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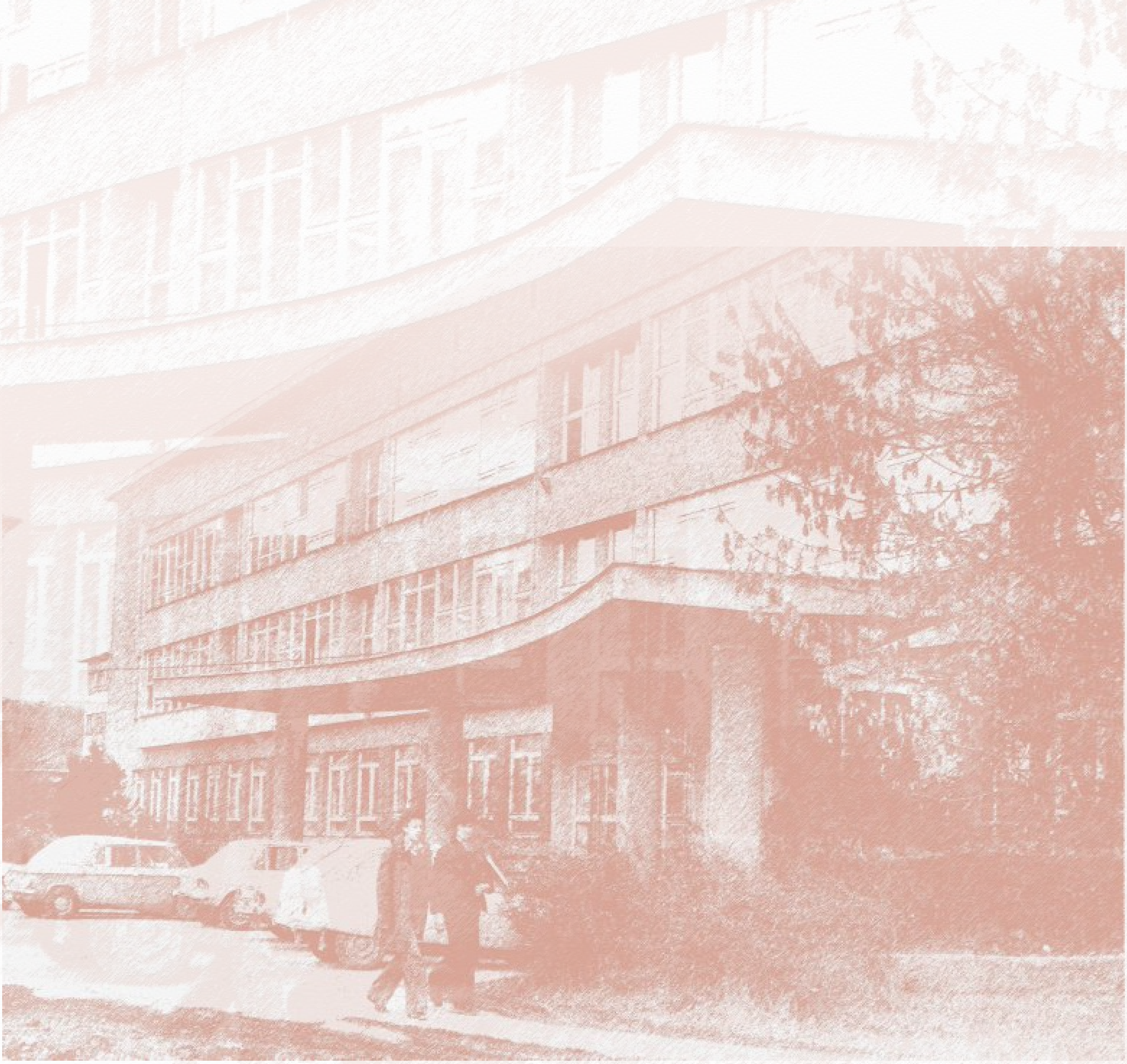

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CONTENT

Prof. Rejhana Dervišević
Editor in Chief

Dear readers, it is our great pleasure to offer to a scientific and professional public insight at the new issue of "Journal of Faculty of Mining, Geology and Civil Engineering".

In almost six decades of our Faculty's work, besides education was also conducted a research work, achieved through 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 educational work and those are: Mining, Geology, Civil Engineering, Borehole Exploitation of Mineral resources, Safety Studies as well as 15 scientific fields at which scientific work has been carried out (science fields 1.5, 2.1 and 2.7; Frascati).

Work on promoting and raising the quality, as well as affirming this publication, is a great challenge for every editor in chief. To accomplish this goal, current scientific and professional work, as well as systematic work, and successful co-operation of members of the Editorial and Advisory Board, reviewers and authors are necessary.

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 publication, and promotion of scientific thoughts and scientific results as well.

Scientific Paper

IMPORTANCE OF WELL TESTING IN OPEN HOLE OF OIL DEPOSIT

Adnan Hodžić[1], Sanel Nuhanović[2], Zvonimir Bošković[3], Jovana Munjiza[4]

SUMMARY

We use many different methods for the research of hydrocarbon deposits and its defining. All of those methods have a same purpose, which is to collect adequate quantity and quality of data for making the best decision about status of exploring objects and deposit in general. Those data save our time and money in the next phases of work.

That is why the well testing is one of the most important operations in economic assessment of deposit, because the value of those information is much more important and precious than the cost of investments.

We begin with testing when we detect an oil traces on the drilled rock fragments, which can happen several times during the wildcat drilling operations.

In most of cases, well testing is done in the zones with unknown potential productivity, but sometimes, well testing can also be used in production wells.

Key words: well, oil, drill stem test, well testing, production

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1. INTRODUCTIONS

Open hole well testing is performed using a special tool, so-called. "Tester", located at the bottom of the well (Drill Stem Test – DST). Basically, it is a short-term conquest of the well, (Figure 1). Productive layer (formation of interest) is separated from the rest of hole with packers, and mud hydrostatic pressure is eliminated, while the interest layer is now connected to a drill pipe pressure which is always smaller than formation pressure. This way, it is allowed the flow of fluid from the layer to borehole and his transport to the surface.

DST is a conventional method of tank formation and estimation, which provides reservoir data in dynamic (and not static) conditions.

Based on the data obtained during the test, important collector data can be obtained such as: permeability, damage of near well-bore zone (skin effect), pore pressure level, productivity coefficient, drainage radius, barriers etc.

2. TESTING IN OPEN HOLE OIL WELL

This type of test (Figure 1) performs when, during the drilling process, it is noticed a hydrocarbon traces in crumbling rocks, with the following purpose:

- to provide evidence of the productivity of a layer that has shown positive signs of fluid content, during drilling or coring,
- testing the productivity of the layer in which LWD gave interesting results.

