts of the municipalities of Travnik, Vitez, Busovača and Zenica. The total length of the main transport line of the regional water supply system from the spring "Plava voda" to the Putovići reservoir is 32.878,91 m. Polyester pipes (GPR) are planned for the main project of the regional water supply system. In this paper, the possibility and justification of the application of ductile water pipes will be analyzed.

Key words: Regional water supply, polyester pipe, ductile pipe, pipe characteristics, application.

INTRODUCTION

The main project of the regional water supply system "Plava voda" was finished during 2010 and 2011. The total length of the main transport line of the regional water supply system from the spring "Plava voda" to the Putovići reservoir is 32.878,91 m. The route of the main water transport line of the regional water supply system "Plava voda" begins at the water spring "Plava voda" in the municipality of Travnik, and then passes through parts of the municipalities of Travnik, Vitez, Busovača and Zenica. In the area of Travnik and Busovača municipalities, the route is mostly located and laid down along the old narrow-gauge railroad Jajce-Lašva. In the area of Vitez municipality, it is laid down along the old narrow-gauge railroad, after which it crosses the river Lašva, and then partly passes through the agricultural land and again integrates into the old narrow-gauge railway.

In the territory of Zenica municipality, the route of the main pipeline is planned along the old narrow-gauge railroad to the estuary of the river Lašva to the river Bosna, where it crosses the river and continues parallel with the existing railroad Šamac-Sarajevo, on its right and then on its left side to the village of Janjići. In the village of Janjići, the main water supply line crosses the main road M-17 and the river Bosna, and then it is traced (routed) to the "Putovići" reservoir in the village of Putovići.

According to the completed and given Main project, the diameter of transport line is DN 700 mm in the length of 19.395.18 m, then the diameter of DN 600 mm in the length of 4.101.20 m, and the diameter of DN 500 mm in the length of 9.382.53 mm, with rated/nominal pressures of NP10, NP16, NP20 and NP25. The main project of the regional water supply system "Plava voda" plans the use of polyester pipes (GRP) with strength of SN10000 for the transport pipeline, and in the smaller part where the agricultural land is, the pipes with strength of SN5000.

According to available data from water pipe manufacturers, polyester pipes (GRP) are manufactured in lengths of 6 and 12 m and are connected via coupling. Since these are large diameters, the free angle of rotation along the vertical and the horizontal side extends to 2° for diameters of DN 700 and 600 mm, and for DN 500 mm is up to 3°. The angles over 2°, respectively 3° are overcomed by fittings or by pipe bends.

The main transport line of polyester pipes is laid down, according to the technical conditions for this type of pipe, in the manner that the height of the overlay is above the pipe of about 1.2 m. In cases of laying

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pipelines through the urban roads, and below main roads, railways or other characteristic locations, the height of the overlay should be at least 1.5 m. Based on the available data of the producer of water polyester pipes and on the basis of technical regulations and norms, the minimum width of the trench for laying down these pipes is 2xD, and the bottom of the trench must be arranged and brought to the projected elevation.

The planned bed is 10 cm thick, and it must be aligned and compacted. As a bedding material and for a layer up to 30 cm above the pipeline's top, incoherent materials are embedded, such as the pebbles, sand, gravel or fine crushed rocks. These non-coherent materials need to be compacted to the required compaction. For the main transport line, in the mentioned Main project, a cover from the 8-16 mm dolomite granulation is planned for. Dolomite cover has been adopted because in the area of the planned regional water supply system there is a certain number of dolomite quarries. For the installation of GRP polyester pipes, valid guidelines are ONORM B 2503, ONORM EN 1610, ONORM B 2538, T1 and T2, and other relevant standards, guidelines and occupational safety regulations. The laying down of the pipeline needs to be expertly planned and carried out in compliance with the appropriate standards. Appropriate professional and carefully installed installation guarantees the efficiency of high quality GRP polyester pipes.

The route of main water line should be selected so as to achieve the level of the running line as straight as possible, because the change in the direction of the pipe increases the friction resistance. It is necessary to avoid slopes in the opposite direction, if any, and must be able to anticipate the possibility of airing at the highest angles (air valves) and the possibility of emptying at the lowest angles of the terrain (sludge/mud valves).

The main project of the regional water supply system "Plava voda" plans procurement, transport and installation of GRP pipes DN 600 mm and DN 700 mm, NP 10, NP 16 and NP 20, strength of 10000, and GPR pipes DN 500 mm NP 20 and NP 25 with strength of 10000. The pipes should be laid on the prepared substrate from the pebbles and installed according to the project. Also, it is planned procurement, transport and installation of GRP pipes of DN 700 mm, NP 10 with strength of 10000 with thermal protection from polyurethane foam and polyethylene coating. The thickness of this protection is 8 cm. The pipes should be laid in a bridge construction where the route of regional waterway passes over watercourses and existing or planned bridge structures. In addition, according to the Main project, the procurement, transport and installation of fittings of GRP with diameter of 700 mm, NP 10 and strength of 10000 is also needed. The fittings are laid on the prepared substrate from the pebbles and are mounted according to the project and technical norms for the various corners of the fracture. It is necessary to carry out expert installation of GPR fittings with diameter of 700 mm, NP 10 and strength of 10000 with thermal protection. These fittings are laid out on a bridge construction and are mounted according to the specified Main project and the necessary conditions of protection from high waters of return period 1/100. On the route of the main transport line, more branches are planned and all branches transport the water to the distribution reservoirs. According to the aforementioned Main project, the total length of the branching pipeline is 15.194,72 m. All planned branches have the same type of coupling, or branching from the transport line. A GRP (polyester) T fitting-piece with an output diameter is planned, as well as the branch diameter. Directly along the main transport line (made of GPR pipes by the project), and on branches there is a shaft of the mud outlet or a shaft of the airing valve (in dependence from the elevation altitude on the route) into which the section branch seals are planned. In this way, each branch can be closed at the start, or disconnected from the system. According to the Main project of the regional water supply system "Plava voda", it is planned to use polyethylene pipes (PE) for the branch pipeline, with additional protection and built-in detectable wire, from 140 mm to 280 mm diameter. For these diameters, the manufacturers of polyethylene pipes produce them in 6 and 12 m long rods.

2. CHARACTERISTICS OF POLYESTER PIPES

Polyester pipes are the product of the appropriate machine for continuous filament winding, the common name GPR pipes. By combining glass fibers, thermostable resins and special fillers in the appropriate proportions, pipes with a wide range of mechanical-physical and chemical characteristics can be produced. Polyester pipes are made of non-corrosive a material, which means:

- Long and efficient operating life
- Unnecessary expensive cathodic protection
- Unnecessarily expensive coating of pipes, covering and painting
- Relatively low maintenance costs
- The hydraulic characteristics remain unchanged for a long time.

The good physical and chemical characteristics of polyester pipes resulted in widespread use in the following works and buildings, such as:

- Sanitary-sewerage systems
- Drainage of rainwater from bridges
- Transport of raw water
- Transport of industrial wastewater
- Irrigation systems
- Ventilation systems
- Drainage systems
- Pipelines for hydroelectric power stations
- Pipelines for mining shafts and suspended pipelines.

In our country, even in the region, it is quite rare to use polyester pipes for the main route of water supply systems, especially regional water supply systems, due to insufficient knowledge of the behavior of these materials in long-term use. Today, for such expensive regional water supply systems, in the region, there is mainly the application of ductile water pipes due to its very good physical and hydraulic properties. However, polyester water pipes have their own characteristics and characteristics, such as:

a) Relatively easy installation. There is no need for expensive pipe installation equipment and transport costs are low.
b) Very light weight of deposited sludge, which contributes to low maintenance costs (because of this, these pipes are recommended and often used to drain rainwater and transport of raw water to the conditioning plant).
c) Lightweight joining, which contributes to less time for pipe mounting.
d) Water tightness with efficient couplings designed to minimize the waterproofing of compounds, i.e. infiltration of water into the ground transported by polyester pipes.
e) Polyester pipes are produced using a fiberglass that has very good strength characteristics against the weight of the pipe, so in this regard they are more efficient than, for example, steel pipes.
f) Relatively small weight (25% of the weight of cast iron pipe).
g) Excellent smoothness of the walls, which means less friction in the flow of water in long pipelines and less energy losses.

Polyester pipes have significant advantages in the flow of liquid thanks to its smooth inner surface, corrosion resistance and resistance on accumulation of deposits (suitable and used for the transport of wastewater), in almost all conditions of exploitation. The smooth interior of the polyester pipes results in less resistance of the fluid, in this considered case of water. According to the available data from the producers of these pipes, their absolute roughness is k=0.012 mm, while the Manning number ranges from n=0,0095-0,012 $m^{-1}/3s$. Polyester pipes are resistant to a wide range of different chemicals and temperatures, and also they can be produced to be especially resistant to abrasion, weather influences, and are therefore often used for wastewater drainage. Hydrostatic testing of polyester pipes is performed for all pressure pipes, unless otherwise agreed, and it is the main indicator of pipe quality. The test pressure is 1,5xPN (PN-nominal pressure).

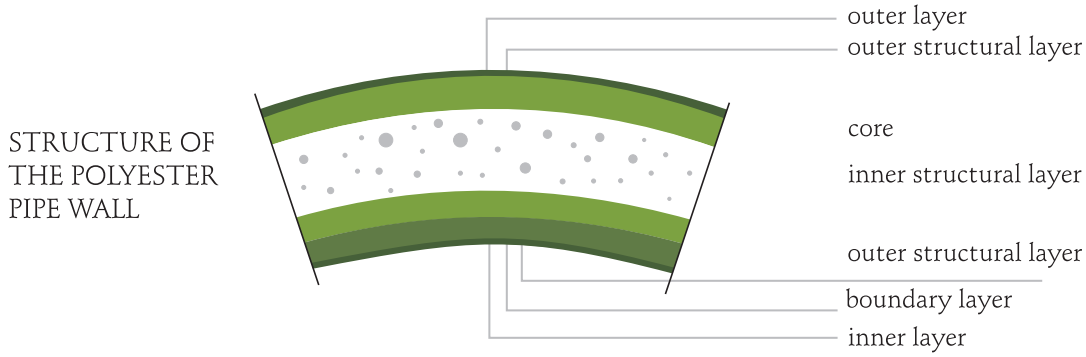

Figure 1. Structure of the polyester pipe wall

The inner layer of surface or wall of the polyester pipe is made of "C" glass and has the role of protection (Figure 1), while the boundary layer also has a protective role and is made of chopped glass fibers. The inner structural layer has the role of reinforcing the pipe construction and is made of glass fiber and chopped glass fiber. The core of the polyester pipe wall is silicon sand and chopped glass fibers, and the outer structural layer as well as the interior, has the role of reinforcement and is made of the same components as the inner structural layer. The outer layer, according to Figure 1, has a protective role and is constructed by "C" glass. In each of the mentioned layers the existence of a thermostable resin is default.

2.1. LOADINGS OF POLYESTER PIPES AND THEIR INSTALLATION

When there is a traffic load in the application of polyester pipes, all material in the pipe backfilling zone must be compacted to the ground level. For maximum load from trucks, the minimum height required for the over-layer should be 1.0 m, and if it is expected that lorries cross over the polyester pipeline route, the minimum thickness of the ground over-layer must be 1.5 m. The long operating life and good characteristics of polyester pipes can be achieved only by proper handling and installation. The pipe is so constructed that it uses both the bed and the backfilling zone of the pipe as a support.

Based on past experiences, I consider that well-compacted granular grounds are extremely good for backfilling of these pipes, and this should be especially taken into account if the installation of polyester pipes is planned for the main transport line of the regional water supply "Plava voda". The trench bed should be made of a suitable material that must ensure an adequate compaction for the smooth and continuous support of the pipe. Material for the pipe bed can be sand or pebbles. The bed should be compact to a minimum of 90% of the standard density by Proctor (70% of the maximum relative density for pulverized stone and pebbles), and these important data and conditions should be taken into account especially if the insufficiently used polyester pipes are planned for the main transport line of the regional water supply „Plava voda". The finished bed should be straight. Namely, in order to ensure a satisfactory system of "polyester pipe-ground", the correct backfilling material must be used. Most coarse grained ground (according to the classification of the land qualification system) is acceptable material of the pipe zone and for the bed. This is an important data for the long run route of the regional water supply „Plava voda".

Quality installation of materials in the pipe zone is vital for the efficient operation of the pipeline in the given warranty period by the contractor. During the backfilling, it is checked whether the grain material is placed completely underneath the pipe, in order to achieve a complete support. The board or some other blunt tool can be used for pushing and to compact the filling material under the pipe (this can additionally slow down the installation of polyester pipes). Thorough implementation of this procedure is a very important phase of pipe backfilling. When backfilling reach the half of the pipe (half of the pipe diameter), the compaction must be carried out first close to the trench walls and then continue toward the center, which additionally slow down the works around the trench backfilling, where the polyester pipes are laid down planned by the Main project.

The material from which the polyester pipes are made has a relatively low modulus of elasticity so that the control of vertical deflection of the pipe diameter during installation is the most relevant indicator of quality installed pipes. The pipe deflection must not exceed 5% of the nominal diameter on a long-term basis. Convexity, bumps or other sudden changes in the curvature of the pipe wall are not allowed. The deflection should be checked immediately after the first installed pipe is completely backfilled and to continue with it periodically through the entire project, i.e. along the entire route, which is very long in the given project. This may be an additional problem when installing and backfilling of polyester pipes and a longer period of installation of pipe with the length of almost 33 km.

2.2. THE RECENT APPLICATION OF POLYESTER PIPES IN THE REGION AND IN BOSNIA AND HERZEGOVINA

The application of polyester pipes in the region, based on the available data of the author of this paper, was for the following investors and for the application of the following facilities and systems:

- MHE „ERS " Laktaši, Bosnia and Herzegovina — exploitation of water potential
- MHE „Gorno Belički izvori", Skoplje, Macedonia — exploitation of water potential
- „Rose Wood" Gornji Vakuf, Bosnia and Herzegovina — exploitation of water potential
- RTB Bor, Serbia — transport of technical water for the mine

- Water supply and sewerage Belgrade, Serbia	sewerage system
- Water supply in Pale, Bosnia and Herzegovina	transport of drinking water
- Water supply Novi Sad, Serbia	transport of raw water
- Water supply and sewerage Zemun, Serbia	sewerage system
- Teslić, Bosnia and Herzegovina	transport of technical water
- Water supply Šabac, Serbia	transport of drinking water
- Foča, Bosnia and Herzegovina	transport of technical water
- Obrenovac, Serbia	transport of technical water
- Stolac, Bosnia and Herzegovina	transport of drinking water

Based on the aforementioned known applications of polyester pipes, it can be concluded that their application is most common in the construction of mini hydro power plants, the transport of raw (unprocessed) water and the transport of technical water. Until now, the use of polyester pipes for the main transport line of regional or some other water supply system in our country and region has been rare.

3. CHARACTERISTICS OF DUCTILE WATER PIPES

Nodular cast is a type of iron cast in which the carbon is excreted in the form of graphite nodules (beads). Precisely because of the specific (nodular or ball-shaped) form, graphite has a favorable combination of its properties. It is characterized by high stretching, high stretching margin (in relation to gray cast), good ductility and mechanical workability, while the tensile strength is at the level of the tensile strength of the steel cast. The nodular cast is, in contrast to the gray cast, plastic, deformable and stretchable material. Often, in practice, this material is known by the term ductile or ductile cast as a derivative from German language (*duktiles Gusseisen*), or English language (*ductile iron*). The word ductile means stretchable, extensible. Overloading of pipes by deforming the material is distributed so that there is no breakage or pipe burst. The internal protection of ductile pipes is a cement mortar, a centrifugal application of 3 to 9 mm thickness and low roughness (k=0,1 mm), and external protection is a galvanized layer of 200 g/m^2. Ductile water supply pipes are manufactured from different diameters, from DN 60 mm to DN 2000 mm. The external protection of ductile pipe can also be with a significantly higher surface mass, i.e. 400 g/m^2 of zinc, or with PE protection of 900 microns thickness, which is applied when placing these pipes into very aggressive soil.

Natural soil movements are one of the main problems we can face with in water supply network or a water supply route for the supply of the population. In order to minimize the effect of these ground movements, the pipe material and fittings should be able to resist the bending and impact forces without being deformed. Such soil movements can be expected on a very long route of the regional water supply network "Plava voda", due to the different characteristics of terrain.

The distribution network and the water supply system is a very important and costly investment, where the cost components must be carefully defined. Therefore, during the project and phases of feasibility studies, the cost of durability and operating life, low maintenance costs, ease of installation and repair costs should be taken into account. For all of the mentioned, the ductile water pipes, in practice so far, have proved to be extremely good and practicable.

Ductile water supply pipes are a unique product because they have a very high resistance to excessive loads that can be caused by internal positive and/or negative (vacuum) pressures due to the effect of water impact and external soil movements. Nodular cast pipes, or ductile pipes, can be used for all pressures occurring in water supply system. Thanks to the high pressure of the burst they sustain, ductile pipes are applicable with a particularly high safety margin.

3.1. EXTERNAL LOADS OF DUCTILE WATER PIPES AND CORROSION PROTECTION

External loads of embedded pipes are mainly the result of loads caused by soil and dynamic traffic loading. The magnitude of these loads and influences depends on the elasticity of the pipe. If the pipe is elastic, it is more capable of by redeploying the load to take over the stresses caused by these external loads. Also, the heavy traffic loading, landslides caused by soil movement and load of the ground on the laid pipes, create extremely high forces that affect the pipes positioned underneath the earth. Based on the available literature, it is known that tests performed on pipes made of various materials have shown that ductile pipes are the most resistant to distributed and concentrated loads.

In case of longitudinal bending effect, the ductile pipes of higher nominal diameter (DN 500 and more - which is planned in the regional water supply system "Plava voda"), due to its higher bending resistance, show the characteristics of self-load-bearing. In ductile pipes there is no overload due to internal pressure and external loads. The greatest of all these stresses determine the required thickness of the pipe wall. Ductile iron pipes act as steel profiles under high load effects due to their ductility (extensibility). This feature ensures that ductile pipes serve effectively in distribution networks and pipelines under special loads and influences, which is to be expected on the main water supply line of the regional water supply system „Plava voda".

Exceptional physical characteristics and high resistance of ductile pipes to the load, protect the pipes from impact during the transport and assembly phase. Especially for seismic areas and unstable terrains and grounds, ductile iron pipes have no alternatives and are far better than the polyester pipes planned in the aforementioned Main project of the regional water supply „Plava voda".

According to the available data and statistical analysis of the results of soil research, in more than 90% of applications of ductile pipes with a zinc coating of 200 g/m^2 and with a cover layer, it meets the requirements that ensure long lifetime of the pipe. Namely, EN 545/598 requires a minimum zinc content of 200 g/m^2. Accordingly, special measures of corrosion protection are only required in rare cases, and are determined by soil analysis, so that it is possible to say that the product itself or the ductile pipe with its own protection is sufficient for anticorrosive protection of aggressive soil and groundwater with which pipes on the regional water supply route "Plava voda" can come into contact. It is especially important to emphasize that as long as the ductile pipe is not laid down in the ground, or in the trench, the cover layer protects the zinc from meteorological influences. Namely, in the pores of the cover layer, the reaction of zinc with precipitated water and carbon dioxide from the air produces zinc carbonates that close the pores and stop further chemical reaction, and for this reason the use of ductile pipes is especially justified. When the ductile pipe is laid down in the soil, the zinc layer eventually turns into a thick layer of insoluble compounds, which is tightly adhered and impermeable. Most of them are zinc oxides, hydrates and salts of various compositions. A layer of corrosive zinc products can be attributed to the ability to retain its protective activity even after the original zinc has been transformed, or after all the protective galvanic activity has stopped. Under the environmental conditions in which it is formed, the mentioned layer of zinc corrosion products is stable. The existence and maintenance of his protective activity in aggressive soil has been proven in the tests that have been conducted in the field for the past twenty years. The external and internal pipeline protection is selected according to the soil composition, according to the data of the manufacturer of ductile pipes.

According to the available literature and conducted studies, the expected ductile pipe operating life is 100 years, which was obtained on the basis of test results, field inspections and working operations over the past 50 years. In order to ensure the water of impeccable characteristics to end consumers (physical, chemical and microbiological characteristics), pipelines as well as all other facilities in the water supply network must be in a proper hygienic state. The pipes and fittings of nodular cast (the ductile iron) meet the hygienic requirements of materials that come into contact with the drinking water, which ductile pipes completely meet due to their large application in the current practice of water supply of the settlements.

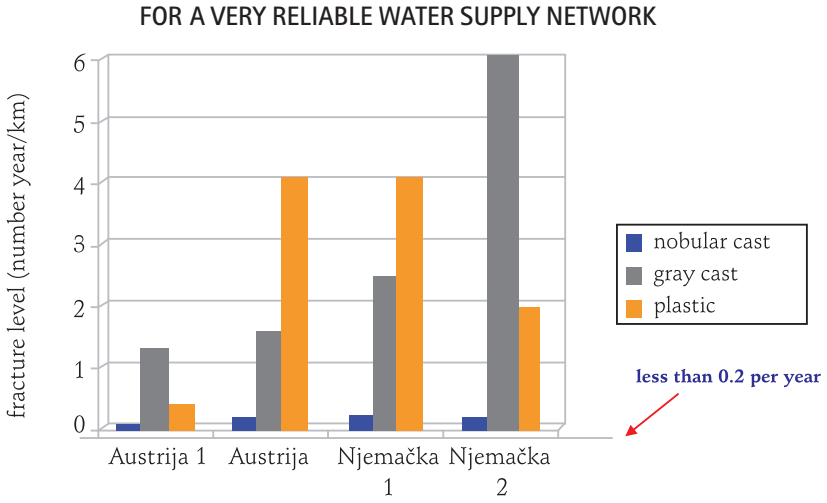

Figure 2. Fracture level of pipes of various materials in the water supply network

It is of particular importance that the friction losses of the ductile pipes are lower because their inner diameters are larger than the pipes with the same nominal diameters made of other materials. High flow coefficients also provide lower pumping costs and provide the most cost-effective solutions in terms of the cost of the lifetime of water supply system, and especially with demanding and costly regional water supply system "Plava voda", which gives them the advantage over polyester pipes.

According to the available data on the application of ductile water pipes, a fracture level diagram can be given, i.e. the number of fractures per year per km of pipeline route in developed countries such as Austria and Germany, comparing nodular cast (ductile iron), gray cast and plastic pipes, as shown n Figure 2.

Based on the diagram in Figure 2, we conclude that the minimum pipe burst (fractures) occurs in water pipes made of ductile cast, which gives complete validity of the use of this material in relation to the polyester pipes planned by the Main project of the regional water supply „Plava voda".