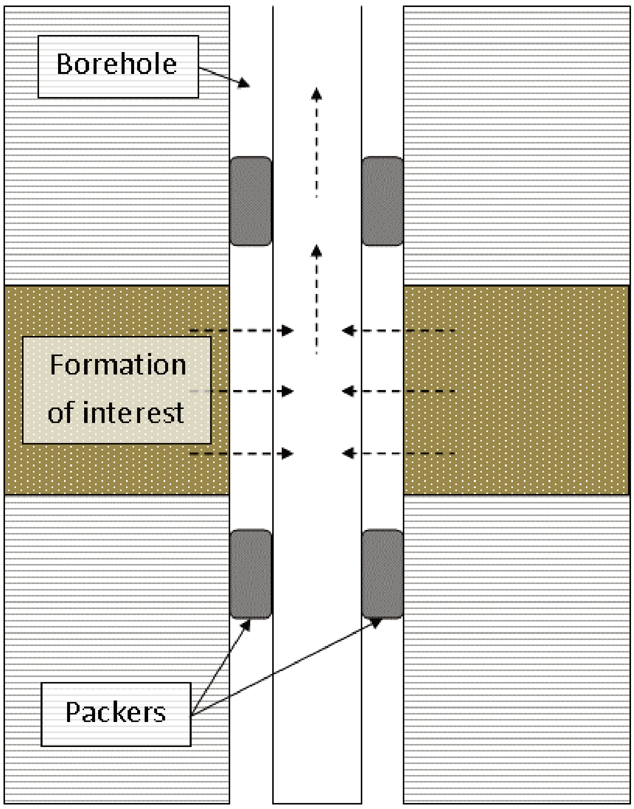

Figure 1. Scheme of equipment for DST

Drill Stem Test is simple. During the test the pressure and time are recorded, and during the removal of the tester, a sample of the formation fluid for analysis is taken.

Registrar equipment are an integral parts of DST. Many operators use two instruments, in case one is cancelled. Written diagrams show the pressures present at the bottom of the hole, as well as the pressure increase during the flow and closing period.

The Figure 2 shows graphic generated during the well testing in an open hole oil well. Well testing was carried out with two flow periods and two closing periods at the bottom of the well. All components of the diagram are recognizable and can be used for interpretation. Diagram analyse points to the reduced formation pressure.

Amount of obtained oil in drill pipes is 485 litres. Oil sample is taken for laboratory analysis.

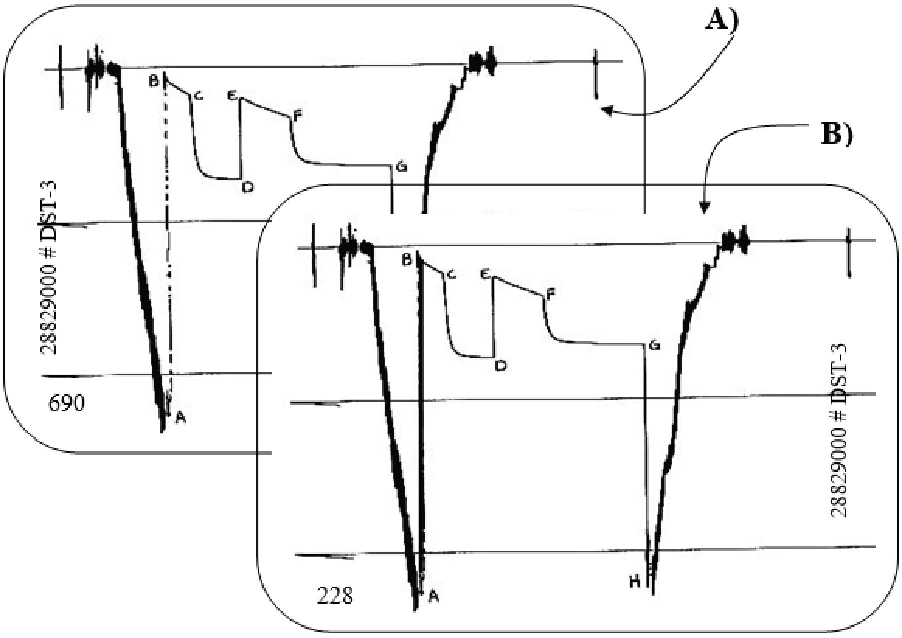

Figure 2. Well testing diagrams of oil deposit

POINT		MANOMETER Nº: *228* Depth: *1399* m A Clock Nº: 2414, with capacity: *12* hours			MANOMETER Nº: *690* Depth: *1381* m A Clock Nº : 3227, with capacity: *12* hours		
	POINT NAME	Time (s)	Pressure (cm)	Pressure (bar)	Time (s)	Pressure (cm)	Pressure (bar)
A	PHP	-	6,431	161,69	-	6,56	165,08
B	PDP	0	0,053	1,39	0	0,051	1,21
C	KDP	0,54102	0,142	3,60	0,49784	0,145	3,66
D	KSP	1,30937	1,341	33,68	1,24206	1,365	33,61
E	PDP		0,161	4,62		0,167	4,36
F	KDP	2,37236	0,281	7,06	2,28092	0,288	7,11
G	KSP	3,17627	1,308	32,86	3,05562	1,336	32,82
H	KHP	-		157,87	-	6,286	158,00

Table 1. Values of characteristic points from the diagram on figure 1.

		MANOMETER Nº: *228* Depth: *1399* m A Clock Nº: 2414, with capacity: *12* hours		MANOMETER Nº: *690* Depth: *1381* m A Clock Nº : 3227, with capacity: *12* hours	
PERIOD NAME	TIME (Proceedings)	LENGTH (cm)	SPEED FACTOR (cm/min)	LENGTH (cm)	SPEED FACTOR (cm/min)
B do C	30	0,54102	0,0180340	0,49784	0,016595
C do D	45	0,76835	0,0170744	0,74422	0,016538
E do F	60	1,06299	0,0177165	1,03886	0,017314
F do G	45	0,80391	0,0178646	0,77470	0,017215
Σ B do G	180	3,17627	0,0176459	3,05562	0,0169756

REAL TIME CALCULATE			
FLOW = 30,66 (minute)	**1^{st} CLOSING =43,54** (minute)	**FLOW = 60,24** (minute)	**2^{nd} CLOSING = 45,55** (minute)
Calculated real times (on a base of speed factor) of well testing phases are: 0,0176459 cm/min.			
FLOW = 29,33 (minute)	**1^{st} CLOSING = 43,84** (minute)	**FLOW = 61,19** (minute)	**2^{nd} CLOSING = 45,63** (minute)
Calculated real times (on a base of speed factor) of well testing phases are: 0,0169756 cm/min.			

Table 2. Speed of a clock mechanism estimate

Manometer Nº: 690, Depth: 1381 m A Clock Nº: 3227 with capacity: *12* hours						Manometer Nº: 228, Depth: 1399 m A Clock Nº: 2414 with capacity: *12* hours					
Point	Time min.	Pressure bar	ΔP bar	(TxΔt) (T+Δt)	(T+Δt) Δt	Point	Time min.	Pressure bar	ΔP bar	(TxΔt) (T+Δt)	(T+Δt) Δt
1st FLOW						**1st FLOW**					
B 1	0	1,21	-			B 1	0	1,39	-		
2	2	1,47	0,26			2	2	1,50	0,11		
3	4	1,70	0,49			3	4	1,72	0,33		
4	6	1,89	0,68			4	6	1,97	0,58		
5	8	2,05	0,84			5	8	2,12	0,73		
6	10	2,22	1,02			6	10	2,29	0,91		
7	12	2,37	1,16			7	12	2,39	1,00		
8	14	2,53	1,33			8	14	2,54	1,15		
9	16	2,66	1,46			9	16	2,66	1,28		
10	18	2,82	1,61			10	18	2,79	1,40		
11	20	2,97	1,76			11	20	2,93	1,54		
12	22	3,10	1,89			12	22	3,08	1,70		
13	24	3,23	2,03			13	24	3,22	1,83		
14	26	3,36	2,16			14	26	3,36	1,98		
15	28	3,50	2,29			15	28	3,46	2,07		
C 16	29,33	3,66	2,45			C 16	30,66	3,60	2,21		
1st CLOSING						**1st CLOSING**					
C 1	0	3,66	-	-	-	C 1	0	3,60	-	-	-
2	1	5,31	1,65	0,97	30,30	2	1	4,44	0,84	0,97	31,66
3	2	6,89	3,23	1,87	15,65	3	2	5,66	2,06	1,88	16,33
4	3	8,87	5,21	2,72	10,77	4	3	7,36	3,76	2,73	11,22
5	4	11,90	8,24	3,52	8,33	5	4	9,65	6,05	3,54	8,67
6	5	15,83	12,17	4,27	6,86	6	5	12,76	9,16	4,30	7,13
7	6	20,08	16,42	4,98	5,88	7	6	17,30	13,70	5,02	6,11
8	7	24,04	20,38	5,65	5,19	8	7	21,75	18,15	5,70	5,38
9	8	26,68	23,02	6,28	4,66	9	8	25,26	21,70	6,34	4,83
10	9	28,60	24,94	6,89	4,26	10	9	27,65	24,05	6,96	4,41
11	10	29,66	26,00	7,46	3,93	11	10	29,16	25,56	7,54	4,07
12	12	30,94	27,28	8,51	3,44	12	12	30,77	27,17	8,62	3,56
13	14	31,59	27,93	9,47	3,09	13	14	31,56	27,96	9,61	3,19
14	16	32,03	28,37	10,35	2,83	14	16	32,01	28,41	10,51	2,92
15	18	32,35	28,69	11,15	2,63	15	18	32,38	28,78	11,34	2,70
16	20	32,57	28,91	11,89	2,47	16	20	32,63	29,03	12,10	2,53
17	22	32,76	29,09	12,57	2,33	17	22	32,83	29,23	12,81	2,39
18	24	32,87	29,21	13,19	2,22	18	24	33,00	29,40	13,46	2,28
19	26	33,03	29,37	13,78	2,13	19	26	33,15	29,55	14,07	2,18
20	28	33,14	29,48	14,32	2,05	20	28	33,22	29,62	14,63	2,10
21	30	33,24	29,58	14,82	1,98	21	30	33,33	29,73	15,16	2,02
22	35	33,40	29,75	15,95	1,84	22	35	33,50	29,89	16,34	1,88
23	40	33,54	29,88	16,91	1,73	23	40	33,63	30,03	17,35	1,77
D 24	43,84	33,61	29,95	17,56	1,67	D 24	43,54	33,68	30,07	17,99	1,70

Table 3. Values of well testing by phases – 1st measurement

Manometer N°: 690, Depth: 1381 m A Clock N°: 3227, with capacity: *12* hours						Manometer N°: 228, Depth: 1399 m A Clock N°: 2414, with capacity: *12* hours					
Point	Time min.	Pressure bar	ΔP bar	(TxΔt) (T+Δt)	(T+Δt) Δt	Point	Time min.	Pressure bar	ΔP bar	(TxΔt) (T+Δt)	(T+Δt) Δt
2nd FLOW						**2nd FLOW**					
E 1	0	4,36				E 1	0	4,62			
2	3	4,19				2	3	4,15			
3	6	4,40				3	6	4,42			
4	9	4,58				4	9	4,54			
5	12	4,70				5	12	4,71			
6	15	4,85				6	15	4,85			
7	18	5,03				7	18	5,03			
8	21	5,16				8	21	5,21			
9	24	5,28				9	24	5,34			
10	27	5,40				10	27	5,47			
11	30	5,54				11	30	5,61			
12	35	5,84				12	35	5,93			
13	40	6,09				13	40	6,13			
14	45	6,34				14	45	6,37			
15	50	6,58				15	50	6,59			
16	55	6,80				16	55	6,81			
F 17	61,19	7,11				F 17	60,24	7,06			
2nd CLOSING						**2nd CLOSING**					
F 1	0	7,11	-	-	-	F 1	0	7,06	-	-	-
2	1	9,42	2,31	0,9	91,52	2	1	8,66	1,59	0,99	91,90
3	2	11,50	4,39	1,96	46,26	3	2	10,66	3,60	1,96	46,45
4	3	14,07	6,96	2,90	31,17	4	3	13,02	5,95	2,90	31,30
5	5	20,17	13,06	4,74	19,10	5	5	19,11	12,04	4,74	19,18
6	6	23,13	16,02	5,63	16,09	6	6	22,05	14,98	5,63	16,15
7	7	25,40	18,30	6,50	13,93	7	7	24,80	17,74	6,50	13,99
8	8	26,79	19,68	7,35	12,32	8	8	26,73	19,67	7,35	12,36
9	9	28,13	21,02	8,19	11,06	9	9	28,04	20,97	8,19	11,10
10	10	29,02	21,91	9,01	10,05	10	10	28,96	21,89	9,01	10,09
11	12	30,08	22,97	10,60	8,54	11	12	30,13	23,07	10,60	8,58
12	14	30,72	23,61	12,12	7,47	12	14	30,776	23,69	12,13	7,49
13	16	31,12	24,01	13,60	6,66	13	16	31,20	24,14	13,61	6,68
14	18	31,39	24,28	15,01	6,03	14	18	31,51	24,44	15,02	6,05
15	20	31,68	24,57	16,38	5,53	15	20	31,72	24,65	16,39	5,55
16	22	31,87	24,76	17,70	5,11	16	22	31,94	24,88	17,71	5,13
17	24	32,02	24,91	18,97	4,77	17	24	32,07	25,00	18,99	4,79
18	26	32,12	25,01	20,20	4,48	18	26	32,19	25,12	20,22	4,50
19	30	32,34	25,23	22,53	4,02	19	30	32,40	25,33	22,56	4,03
20	40	32,69	25,58	27,74	3,26	20	40	32,74	25,68	27,78	3,27
G 21	45,63	32,82	25,71	30,34	2,98	G 21	45,55	32,86	25,80	30,34	3,00

Table 4. Values of well testing by phases – 2nd measurement

In order to determine the minimum time needed to start an uninterrupted flow, it is used 'Diagnostic Diagram" (Figure 3), in which the pressure is applied on the ordinate, and on the abscissa, the time of the pumping. Well effects last as long as the points in that diagram fall to a direction with a slope of approximately 45°. The deviation from that direction represents the end of the borehole effect period.