3.2. THE RECENT APPLICATION OF DUCTILE WATER PIPES

The application of ductile water pipes in the region and in the European countries is very high, especially when the quality and durability of the water supply system is required. There are many types of application of ductile pipes for water supply systems, and for example, by decision of the Tuzla Municipal Council in January 2014, on the adoption of the amendment to the regulatory plan for the subsidence area in Tuzla, the old town area Hendek-Pazar in Tuzla, the use of ductile cast pipes is planned. Also, by decision of the city council of Tuzla in June 2016, on the adoption of the regulatory plan for the unrealized part of Pecara 2 spatial unit in Tuzla, ductile water pipes are planned, primarily due to their good mechanical and hydraulic characteristics and excellent properties during the long exploitation period and maintenance of the water supply system.

On the territory of Sarajevo Canton, about 115 km of water supply route is made with water ductile pipes with the diameter of DN 80 mm to DN 600 mm, and with plastic pipes only 11 km of water supply line. In the area of Vogošća municipality, more precise in the area of Donji Hoton, the reconstruction of the water supply network with the request from tendering documentation is planned and done (from October 2015) exclusively with ductile pipes according to DIN EN 545 with tyton joint and with fittings made of nodular cast or ductile iron. According to data from JP „Vodovod i kanalizacija" Sarajevo, since 1992, according to the technical norms of this company, the obligation is to install ductile pipes, which are also the highest quality pipes on the world market. This also applies to the reconstruction of the water supply network in the city of Sarajevo, due to the large losses in the water supply network, old and inadequate water pipes, and due to the sinking of the ground and fractures of water pipes. For this reason, ductile pipes are very elastic and have become an obligation to install in this water supply company.

Urban plan in Suha, Zadar (Croatia) from 2013, planned the installation of ductile water pipes.

4. CONCLUDING DISCUSSION

Considering the above mentioned characteristics of both polyester pipes and ductile pipes for the main transport pipeline of the regional water supply system "Plava voda", the following can be concluded:

- Application of polyester pipes for regional water supply systems, and especially for the main transport pipeline, is rare in the world, because the exact behavior of these materials over the long period of time is still unknown.
- Today, mainly for main lines in the water supply system, ductile pipes are used, as can be seen from several examples listed in our country and the region.
- Ductile water pipes have a high load capacity, very well tolerate deformations and soil sinking in relation to other pipe materials, and especially for those materials (such as polyester) for which we cannot with reliable and proven experience determine the behavior on soils that are subject to subsidence or sinking.
- According to the available data and tests, pipes of ductile iron have the best tolerance to concentric and distribution loads, as in the case with the water supply system "Plava voda", and its main transport water line.
- According to the standard NF EN 545-2007, pipes and fittings made of ductile iron give an important safety margin from other water pipes and fittings.

- The construction of a regional water supply system is a great investment that needs to be permanent and safe. Thanks to the qualities of ductile iron, the pipelines can withstand unplanned situations both on the construction site and during their exploitation for several tens of years in advance, such as unexpected excessive pressures in the network, a water impact, shifting of the trench excavation bottom, placing the pipeline in contact with the rocks which can cause the pipe to burst or its cracking, which is not the case with ductile pipes (ductile iron pipes) due to their flexibility.
- Nodular cast does not get old and over time maintains its mechanical strength.
- The standard ductile pipe joints have a high degree of angular motion, where no fittings are required, and it is possible to adapt to any change in the terrain configuration. Standard joints of ductile pipes absorb soil or unstable and poor bearing/supporting soils, and these joints with a bend have a good adaptation of the pipeline to the deformations that occur due to the movement of soil.
- Today, worldwide, from Europe to the United States and Japan, the highest use of pipelines for main transport water supply systems is from ductile iron (nodular cast) due to its high reliability, which has been proven over the past 50 years.

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METHODOLOGY OF LANDSLIDE SUSCEPTIBILITY MAPS CREATION IN SMALL SCALE ON MUNICIPALITY PROZOR-RAMA EXAMPLE

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SUMMARY

As part of the research for the project "Translational management of the land use risk through the creation of landslides susceptibility maps", within the Interregional IPA cross-border cooperation program Croatia - Bosnia and Herzegovina - Montenegro 2014 - 2020, data which define the methodology for Landslide Susceptibility Map (LSM) scale 1: 100,000 for the whole of Bosnia and Herzegovina, were collected and processed.
Susceptibility maps show the spatial probability of landslide occurrence. They are made in different scales, which primarily depend on the purpose and size of the research area, but also on the scale and detail of the available input data. According to the given scale and in accordance with the available data, the map presented in paper was created by a heuristic (experiential) method. Input data, processing and analysis of data, as well as generating the landslide susceptibility map itself, was carried out in the GIS environment, and the size of the cells of all the grids that entered the analysis was 20 x 20 m.
Making landslide susceptibility maps (LSM) is an important step in defining spatial plans in which landslide occurrence is possible. Namely, the separation of areas subject to landslides is the basis of rational land use management with an emphasis on safe and planned construction. The paper presents the preliminary methodology for making the landslide susceptibility map on the example of the municipality of Prozor-Rama.

Key words: Landslide susceptibility maps, Spatial planning, GIS (Geographical information system)

1.INTRODUCTION

Landslides in the broader sense refer to mass movements on slopes and represent geo-hazardous events that can significantly affect the safety of people and their property. The well-known fact is that some of the consequences of climate change are extreme weather conditions and floods, which consequently leads to soil instability. The main triggers of the landslide are related to natural phenomena: the geological structure of the terrain and significant precipitation. The appearance of the landslide is also significantly influenced by the man, who through his interventions in the environment disturbs the natural state of the slope (inadequate drainage, overburden of the slope, illegal construction, cutting of the slope toe, etc.).

Adequate zoning of the terrain can assess the degree of landslide susceptibility, which is the first step toward the final goal - determining the zone of increased hazard and definition of risk. These activities allow planning to reduce the level of vulnerability of people and property. Landslide susceptibility maps are just the first, but necessary step in systematically managing hazards and landslide risks.

In order to develop an adequate methodology for developing a landslide susceptibility map, Faculty of Mining, Geology and Civil Engineering-University of Tuzla, together with partners (Croatian Geological Institute Zagreb, JU Institute for Geological Research from Podgorica and Development Agency Žepče)

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launched the project "Risk Management (HR-BA-ME59), within the IPA-CBC Croatia-Bosnia-Herzegovina-Montenegro 2014-2020 IPA Program, implemented from June 1, 2017. The project is worth 974,695.50€ of which 234,851.90€ is the Faculty budget. The project safEarth deals with the common cross-border challenges of landslide hazard in the region. Many landslides are located in densely populated areas and directly threaten people and property. Given this high risk, the project's goal is to identify and classify risk areas by designing and mapping of landslide susceptibility map (LSM), which is recognized as one of the priorities in risk management and prevention (Priority axis 2.1).

Creating landslide susceptibility maps (LSM) is an important step in defining spatial plans for areas in which there is possibility of landslides occurrence. Namely, the separation of areas subject to landslide is the basis of rational land use management, with an emphasis on safe and planned construction.

The proposed partnership consists of supporting and implementing the policies of each of the representatives. They will jointly define landslide risks due to climate change and floods in pilot areas through applied research, technology transfer, knowledge dissemination and simpler remediation measures.

The main objective of the project is to use cross-border cooperation in order to define a zone with critical landslide hazard, which creates the preconditions for widespread use of LSM in the region, for better management systems and risk prevention. Defining recommendations for authorities at the local and national levels in order to use this strategy for better land management and utilization, will be elaborated and implemented during the SafEarh project.

The main results of this project will be the production of LSM through specific applied research, which will be available to the public. LSM will have practical application in providing information to local authorities and citizens in areas such as spatial planning, protection of human health, biodiversity and nature. These maps are intended to be used before any major investment by individuals, municipalities, private companies, as well as major investments from the state relevance.

Creating landslide susceptibility also allows:

- definition of zones that are currently or potentially most vulnerable,
- reduction of damage to property and human victims,
- reduction of costs of landslide rehabilitation,
- introduction of measures to reduce the intensity and number of anthropologically initiated landslides and
- enables the production of other, related basic documents (more detailed engineering-geological and geotechnical studies, spatial plans, conceptual projects for large infrastructure facilities, environmental impact studies, etc.).

As an example for creating a landslide susceptibility map, the following section shows the area of the municipality of Prozor-Rama, where data collected and processed, enable the production of LSM maps of a scale of 1: 100 000. The paper presents geological and other relevant data that characterize the area, that were used for spatial analysis. The results of the descriptive statistical analyzes are also presented.

2. METHODS

In accordance with the scale (1: 100 000) and the current availability of data, an experiential (heuristic) approach was used, allowing the assessment of susceptibility without the use of a landslide cadastre. Since this approach is based on engineering experience, optimal results have been achieved through numerous iterations. Factors that are most likely to have an impact on the occurrence of terrain instability, such as the slope of the terrain, the lithological features of the area and the use of the soil [9], were taken to make the landslide susceptibility map. The use of GIS technology enabled the implementation of several iterative procedures, based on which valid conclusions were drawn for the development of the landslide susceptibility map for the municipality of Prozor-Rama.

The following Fact maps were used to create a landslide susceptibility map for a scale of 1: 100,000 (Table 1):

Source Factor Map	Original scale	Fact Sheet
Digital Relief Model (DMR)	1:25.000	Slope of the terrain
Basic geological map	1:100.000	Engineering geological units
Land Cover (CORINE Land Cover - CLC)	1:100.000	Land Cover

Table 1. Input data for making a landslide susceptibility map on a scale of 1: 100.000

The map of the slope of the terrain was obtained from the digital elevation model - DEM made on the basis of a 1: 25.000 topographic maps, the size of the grid cell 20 x 20 m.

The basic geological map (Prozor and Livno sheets) was used as the basis for the definition of engineering-geological units in the scale of 1: 100.000, and units were separated based on basic engineering-geological features. The land cover map is based on the CORINE Land Cover (CLC) 2012 base. This map is made according to the CORINE standards that define the output scale 1: 100,000, the minimum mapping area is 25 ha and the minimum width of the polygon 100 m. The CLC nomenclature includes 5 Class of 1 Level, 15 Classes of 2 Level and 44 Classes of 3 Level. The 3rd level of the CLC nomenclature was used for the purposes of making the landslide susceptibility map. All listed factors are classified, i.e. are classified into several groups of similar characteristics. Each of these classes has been assigned the appropriate number of points that quantified its impact on the landslide occurrence. The highest number of points is assigned to classes that represent the most unfavorable factors of the factors regarding the landslide susceptibility, and the smallest number of classes that represent the most favorable factors. There is a range of points for all factors between 0 - 40.

The influence of each individual factor on landslide susceptibility is defined by weight factors. It was found that the slope of the terrain most contributes to the landslide susceptibility, and then the lithological features defined through engineering-geological units. Land cover slightly contributes to sliding [10,11]. The weight factors 0.6: 0.30: 0.10 (slope: engineering-geological unit: land cover) were used to create a landslide susceptibility map for this area [1, 2].

3. RESULTS OF RESEARCH

The municipality of Prozor - Rama is located in the area with developed hill and mountain relief and steep deep valleys of the river Rama and its creeks. The relief of the central and eastern part of the municipality is characterized by quite steep slopes and clear surface erosion. The western part of the municipality belongs to the high karst zone with a lack of surface flows and numerous karst phenomena on the terrain surface. In hypsometric view, the relief in the area of the municipality was developed between elevation of 200 to over 1500m. [6]

3.1. SLOPE OF THE TERRAIN

The slope of the terrain is described by continuous values that are divided into 4 classes for well and poorly petrified rocks [3], Table 2. The poorly-petrified rocks are represented by the gray fields in Table 2.

Class	Slope [°]	Surface [km^2]	Number of points
1	0 – 0,1	15,84	0
2	0,1 – 25	103,58	10
3	0,1 – 30	268,23	10
4	25 – 30	23,20	20
5	30 – 35	15,82	30
6	30 – 44	50,66	20
7	35 – 90	11,70	40
8	44 – 60	3,51	30
9	60 – 90	0,50	40

Table 2. Classification of the slope angle and number of points associated with each class

Unfavorable slopes with a range of 30 and 40 points in poorly petrified rocks cover classes 5 (slope angle 30° - 35°) and 7 (slope angle 35° - 90°). In well-petrified rocks, these are classes 8 (slope angle 44° - 60°) and 9 (slope angle from 60° - 90°). The total area covered by these slopes is about 31.53 km^2, or 6.4% of the surface of the municipality of Prozor - Rama.

3.2. ENGINEERNIG-GEOLOGICAL UNITS

Engineer-geological units are defined on the basis of selected members from the basic geological map of the sheets Livno and Prozor, scale 1: 100.000 [4, 5, 7, 8]. The unified geological legend for a wider area consists of 34 lithostratigraphic members that, after analyzes, were classified into 8 engineering geological units (Table 3, Figures 1 and 2).

IG unit	Mark on the map	Engineer-geological units	Number of points	%	Surface km^2
1	-	Water	0	3	16,25
2	R1	magmatic and metamorphic rocks alluvial sediments	10	2	7,45
3	R2	carbonate rocks	15	49	237,44
4	R3	clastic rocks, large grain size, bound	20	11	52,46
5	R2a, R3a	clastic rocks, large grain size, poorly bound weak carbonate rocks	25	17	82,91
6	R4	changes in hard and weak rocks	30	9	45,22
7	R5	clastic rocks, large grain size, unbound	35	4	17,80
8	R6	weak metamorphic rocks clastic rocks, large grain size, poorly bound	40	5	22,19

Table 3. Engineer-geological units (IGU), number of points and area associated with each class

18% of the surface of the municipality of Prozor-Rama belongs to unfavorable terrain from the aspect of landslide susceptibility (classes with 30, 35 and 40 points). These terrains are built from different lithological groups. Characteristic are changes in hard and soft rocks, the presence of poorly bounded clastic rocks and weak metamorphic rocks.

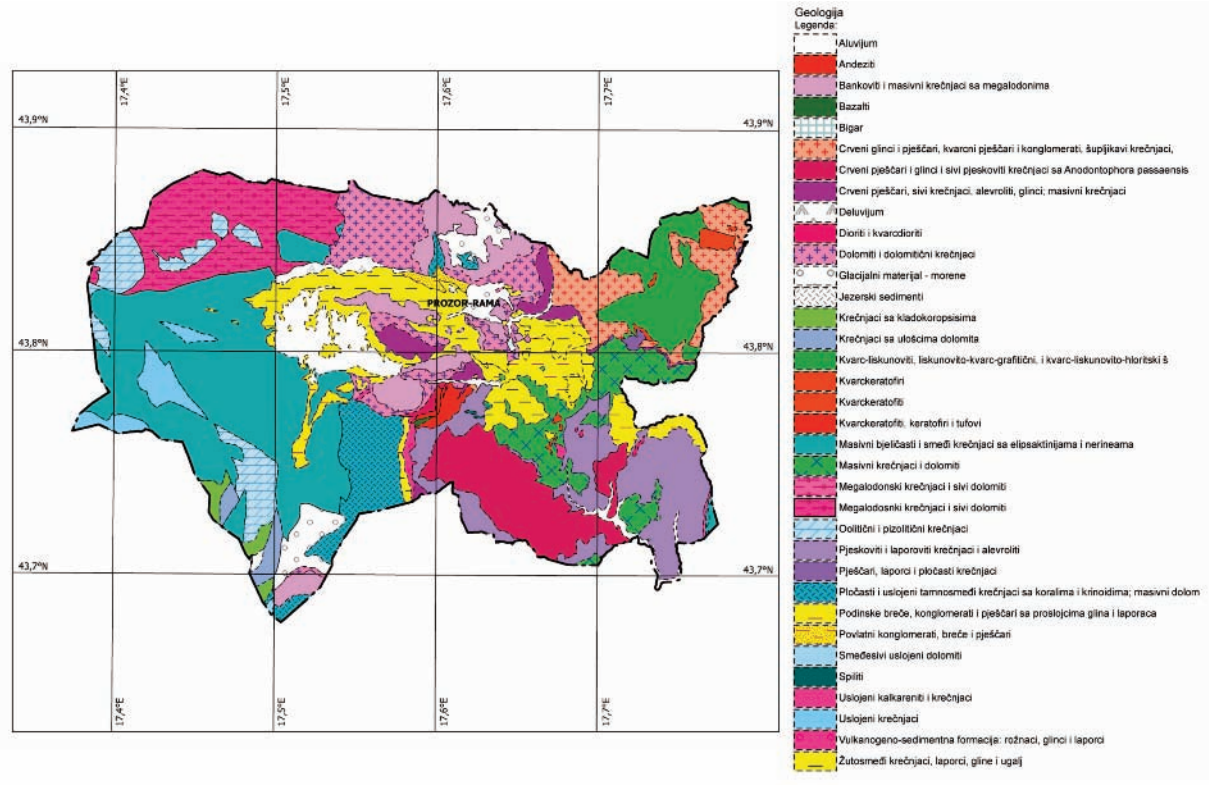

Figure 1. Basic geological map of Prozor-Rama municipality

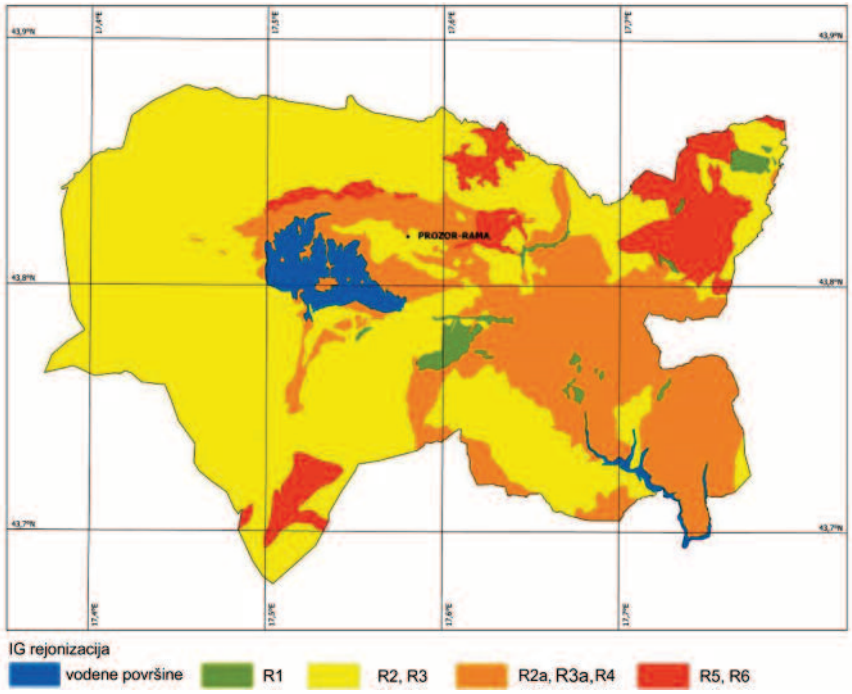

Figure 2. Schematic presentation of the separated engineering-geological units of Prozor-Rama municipality

2.1. LAND COVER

The initial land cover classes are based on 44 classes 3.level, which are reduced to 5 classes by reclassification (Table 4).

Class	Code	Naziv klase CLC	Class name CLC	Broj bodova
1	512	Vodna tijela	Water bodies	0
2	112	Nepovezana gradska područja	Discontinuous urban fabric	10
	231	Pašnjaci	Pastures	
3	222	Voćnjaci	Fruit trees and berry plantations	20
	311	Listopadna šumska vegetacija	Broad-leaved forest	
	312	Četinarska šumska vegetacija	Coniferous forest	
	313	Mješovita listopadna i četinarska šumska vegetacija	Mixed forest	
	324	Sukcesija šumske vegetacije	Transitional woodland-shrub	
4	242	Grupe obradivih parcela	Complex cultivation patterns	30
	322	Visokoplaninska šumska vegetacija i vrištine	Moors and heathland	
5	243	Poljoprivredne površine sa značajnim udjelom prirodnog biljnog pokrova	Land principally occupied by agriculture, with significant areas of natural vegetation	40
	321	Prirodni travnjaci	Natural grasslands	

Table 4. Land cover classes and number of points associated with each class for the municipality of Prozor-Rama

From Table 4, it is visible that 60% of the land is built from orchards (fruit trees and berry plantations), broad-leaved forest vegetation, coniferous forest vegetation, mixed deciduous and coniferous forest vegetation and from transitional woodland-shrub. Classes with the highest scores in terms of landslide susceptibility (30 and 40 points) occupy 35%, between 9% and 26% of the total area. They were built from groups of moors and heathland, group of cultivated plots, and natural grasslands and land principally occupied by agriculture, with significant areas of natural vegetation.

Detailed descriptions of individual groups are given in Table 5.

Classa	Surface / km^2	Points
1	15,84	0
2	10,28	10
3	288,93	20
4	41,78	30
5	124,90	40

Table 5. Surfaces of the CLC class and points for the municipality of Prozor-Rama

2.2. LANDSLIDE SUSCEPTIBILITY MAP

The graphic part of the landslide susceptibility map (Figure 3) consists of:

- basic map - landslide susceptibility map for the scale of 1: 100.000 with a legend (base map);
- service maps - three factor-based maps of input parameters in scale 1: 350.000: slope map, map of IG units and map of the land cover
- survay map of Bosnia and Herzegovina in the scale: 1: 2.000.000, with marked position of the municipality of Prozor-Rama, for which a landslide susceptibility map was prepared.

The total number of points of each cell obtained in the described manner represents the relative susceptibility to sliding for the area of 20 x 20 m. However, such an overlay is too complex for the defined scale, so for the final display of the landslide susceptibility map in the scale of 1: 100.000, five classes are separated according to the ranges shown in Table 6. The low landslide susceptibility is shown on the map in green, while for high the susceptibility he warm color used - orange and red were used. Some classes are called in qualitative terms such as very high, high, low, and very low. The water areas are colored blue and separated as unclassified.

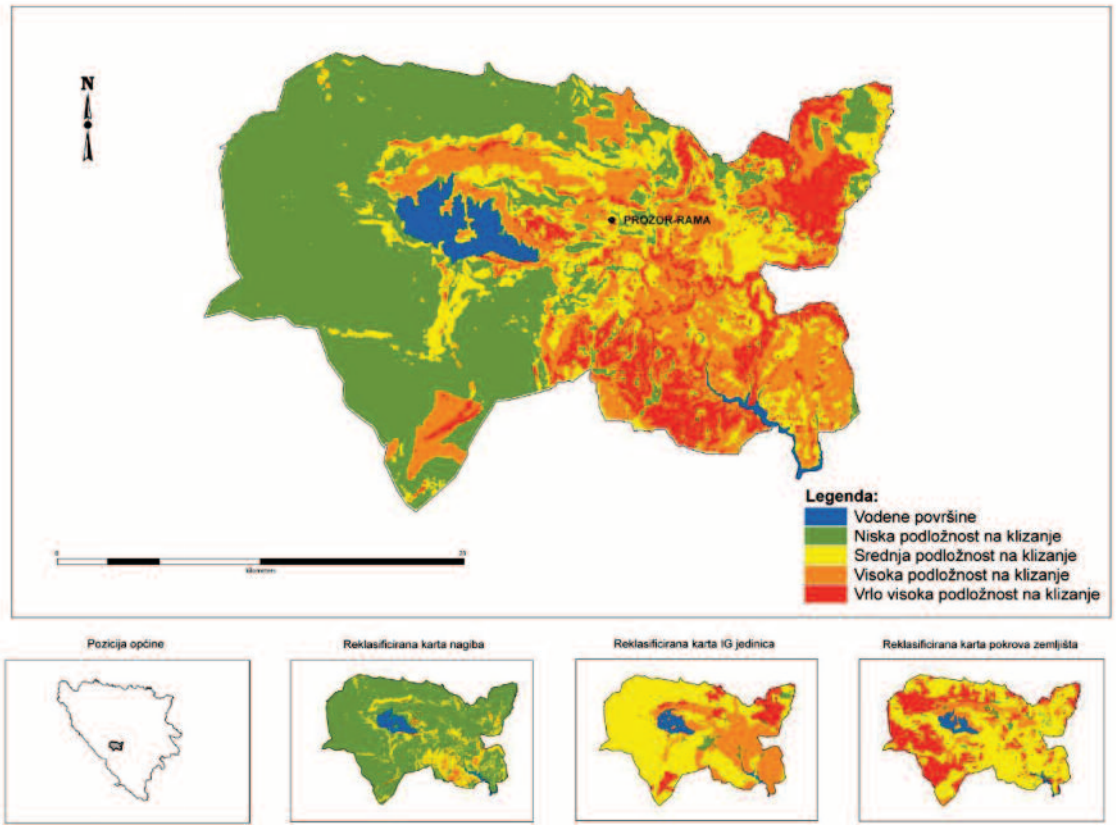

Figure 3 Landslide susceptibility map M 1: 100 000 of municipalitie Prozor-Rama

Klasa	Landslide susceptibility	Number of points	Surface / km^2	%
0	Water surface	0	15,84	3
1	Low	1-80	215,98	46
2	Medium	81-100	85,04	18
3	High	101-120	97,79	21
4	Very high	> 121	59,44	12

Table 6. Landslide susceptibility classes with associated colors

From the presented data it follows that 51% of the research area has medium, high to very high landslide susceptibility, and further research should be directed to these areas. From the landslide susceptibility map it can be seen that this primarily refers to the northeastern, eastern and southeast parts of the municipality of Prozor-Rama.

3. CONCLUSIONS

The landslide susceptibility map does not predict where landslides happen, so it is important to point out that the red areas on the map (very high landslide susceptibility slope areas) do not have to mean that there is a landslide or that nothing can be build on this ground.

Landslide susceptibility zones represent differences in the likelihood of a landslide occurrence in a given area, and it is not possible to predict in which time the landslide will be activated. It should also be pointed that, for the interpretation of the map, it is essential to know the input data and the methodology of making the map. For the purpose of single out the area susceptible to landslide, reclassification of factor maps requires generalization. In this way, specific locations within certain susceptibility areas may in reality have a different degree of susceptibility to the estimated.

The heuristic approach used to create landslide susceptibility map at scale 1: 100,000 implies engineering experience, and this subjectivity is also the main deficiency of the method. However, given the level of landslide susceptibility estimation, that can be displayed at a scale of 1: 100,000, and the ability to make estimates without the use of landslide cadastre, the chosen approach justifies the high cost-benefit ratio and cost of production.

Landslide susceptibility maps at scale 1: 100,000 cover the landslide susceptibility at state, entity, cantonal and municipal / city level, and therefore cannot or may not be used to estimate the stability of a specific location. In this context, the regional map of susceptibility to landslide cannot replace detailed engineering geological and geotechnical research.

The Landslide susceptibility map at 1: 100,000, as a basis, may also be used for:
- creation of segment of cantonal and municipal / city spatial plans related to geotechnical features of the area, terrain stability, space management, definition of special construction conditions,
- to point out the problem areas in terms of slope stability (sloping slopes) at cantonal and municipal level / city level,
- choose locations where detailed engineering-geological surveys are required and create landslide susceptibility maps in a large (1: 25,000) and detailed scale (1: 5000),
- development of disaster risk management strategies (as one of the basics),
- planning regional development projects,
- defining engineering constraints for large projects and
- informing the local community structure and the public at large.

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CHROMIUM (CR) AND NICKEL (NI) IN TUZLA'S URBAN AREA SOILS

Željka Stjepić Srkalović[1], Dado Srkalović[2], Elvir Babajić[3]

SUMMARY

Research on potentially toxic elements chromium and nickel and laboratory testing of their concentrations was carried out in urban part of the Tuzla city, with the aim to detect and determine their quantities, which gave the basis for discussion about origins of these pollutants in the soil. The geochemical - pedogeographic soil researches (soil sampling) were made in the urban area of Tuzla (on the area of about 100 km^2), in the proper network of 1x1 km, and according to URGE instructions. Concentration of Cr and Ni are obtained by the most sophisticated laboratory method (ICP-MS), with a highly sensitive detection threshold (0.1 to 10,000 ppm). The evaluation of test results showed that concentrations of Cr (max. 1582 ppm, min 145 ppm, average 417,9 pmm) and Ni (max 1005 ppm, min 40,8 ppm; average 309,5 pmm) are significantly increased in every sample compared to the concentrations prescribed in the Regulations on determination of allowed amounts of harmful and hazardous substances in soil (Cr max = 100 ppm and Ni max = 50 ppm). The increased concentrations of Cr and Ni are primarily a consequence of anthropogenic impacts in enviroment, i.e. pollution caused by industrial growth, traffic, improper waste disposal etc.

Key words: potentially toxic elements, Cr and Ni, soil, Tuzla, concentration, genesis.

1. INTRODUCTION

The area of Tuzla geographically belongs to the region of north-eastern Bosnia, i.e. to the subregion of the Spreča-Majevica region. Tuzla is located in the valley of the Jala river. From the northeast, it's surrounded by medium high mountain morphostructure of Majevica, and from the south by the Spreča valley. The urban area of Tuzla is located between 18°56′ and 18°79′ E and 44°48 'and 44°60′ N, at an altitude from 202 and 480 m. The urban area of Tuzla covers about 98.37 km2 and it's located on the northern slope of the Dinarid mountain system, and is generally mildly tilted towards the Gornja Spreča valley [9]. There are about 110,979 inhabitants living in 66 settlements in this area [7].

The area of Tuzla and it's wider surrounding is marked by the processes of urbanization and deruralization, industrialization and deagrarization, which are contributing mostly to the pollution, degradation and devastation of soil [11]. Due to the correct data interpretation, the geological and pedogeographic characteristics of the researched area had to be considered.

The main goal of the research was to determine to which extent the urban area of Tuzla is contaminated with the potentially toxic elements of chomium (Cr) and nickel (Ni). Considering the defined goal, the detailed soil analyze for the presence of potentially toxic elements of the Tuzla's urban area, was carried out. On the research results basis of the presence and quantity of the mentioned elements, it has been concluded that the Cr and Ni concentrations have been overly exceeded on the entire researched area. This paper gives an review on the origins of these two, scientifically proven, highly toxic elements.

Potentially toxic elements are dangerous for humans, plants and animals depending on their concentration, bioavailability and bioaccumulation.

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2. GEOLOGICAL SETTINGS AND PEDOGEOGRAPHIC CHARACTERISTICS

2.1. GEOLOGICAL SETTINGS

The oldest structures belong to the Tuzla's lower miocene formations in which organogenic limestones are prevailing ("slavinovićki" limestones and dolomites) with sporadic marls. Above them, the clasts were deposited with characteristic reddish coloring sandstones and conglomerates, building the "red" series. The continuation of the sedimentation cycle is made of a "trakasta" series, where the salt formation with accompanying dolomite, anhydrite and tufts are developed. The organogenic limestones, clays, marly clays, sands and subsidiary conglomerates are belonging to the youngest miocene products

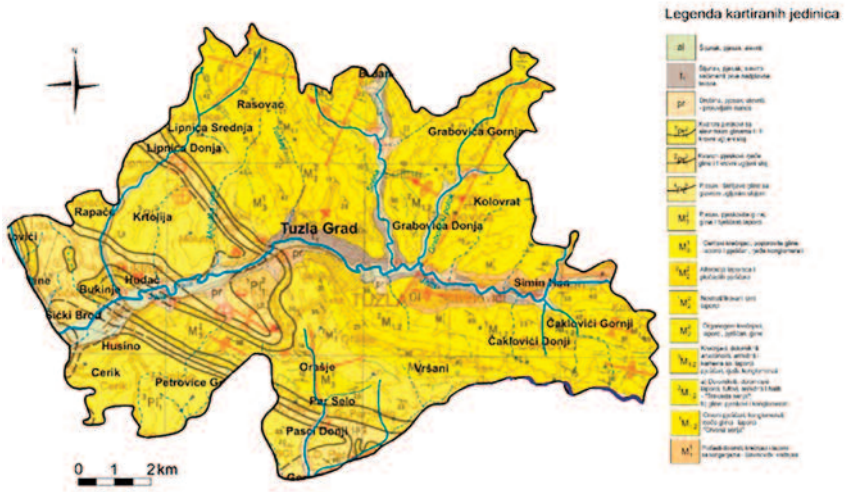

Fig. 1: Geological map of the Tuzla's urban area

The development of the lower pliocene is characterized by the deposition of several seams of lignite (main, base and top seams). Vertical development of the pliocene formation has the characteristics of rhythmicity: quartz sand, clays (slate and alevrite) and lignite. Quaternary formations were developed along the streams in the form of proluvial depositions (debris) and as precipitated terrace and alluvial sediments (sand and pebbles) (Fig. 1) [1, 10].

2.2. PEDOGEOGRAPHIC CHARACTERISTICS

On the pedological map (R - 1: 50 000) of the Tuzla's urban area, there are 16 (mostly automorphic) soil types (Stjepić Srkalović, 2015) (Fig. 2). The most common types of soil in the researched area are yellowish-brown soils on sands and sandstones, brown degraded soil on clays and loams, brown medium deep and deep soil on limestones, grey-brown carbonate soil, grey-brown deeply-soaked soils, pelosols and vertisols. It should be noted that high percentage of this soils is covered with urban infrastructure and isn't used for agricultural purposes.

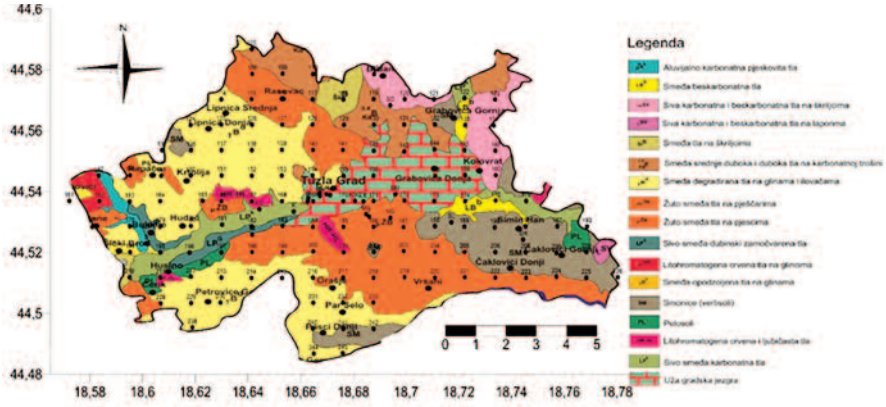

Fig. 2: Pedological map of the Tuzla's urban area

3. RESEARCH METHODS

The methods of research and laboratory testing included the analysis of previous research findings, terrain observation, sample preparation for laboratory testing, laboratory research and textual and graphical processing of results.

Terrain work was based on soil sampling (129 samples) from the area of about 100 km^2 (urban part of Tuzla) (Fig. 3a). The samples were collected according the composite sampling scheme i.e. 5 subsamples collected from the corners and the center of the square made 1 sample (Fig 3b). Samples were taken from a depth of about 30 cm and stored in PVC bags with the specified number, location, coordinates and other data.

Soil sampling was conducted according to the geochemical expert group (The Urban Geochemistry Project (URGE)) [5].

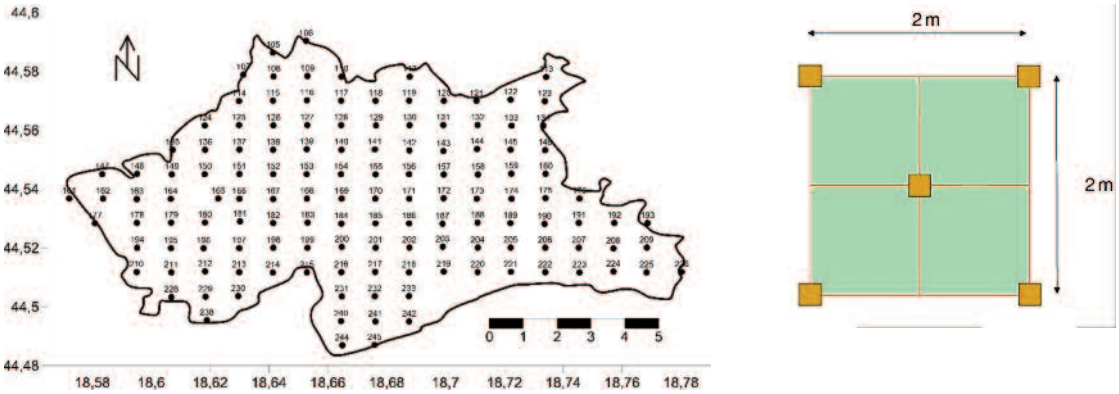

Fig 3. a) Sample locations and b) soil sampling scheme

Preparation of soil samples for laboratory analysis (sowing, drying, grinding, weighing) was carried out on the Faculty of mining, geology and civil engineering of the University of Tuzla.

Laboratory analysis was performed at Bureau Veritas Commodities Canada Ltd., Laboratory in Vancouver - Canada, by Ultra trace ICP-MS method (Inductively Coupled Plasma - Mass Spectrometry), code MA250. The detection limit of this method for Cr and Ni is 0,1 – 10.000 ppm.

The graphical processing of the results was made in the Golden Software Surfer 12 software package.

4. RESEARCH RESULTS

The Cr and Ni concentrations were analyzed in 129 soil samples collected in the urban part of Tuzla and shown in Table 1. Graphic display of the Cr and Ni concentrations in the soil is shown in Fig. 4 and 5.

Sample	Cr (ppm)	Ni (ppm)	Sample	Cr (ppm)	Ni (ppm)	Sample	Cr (ppm)	Ni (ppm)	Sample	Cr (ppm)	Ni (ppm)
105	633	599.7	147	437	724.9	186	505	351.2	224	164	51.1
108	248	174.8	148	428	395.6	187	1307	839.2	225	462	159.2
109	664	570.9	149	465	351.0	188	531	287.8	226	224	247.0
110	165	231.4	150	301	183.7	189	1160	1005.0	228	259	183.3
112	251	261.0	151	391	168.9	190	456	403.7	229	237	132.3
114	528	218.5	152	1582	82.1	191	412	305.3	230	380	313.0
115	776	574.5	153	430	297.2	192	215	197.2	231	536	229.6
116	796	763.5	154	295	266.1	193	471	315.1	232	316	71.1
117	223	225.0	155	451	451.6	194	399	312.6	233	224	40.8
118	202	241.9	156	216	241.3	195	337	421.2	238	352	136.8
119	211	199.2	158	282	312.1	196	547	145.1	240	321	71.5
120	533	510.9	159	224	224.5	197	1126	190.0	241	375	128.4
121	618	469.8	160	215	201.8	198	355	300.6	242	461	300.8

Sample	Cr (ppm)	Ni (ppm)	Sample	Cr (ppm)	Ni (ppm)	Sample	Cr (ppm)	Ni (ppm)	Sample	Cr (ppm)	Ni (ppm)
122	178	233.9	161	412	169.5	199	341	344.1	244	412	229.8
123	154	199.5	162	350	191.9	200	567	551.3	245	575	372.8
124	253	58.0	163	521	699.1	201	469	180.5			
125	182	113.5	164	504	505.1	202	453	434.0			
126	649	607.3	165	282	88.3	203	385	400.4			
127	599	452.5	166	410	238.5	204	332	272.7			
128	278	244.6	167	599	426.0	205	359	200.9			
129	284	274.0	168	488	124.8	206	294	277.8			
130	242	249.4	169	384	123.8	207	193	208.4			
131	185	193.8	170	467	311.0	208	348	368.4			
132	307	345.4	171	555	402.8	209	450	267.8			
133	247	220.8	172	619	453.7	210	281	239.4			
134	149	205.2	173	509	440.8	211	518	560.8			
135	397	250.2	174	288	247.0	212	179	117.8			
136	492	158.9	175	940	809.8	213	300	164.1			
137	259	75.6	176	1159	833.4	214	520	834.6			
138	359	153.8	177	139	77.1	215	252	222.5			
139	272	214.1	178	423	315.6	216	166	108.5			
140	570	587.8	179	613	571.6	217	693	434.1			
141	286	311.5	180	393	184.4	218	377	268.8			
142	203	197.6	181	596	235.8	219	422	371.5			
143	222	265.2	182	336	398.7	220	378	402.1			
144	279	241.2	183	522	426.5	221	485	280.9			
145	253	275.9	184	333	146.8	222	477	345.6	Median	380	265,2
146	145	195.9	185	464	342.9	223	237	288.3	Avg.	417,9	309,5

Table 1. Cr and Ni concentrations in soil of Tuzla's urban area

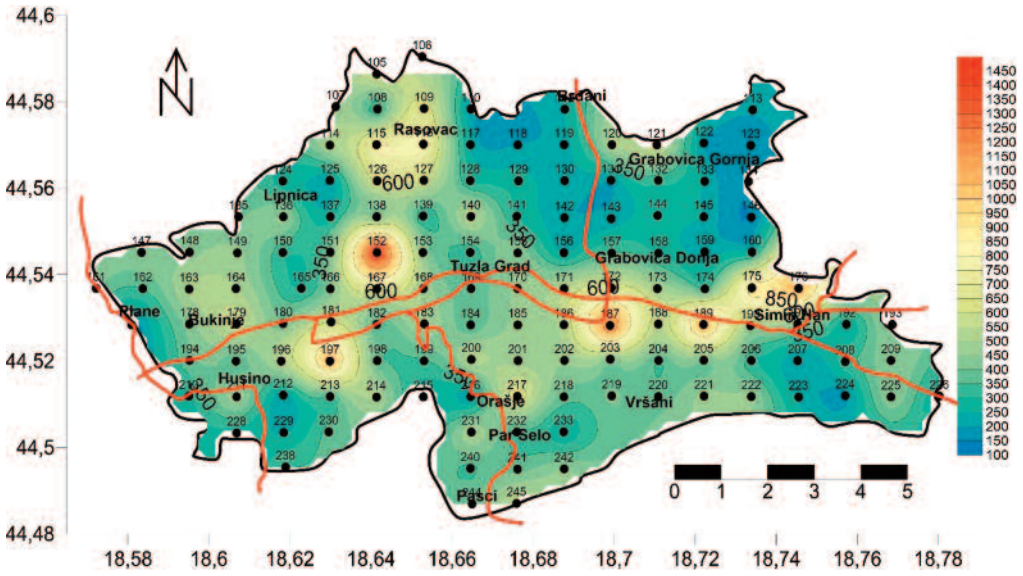

Fig 4. Cr concentrations in Tuzla's urban area soil samples

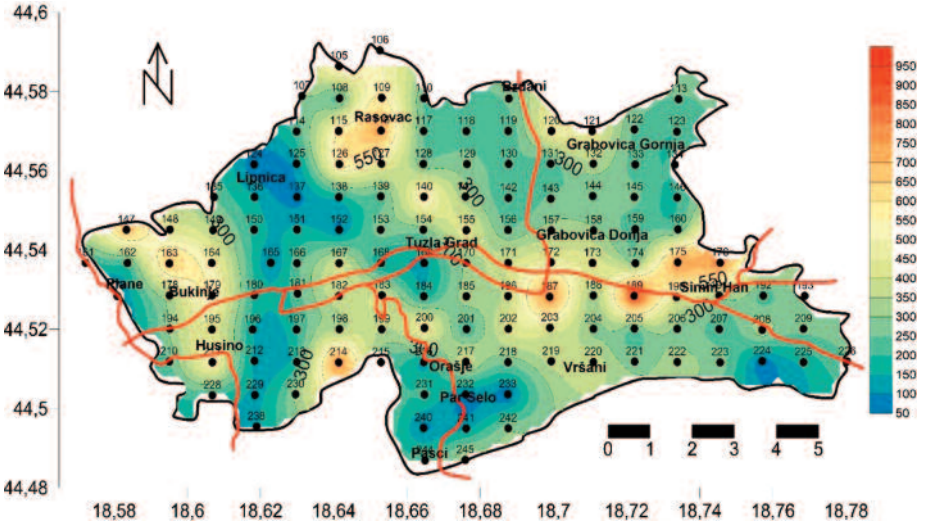

Fig 5. Ni concentrations in Tuzla's urban area soil samples

5. DISCUSSION

Chromium is a lithophile element. Geohemically associates with Fe and Mn, and it is an indicator for ultramafic and to a lesser extent mafic igneous rocks. Average content of chromium in rocks is shown in Table 2.

Concentration of chromium in soils depends on the parent rock. Concentration range is wide (5 ppm -1%). The average value is about 40 ppm. It can be reduced, oxidized, left in solution or adsorbed on mineral and organic complexes. Most of chromium is found in parent minerals: chromite - $FeCr_2O_4$ (up to 46.5% Cr), magnetite - Fe_3O_4 and ilmenite - $FeTiO_3$. His mobility is low.

Chromium appears in pyroxene, amphibole, mica, chlorite, spinel. During magmatic crystallisation is fractionated in the first stages. It hydrolyses at pH 5.5. By alteration of mother rocks, chromium is fixed in clay minerals, as the final products of rock decomposition. The higher concentrations of chromium are related to fine grained (pelite) products of decomposition. In normal conditions chromium is not toxic, unless in the above mentioned ultramafic rocks and their derivatives - serpentinites. Toxicity depends on the valence state: Cr^{3+} is untreated, Cr^{2+} and Cr^{6+} are highly poisonous. Chromium is an essential micronutrient for energy metabolism of organisms (plants, animals and humans). Cr is dispersed in enviroment by industrial waste waters, alloy decompositions, fosill fuel power plants and waste incineration [3, 12].