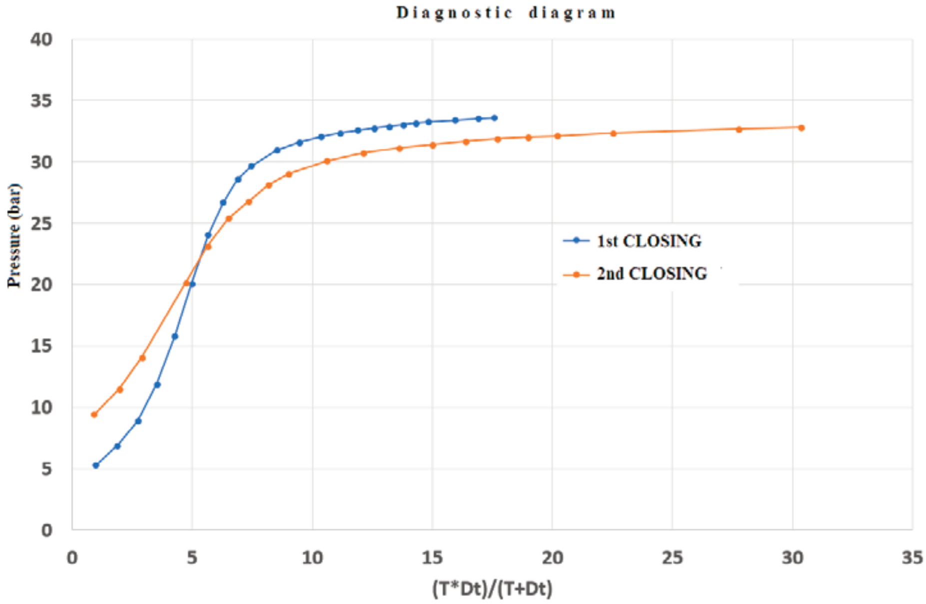

Figure 3. Diagnostic diagram (Excel)

By analyzing data on pressure increase, data on collector bandwidth and damage of heterogeneity in the boundaries of the deposit are obtained. For this purpose, the most commonly used method is Horner's method of pressure variations (Horner plot) (Figure 4).

According to Horner's method (Figure 4), the measurement results are displayed by applying a pressure to the ordinate and to the abscissa ratio log ((T + Δt) / Δt). "Horner time", in logarithmic scale, and data not lying in the direction refer to the period of the fluid storage.

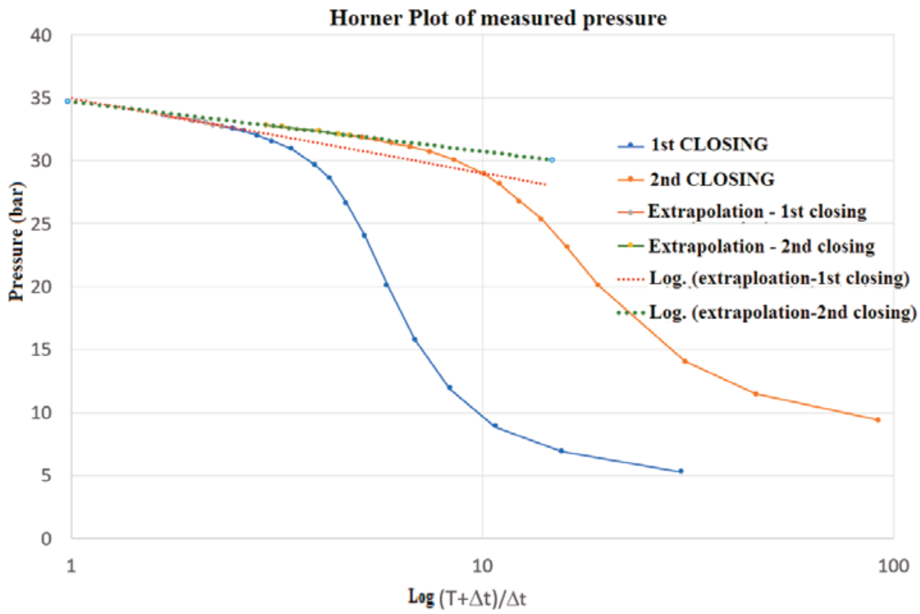

Figure 4. Extrapolation of static diagram

From the Horner plot, we can estimate next values:
Maximum formation pressure (Horner's plot – 2nd closing):

P_s=34,8[bar]

The slope of linear part of increase curve:

$$M = P_1 - P_{10} = 34,80 - 31,60 = 3,20\left[\frac{bar}{\log.cikl.}\right]$$

Pressure gradient:

$$GP = \frac{P_s}{H_r} = \frac{34,80}{1381} = 0,0252\left[\frac{bar}{m}\right]$$

Transmissibility:

$$T_r = \frac{k \cdot h}{\mu \cdot B} = \frac{21,207 \cdot Q}{M} = \frac{21,207 \cdot 2,13}{3,20} = 13,43\left[10^{-3}\,\mu m\right]$$

Results of the well stream laboratory analysis are shown in table 5.

Fluid characteristic	Value
Oil density	0,83 kg/dm^3
Gas density	-
Layer temperature	72 °C
Thickness of layer	6 m
Drill collars capacity	3,167 dm^3/m

Table 5. Results of the well stream laboratory analysis

Well testing in open hole helps the drilling team to analyze the productivity of the layer. Through this test, many data are identified, such as: well production, maximum pressure, layer permeability (transmissibility), etc. The data collected for the borehole production determines the bulk volume of the fluid produced over a given period of time. The data is not entirely accurate, but can be used as a relevant predictor of the total amount of oil that will be produced by one well.

Production during the test:

$$Q_a = \frac{1440 \cdot V}{T_{1+2}} = \frac{1440 \cdot 0,146}{90,9} = 2,13\left[\frac{m^3}{dan}\right]$$

Estimated pollution coefficient:

$$EDR = \frac{P_0 - P_F}{M(\log T + 2,65)} = \frac{34,80 - 31,60}{3,2 \cdot (\log 90,52 + 2,65)} = 1,88$$

Theoretical well production (for testing layer):

$$Q_t = Q_a \cdot EDR = 2,13 \cdot 1,88 = 4\left[\frac{m^3}{dan}\right]$$

Quantity	Equation	Manometer Nº: 690 Depth: 1381 m		Manometer Nº:228 Depth: 1399 m		Measuring units
		Initial	Utmost	Initial	Utmost	
Testing periods – flow-closing		1	2	1	2	
Total flow time		29,33	61,19	30,66	60,24	minute
The one cycle pressure		29,87	31,60	29,87	31,60	bar/log cycle
Extreme dynamic pressure (P_{KDP})		3,66	7,11	3,60	7,06	bar
Production (Q)	$Q = \frac{1440 \cdot V}{T_{1+2}}$	4,14	2,90	3,74	2,13	m^3/day
Formation pressure (Ps)	Horner-plot	35	34,80	35	34,80	bar
The slope of curve (M)	P_1-P_{10} = M	5,13	3,2	5,13	3,2	bar/log cycle
Pollution (EDR) $EDR = \frac{P_s - P_{KDP}}{M \cdot (\log_{10} T + 2{,}65)}$		1,48	1,88	1,48	1,88	-
Transmissibility (T) $T = \frac{k \cdot h}{\mu} = \frac{21{,}207 \cdot Q \cdot B}{M}$		17,11	19,22	15,46	14,12	10^{-3} $\mu m^2 m/mPas$

Table 6. Calculated values of oil deposit

DISCUSSION

What is important to emphasize, after calculating and interpreting the test results, it is possible to define a layer permeability values, his eventual skin (s), eventual existence of barriers inside drainage diameter, pore pressure decrease rate, and generally, whether the examined layer is perspective for production or not.

Based on the results presented, it can be concluded that this layer has good characteristics and is very perspective for production.

Theoretical one - well production (Qt = 4 m3/day) is not quite good, but on the other side pollution coefficient (EDR=1,88) is also not too big, so well production could be better with appropriate stimulation works (acid stimulation).