Rocks								
igneous	Cr	Ni	sedimentary	Cr	Ni	metamorphic	Cr	Ni
ultramafitic	3000	2000	sandstones	35	2	shale	90	68
Toleite basalt	300	-	carbonates	≤ 10	10			
basalts	170	130						
granodiorite	20	15						
granite	4	5						

Table 2. Concentrations of Cr and Ni in rocks

According to geochemical properties nickel is siderophile element, but also can be halkophile and lithophile. It belongs to the feric group and associate with Mg, Fe, Co, Cr and V. The most important isotope is Ni^{2+}, because it's associated within largest number of minerals (sulfides, arsenides, silicates). Average nickel content in rocks is shown in Table 2.

Nickel is distinguished in the first stages of magma crystallization in peridotite-gabroid rocks. In exogenous conditions, nickel is transferred by surface waters and deposited in weathering crust at a pH of 6.5. For the behavior of nickel in exogenous conditions it is a significant character of the geochemical environment (alkalinity and oxidation-reduction potential). It is poorly movable due to strong adsorption on clay minerals and Fe-Mn oxides and hydroxides [4].

Concentrations of nickel in the most common types of soil ranges from 5 to 500 pmm, an average concentration is about 40 ppm. In soils formed over the ultramafic rocks, concentrations of nickel ranges from 100 pmm to 0.5%.

In magmatic crystallization, nickel usually enters in the olivine structure, but also can be incorporated in pyroxene and amphibole. Nickel concentrates in a sulfide mineralization together with Co, Cu and As. In deposited sediments nickel is related to the fine-grained fraction. It is poisonous for plants in concentration >50 ppm. Increased nickel concentrations may have genotoxic, neurological, reproductive, allergic and cancerous effects.

Ni is dispersed in the enviroment by industrial dust, waeste and waste waters and fosill fuel incineration [3, 12].

The concentrations of Cr in soil samples ranges from 145 to 1582 ppm (average 417.9 ppm, median – 380 ppm). the maximal values were recorded in the area of Moluhe (1582 ppm). The highest average concentrations of Cr were recorded in the eastern part of the city, close to the main roads (samples 176, 187 and 189) and highly exceed the limited values, and the lowest values are recorded in the northern and northeastern part of the town, where the concentrations are also above the limited values (table 1 and 3).

The concentrations of Ni in soil samples ranges from 40,8 to 1005 ppm (average 309,5 ppm, median 265,2 ppm). The maximal value was registered in the Slavinovići area (1005 ppm), and minimal values were recorded in the area of Čaklovići Donji (40,8 ppm). The highest Ni concentrations were detected by the road Brčanska Malta- Simin Han, and in settlements Bukinje, Husino, Pasci and Rasovac (Tables 1 and 3).

The general conclusion is that the exceeded concentrations of Cr and Ni are related to the city area that are connected to roads, depots and power plant „Tuzla". The intensity of recent exogenous processes, as well as anthropogenic activities, is less evident in suburban regions, where is evident small fall of the values of Cr and Ni concentrations in the soils (Fig 4 and 5).

Based on the isolines of average Cr and Ni values, a strong correlation between these two elements can be observed: high concentrations of chromium in most samples match with high concentrations of nickel (Figures 4 and 5). According to the regulations of determination of permissible quantities of harmful and hazardous substances in the ground and methods of their research [8], the limited chromium and nickel concentrations depending on soil structure are:

Heavy metal	Sandy soil (ppm)	Silty-loam soil (ppm)	Cleyey soil (ppm)
Cr	50	80	100
Ni	30	40	50

Table 3. The limited values of Cr and Ni concentrations in soil

The lowest concentration is 1,5 times higher than the maximally alowed concentration, and average value is about 4 times higher. Considering the limited concentrations (according the „Pravilnik"), the lowest concentration of nickel is a litlle bit lower (40,8 ppm) than it's maximally alowed, and average value of nickel is about 6 times higher.

Soil contamination in Tuzla's urban area is predominantly anthropogenic (gained concentrations from the soil samples highly exceed the values of Cr and Ni in geological substrate). This can also be concluded based on smaller differences in concentrations of Cr and Ni in soil samples in urban and suburban part of Tuzla.

6. CONCLUSION

The concentrations of chromium (Cr) and nickel (Ni) were analyzed in 129 samples collected in the urban part of Tuzla. Samples were taken in a proper network (1x1 km), on the area of about 100 km^2. The results of the soil analysis are processed in the Golden software Surfer 12 program package and are displayed on thematic maps. On the aforementioned maps it is apparent that the range of Cr concentration in the investigated area ranges from 145 to 1582 ppm with a median of 380 ppm and Ni from 40.8 to 1005 ppm with a median of 265.2 ppm.

The increased concentrations of Cr were determined in all 129 samples collected in the urban area of Tuzla. Maximum chromium concentrations, determined in the central and eastern part of the exploration area, were 15 times higher than the maximum of limited values.

The increased nickel concentrations were determined in 128 soil samples. Maximum concentrations of nickel were recorded in the Slavinovići, Bukinje, Husino, Pasci and Rasovac settlements, and along B.Malta - Simin Han main road. Considering that city of Tuzla was for a long period of time an industrial city, and locations of landfill sites, roads and thermal power plant, the increased concentrations of Cr and Ni in soil samples can be attributed to anthropogenic impact on the enviroment.

ACKNOWLEDGEMENT

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COMPARATIVE ANALYSIS MOTORWAY CONNECTION WITH THE MAIN ROAD IN ZENICA

Zahid Bašić[1]

SUMMARY

The study included research and analysis of the optimal solution of surface intersections, quadrangle and circular flow in relation to the already defined space, the connection of the Zenica-Sarajevo highway with the main road M17. The geometric elements of the connecting directions are calculated and adopted and aligned with the already defined available space. The aim of the paper is to carry out analyzes, presentations of evidence and presentations to determine the optimal solution of the surface intersection. Two cases of traffic flows were observed and presented. The first case concerns the formation of an intersection for the main traffic direction where it is necessary to carry out separate turning bands. This research solves the existing state of the node at the mentioned roads. The second case involves the formation of a crossroads of the circular flow, and for the reason of the previously established high intensity of traffic. On the basis of parameters, a one-way circular crossroads is selected, which, unlike the classical intersection, has a significantly smaller number of conflicting points and the size of the conflict area. The research also included proposals for the formation of transverse slopes at the surface intersection, and for the purpose of efficient drainage of surface and atmospheric waters.
In the concluding observations, the advantages of the intersection of the circular flow are defined in relation to the four-point intersection in terms of the total cost of carrying out the works, the occupancy of the surfaces, the price of signaling, the number of conflicting points and the maintenance cost.

Key words: crossroads, directions, analysis, solutions, roads

1. PRICE EXECUTED WORKS

On the basis of the pre-trial work, according to certain categories of installations and the whole, the operations of carrying out the works and their number as well as the types of materials and equipment whose consumption is predicted are stated. Projections are given for the prices of operations for the execution of works, materials and equipment necessary for the execution of works. On the basis of the case and the calculation for the four-way intersection and the circular flow it is evident that the price of the four-way crossroads is 555.675,12 KM, while the price of the circulating stream is 475.435,64 KM.

The diagram shows the cost of the four-way intersection and the circular flow.

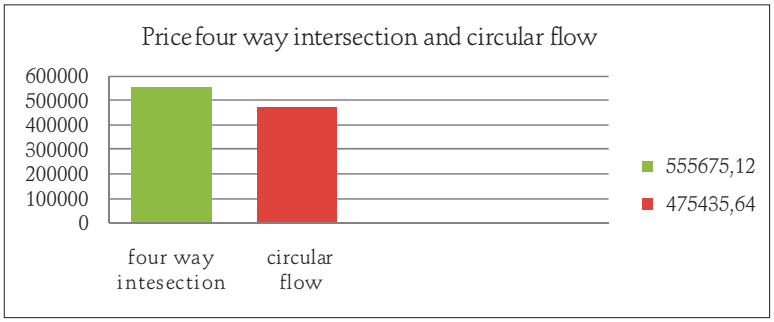

Figure 1. The prices of the four-way intersection and the circular flow

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Since the four-way intersection occupies a larger area than the circular flow, the works and cost of the goods are therefore higher. The price of works on the positions of earthworks is higher by 17,300 KM, while the price of construction of the pavement structure is higher by 20,935 KM.

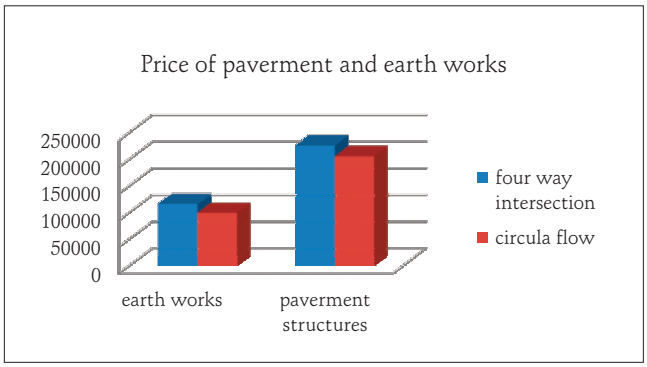

Figure 2. Prices of pavement structures and earth works

From Figure 2. it is evident that the price of earthworks at the four-way intersection amounts to 117,440 KM, while the price of the same at the circular flow is 100,100 KM. Also, the price of pavement structure is shown, which amounts to 227.290 KM for the four-way intersection, and for circular flow 206.355 KM.

2. SURVEILLANCE OF THE SURFACE

Based on the calculation of the take-up of the surfaces, it is evident that the circular current occupies a smaller area than the four-way intersection, as shown in Figure 3.

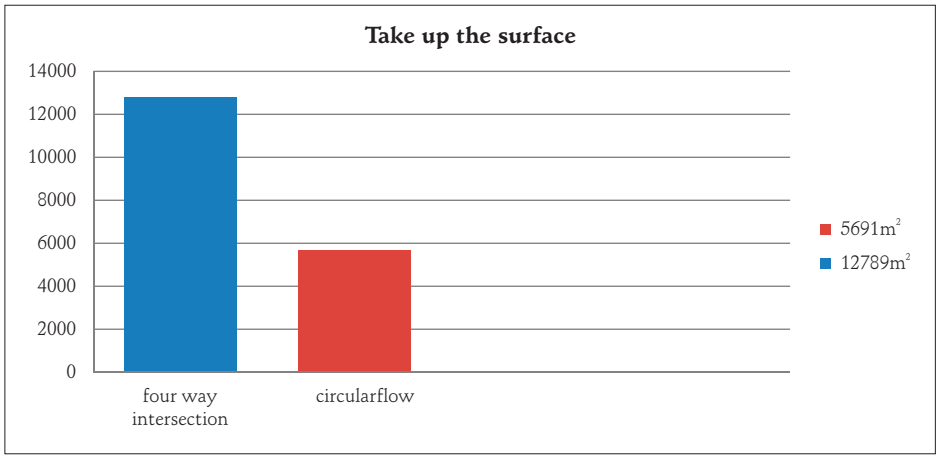

Figure 3. Take up the surface

The application of surface intersections with a circular flow is based on the general concept of narrower profiles between intersections that are larger in size compared to crossroads with intersection of traffic currents. On the other hand, traffic intersections intersect with a narrower conflict zone at which all intersection of the vehicle flows takes place and occupy a larger area than the circular intersections.

3. ROAD SIGNAL

Signalization of the road and the intersection is of great importance for the participants in the traffic. By means of signalization, the participant in traffic is able to find the desired path and direction of movement, to take appropriate actions and to act on the way as expected. The four-way intersection has a significantly higher number of elements of traffic signalization, and therefore the price is higher.

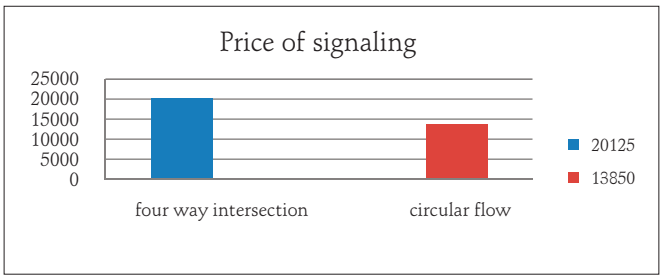

Figure 4. Price of signaling

4. NUMBER OF CONFLICT POINTS

The four-way intersection of the two-way roads has 32 conflicting points (16 crossings, 8 separations and 8 associations), while the circular intersection with one tape has only 8 points of lower order (4 separations and 4 associations). The crossroads have a higher number of conflicting points and the greater the conflict area, the level of traffic safety is lower. The level of traffic safety of crossroads can be increased by reducing the number of conflict points and by reducing the size of the conflict area. This is achieved by choosing the method of managing traffic flows, ie by designing and arranging the crossroads and selecting the type of intersection.

Due to the circular geometric form, the number of conflicting points in the circular flow is reduced compared to classical intersections. Circular currents with four connecting arms always have 4 separation points. In single and turbo circular currents, conflicting crossing points are avoided. The one-way circular flow has only 4 potential conflicting points of connection, 4 points of separation and no cross-linking conflicts.

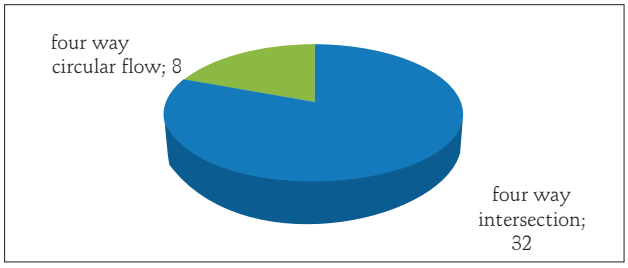

Figure 5. Conflict points of the four-way intersection and four-way circular flow

One four-way intersection of two-way roads contains 32 potential conflict points (16 crossings, 8 separations and 8 junctions), three-crossroads 9 (3 crossings, 3 separations and 3 merge).

Circular currents with three connecting arms always have 3 separation points. The one-way circular current has only 3 potential conflicting points of connection, 3 points of separation and no cross-linking conflicts. One three-way intersection of two-way roads contains 9 potential conflict points (3 crossings, 3 separations and 3 junctions).

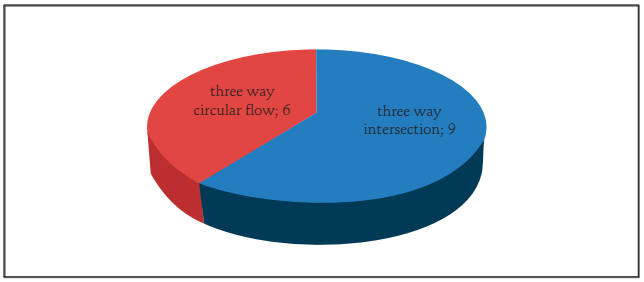

Figure 6. Conflict points of the four-way intersection and triangular circular flow

Figure 6. shows conflicting points of comparison of the three-way intersection and triangular circular flow. Due to the circular geometric form, the number of conflicting points in the circular flow is reduced compared to classical intersections.

5. PRICE OF MAINTENANCE

In the whole world, especially in Europe, the traffic network has been completed, so about 10% of the total funds for roads are used for road maintenance. Since it is a newly constructed road, it is foreseen that it will be allocated annually on maintenance roads of 10% of the total cost price. The diagram shows the maintenance cost for a four-way intersection and a circular flow. Maintenance of the four-way intersection is more expensive for about 8000 KM in relation to the circular flow on an annual basis.

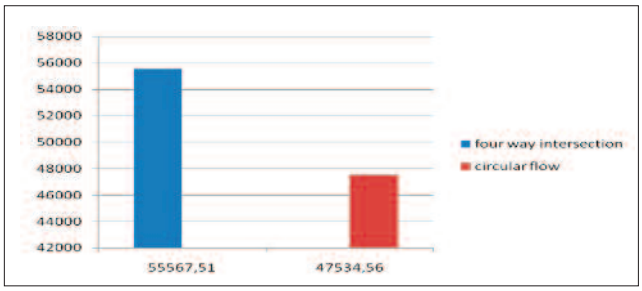

Figure 7. Maintenance price

6. CONCLUSIONS

The aim of this paper is to show optimal geometric solutions of the type of surface intersection in relation to the available space at a given location. The geometric elements of the connecting directions are adopted depending on the size and the available geometry. The maximum and optimal orientation of traffic flows, inlays and outflows was applied. The defined, defined and selected geometric elements of the surface intersection are calculated, in order to obtain an optimal geometry in comparison with the obtained results, in terms of the total cost of contracting and maintenance work.

Based on the subject of the research and presenting all the aspects defined by the motives of the research, the goals and purpose of the research, and after the extensive analysis and comparison of the results, the following conclusions were reached:

- The total cost of carrying out the works of the four-way intersection is 555.675,12 KM, while the price of the circulating stream is 475.435,64 KM. On the basis of these exact indicators, the price of the circular flow is lower by KM 80,239.48 (Figure 1). Prices of works by group of works, earthworks, pavement structure are also less at the crossroads of the circular flow compared to the four-way vertical intersection (Figure 2)
- Based on the calculation of the take-up of surfaces, it was determined that the circular flow occupies a smaller area than the four-point intersection (Figure 3)
- The price of signaling at the circular flow is 13,850 KM, while at the four-way intersection it is 20,125 KM, which means that the price is lower at the intersection of the circular flow (Figure 4)
- Four-way crossroads of two-way roads have 32 conflicting points (16 crossings, 8 separations and 8 associations), while the circular intersection with one strip has only 8 points of lower order - 4 separations and 4 associations (Figure 5)
- The maintenance price at annual level with the surface quadrangle intersection is 55,567.51, while at the crossroads of the circular flow it amounts to 47,534.56 KM, where it is visible that the maintenance costs at the intersection of the circular flow are lower.

In addition to the conclusions drawn about the advantages of the intersection of the circular flow in relation to the classical intersections, it is also evident in the following; increased traffic safety, high traffic density, continuous traffic flow, smaller surface for crossroads formation, lower noise, aesthetic value and a number of other benefits and benefits.

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CONSTRUCTION OF NEW REGIONAL ROADS IN FUNCTION OF THE INCREASING EFFECT OF GENERAL DEVELOPMENT AREA ON THE ROAD TRANSPORT CORRIDORS

Azmir Spahić[1]

SUMMARY

The paper analyzes the existing transport infrastructure and provides a predisposition to the potential inter-entity economic and social development between Maglaj, Zepce and Teslic Municipalities in Bosnia and Herzegovina as a result of the construction new route of the regional road in the form of a joint of regional roads R473 Bistricak – Nemila in Republika Srpska and R474 Jelah - Ozimica in the Federation of BiH . The merger of the regional roads R473 and R474 opens the possibility of faster economic and social development of the municipalities of Maglaj, Zepce and Teslic. Building a connection of regional roads through Novi Seher creates the possibility for potentially creating new values in other branches of industry primarily for mining, agriculture and forestry, because this would systematically make a solution of the traffic infrastructure problem of this region and thus eliminate administrative barriers for the start of exploitation of natural resources in this area (friendly environment, concessions on exploitation of mineral resources, etc.). Likewise, the potential regional branch would significantly reduce the existing length of the road between the towns of Meglaj, Zepce and Teslic and would open the possibility for faster access on the Vc motorway which route, according to the preliminary design, is precisely tangering the Novoseher Region and thus creating the conditions for faster access of people, goods and service to the pan-European transport corridor 5.

Keywords: Road, Regional Road, R473, R474, Construction, Inter-Entity Development, Maglaj, Zepce, Teslic.

1. ANALYSIS DEVELOPMENT STRATEGIES OF THE MUNICIPALITIES MAGLAJ, ZEPCE I TESLIC

Analyzing the developmental strategies of the Maglaj, Zepce and Teslic Municipalities, it can be concluded that they are practically a planning document of a local development policy that determines the strategic goals and priorities of the long-term sustainable economic and social development of these municipalities. These development strategies are practically the vision of the development of individual municipalities, which creates predispositions for the environment of a pleasant environment for the life, work and rest of its inhabitants.

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Figure 1. Potential area for a new regional route

However, if we withdraw the parallel between identified problems or challenges and practical development, we can conclude that the municipalities do not have very good results on the ground, as it is visible from the data of the competent Statistical Office that the negative natural increase of the population is evident in these areas. One of the reasons of negative natural population increase is that there are no inter-municipal development strategies. These strategies would, based on bilateral or multilateral strategies for the development of the regions, help and complement each other in certain segments (transport infrastructure, wastewater, landfills, electricity infrastructure, heating, etc.).

If we look at the topography of the Maglaj Municipality, Zepce and Teslic and the development of transport infrastructure, it is evident that the regional roads R473 Bistricak - Nemila in Republika Srpska and R474 Jelah - Ozimica in the Federation of Bosnia and Herzegovina practically represent two parallel roads to the inter - entity border without visible touching points (Figure 1). The municipalities are not responsible for the maintenance of regional and main roads. However, through their development strategies, they must be involved and instruct other competent institutions to make better road infrastructure in all of these municipalities.

1.1. POTENTIAL AND CONDITION OF THE EXISTING INTERCITY TRANSPORT INFRASTRUCTURE MAGLAJ – ZEPCE – TESLIC

Analysis of the movement of people, goods and services from the direction of Teslic to Maglaj shows that they must move along the main road M4 Prijedor - Tuzla and join the road M17 Bosanski Samac - Capljina in Matuzici. The length of the M4 traveled on this route is 20.6 km while the length of the M17 is 18.8 km. The total length of driving is 42.9 km, Figure 2. The time for crossing this route is about 51 minutes.

The analysis of the traffic infrastructure of Teslic-Zepce shows that one has to go over 67.3km by using the route of the regional road R473 including the section of the main road M17. The length of the regional traffic on the R473 is 38.9 km, while the length of traffic over the M17 is 17.3 km (Figure 3). The total time required to go over this route Teslic - Zepce is about 1 hour and 23 minutes.

The regional road R473 was badly damaged in May 2014. On that occasion, the sandy material was deposited in the riverbed, which was again deposited in the bridge zone at the hydro-power plant of the mini hydroelectric power plant and threatened to block the flow profile of the bridge. Likewise, the local river, which is of a torrential nature, has by its power greatly destroyed this regional road, pouring out of the riverbad and undermined the road itself.