CONCLUSIONS

Wildcat well testing is important to define hydrocarbon saturation of deposit and determine, or at least, point to its possible commercial resources, that can be proved afterwards, by hydrodynamic measurements.

Investments in well testing are always justified with the results, which can be used for the future optimal well using. Well testing gives us enough precise answers to the questions about deposits permeability and damaged (skin effect) of near-wellbore zone.

The skin effect value can give us better knowledge about possible well production level. It is the basis for the future well works, as well stimulation, eventually canning or leaving the well works.

The most common mistake that happens during the test is its standardization, because each deposit and well are specific. It is possible to standardize some basic equipment, but not the whole procedure and tools.

Successful test provides the very important data for the future well and deposit works.

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Original Scientific paper

OPTIMIZATION SOLUTIONS WITH VERTICAL REVETMENTS OF WATERCOURSE

Mufid Tokić[1], Jasmin Hrnjadović[2], Anadel Galamić[3]

SUMMARY

This paper covers water management issues from the aspect of design (preparation of conceptual solutions, design projects, main and execution projects), execution of works and maintenance of regulated watercourses as a hydrotechnical facility within or outside the center.

Experts from various professions (engineers of hydro engineering, construction, geomechanics, hydrogeology, lawyers and economists) are involved in the design of project solutions and works.

This paper deals with vertical shorelines, their advantages and disadvantages, technical characteristics from the aspect of hydrotechnics, construction, geomechanics. In order to have a clearer view of the problem, the main project of regulation of brook Lukavčić was made upstream of the regulated part, where through three variants (solutions) the optimal solution was analyzed both from hydrographic and economic aspect.

Key words: regulation, projects, variants, hydrotechnic, analysis

1. INTRODUCTION

Coastal areas are the regulatory buildings in the watercourse basin that are shielded from erosion and erosion processes, and are channeled along the waterway along the coast. They are one of the most sophisticated regulatory buildings that are now being applied as protection against water and erosion. They are used in places where the existing and projected coastline is very close to avoid large ground excavation and / or bulk excavations. They fall into parallel primary regulation structures. [1]

In practice, there are many types of obelisk construction constructions used in waterworks. The largest application of the burial ground is in practice on the shores of the sea, where it protects the shore from waves that destroy the natural state of the coast, in ports - the ships' docks, and are constructed of burial grounds in the form of chinese walls. When it comes to river hydrographics, coastal bridges have been found to be a major application for shore protection in concave curves where the river breaks along its coast, especially in large waters, at high speeds. The removed material of the coast is deposited on the convex part of the curve. [2] [5] [6]

The basic division is on the vertical and the hair construction. The basic difference, in a constructive sense, is in the transmission of horizontal loads. Vertical structures should load horizontal loads into the ground, while on the ground construction only the ground takes over these loads (the question of stability slope). Vertical constructions are divided into two basic groups, also related to the transmission of horizontal forces. The first group includes gravitational structures in which the horizontal loads are transferred to the ground by the weight of the building itself. With this type, no tension tensions occur in the construction itself. The second group represents the types in which the horizontal loads are transferred to the ground by the internal forces in the construction. Tensile stresses also appear in them.

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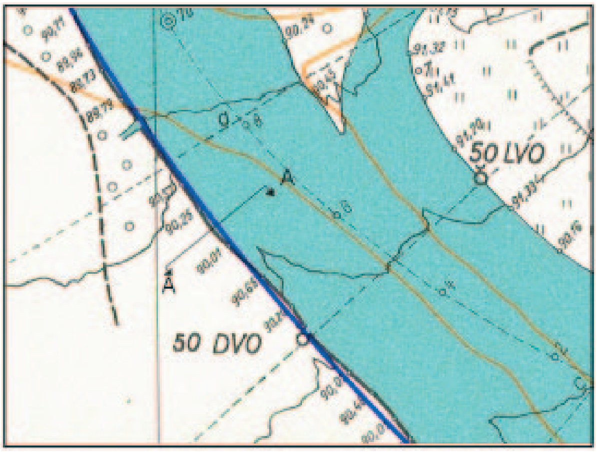
2. ANALYSIS AND OPTIMIZATION OF SOLUTIONS

The subject of the study is the vertical obliquity and the optimization of the solution in the selection of materials or constructions in water regulation.

TYPES VERTICAL REVETMENTS OF WATERCOURSE	
VERTICAL CONSTRUCTION	SLOPE CONSTRUCTION
▪ Gravity structures (concrete and reinforced concrete, gabions, reinforced earth) ▪ AB L-walls, slots and diaphragms (steel reinforcement, reinforced concrete, reinforced concrete diaphragm)	▪ protection of coastline with natural materials (biological waterworks) ▪ stoneware, gabion and Reno mattresses ▪ concrete constructions ▪ geotextile and geomembrane ▪ asphalt constructions

Table 1: types of vertical revetments of watercourse



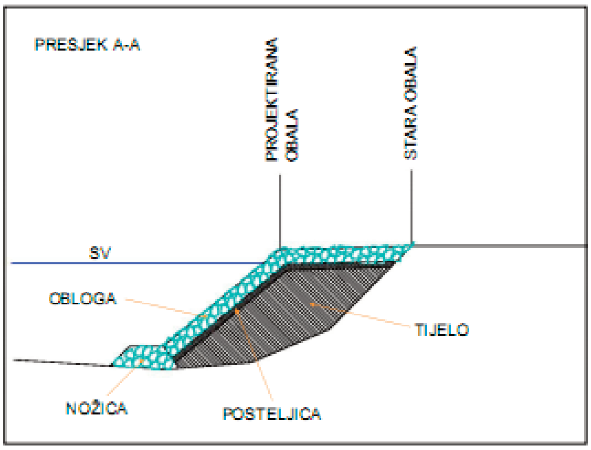


Figure 1: Schematic representation of the vertical revetments of watercourse

The choice of an optimal solution where the technical (static) stability of the construction is to be met, and an economically acceptable solution. Choosing solutions that will meet the above factors will affect a whole set of parameters such as:

- geometric characteristics (slope, slope, slope length, slope, etc.);
- Intended mode of exploration of the coast;
- Geotechnical properties of the material from which the coast was built (granulation, angle of internal friction, cohesion and others);
- Hydrological water regime (extreme flows, amplitude and velocity of water oscillation, duration of flow, etc.);
- hydraulic flow characteristics (traction, medium speed, local speed, flow direction, waves and the like);
- groundwater level (level, curve depression position, infiltration);
- temperature (conditions for ice formation, soil freezing influence and others);
- Building materials (landfills, landfills);
- construction machinery (availability, workability);
- security factors of the object (roll over, skid, structure fracture).

The following calculations should be used to check the adopted solution:

- Analysis of the general stability of the slopes,
- Analysis of stability in relation to the influence of dynamic effects of water,
- Analysis of stability in relation to the effects of waves,
- Analysis of the stability in relation to the impact of groundwater,
- Other analyzes.

3. ELECTION OF OPTIMAL SOLUTION, TECHNICAL-ECONOMIC ANALYSIS

When choosing the optimal solution, ie selecting waterproofing material for water flow control, the choice of the most favorable construction that will satisfy technical stability and be economically justified, there is no universal approach. In the various literary data, in practice, there are no concrete guidelines because of the great specificity of each particular case. The choice of an optimal solution depends on many input parameters and the results of the budget being carried out when designing such facilities. The most common factors that ultimately give the optimal solution are: a normal profile of sufficient permeable power to count the return period, flow rate, channel flow, flow regime, terrain configuration, building facilities, infrastructure, and the cost of performing the work as well as the mechanization that is available for performing works of hydro-technical facilities.

In order to demonstrate the above mentioned problems, an example will be given here, which relates to regulating Lukavcic brook upstream from the implemented regulation in Lukavac Place settlement. Lukavcic Stream has been running problems in the inhabited part of Lukavac (Lukavac Place) for a number of years, pouring out of the ravine and swirling surrounding objects, infrastructure and surfaces beside it.

Therefore, in 1987, the conceptual solution of Lukavcic brook regulation was completed, and in October 1988 the main project for Lukavcic brook regulation in Lukavac was 4 900 m long. The project documentation was made by the MVP "Spreča" Tuzla.

During 1999, a new part of the Lukavcic Stream project was developed by Vodobiro, a bureau for the design and supervision of water supply and sewerage facilities and the Gračanica Road, and in 1999 it was realized. This new project did not deliver a solution to the revised Major Project. The profile is derived as an open reinforced-concrete "U" profile of average dimensions b = 3.5 m and height h = 2.30 m. The derived profile has a slightly lower Q 1/10 appearance.

Since the joining of the joints for the new project in 1999 rose by about 1.8 m compared to the joint level given in the main project elaborated by the MVP "Spreča" Tuzla (1988), so the problem of continuation of the upstream part (the regulatory work of the 1988 Master Project could no longer be applied).

In this paper, the mentioned stream was analyzed in three variouses, namely:

- Various I: profile "U" whose width b = 6.0 m and height h = 2.0 m (implemented regulation),
- Various II: profile with reinforced - concrete bottom and coastline protected by gabion walls as the boundary of the hull width of 6.0 m and height h = 2.0 m,
- Various III: profile with reinforced - concrete bottom plate - bottom and shore of the coasts protected with reinforced - concrete thin walls thickness d = 25 cm at which the bottom of the AB slab is laid, the width of the crane is 6.0 m in height h = 2.0 m.

In the first variant, the existing state of the implemented regulation was analyzed, with the so-called " The "U" profile projected with the entire section in length L = 202.75 m.

After the hydraulic calculation was made, it was concluded that the existing variant (variant I) can receive a high water level of reporting 1/100 years (Q1 / 100 = 45 m3 / sec) as well as the remaining two variants (variant II and variant III) without reserve height h = 0.80 m. But on the profile of the bridges that are on the considered section, they can not receive the mentioned large water, and it is necessary to extinguish it.

On the basis of the hydraulic calculation and modeling of Lukavcic Creek basin in the HEC-RAS program package, it was also concluded that the results of the hydraulic calculation for all three variants are approximate, for some results identical, and from the hydraulic aspect all three variants can be used as optimum the solution of vertical bays. [3]

Since there was no optimum solution from the hydraulic aspect, the proportion of the pre-calculation of the works, or economic analysis of all three variants, was made. Economic analysis has shown that these three variants are not nearly equal or identical and there is a difference between them. Below you will find the results of the economic analysis, ie the total cost of the cost for all three variants in particular. [4]

	Total price cost of work	The cost of performing works per meter
	KM	KM/m`
Various I	233.558,71	1151,95
Various II	**190.120,56**	**941,00**
Various III	243.631,51	1201,64

Table 2: Economic analysis in the choice of optimal solution of vertical revetments of watercourse - brook Lukavčić in length L = 202,75 m

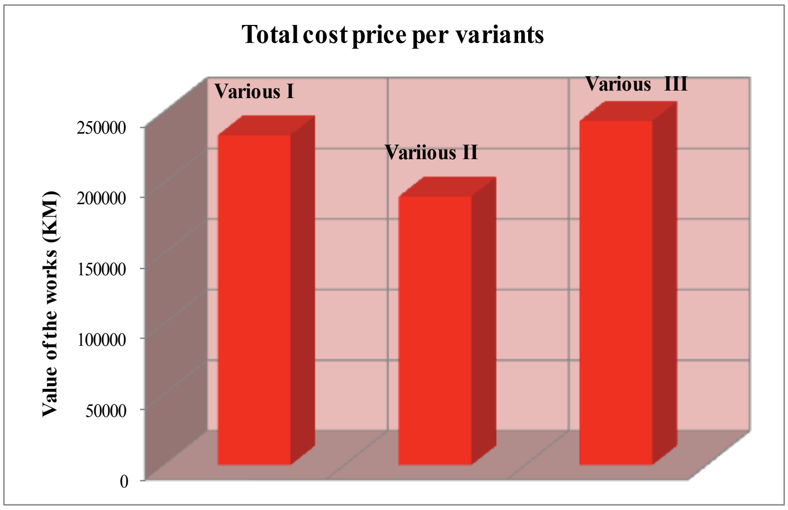


Figure 2. Price of the cost by variants

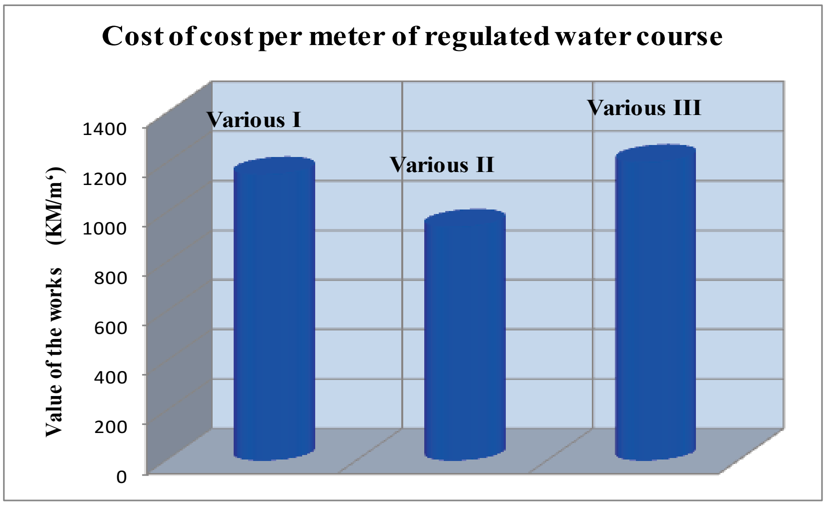


Figure 3. The cost price of works per meter

4. CONCLUSIONS

The aim of this research is to optimize the solutions of vertical bays in water regulation. In accordance with the above mentioned subject of research, the main purpose and objectives of this paper are to provide an overview of the current research into the type and type of waterborne river basin construction, to analyze the methodology for selecting the type of coastline in the watercourse regulation, to define the criteria for selecting the type of coastline when controlling the watercourse, confirm the validity of the hypothesis set.