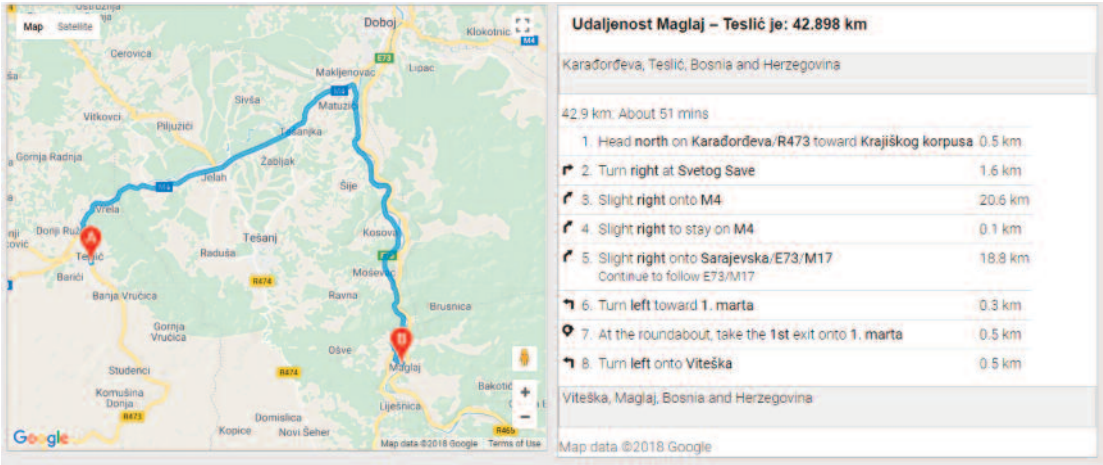


Figure 2. Route of movement of people, goods and services Teslic – Maglaj

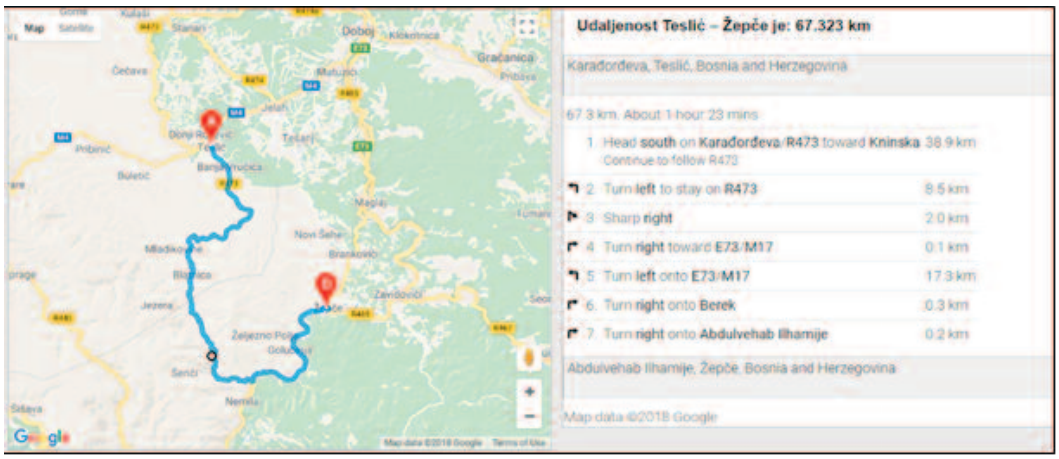


Figure 3. Route of movement of people, goods and services Teslic – Zepce

Figure 4. The regional road R473 after the May 2014 floods

It is important to point out that each of these three municipalities has a favorable geographical position because they are located in the part of Bosnia and Herzegovina, through which most of the traffic takes place in the north-south direction. What is even more important to point out is that the corridor route of motorway Vc which is planned to be constructed in the near future, is in the immediate vicinity of these municipalities and gives them an additional advantage and potential for local development.

The length of roads by categories within individual municipalities is presented by the following (Chart 1).

Chart 2 shows the area and the density of the population of individual municipalities.

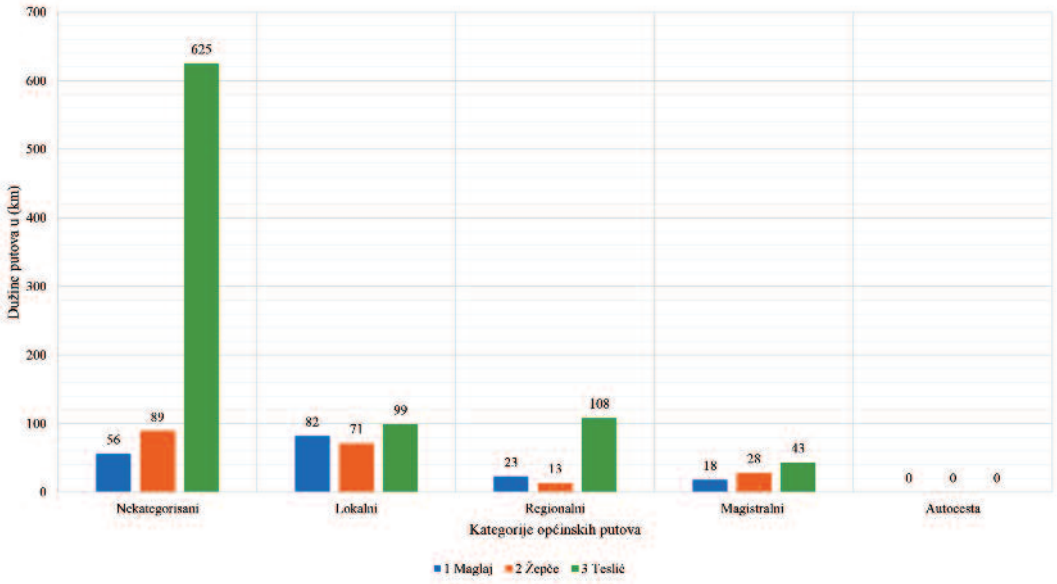


Chart 1. Traffic infrastructure of certain municipalities

Chart 2. Area and population density of individual municipalities

2. SOCIAL - ECONOMIC DEVELOPMENT POTENTIAL AS A PRODUCT OF CONNECTION OF REGIONAL ROADS R473 AND R474

Analyzing the natural resources of the area, it is evident that in the area of the Novosehersk basin as a central part of this region there are explored reserves of coal in proven reserves of about 2 mil. tons, a potential surface deposit of stones in reserves of about 10 mil. t, a lot of forest wealth, unprocessed agricultural land, etc.

However, due to the underdeveloped infrastructure in this area, precisely due to the difficult access to the R473 and R474 regonal roads, this natural potential has not been used (Figure 5). When finances are in question according to economic studies, this is the potential for creating new values of about 250 mil. KM out of which almost 75 mil. KM is deducted from various direct and indirect taxes that should end in the state budget. Creating a new value opens up the possibility of permanent employment of the local population. According to the analysis and economic study, it is about 120 new jobs.

Looking at the shortening of the road with movements of people, goods and services from the direction of Teslic to Maglaj, it is shown that the potential conection of these two regional roads, precisely through the Novosehersk region, reduces the road to 34.3 km, which is 8.6 km shorter compared to the existing section. Similarly, the section of the Teslic-Zepce road is reduced to 36.8 km, which is 30.5 km shorter road route (Figures 6 and 7).

Given that the area of the Maglaj Municipality has a relatively full industrial zone, this analysis opens potentially new areas around the area of Novi Seher for the creation of new industrial zones. The area around the settlement of Novi Seher and Domislica is definitely a favorable area, as the relief is fairly flat, and the potential route of the regional road connection would enable faster connection with the regional roads R473 and R474.

It is important to point out that three new potential routes for the connection of regional roads were analyzed, but this one, called Novosehersk, proved to be the most rational because it follows a part of the existing local and forest roads and the expropriation for the potential route of connection is reduced to a minimum.

Figure 5. Potential new regional road

Figure 6. Potential route of movement of people, goods and services Teslic – Maglaj

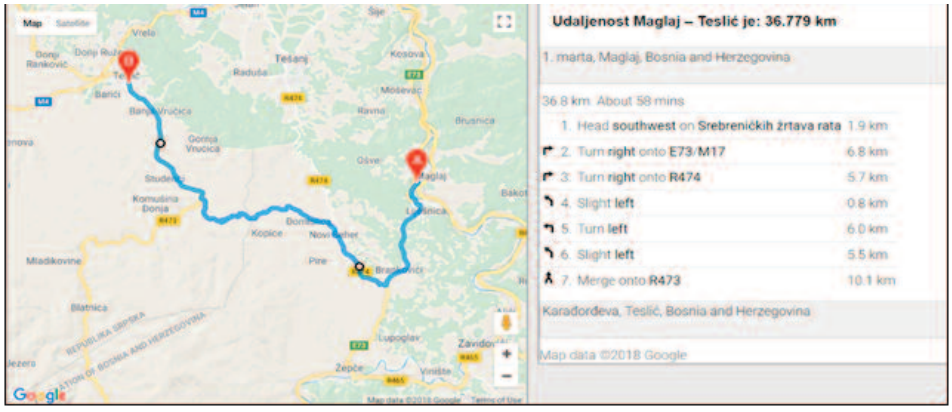
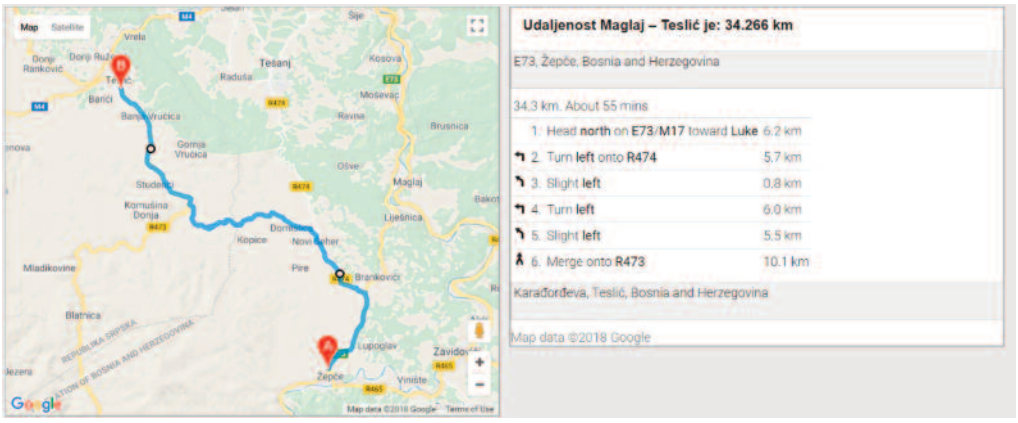


Figure 7. Potential route of movement of people, goods and services Teslic – Zepce



For the connection of the two existing regional roads R473 and R474 over the area of Novi Seher (FBH) – Domislice (FBH) – Brezove Dana (FBiH) – Dubrava (RS) – Kamenice (RS) it is necessary to

strengthen and adapt the existing macadam and partly asphalted local road and adjust it to the regional road category (Figure 8).

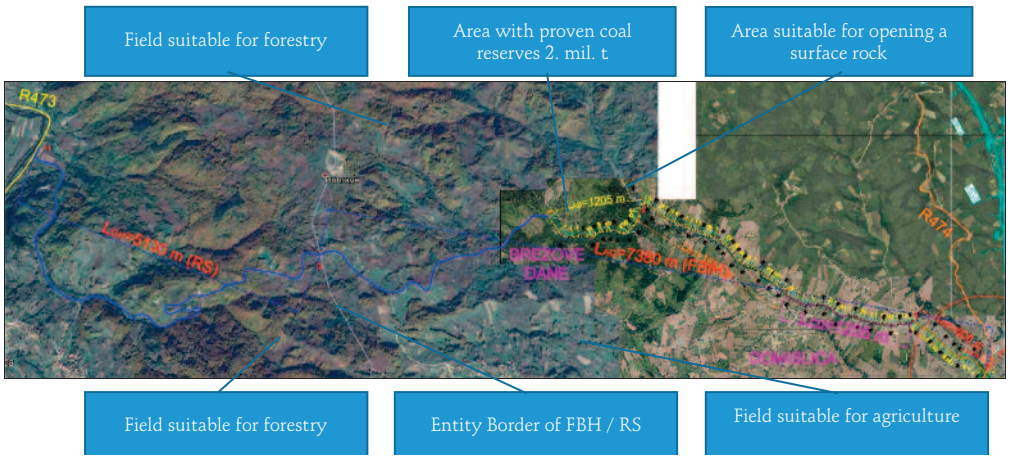


Figure 8. The route of connecting the regional roads via Novi Seher (FBH)-Domislica

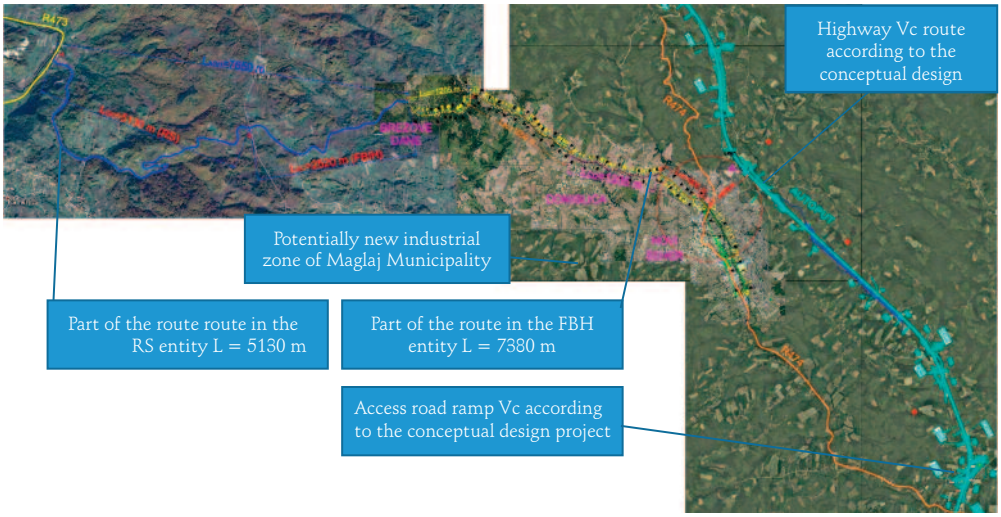


Figure 9. Selection of routes in RS and FBH and potential for development of Novoseher region

Furthermore, the analysis indicates that the construction of this new section would make the potential access to the future highway of the corridor Vc which, according to the Preliminary Motorway Project of the Corridor Vc tangier, Novi Seher has about 500 m of its access ramp to the administration of the Novosehersk region (Figure 9). This means that the potential route of the regional road connection access to the highway corridor Vc from the direction of Teslic, i.e. fast access to the pan-European transport corridor 5.

2.1. ANALYSIS OF THE PRICE OF THE CONSTRUCTION COST OF THE CONNECTING BRIDGE OF THE REGIONAL ROADS R473 AND R474

The connection rings of the regional roads R473 and R474 are analyzed for potential three routes. However, the two routes, one more north and the other south of the previously mentioned Novosehersk, showed that significant investments would be needed even up to 30% more which would be spent on correcting the slope of the route (quite large slopes, which makes the length of the route considerably increase, the calculation speed of the route decreases, many serpentine and others appear).

However, the existing regional road R474 passes directly through the village of Novi Seher and in the central part of this megalithic settlement falls into a couple of non-transparent curves of up to 90°. Such

heavy curves create traffic congestion which leads to its load and poor driving characteristics of the same. By fixing the connecting branch of the regional roads, thislocation of the road could also be solved in the manner of the displaced part of the regional road R474 by the bypass around Novo S?her. By this bypass, the solution of the route would be in line with the latest expert knowledge in the area of design and construction, which would guarantee the safe traffic of all traffic participants, as well as the harmonization of public roads with other interventions in the area and the environment through which they are stretched.

The profile of the regional road for which analyzes and valorisations of the cost of construction of the connecting for regional roads R473 and R474 were performed are shown in the next Figure 10.

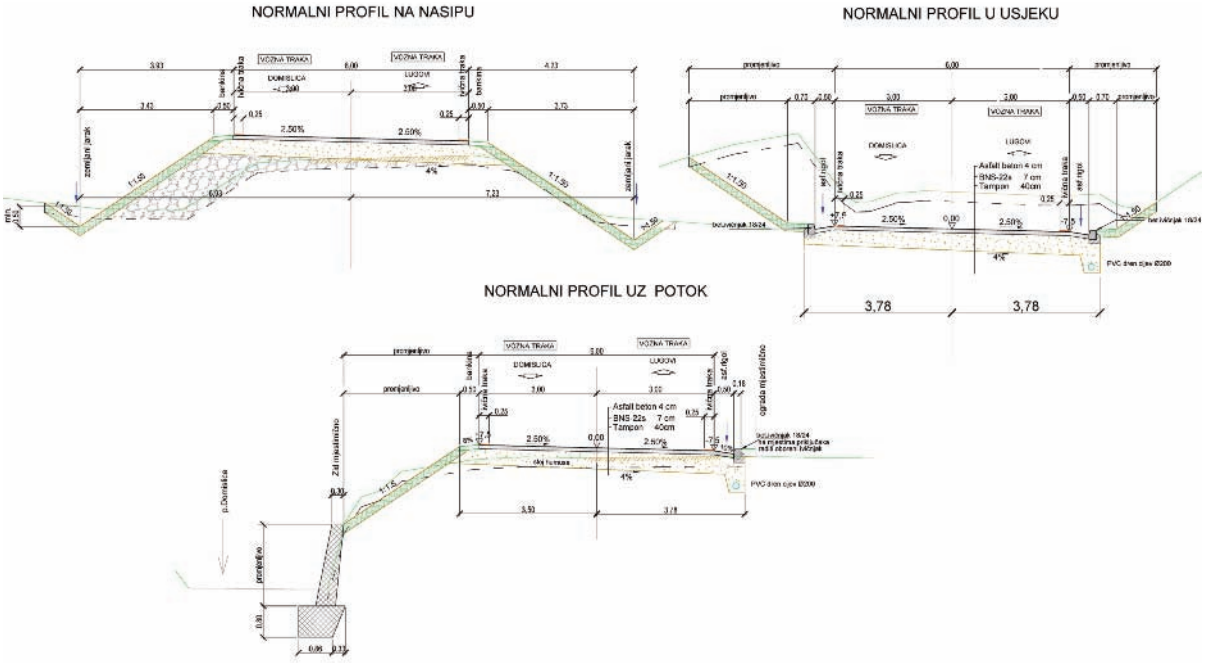


Figure 10. The characteristic cross-section of the analyzed variants of the connecting road for R473 and R474

The estimated value of the new arm of the coupling is shown in the following Table 1 with the cost of construction costs and the length of individual shares on this entire route.

Nr.	*Subscriber name*	*Length (m)*	*Price of construction (KM)*
1.	Novi Šeher, connection R474 –Mladoševica (FBiH)	800 m	834.951,60
2.	Mladoševica – Domislica (FBiH)	1205 m	1.111.655,16
3.	Domislica – Brezove Dane (FBiH)	1650 m	1.256.210,80
4.	Brezove Dane – Lugovi (FBiH)	1205 m	945.650,16
5.	Lugovi – Dubrave, entity border (FBiH)	2520 m	1.653.714,72
6.	Dubrave, entitiy border -Kamenica, con. R473 (RS)	5130 m	2.735.236,55
	TOTAL:	**12.510 m**	**8.537.418,99**

Table 1. The estimated value of the price of the construction of the road section of the regional roads R473 and R474

Chart 3 shows the cost of construction of individual sub-units for the connection of regional roads R473 and R474 with facilities on the route in accordance with the profile shown in Figure 10.

Chart 4 shows the average value of the cost of one meter of the long route in KM/m.

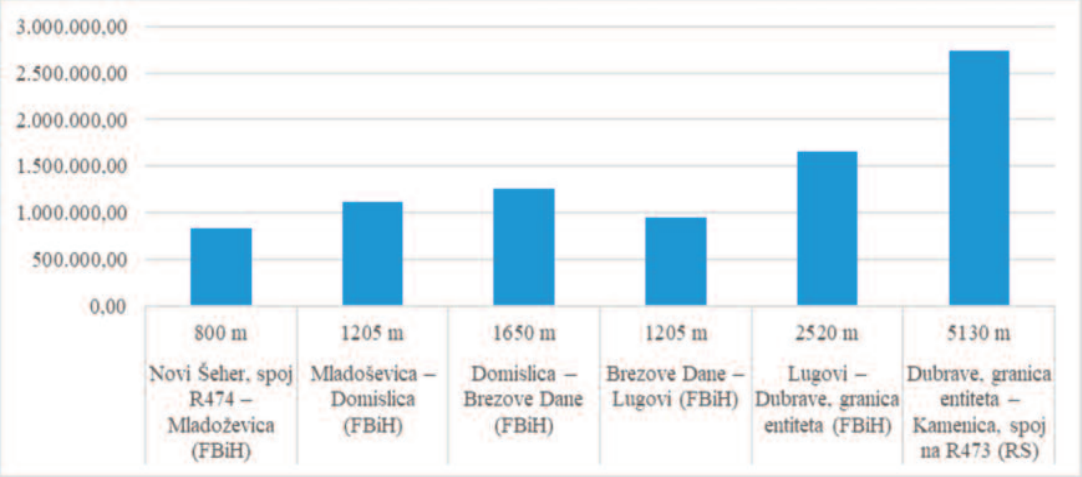


Chart 3. Costs of construction for road section of regional road R473 and R474

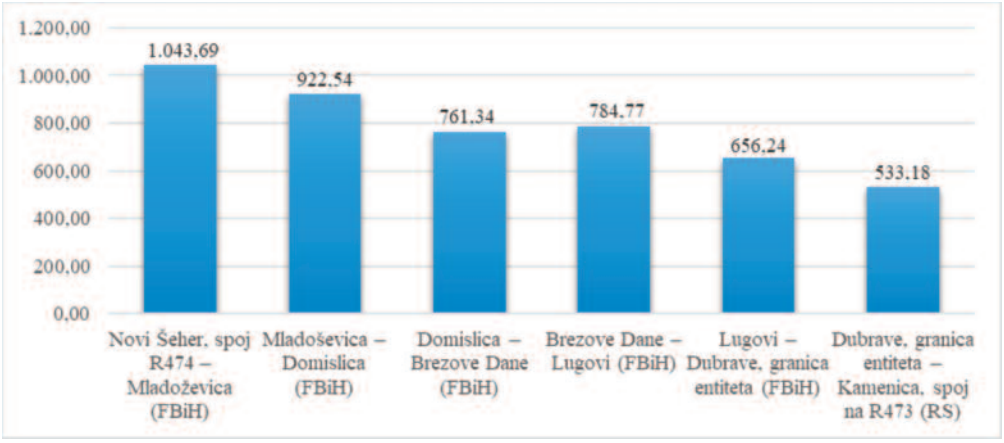


Chart 4. The average price of the construction cost of the road section of the regional roads R473 and R474 per meter

From the previous graphs, it is evident that the section of the road Novi Seher, the connection R474 - Mladosevica, which is located in the FBH, is the most expensive, because it contains a large number of buildings, a bridge and several supporting structures, and the route is mostly in cuts. This section is 800 m long and has an average construction price of 1043.69 KM / m, which totals 834.951,60 KM for the entire share.