In this paper, the application of vertical bays is illustrated by a concrete example of Lukavcic stream regulation upstream of the implemented regulation. Three variants were made, namely: variant I as the "U" profile which was also the control, variant II with the protection of the slope of the gabion walls and the variant III with the protection of the sloping sloping concrete wall. In all three variants the bottom is taken as an armored - concrete bottom of the variable cross section. Through the elaboration of Lukavcic brook regulation, variables were analyzed from the point of view of hydrotechnics (calculation of the permeable power of the profile, water velocity in the basin, flow regime, etc.), and the economic aspect (the price of the works or regulation as a hydroelectric facility) vertical obelisk. The first hydraulic analysis showed that for all three variants the results have approximate results, in some profiles even identical, while for the second analysis, the economic, variant II is the most favorable, ie cheaper, as shown in item 7 of this paper (Optimal Choice solutions, technical-economic analysis). It is also possible to say that variant II is also the most favorable from the aspect of aesthetic appearance of the construction itself, that is water regulation.

When selecting watercourse protection materials, several universal guidelines may be given which should be followed when designing and / or carrying out works on watercourse regulation:

- that the defensive material has good physical and mechanical properties,
- to be easily embedded,
- to meet the ambience, aesthetics, urban planning and other criteria,
- that is cheap,
- tavorable for maintenance during exhalation.

Water protection (flooding) is a imperative of the modern age and in this respect there must be a general social agreement and development of strategies for the development of an area including water management. The development of industry, agriculture, urban areas and so on must take care of ecology. In this context, water management plays a particularly important role because of the enormous importance of water for the environment. Access to water management and management must be based on the harmonization of water management and ecological goals. Regardless of large investment, such an approach must be the commitment of every man in the future. The task of water management or water management experts would consist of constantly monitoring the world trends and achievements in the area of water planning, use and protection as well as in the analysis of positive and negative experiences of other countries.

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Scientific Paper

REGULATION OF WATERCOURSES IN URBAN AREAS

Anadel Galamić[1], Mufid Tokić[2], Jasmin Hrnjadović[3]

SUMMARY:

This work covers problems of water regulation, as a hydrotechnical facility in Banovic's urban zone.
The paper deals with variant solutions for the regulation of the Litva watercourse in Banovići, and analyzes and comparisons of these cost-cutting solutions, the technology of conducting works on regulation, as well as from the aspect of obtaining final results and regulatory functions. In order to gain a clear insight into the issue, two variants of the solution were made. The first variant solution is the closed-type regulation with a transversal cross-section. Another variant solution is water flow regulation with reinforced reinforced concrete slabs. Through these two variants (solutions), an optimal solution of water regulation in the urban zone was analyzed, both from hydrographic and economic aspects. Solutions have been analyzed, in accordance with the organizational and technological aspects of regulation implementation, taking into account the value of building land in the urban area.

Key words: regulation, variants, analysis, solutions, urban zones,

1. INTRODUCTION

Waterfalls represent natural or artificial waterways in which, within the system of circulating water in the nature, continually, or occasionally, run smaller or larger amounts of water. Watercourse regulation is done to achieve a variety of goals. Regulatory works achieve effects whose economic significance is easily perceived. Some of the goals of watercourse regulation in urban areas are protection against settling floods, flooding of the road infrastructure, improving the aesthetic appearance of rivers in settlements as well as obtaining areas in the function of urban development. The urban area of Banovići is located in the river basin of Lithuania, which is also the largest watercourse that flows through the city itself.

The Lithuanian river itself is part of the flood waters of the third category of buoyancy. The degradation of the watercourses causes a large presence of suspended solids and organic materials, which can not be sufficiently diluted, as they are low flow watercourses. [1]

Average flows in the river Litva are:

average year 0.73 m^3 / s
dry year 0.48 m^3 / s
wet year 0.91 m^3 / s

Almost in all cases, regulation of watercourses in the populated place of approaches to achieve the necessary degree of safety from flooding, riverbed stabilized and provided a belt of urban space. When selecting the elements of a regulated basin in the urban area, it is necessary to take into account the requirements that arise from the standpoint: maintaining the environmental characteristics of the area, integrating into urban settlement of settlements, providing possible recreational opportunities for water, easy and efficient maintenance of the basin do not undertake works of greater magnitude), the provision

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of special aesthetic effects, the preservation of water drainage from rainwater drainage, and the alignment of relations with other urban infrastructure elements. [2]

2. ELECTION AND ANALYSIS OF VARIOUS SOLUTIONS

The research in this paper shows that the comparative analysis of the variants of the water supply regulation finds the optimal choice of regulation, selecting the flow profile from the hydraulic calculation of the condition, using different types of building materials, taking into account the organizational and technological aspect. [3]

In the city's construction zone of Banovici, the river water regulation of the Litva and Radina rivers has been settled. The closed-type Radina river regulation was carried out in a narrow urban area that provided a functional space for the infrastructure and city parks. Also on certain sections, closed regulations of the river of Litva were conducted on the part of the city market and sport center. These regulations also provided a functional space for further development of the city.

The subject of the study is two variants of the regulation of the river of Litva in the town building zone of Banovici, with a special reference to regulation in the immediate vicinity of the administrative building of the main direction of the brown coal mine "Banovići" d.d. , with the aim of finding the optimal solution and the economic viability of the variants in order to provide the construction land necessary for further urbanization of the city. [4] [5] [6]

2.1. VARIOUS I

A various solution envisages the development of closed regulation of the Litva River, which is a natural barrier between the existing main city road and the planned complex of the mining museum with accompanying facilities. It is therefore envisaged to regulate the river of Lithuania on the move between two bridges with a closed projection profile of a molded profile, through which a access platoon was created to the "mining museum" with a parking space for visitors to the administrative building of the mine and a parking space for visitors to the museum '.

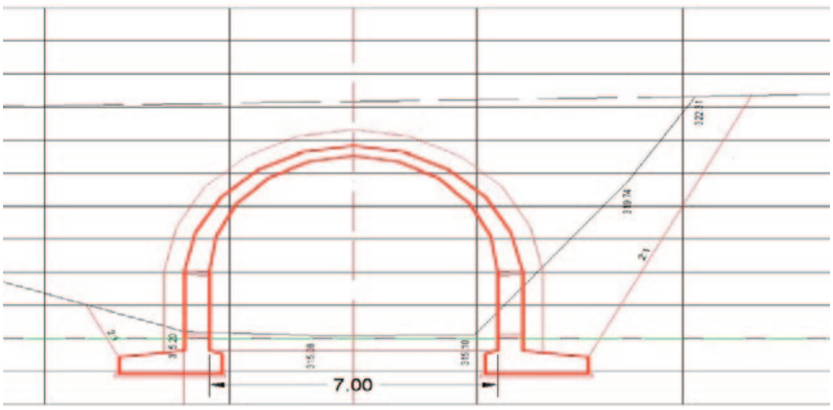

Figure 1. Cross section of river regulation Litva- Various I

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.

2.2. VARIOUS II

Various Solution II provides for the regulation of the Lithuanian River in a trapezoidal profile with an armored - concrete bottom plate - bottom and shore of the coast protected by reinforced - concrete walls of thickness d = 25 cm, bar width is 8.0 m and height h = 6.5 m.