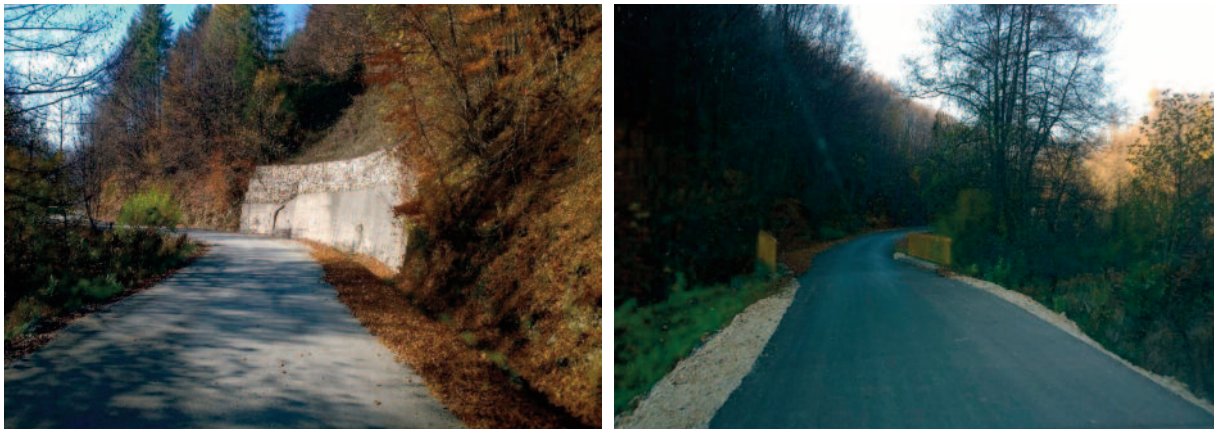


Figure 11. Road section in RS Dubrave, entity boundary - Kamenica, connection to R473

The section road of the Dubrava route, the boundary of the entity – Kamenica, the connection to R473 located in the RS is the cheapest according to the analyzes and amounts to an average of 533,18 KM / m. This section is partly paved and its reconstruction is possible to achieve favorable elements of the road that has a regional road (Figure 17).

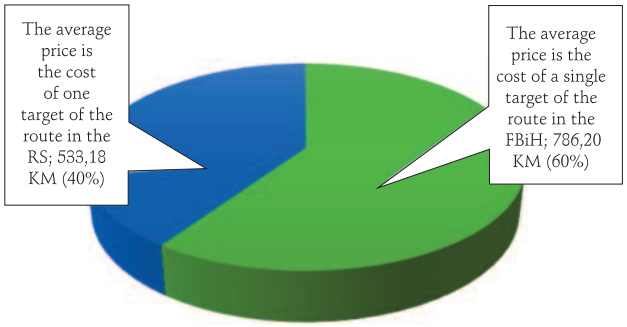


Chart 5. The average cost of the cost of building one meter of a new debt route for connecting R473 and R474

So, the average cost of the construction cost of one meter new road which connecting R473 and R474 would amount to 786,20 KM / m in the FBH, and in the RS part 533,18 KM / m. Percentually, this means that 68% of the financing of the new route is on the FBH, while 32% should be financed from the RS.

3. CONCLUSIONS

Part of the regional road that would connect or merge two regional roads R473 Bistricak - Nemila in Republika Srpska and R474 Jelah - The Ozimica in the Federation of BiH would practically represent the potential key to the economic and social development of the municipalities of Maglaj, Zepce and Teslic. A potential route linking these two regional roads, in addition to opening up the possibility of improving the driving characteristics of the existing regional and unloading of local transport infrastructure, would increase safety and security in the traffic and quality of transport services. This would stimulate economic growth, development of villages and rural tourism in this region, and create predispositions for the opening of new industrial zones.

By linking these two regional roads, there would be a predisposition for the development of the mining, agriculture and forestry sectors of this region, which could potentially create about 120 new jobs. This would create a prerequisite for signing a friendly environment agreement and the possibility of obtaining and processing all licenses for concessions for exploitation of coal and stone on the surface of Brezova Dane.

On the other hand, the length of travel from Teslic towards Maglaj and Zepce will be significantly reduced by 8.6 km and 30.5 km respectively. In addition, the possibility of short access of people, goods and services from the regional road R473 to the future corridor Vc, which according to the adopted conceptual project will be tangled in the Novoseherski region, thus opening the possibility of faster access to the pan-European transport corridor 5.

Although a large number of potential connecting routes have been analyzed, Novoseherska would have a length of 12.510 m and the price of construction would amount to about 8.537.418,99 KM. Of this amount, 68% or about 5.8 mil. The KM should be financed by the FBiH for a length of 7.38 km in this area, while 32% or around 2.74 mil. KM should be financed from the RS for the length of 5.13 km that would be in this area.

Based on the analyzes and valorisation of the results, it can be concluded that the potentially new route of the regional road connecting R473 and R474 would represent the potential key to the economic and social development of the municipalities of Maglaj, Zepce and Teslic which would greatly increase the chances for realization development strategies of these municipalities.

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POTENTIAL OF NON-METALLIC MINERAL RAW MATERIALS IN THE GRAČANICA AREA

Damir Baraković[1]

SUMMARY

Mineral raw materials as natural resources constitute the backbone of the development of the national economy of each country, and their valorization should be placed in their strategic development plans.Polyvalent industrial branches of the economy today are unthinkable without adequate supply of raw materials, analysis of the raw material base, their preparation and processing, technologies of breeding and possible applications.
Non-metallic mineral raw materials have an extremely high importance in the economies of all countries of the world, and especially industrial development. In the global consumption of non-metals, mineral raw materials account for the following shares: all types of stone 49%, sand and sandy material 43%, wedges, salt, phosphates and gypsum 7%, other types of non-metal 1% representing 70% of the world's total production of all mineral raw materials.
In the dynamic development of all branches of the economy, in order to find new reserves, improve quality and ensure continuous supply of production, on a long-term basis, a special place is taken of the research of natural resources.

Key words: non-metallic mineral raw materials, potential raw materials, deposits.

1. INTRODUCTION

Gračanica is a city in the northeastern part of Bosnia and Herzegovina, part of Tuzla Canton and the center of the homonymous municipality. It covers most of the valley of the river Spreča in its central part of the mountain stream and Trebava. Spreča River Basin and Sprečanska depression occupies the central space of the northeastern part of Bosnia and Herzegovina and belongs to the hydrographic system of the river Bosna, and together with the Krivaja River makes its largest right tributary. Within the territory of the municipality of Gracanica is concentrated more deposits of which this work highlighted and processed in the area of Gračanica site "Grabovac" of Pribava site "Luke" and places Stjepan Polje between localities "Muratovići" Dzebo, Malešići site assembly and Prijeko Brdo-Dobarovci.

Bearings are from the town of Gracanica municipality fan-shaped in a half circle whose radius is approximately 3 km following the flow of the river Spreča from Tuzla to Doboj. Lately, there is a need for solution that will prevent any faster, higher and irrational extraction of natural resources. exploitation and distribution.

Introducing the proper solution "for further conquest of nature" or natural resources, their wider disclosure, rational exploitation and equitable distribution, provides the further development, technological prosperity, peace and employment. With respect to the subject area, expands the space of Gracanica is quite interesting from the point of occurrence of non-metallic mineral raw materials, which are here formed at the endogenous and exogenous neogenic and quaternary processes (outside ultramafic complex), such as bentonites, kaolins, quartz sands, tuffs, refractory and ceramic clay, resulting in image neogen-quaternary decomposition and deposition, respectively Postmagmatic activities neogenic volcanic activities.

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2. GEOLOGICAL CHARACTERISTICS OF THE INVESTIGATING AREAS

Area exploration area in terms of geological structure, morphogenesis, genetic types and shapes in relief, is a typical example of areas on the periphery of the former Pannonian Sea, at his touch the inner Dinarides. Geological and tectonic relations exploration area in the central part of the river in a wider area Spreča Gracanice and Sočkovac is given according to the data OGC 1: 100,000 sheets DOBOJ (L34-109) and ZAVIDOVIĆI (L34-121) [1].

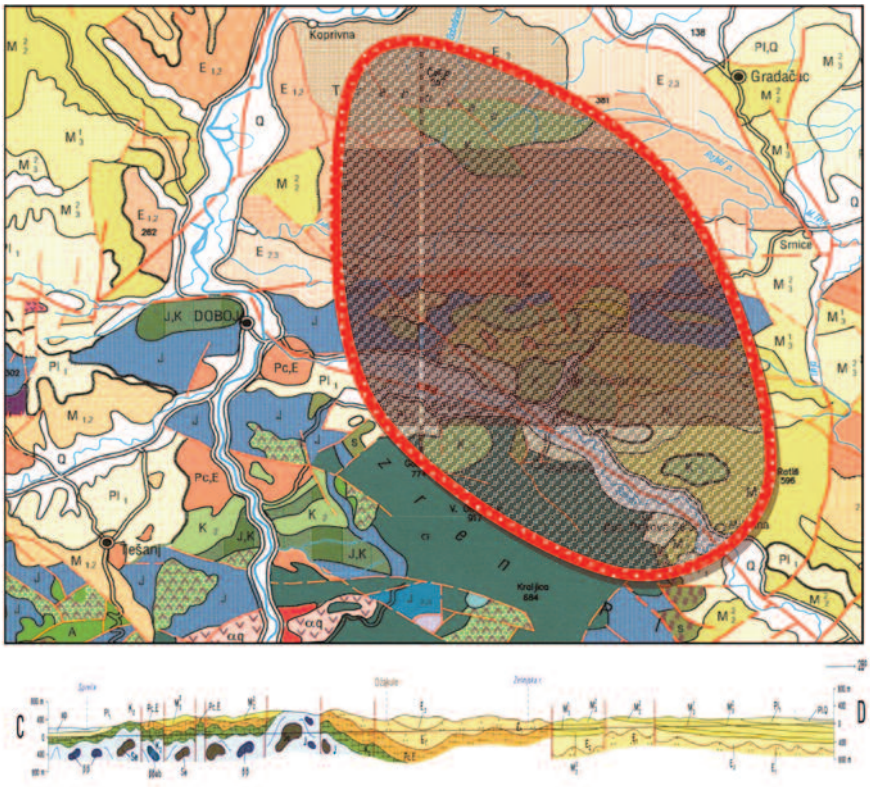

Figure 1. Geological map of BiH R 1: 300,000
Investigation area with a profile C-D

The geological structure of the study area is quite diverse. rties (mainly Jurassic and Cretaceous age, and there are around Gracanica and mountains Ozren and Trebava). In the morphogenesis of the area of Gracanica initial lines are provided orogenic movements of engagement (Alpine erogeneze), tectonic movements (the most important are those dinarskg directions), lake abrasion (Sprečanskog Coast and the lake), and the final form of fluvial-denundation processes that were grafted in the previous and consists of the most prominent part of the relief (fluvial-denundation surfaces and fluvial terrace). Sprečanska depression in the geological past is filled waters of the Pannonian Sea. Originally, it was a bay, Spreča and Tuzla, which was communicated to the west with Ukrinska, east of Zvornik (Drina), and to the north along the trench tinja (originated in the Miocene and separated Horst Majevice Trebave) the parent can not.

The Sarmatian and Pannonian Sprečanska and Tuzla Lake became an independent and gradually sweetened and dehumidified. The pier is at the bottom of a shallow but quite sweet and lake sediment layers rich lignite coal.

thick-ness. (m)	Age	Lithology		Environment	Fossil
50	M_3^2				
		formation quartz sand	Coastal marshes and shallow sea		
	M_2^2		Oolitic limestone, marl clay, conglomerate		
	$^2M_2^1$		conglomerates, with layers of sandstone and shale		
400	M_2^1		lithotamnic limestone, sandy limestone, marl, conglomerate sandstone		
500	E_3		Flysch; sandstones, shales, marls, conglomerates		
800	E_2		Marly sandstone, sandy limestone	shallow sea	Nummulites, Goniastraea, Plocophyllia, Lucina,
300	Pc, E_1		alternation sandstone, shale and marl (turbidites)	Deep sea	Operculina sp.
250	Discocy-clins seunesi				
	D. sca-laris				

Figure 2. Geologic column Trebovac mountains, (according to a simplified Jelaska, 1978.)

2.1. NON-METALLIC DEPOSITS AND OCCURRENCES NORTH OF THE FAULT ZONE SPREČA

Potential non-metallic resources in the Gracanica characterized by deposits and occurrences of bentonite, ceramic and brick clay, limestone and quartz sands, thermal mineral water, whose valorization pending possible.

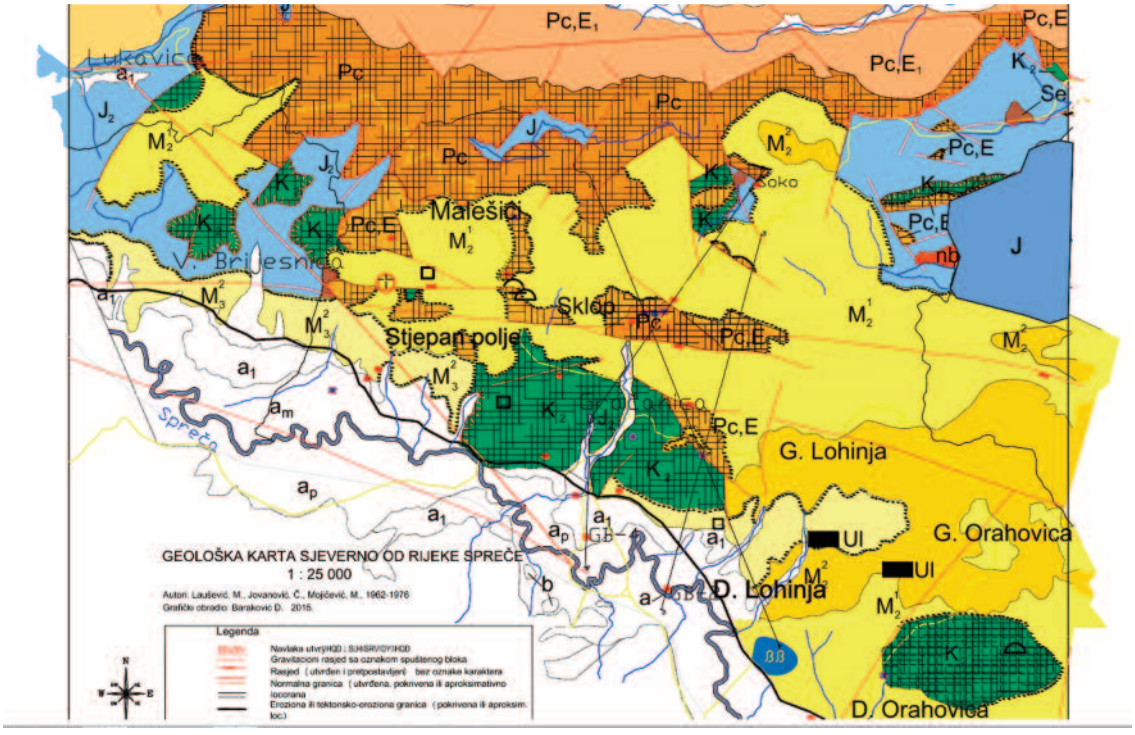

Figure 3. Geological map north of the river Spreča

Resource	Non-metallic Mineral Resources
Large potential (practically unlimited)	1. Limestone (15 x 10^6t) 2. Thermal-mineral water with CO_2
Considerable potential	3. Ceramic and brick clay (8,5 x 10^6 t) 4. Quartz sand (3,5 x 10^6 t)
Medium potential of need be investigated further	5. Bentonites (200.000 t) 6. Bauxites (343.750t) 7. Diabase (170.000 t)

Table 1 - Potential natural resources areas north of Gračanica

Existing natural resources nonmetallic mineral resources areas of Gračanica, and in the context of internal Dinarides of Bosnia and Herzegovina are important, insufficiently explored Prosperous and utilized, and therefore in order to be broader valorisation in the coming period should be paid more attention. Significant are the basis for rehabilitation of existing and development of new industrial and processing capacities.

2.2. NON-METALLIC DEPOSITS AND OCCURRENCES SOUTH OF THE FAULT ZONE SPREČA

Is composed of different types of ceramic and refractory clay, quartz sands, deposits of asbestos and talc deposits whose characteristics are given in the following table.

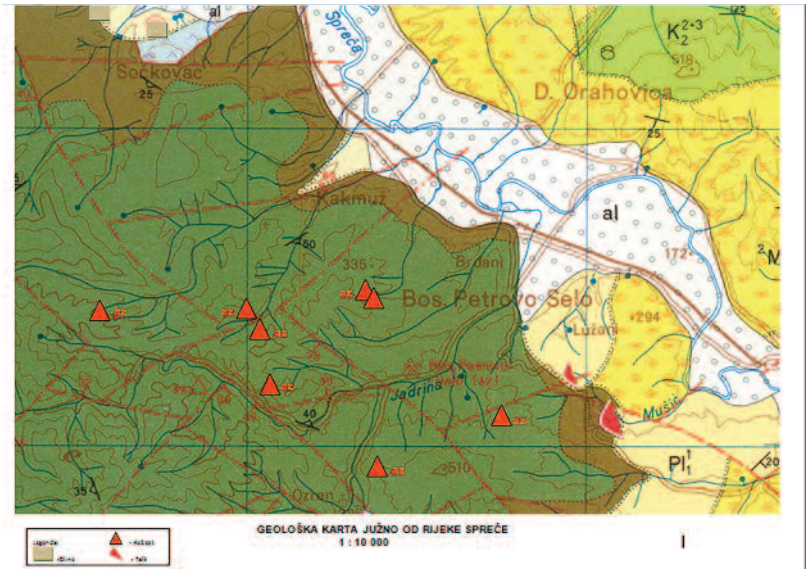

Figure 4. Geological map south of the river Spreča.

Resource	Non-metallic Mineral Resources
Large potential (practically unlimited)	1. Thermal-mineral water with CO_2 2. Asbestos (50 x 10^6 t)
Medium potential	3. Ceramic and brick clay (8,2 x 10^6 t) 4. Talc (6 x 10^6 t)
Vaguely potential of need be investigated further	5. Quartz sand (1,5 x 10^6 t)

Table 2 - Potential natural resources areas south of Gračanica

3. POTENTIALITY OF NON-METALLIC MINERAL RESOURCES OF THE WIDER AREA OF GRAČANICA

The wider area of Gračanica a relatively small area, the bearing and the occurrence of non-metallic mineral raw materials such as: a technology construction stone, ceramic, fireproof and bentonite clays, quartz sands, thermo-mineral, asbestos and talc. Said mineral raw material was subject to certain geological and mining research during most of the 20th century. On some reservoirs was organized exploitation of some of the mineral deposits. This fact and today's market and economic conditions prevailing in the region, it will take a lot of organized efforts of the interested domestic and foreign investors, in order to use existing natural resources of the wider area of Gračanica. entiality of thought primarily to geological potentiality not to direct the possibility of opening new deposits. Were not considered nor socio-social aspects of potentiality - whether it's on a potential area of spatial plan allowed exploitation or not.

3.1. CRITERIA PROGNOSTIC ASSESSMENT POTENTIALITY

Prognostic score any natural solid mineral resources of certain areas, including non-metallic raw materials in the wider area of Gračanica, based on specific sign certain types of deposits that are located in that area or its vicinity in similar geological and geotectonic conditions. General criteria ore, on the basis of which the minerogenetic - prognostic score defined Jankovic (1994) and mainly developed for a forecasting metallic mineral resources. However, some of these criteria are used for evaluation Prognostic and non-metallic minerals (Simic, 2004; and Bozovic Simic 2015; Bozovic, 2016), [3]. Criteria mineragenetic - prognostic assessment resources non-metallic mineral raw materials, so far are generally poorly considered.

From the aspect of resource nonmetallic minerals extracted are other important prognostic criteria:

- stratigraphic
- lithological
- Structural
- paleogeographic
- technology
- geological – economic.

3.2. CATEGORIES POTENTIALITY TESTED NONMETALLIC MINERAL RESOURCES

In determining the category of potentiality study area wider environment Gracanica had it in mind that this area has not been systematically investigated in terms of non-metallic raw materials, but when research work started from the already well-known phenomenon in the field and then approached detailed investigations [9]. So no degree of exploration of non-metallic raw material is not the same, neither the same nor their potential. Based on the consideration of criteria prognostic assessment the following are the categories of potentiality wider area of Gračanica:

1. Area of great potentiality
2. Areas of medium potentiality
3. Areas of vague potentiality.

In the field, characterized by a certain potentiality mineral raw materials is introduced in detail how genetic formation conditions, and technological characteristics, and there are open bearings and occurrence of these non-metallic materials. The terrain that is characterized by secondary potentiality of non-metallic mineral resources allocated on the basis of knowledge above all lithologic and stratigraphic criteria assessment of potentiality, based on analogies with already known deposits and occurrences certain raw materials. Areas with a vague potentiality singled out as such because there is no data on the preliminary or detailed investigations, nor the quality of raw materials (for example bauxites Stephen fields or shoots a hostage around Petrova).

The following table provides an overview of the potentiality of non-metallic mineral resources of the wider area of Gračanica, divided into two parts, ie those that are located north of Spreča fault zones belonging to the Cretaceous-Tertiary rock complexes so-called "inner ophiolitic tectonised melange", and others, located south of Spreča fault zones belonging volcano-sedimentary rocks from the rock, and the complex so-called "central ophiolitic mélange", as shown in table 3 [2].

NON-METALLIC MINERALS NORTH OF SPREČA FAULT ZONES				
Type of raw materials	Location	Character resources	Mineral reserves m^3	Potentiality
Limestone	„Drijenča“	reserves	A+B+C_1 4.600.000 C_2+D_1 11.600.000	big
	„Sklop“	reserves	A+B+C_1 3.250.000	
	„Greblje“	reserves	A+B 1.250.000	
	Orlovača Lipac	reserves	A+B+C_1 1.220.000	
	Karabegovac Lipac	reserves	A+B+C_1 4.600.000 C_2+D_1 11.600.000	
Clay	Grabovac - clay	reserves	A+B+C_1 3.200.000	medium
	Pribava-clay	reserves	A+B+C_1 2.250.000	
	Stjepan polje-clay	reserves	A+B+C_1 2.300.000	
Bentonites	“Džebe“ Stjepan Polje	appearance	D_1 340.000	
Qùartz sand	Pribava- D.Lohinja	appearance	D_1 3.500.000	big
Diabase	Donja Lohinja „Durać“	appearance	D_1 400.000	medium
Bauxites	Stjepan polje – „Džebe“	appearance	D_1 340.000	vaguely
NON-METALLIC MINERALS SOUTH OF SPREČA FAULT ZONES				
Type of raw materials	Location	Character resources	Mineral reserves m^3	Potentiality
Ceramic clay	Kečkovac Sočkovac	reservoirs	A+B+C_1 2.500.000 or 6.300.000 t	big
	Lipovac-Brezici Karanovac	reservoirs	A+B+C_1 760.000 or 1.900.000 t	medium
Quartz sand	Kečkovac Sočkovac	reservoirs	A+B+C_1 540.000 or 1.130.000 t	big
	Lipovac – Brezici Karanovac	reservoirs	C_2 5.500.000 or >11.000.000 t	
Chrysotile asbestos	Delić Brdo – Brđani Petrovo	reservoirs	A+B+C_1 56.000.000 t ore with 1.100.000 t asbestos fibers	big
	Bjeljevine Jovanovići-Njivice Kakmuž	reservoirs	C_1 2.000.000 t ore	medium
Talc	Mušići Porječina	reservoirs	C_1 2.200.000 t ore sa 550.000 t tale C_2 900.000 t ore 220.000 t tale	big
	Žarkovac Porječina	reservoirs	C_1 2.400.000 t ore C_2 1.850.000 t ore	medium
	Rustina Petrovo	appearance	Talc 50 x 10 m perspective	vaguely
	Tešanovići Boljanić	appearance	Talc zone 500 x 100 m perspective	

Table 3. The degree of potentiality and spatial disposition of non-metallic mineral deposits

All deposits and occurrences contained in Table 3, are deployed within oleate declared mineral raw material resources of the wider area of Gračanica.

3.3. OLEATE POTENTIALITY

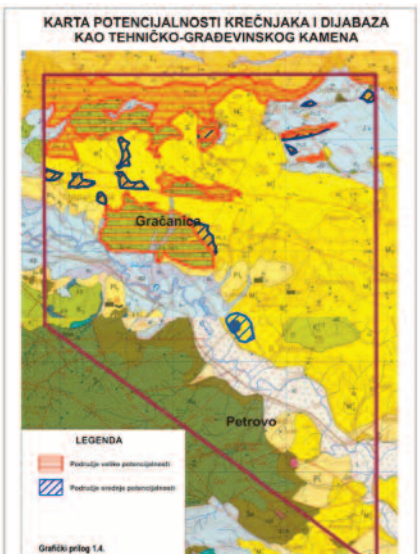

Fig. 5. GP 1.4.

Fig.6. GP 1.1.

Figure 7.

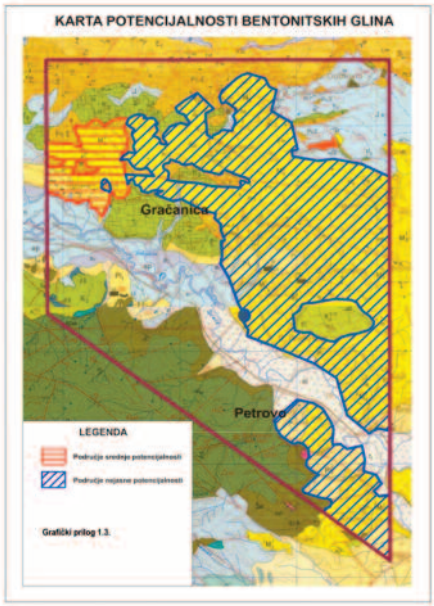

Figure 8.

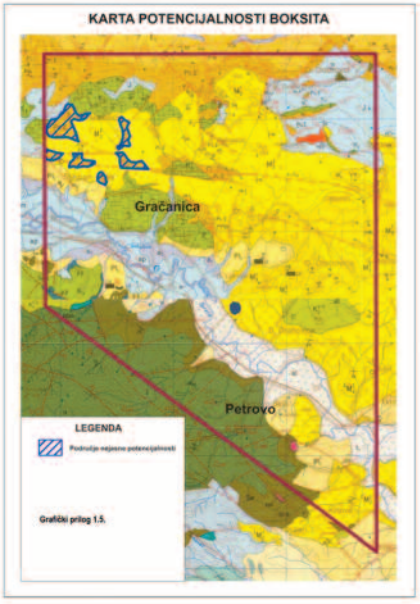

Figure 9.

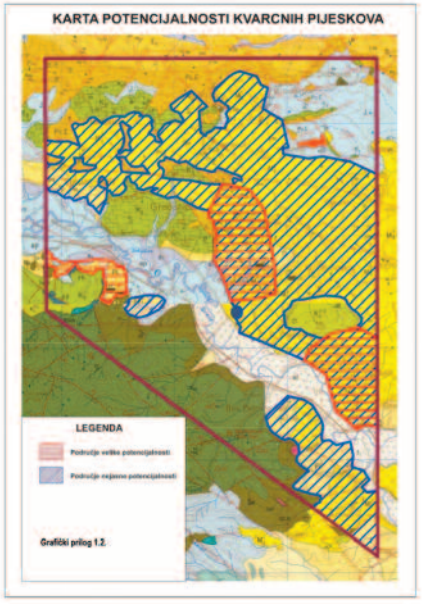

Figure 10.

Figure 11.

Figure12.

4. CONCLUSIONS

By analyzing the wider area of Gračanica it is established that there is no complete overview of the adequate degree of exploration of existing deposits and the occurrence of non-metallic mineral raw materials of the wider area of Gračanica as well as the evaluation of the potentiality expressed through oleate.

In addition to the geological-genetic, qualitative and quantitative characteristics of each deposit and the occurrence of non-metallic mineral raw materials, the contours of deposits, the tectonic characteristics, the established reserves and the potentiality of the individual reservoirs have been determined, and on the basis of the technological features in the process of cultivation there is also a scientific review on the possibility of valorisation , which defines a higher degree of investigation of the qualitative and quantitative characteristics of deposits and the appearance of non-metallic mineral raw materials and the determination of the potentiality of the area through the oleate of the mineral raw material potential of the wider area of Gračanica, which is extremely important for future spatial planning, urbanization, valorization of natural resources and nature protection measures environment.

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MORPHOLOGICAL AND MORPHOTECTONIC CHARACTERISTICS WITH SOME NEGATIVE ANTHROPOGENIC PROCESSES IN THE UPPER DRAINAGE BASIN OF THE GOSTELJA RIVER

Alen Lepirica[1], Semir Ahmetbegović[2], Senad Gutić[3], Željka Stjepić Srkalović4[4]

SUMMARY

This paper is focused on the morphological and morphotectonic analyses of the upper drainage basin of the Gostelja River. The researched area is situated mostly in the northern part of the Kladanj municipality in Bosnia and Herzegovina, in the zone of the Internal Dinarides, which were geomorphologically reshaped on heterogeneous lithological substrate. Based on the terrain researches and morphological analysis, the relief structure, hypsometric characteristics, relief energy and slope inclinations were determined. The results obtained by morphotectonic analyses showed that relief is unconform, which is caused by recent fault activity through the neotectonic uplifting and different orientation and tilting direction of microblocks, which alters on the short distances. Finally, it emphasises some destructive anthropogenic processes on recent relief.

Keywords: Upper Gostelja drainage basin, fault, neotectonic, morphological and morphotectonic features, negative anthropogenic influence.

1. INTRODUCTION

The analysed catchment area of the upper drainage basin of the Gostelja River covers 140,96 km^2. It is formed in the Internal Dinarides and located about twenty kilometers southern of the city of Tuzla. Administratively, it represents mainly the northern parts of the Kladanj municipality in the Federation of Bosnia and Herzegovina, while the minor upper part of the the Suha River valley is in the neighboring entity of the Republic of Srpska. The Gostelja River is 30,9 km long, with an average annual discharge of Qmed = 3,53 m^3/s, originates by merging of the Zatoča and Suha mountain streams in the Stupari settlement (according to Spatial planning of Tuzla Canton for a period 2002-2021., 2000). More precisely, those are drainage areas of the upper Gostelja River valley with headwater components of the Zatoča and Suha Rivers and its left tributary the Tarevčica River (Fig. 1 and 12). Gostelja is stream of a third order according the Strahler (1957). Gostelja is the right tributary of the river Oskova that belongs to the Black Sea drainage area, i.e. to the hydro-system of Spreča River, which is the right tributary of Bosna River. This is a dominantly mountainous-hilly area, which is orographically marked by mountain slopes of Konjuh Mt. (1,326 m a.s.l.), Djedinska Mt. (1,158 m a.s.l.) and Javornik Mt. (1,067 m a.s.l.).

Unlike geological and hydrological researches, the detailed geomorphological research was never carried out. The first informations about the lithological structures were presented by F.Katzer in a Geology map (1906) where he included the "tuffites-jasper layers" (volcano-sedimentary formation) in the Jurassic period. The genesis of the volcano-sedimentary formations i.e. diabase-chert melange of Internal Dinarides

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were presented by Jovanović, R. (1957, 1961), Milojević, M., Maksimović, D., and Veselinović, D. (1959) and Đerković B. (1963). In his papers, Pamić, J. (1964 and 1965) states that discovered ultramafites and amphibolites were tectonically interlayered in volcanogenic-sedimentary formation. Afterwards, the geological mapping and basic geological maps were realised by Strajin, V., Mojićević, M., Pamić, J., Sunarić, O., Veljković, D., Đorđević D., (1978) by a "Geoinženjering" Sarajevo. More recent hydrogeological analyses of the researched terrain were made by: Žigić I., Pašić-Škripić D. (2007), Mešković, A., Kadić I. (2007), Žigić I., Pašić-Škripić D. & Srkalović D. (2009), Srkalović D. (2011), Skopljak F., Hrvatović H., Žigić I., Pašić-Škripić D. (2011) and the Expert Group (2013) from the Mining Institute of Tuzla.

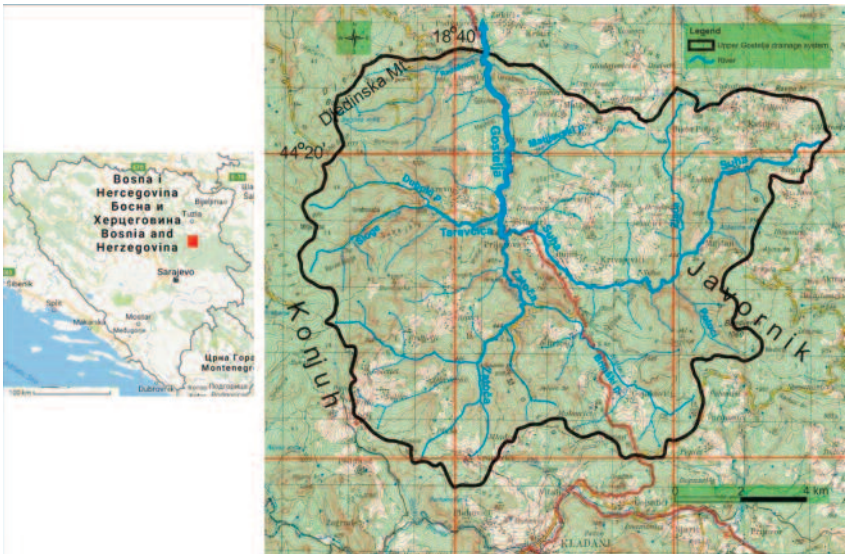

Figure 1. The geographical position of the Upper Gostelja River basin

2. MATERIALS AND RESEARCH METHODS

During the drafting process of the paper, we used topographic maps scale 1:25000, 1:50000 and 1:100000, geological maps 1:25000, 1:100000 and 1:300000, digital map Adria topo 2.10, and the Google satellite map. For a terrain analyses, we used a GPS (Garmin, Montana 600) and geologic compass (Clar). Afterwards, the base of morphometric data was made, which was processed in the GIS using the Map Info Professional 9.5 application, and for creating the thematic maps and we used digital elevation model (DEM) and Satelit imagery google 2017.

At first, the morphological analysis of the orographic structure, hypsometric relations, slope inclinations and energy relief were made. In addition, the terrain researches of the relations between relief, lithological substrate and geological structure were conducted. The Mountain Front Sinuosity, Stream Length-gradient Index, Basin Asymmetry and Elongation Ratio, types and river network density were made by morphotectonic analyses using primary the topographic maps scale 1:25 000. Finally, we analysed the impact of humans on the destructive geomorphological processes on the terrain.

Thus, the goal of this research is to determine the character of the morphology and morphostructures of the terrain and negative anthropogenic influences on the recent geomorphic processes and landforms.

3. RESULTS AND DISCUSSION

3.1. GEOLOGICAL CHARACTERISTICS

Geotectonically, the observed basin is located within lithological volcanogenic-sedimentary complex, which represents the subunit of the Central Dinarides ophiolite zone (Fig. 2). This part of Internal Dinarides marks the Mesozoic tectonic processes under the former western part of the Tethys. It is the area of subsequent subduction closure and its breakout in the upper Jurassic period, which was accompanied by a breaking and impressing of ultramafic blocks in several parts of the lithosphere, by contact metamorphosis and crushing and shredding of the surrounding rocks and creating of specific ophiolite melange (Lepirica, 2013).

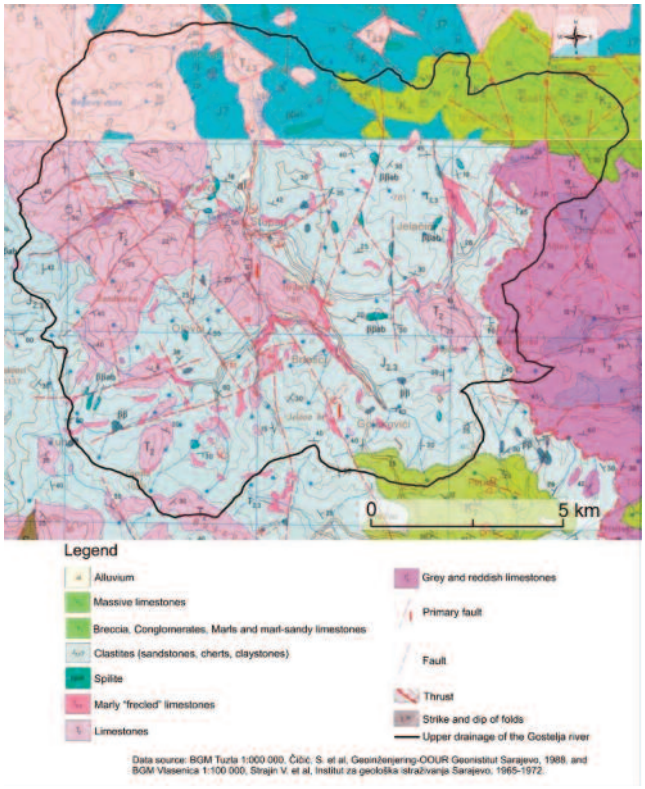

Figure 2. Basic geological map of the Gostelja River drainage basin (Strajin at al., 1980)

During Cretaceous time, there were present the thrust intensifying tectonics and ophiolite obduction. Fault-tectonic contact between ultramafic and sedimentary rocks of the volcano-sedimentary formations are presented by amphibolites and serpentinites (Fig. 2). The composition of the rocks of tectonic subunits that occurred during the formation of volcanogenic-sedimentary formations and sediments were formed and inserted in as olistolithes (Strajin, et al. 1978).

The Central Dinaric ophiolitic complex has been deformed several times during the Alpine orogeny. The central, western and north-western part of the upper drainage basin of the Gostelja River is represented by Crvena Lazina-Ježevik-Hrdar olistolithes (10 km long, 3-5 km in average width), lithologically represented by intensively folded and cracked Mid Triassic limestones (thickness is over 400 m) (Fig. 2 and 3). Limestone olistolithes concordantly overlap the Lower Triassic sandstones, conglomerates and shales. Lower Triassic clastites, common in the surface of the studied terrain, often appear with faults in the form of small narrow elongated zones up to 1 km (Fig 2). Eastern, northeastern and southern parts of the terrain were built by Jurassic clastites: marls, sandstones, shales and cherts, while the northeastern parts were constituted by Cretaceous limestones (Fig. 2).

Figure 3. Intensively folded Mid Triassic limestone of olistolithes Crvena Lazina-Ježevik-Hrdar; Beneath is a fluvial sediment of Zatoča river (photo by: Semir Ahmetbegović)

According to results of previous geological studies presented at Basic Geological Map (BGM) scale 1: 100 000 and detailed geological maps of 1: 25 000, the fold inclinations of 20°-40° are prevalent. Different directions orientation of fold axis in short distances indicates the rotation of microblocks, especially near the Stupari and Tarevo village (Fig. 2).

Primary strike-slip fault Stupari-Mrkalji (SM), 30 km long, with orientation of direction NNW 338°-158° SSE cut the Gostelja and Zatoča River valleys (Fig. 2, 4 and 9).

Figure 4. Faulted breccia in Zatoča gorge marks the trace of primary strike slip-fault Stupari-Mrkalji (photo by: S. Ahmetbegović)

The orientation of stretching of this main fault is subperpendicular with the trajectory of contemporary axis of maximum compression stress $\sigma 1$ (SSW-NNE) on the map of stress (Zoback, 1992). Other local faults, which were a few kilometres long, were characterized by the prevailing directions of NNW-SSE and NE-SW, and rarely with orientation of N-S (Fig 2).

Destructed by faults, the main high.er ridge crests of the older folded-thrusted morphostructures of the Javor Mt. and the Konjuh Mt. are stretching mostly in direction NW - SE. The orientation of ridge stretching indicates the direction of older regional stress $\sigma 1$ oriented in direction 54°NE which is confirmed by neotectonic retrograde rotation movements around 30° of Adria microplate in neotectonic period (Márton. et al., 2003). Based on the vertical speed of the Earth's crust moving (Jovanović, 1971), the wider part of the mentioned area is affected by the neotectonic uplift of 2-4 mm/year. Small, elongated zones of neotectonic subsidence, marked with accumulation processes were connected with the small pull-apart basins of Stupari, Krivajevići and Brlošci villages.

3.2. MORPHOLOGICAL FEATURES OF THE RELIEF STRUCTURE, HYPSOMETRIC RELATIONS, SLOPE INCLINATIONS AND RELIEF ENERGY

Mountain ridge crests, hillslopes, plateaus and composite river valleys represent the upper Gostelja River drainage basin, as a small part of the *„Bosansko sredogorje"* geomorphological macro-entity (Lepirica, 2013). The slopes of the surrounding mountain massifs of Konjuh Mt., Javornik Mt. and Djedinska Mt., which ridge-crests are stretching in different directions, are dominant. Few, spatially more morphologicaly expressive higher plateaus are geomorphically reshaped in the Cretaceous limestones of the Javornik Mt. at elevations of about 700-800 m a.s.l. Some minor slopes settlings represent the gently inclined rocky terraces and glacis where the villages were developed. The lowest terrains were represented by narrow linear landforms of composite valleys of the Gostelja River and its tributaries (Fig. 1).

Hypsometric characteristics are of great importance for determination of the orographic structure, and in combination with other morphometric indicators are useful in the identification of the area of greater or lesser utility for practical needs (Lozić, 1996). The altitudes of 500 – 1,000 meters prevail in this area. Hypsometrically belt with slightly lower altitudes between 260-500 meters are closely retracted along river valleys. The highest terrains, with altitudes over 1,000 meters, are represented with the highest ridges of mountain massifs of Konjuh, Djedinska and Javornik. Generally, left side of the Upper Gostelja drainage basin is more elevated. The lowest point is the riverbed of the Gostelja River at altitude of 260 meters, at the far north, and the highest peak is Bandera 1,207 m in southwest, pointing to an accentuated difference in altitude caused by neotectonic subvertical movements of microblocks.

The steeper and convex slopes of 24˚- 45˚ angle inclination are prevailing (Fig.5). The steepest terrains, inclined over 55˚ are related to microtectonically-cracked limestones with subvertical rocky escarpments of Hrdar, Krš, Ralo, Vranić, and Avdagića Krš. These are subvertical lower slopes of northeastern part of the Konjuh Mt. in drainage basins of the Zatoča and Tarevčica rivers. There are also subvertical rocky sides of the Gostelja and Suha river valleys deeply cut into the Javornik Mountain.

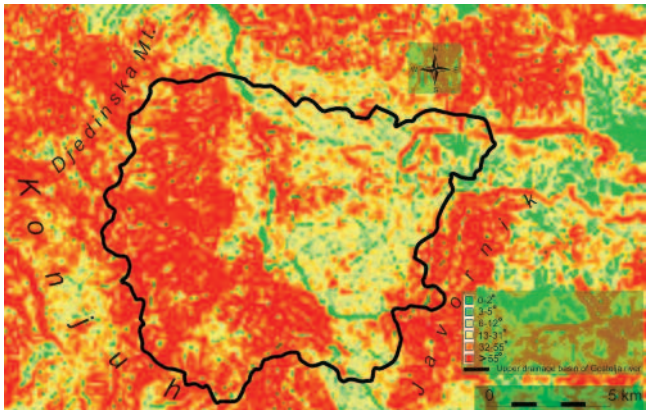

Figure 5. Slope inclination of Gostelja drainage basin (S. Ahmetbegović)

Elongated valley extension, small pull-apart basins of Stupari, Krivajevići and Brlošci, in relief marked with lower river terraces of alluvial-proluvial sediments, were incised by slightly curved meanders of the Gostelja and Suha Rivers. These terrains are characterized by the lowest values of the inclination angle (less than 6˚). Also, some spatially expressed levels of settling are formed at altitudes about 700-800 meters in Cretaceous limestones, south-western from the Ravno brdo (1,019 m a.s.l.), in the areas of Draguša and Javor in the east, and in parts of the Javornik Mt.

Slightly tilted surfaces of pediment fragments and Quaternary accumulated landforms of the glacis-terraces, inclined of 5˚- 12˚, are of microlocational character (Fig. 5, 8).

The relief energy (Er) is expressed by the maximum denivelation between the highest and the lowest point, measured in a given area. If it is calculated for single cells of this parameter, it can indicate the zones characterized by more or less marked erosion (Baioni, 2016).

The highest values of energy relief, from 400 to 500 m/km^2, mark the slopes of Ježevik and Suha Jela in the northeast Konjuh, slopes of Hrdar and steep slopes of Svojčica in the southwest Javornik (which are measured from map 1:25 000) (Fig. 5). Accentuated values of relief energy in this terrain were caused by neotectonic uplifting of the mountain microblocks (Jovanović, 1971) and because of increased denudation of Jurassic clastites within lithological border with mechanically more resistant limestone olistolithes. The values of relief energy of 100-300 m/km^2 are spatially the most common in the upper parts of the Gostelja River valley.

3.3. MORPHOTECTONIC CHARACTERISTICS OF THE RESEARCHED AREA

The relation between relief, lithological substrate and geological structure

Konjuh, Javornik and Djedinska Mts. are fold-thrusted morphostructures uplifted to the todays heights in the recent neotectonic period (Bognar, 1990). In the studied area, those mountains were dissected by composite valleys of Gostelja and its tributaries. The above-mentioned valley landforms are mostly geomorphologically reshaped at the heterogeneous lithologic fundament. Parts of analysed river basin are geomorphologically characterized by contact, covered karst of limestone olistolithes, which is surrounded by impermeable Jurassic clastics on all sides. The fluviokarstic gorges of Gostelja valley (downstream of confluence with Matijevski potok) and deep gorges of Zatoča and Tarevčica, with rocky riverbeds and potholes, cave openings and karst notches, has been geomorphologically reshaped in Mid-Triassic limestones. The limestones in this part of Internal Dinarides are microtectonically fissured and dissected by numerous faults and joints, which resulted with active hydrogeological spring zones near the Stupari, that are used for the Tuzla water supply. There are numerous endokarst cave landforms such as: Henić caves, Aćim cave, cave above the confluence of Tarevčica and Zatoča, Hajdučka cave in the Radašnica valley, swallow-hole near the Duboki potok and other caves and notches in tectonically cracked rocky faces of crests: Hrdar, Krš, Ral, and Vranić (Fig. 6).

Figure 6. In the central part of the photo: neotectonically uplifted Hrdar ridge crest, reshaped in the Mid Triassic limestones and gentle slopes of Papratuša developed on Jurassic clastites in the front (photo by: Alma Lepirica)

Figure 7. The slopes of the Javornik Mountain stretched above the upper Suha River valley; the small, elongated valley extensions with the settlement of Krivajevići in the central part of figure (photo by: Alen Lepirica)

The upper Suha River valley, in the eastern part of the drainage basin, has been incised into the Cretaceous limestones (Fig. 7). The ridge crests Grabić (696 m a.s.l.) which steeply uplifts near the Matijević village is also formed in Cretaceous limestones. More prominent karst valley landforms are related to the flatter terrains of the Mesozoic limestones at Stanovi, southern of Gojaković village.

Figure 8. The village Rujići developed on the gentle inclined inactive glacis (dotted lines) in the hillslopes north-eastward of the Stupari (photo by: Alen Lepirica)

The surrounding areas have completely different morphological composition, than impermeable Jurassic sandstones and shales, with less steep slopes. Mainly, it is undulating slope relief near the Tarevo, Javornik, Lupoglavo, Olovci, Gojakovići and around Stupari where the microlandforms of glacis and active and inactive landslides can be found (Fig. 8, 14c). Generally, slope terrains made of impermeable lithological composition are reshaped by the Quaternary slope processes of: landsliding, creeping and torrential. The spatially smaller, elongated small pull-apart basins (a few dozen square meters) were formed near the fault traces with local subsidence, where the settlements of Stupari, Luke, Krivajevići and Brlošci developed (Fig. 7).

Mentioned V shape transverse profile valleys are generally unconform in relation to the direction of stretching of the fold axis which is the result of movements of the strike-slip faults (Fig. 2, 9 and 9a). Orientation of the stretching directions and morphoevolution of the valleys are controlled by fault neotectonic (Fig. 4, 9). As we have already noted, active faulting can have dramatic impact on fluvial systems (Summerfield, 1991).

In the active fault zones were incised the Zatoča valley, the lower valley of Suha, part of the Gostelja valley downstream of Stupari and hanging valley of Sloga (Fig. 2, 9).

Figure 9. Directions stretching of the faults, valleys and tilting direction of sub basins of Upper Gostelja drainage system (detected on Basic geological map)

The orientation of the stretching directions and morphoevolution of the valleys are controlled by a neotectonic fault (Fig. 4 and 9). The contemporary morphotectonic elbow alterations of valleys and deflections of river channels caused by the activity of the right and left strike-slip faults are evident in the gorge and downstream of the Gostelja gorge, then in the middle flow of Tarevčica, Zatoča, Brloški potok and Suha, upstream of Stupari (Fig. 9). The different orientation of Tarevčica, Zatoča, Suha and Gostelja runoff, on short distances, indicates a microblocks rotation between Tarevo, Stupari and Krivajevići (Fig. 9, 11).

Figure 9a. The cascade stream riverbed of Tarevčica in unconform valley (photo by: Semir Ahmetbegović)

At the fault intersections, where the lithological substrate is tectonically broken, on the Jurassic clastics, the mentioned valley extension of Stupari and Brlošci were formed (Fig. 2). Active hydrogeological zone of karst springs in the Zatoča, Tarevčica valley, seven springs and river Suha spring were also created along fault structures.

The gorge of Gostelja (downstream of Stupari) has been cut in a straight line in direction of N-S, into the Mid Triassic limestones and in a length of 1,050 meters. The Vodice hanging valley, oriented in NE-SW, is also cut along the fault zone in the northeast slopes of Konjuh. The hanging valley of Mladovski stream in the basin of Zatoča, which stretches in a straight line in direction N-S, is transversally intersected by local faults. The dominant stretching in a direction of NE-SW and N-S of straight parts of all four river valleys on short lengths of 1 to 1.1 km indicates the general direction of neotectonic compressive stress. Thus, in the analysed area, the valleys of different orientation, which are transversally intersected by faults are mainly prevailing (Fig. 2 and 9).

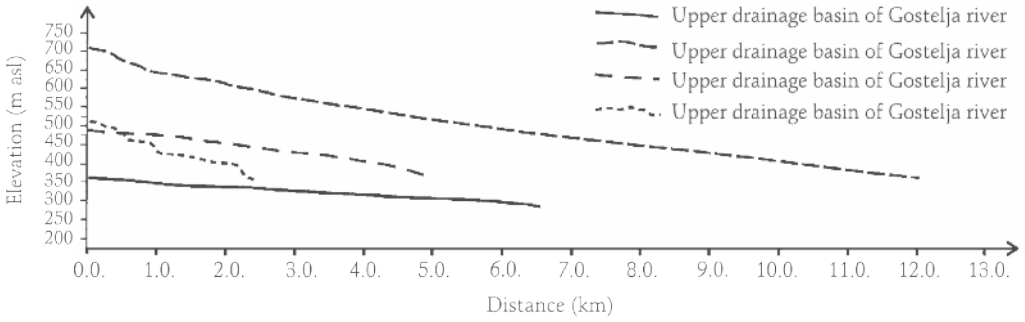

Figure 10. Longitudinal profiles of the Gostelja River and its tributaries in the upper drainage basin

Average values of the longitudinal profile inclinations are (in the analyzed area): Gostelja 15‰, Suha 29‰, Zatoča 25‰ and Tarevčica 68‰, with widened convex parts of their longitudinal profiles that suggest a neotectonic terrain uplifting too (Fig. 10). Sudden changes of longitudinal profile inclinations are commonly caused by the fault activity and geomorphologically reflected by the collapsed rock blocks in the riverbeds with the accompanying features of waterfalls, rapids and cascades (Fig. 9a). Mentioned features in the upper drainage basin of the Gostelja River, were caused by alternating clastic rocks with mechanically resistant limestones, as in the case with 3 m high Tarevčica waterfall formed by regressive fluvial erosion in its lower flow.

Geomorphic indices of tectonic activity in the upper drainage basin of the Gostelja River

Basin asymmetry analyse

This method and their results indicates on presence i.e. absence of Quaternary tilt block tectonic. The asymmetry of the drainage basin is calculated according to the relation: AF= 100 x Ar/At (Keller & Pinter, 1996), where AF is the asymmetry of the drainage basin, Ar is the right side of the drainage basin, while At represents total surface area. It should be noted that if the calculated value is 50, then the area is tectonically stable. Values of AF > 50 suggest tilting of the basin towards the true right, while values < 50 suggest tilting towards the true left. The asymmetry factor was developed to detect tectonic tilting transverse to flow at drainage basin or larger scales (Dhanya, 2016).

Stream	Sub basin (km^2)	Right side (km^2)	AF
Gostelja*	29,73	13,15	44,23
Suha	43,63	26,10	59,82
Tarevčica	18,30	11,36	62,07
Zatoča	49,29	26,12	52,99

Table 1. Asymetry factor of sub basins in upper drainage basin of the Gostelja River

The gained data (AF), in range from 44,23 - 62,07 (Tab. 1 and Fig. 9), are showing the asymmetry of sub-basins in the upper drainage basin of Gostelja, what the fault movements and different lithological substrate influenced. Based on the specific orientation for the tilting direction of the sub-basins (Suha - S, Zatoča - NW, Tarevčica - NE and Gostelja* - E), we determined that the upper drainage basin of Gostelja River is affected by a clockwise rotation of microblocks, what affected the neotectonic activity of strike-slip faults (Fig. 9).

Stream length gradient index

The results of the spatial analysis of Stream Length-gradient (SL) index indicate (1) a perturbation in the drainage network, caused by differences in the resistance to erosion of outcropping lithological units and (2) sub-surface processes, such as active faulting and (3) slope failures, that directly reach the stream channels, particularly in small catchments. Hillslopes are affected by large landslides, earth flows, and rock falls directly reaching the stream bed (Troiani et al 2014).

The SL index is very sensitive to changes in channel slope, and this sensitivity allows the evaluation of relationships among possible tectonic activity in the area (Sarp. et al 2014). According the Hack, J.T. 1973. the stream length-gradient index is defined as:

$(Sl = \Delta H / \Delta L)$ L where:

- Sl - Stream length gradient index
- ΔH - Change in elevation of reach
- ΔL - Length of the reach
- L - Total channel length from the point of interest where the index is being calculated upstream to the highest point on the channel.

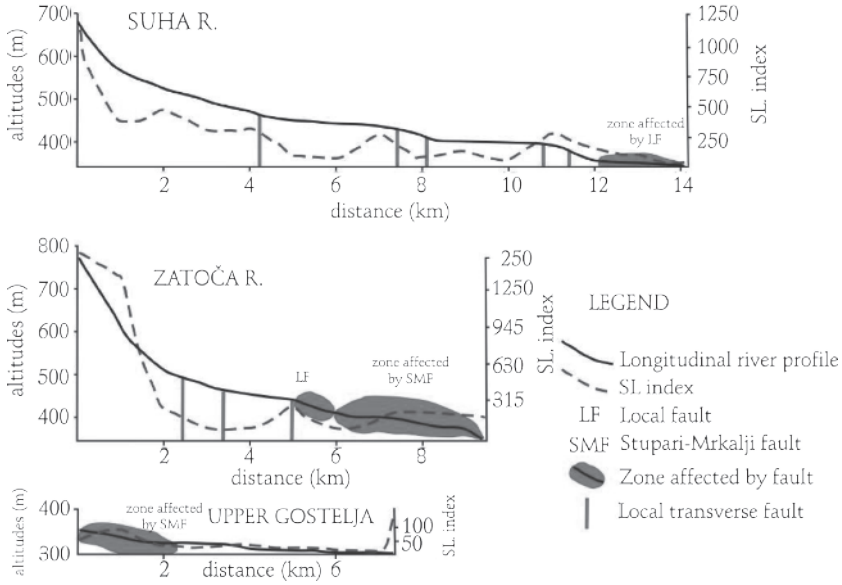

Figure 11. SL index for Zatoča, Suha and Gostelja upper flow

Carefully observing the dotted lines of SL along three longitudinal profiles of the permanent streams of Zatoča, Suha and Gostelja upper flow (Fig.11) we can conclude:

The SL index has the highest vallues near the sources of Zatoča (SL =1,573) and Suha River (SL= 1,162), what is a result of Konjuh and Javornik Mts uplifting (Fig.11). The far lower SL vallues are in the channels in their middle streams, which are partially expressed on places which are transversal intersected by local faults. Lower and more balanced SL values are in the lower stream of Zatoča, which implies a subhorizontal cinematics of that part of the primary SM fault trace (Fig.11). Similar situation is on the lower part of the Suha stream near Stupari, which is affected by a local strike slip fault. The lowest SL vallues are calculated in the middle parts of both streams, which channels are incised into „soft" clastites.

Areas where the stream-gradient indices are relatively low and are associated with two general conditions: areas where soft sedimentary rocks are abundant and along major strike-slip faults, where hori-

zontal movement has crushed the rocks, producing zones low in resistance to erosion (Keller, 1996). That is the case with the channel of the Gostelja upper flow in the zone of main strike-slip fault SM in Luke, two kilometers downstream from Stupari, where the lowest vallue (SL=29) was measured (Fig.11). At places where the upper Gostelja riverbed is incised in resistant Triassic limestones (downflow Tarevčica confluence and in the gorge near the Radašnica stream) the SL vallues are more expressed.

The Mountain Front Sinuosity

The Mountain Front Sinuosity (Smf) is: Smf = Lmf/Ls, where Smf denotes the mountain front sinuosity, Lmf is the length of the mountain front along the foot of the mountain at the pronounced break in slope and L denotes the straight-line length of the mountain front (Elias, 2014). The sinuosity of highly active mountain fronts generally ranges from 1.0 to 1.5, moderate active fronts ranges from 1.5 to 3 and inactive fronts ranges from 3 to more than 10. A sinuosity greater than 3 describes a highly embayed front (Bull & McFadden, 1977).

Smf 1	1,14	Smf 12	1,11
Smf 2	1,22	Smf 13	1,09
Smf 3	1,16	Smf 14	1,83
Smf 4	1,22	Smf 15	1,08
Smf 5	1,30	Smf 16	1,15
Smf 6	1,37	Smf 17	1,30
Smf 7	1,40	Smf 18	1,10
Smf 8	1,08	Smf 19	1,07
Smf 9	1,43	Smf 20	1,11
Smf 10	1,26	Smf 21	1,10
Smf 11	1,31	Smf 22	1,09

Table 2. The Mountain Front Sinuosity (Smf)

Based on the analysed results of this geomorphometric method, the sinuosities of highly active mountain fronts from 1.07 to 1.43 are prevailing in this area (Table 2). Spatially this is the morphotectonic contact of the upper valley of Gostelja, Zatoča, Suha and Brloški potok valley with the surrounding mountains foot (Fig. 12). On the highly tectonic active mountain fronts, beside the primary fault Stupari – Mrkalji and the reshaped valleys of upper Gostelja and Zatoča, the local faults, which are intersecting the valley of Suha, along the Brloški potok gorge, had an impact too (Fig. 12). The only Smf wiht a moderate value of 1,83, was calculated on the south contact of a small Brlošci valley extension with surorounding hillslopes reshaped in the clastites.

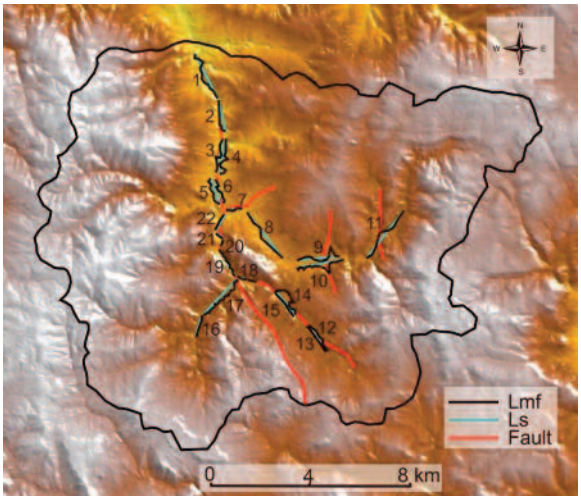

Figure 12. Mountain Front Sinuosity (Smf)

Elongation ratio analysis

If the basin of some drainage area is more elongated, it's tectonically more active compared to those of circular outline which are tectonically more stable which can be determined based on relations: Re = 2 x (A / Π) 0.5/ BL (Burbank & Anderson, 2001). Therefore, the Re represents the extent of elongated drainage basin, A – basin surface of the Gostelja drainage basin (185,0 km^2) and BL – length of the Gostelja drainage basin (22,0 km). When classified known values, the Re = 2 x (185,0 / Π) 0.5/ 22,0 we get that Re = 2,67. Taking a look on Figure 13, a conclusion can be made, that the complete drainage basin of Gostelja river is significatly elongated. Based on the result Re = 2,67, obtained by the analysis method of Gostelja drainage basin elongation, this is a tectonically active area characterised with recent neotectonic uplifting (Fig. 13).

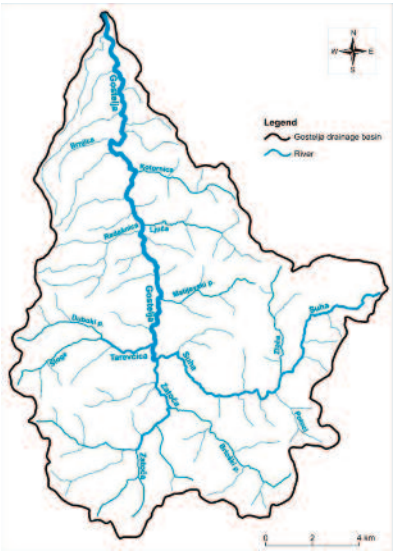

Figure 13. Gostelja River drainage basin

The drainage basins of Zatoča, Suha, Tarevčica and Radašnica, which abruptly narrows in its lower flows, are approximately shaped as a "wine glass", which are morphotectonically marked as neotectonic uplifting areas (Fig.13).

By a simple block uplift with two sloping sides bounded by faults, each flank will be characterized by regularly spaced, similarly sized and shaped basins, sometimes called "wine glass" or "goblet" valleys, due to their wide upper basins tapering to narrow throats as they pass across the active range front (Burbank & Anderson, 2001).

Type and density of river network

The prevailing types of river network are rectangular and dendritic drainage patterns (Fig. 9 and 11). The rectangular type is related to the Triassic and Cretaceous limestones. The dendritic drainage is related to areas of geomorphic reshaped Jurassic clastics. The microlocation of Stupari valley extension is presented by centripetal pattern, where on the small distances, the river valleys of Zatoča, Suha and Tarevčica are perpendicular merging (Fig. 9 and 11). This is actually the subsidenced block in relation to the adjacent, neotectonic uplifted microblocks. Measuring the 141 cells, 1 km^2 in area, on the topographic map 1: 25 000, we concluded that the density of the river network varies from 0 km/km^2 to 3.9 km/km^2. The highest density of permanent and periodic streams (>3 km/km^2) is evident at the Stupari, Krivajevići and Brlošci village, where the valley extensions are shaped in the more impermeable clastites. The lowest density (0 km/km^2) is evidenced at karstified highlands of Javornik with limestones lithological structure.

3.4. SOME NEGATIVE ANTHROPOGENIC IMPACT ON THE RELIEF OF THE RIVER GOSTELJA UPPER BASIN

Slope relief dominantly characterizes the upper Gostelja river basin. The narrow terrains where the prevailing accumulation processes are significantly present at a living area of 5,064 inhabitants (population

density is 35 inhabitants/km^2), distributed in 25 settlements, of which seven have no inhabitants (Census, 2013). The destructive slope processes of landsliding, creeping and other fluvio-denudational torrential processes influenced the slope instability (Fig.14a and 14c) in this area. This primarily refers to the irrational intensive deforestation and unprofessional slope incision for road constructions, which ultimately initiated the entire spectrum of destructive slope processes in clastic rocks (Fig.14a, 14b and 14c). The large number of landslides is evident in the upper Gostelja basin, which is reflected by the appearance and development of a new and reactivation of older landslides, different in size and caused by anthropogenic factor (Fig.14 c).

On the local slope relief, new landslides and reactivated fossil landslides had an impact. Especially in the Jurassic clastics near Gojsalići, Stupari, Tarevac and Hrastić, caused by heavy rainfalls during May 2014. (Fig.14c). The activated landslide in 24.02.2015. damaged the main road M-18 near Prijanovići, where also in the lower parts of the terrain, near Stupari, 10 houses and the road M – 18 were flooded. The communication between Kladanj and Živinice was interrupted due to that.

Figure 14a. Intensive deforestation and delluvial process in slope (right)

Figure 14b. Fine coarse - grained sediment fractions in hanging valley Duboki potok

Figure 14c. Active landslide of the rotation type near the fault in the neigbour Tarevo (photo by: Semir Ahmetbegović)

Especially, the delluvial denudation processes are very intensive, which results with fine grained sediment fraction accumulated in riverbeds of the mountain streams of the upper drainage basin of Gostelja (Fig. 14 a, 14 b). Thus, there are evident changes in the relief caused by human impact on slope processes and landforms. Beside the mentioned destructive geomorphologic processes, the anthropogenic impact on the Gostelja River water quality must be mentioned. Domestic wastewaters, the nearby limestone quarry and the minefileds in the area between Noćajević village and Pelemiš, as the upper valley of the Suha, are affecting the Gostelja River water quality.

4. CONCLUSION

The polymorphic and polygenetic relief, reshaped on the heterogeneous lithological composition, characterizes the analyzed upper Gostelja drainage basin in the Bosnian Central Dinaric ophiolitic zone. Mountain ridge crests with the slopes, high plateaus and composite river valleys are represented with the polymorphy

of the relief structure. This area is of a mountainous-hilly character based on hypsometrical characteristics, the energy of relief and slope inclinations data.

A high degree of correlation between the lithologic fundament of the terrain and genetic types of relief has been determined based on: The slope inclinations data, Drainage pattern, Stream density, Stream Longitudinal profiles, Basin Asymmetry Factor and directly in situ, in terrain. The higher values of relief energy, convex and subvertical outlines of the sharper slopes, derassional rocky faces and rectangular river network that characterize the karstic landforms and fluviokarstic gorges were reshaped in the limestone olistolithes. The surrounding areas with impermeable Jurassic clastic rocks are generally characterized by slopes reshaped by creeping, torrential and sliding with moderate inclination angles, dendritic drainage pattern and density river network (>3 km/km^2) on the more impermeable strata.

This area is mainly represented by the slopes of fold-thrusted massifs of Konjuh, Javornik and Djedinska Mountain and mostly exposed to compression, narrowing, neotectonic uplifting and clock-wise rotation of microblocks. It is confirmed by the results of morphotectonic analyses: Basin Asymmetry Factor (AF 44,23 – 62,07), Elongation Ratio (Re 2,67), Stream Length Gradient Indexes (sub basins: Zatoča SL 111-1,573, Suha SL 42-1,161 and Upper Gostelja SL 29-210), Mountain Front Sinuosity with the highly tectonic active mountain fronts (Smf 1.07 - 1.43) and Drainage pattern analysed from the neotectonic aspect.

Our investigation of active tectonics confirmed that those are mostly the unconform valleys that often intercut with the older fold structures under the sharp angles, which was directly influenced by recent strike slip-faults.

The negative impacts of anthropogenic processes in this area are reflected in unprofessional road construction incisions in the slopes, which are often the cause of development and the reactivation of the new landslides. Intense deforestation, caused by increased destructive torrential, creeping, landsliding processes, instability of slopes, which has disrupted the natural equilibrium of geomorphologically slope processes in this tectonically active area.

Appreciation

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