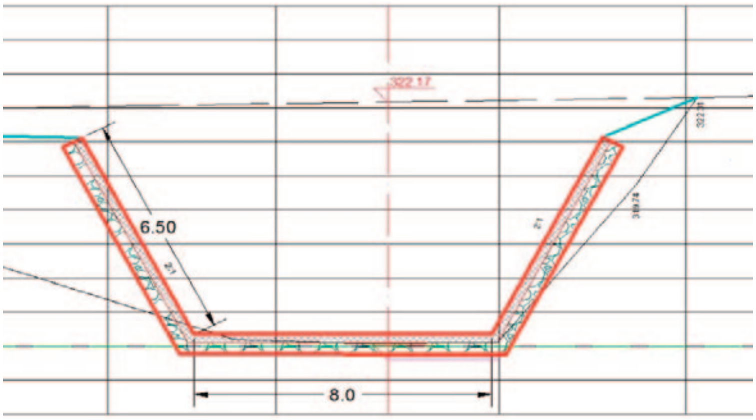

Figure 2. Cross section of river regulation Litva- Various II

3. ECONOMIC ANALYSIS BY VARIANTS

On the basis of the cuts and pre-estimates of the works carried out for all the necessary positions of the works, the total cost of the works was varied. [6]

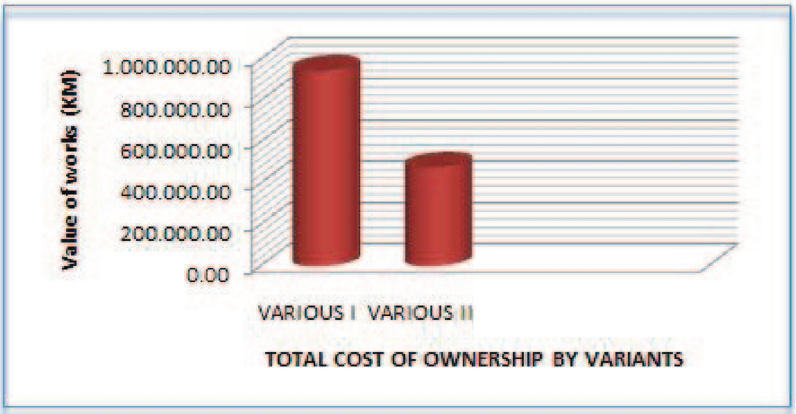

Figure 3. Total cost of water regulation of Litva watercourses by various

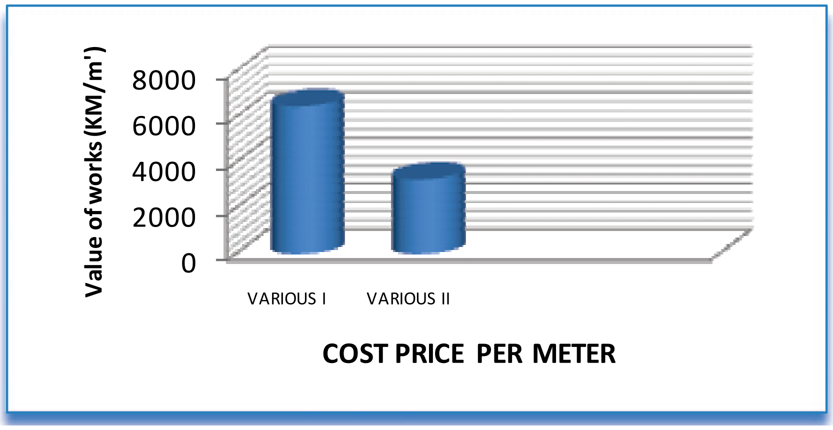

Figure 4. The cost of regulating the Lithuanian watercourse by meter

4. ANALYSIS OF VARIOUS SOLUTIONS

Given that it is the urban zone of the town of Banovici, zone I, according to the valid decisions of the Banovići municipal council, the price per m2 in zone I amounts to 12,00 KM / m^2.

By the variant of the I-closed watercourse, a considerable area in the urban environment is obtained, which according to the plans for urbanization of the city. [7]

Also, by the closed water regulation, there is also an access platoon plot foreseen for further urbanization of the city. On this surface is foreseen a mining museum of 15,000 m^2, equipped with a parking space for Banovići mining and mining museum.

Planned area of accompanying contents (parking space, green area) is 3.800,00 m^2. Plate area of 146.51 m x 9.00 m = 1318.59 m^2, provides and provides access to a plot for the construction of a museum of mining and associated facilities. [8]

The total surface obtained by closed regulation is P = 17,481.41 m^2.

Based on market knowledge, the market value of m^2 of area in ZONE I, where watercourse regulation is 55.00 KM / m^2.

VARIOUS / PRICE	Total priceperforming works	The price of the works per meter	The market value of the land in the urban area	Total price performing works (including market value of m^2 of urban areas)
	KM	KM/m`	KM	
Various I	**947.283,49**	**6465,65**	961.477,55	14.194,06
Various II	478.054,82	3262,95	--------------	----------------

Table 1. Pricing of the cost of water management variant solutions including the market value of m^2 of urban areas obtained by regulation.

5. ECONOMIC ANALYSIS IN THE CHOICE OF THE VARIABLE SOLUTION OF LITHUANIA LITHUANIA REGULATION IN LAMBS OF L = 146.51 M INCLUDING THE MARKET VALUE OF URBAN ZONE

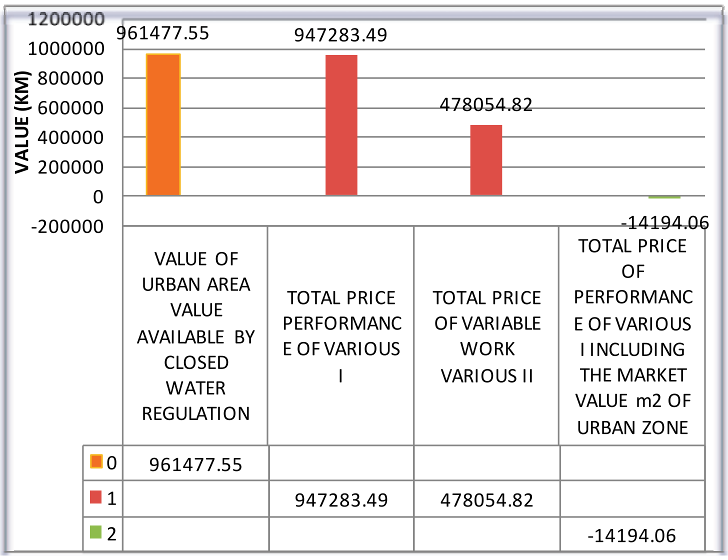

Figure 5. Cost of regulation, including market value of m^2 of urban areas

Given that it is relatively expensive, large investments and for one and the second type of regulation that has been processed, all the elements that ultimately affect the choice of type and type of regulation are analyzed and analyzed.

On the basis of the previous analyzes and the subject of the research, it comes out that by choosing a cheaper version of II - open water regulation, as the final choice we have only a regulated basket. Variant no. 1- Closed water regulation, we come to the water management solution and also get the necessary and functional space, which in urban conditions is a more rational and cheaper solution.

Specifically, including for the design of the water supply regulation variant I, the market value of the land is undeniable that this type of regulation performance is profitable in the first variation ie directly during the construction of the works.

Likewise, in the long run, with regard to the usability of land in the urban area, and in relation to the lifespan of the facilities that are envisaged such an approach brings the necessary profits.

6. CONCLUSIONS

The paper deals with the investigation of two variants of the regulation of the river of Litva in the city's construction zone of Banovici, with special attention to regulation in the immediate vicinity of the administrative building of the main coal mines "Banovići" d.d.

The aim of the research is to find the optimal choice by comparison of the variants of the water supply regulation by selecting the flow profile from the hydraulic calculation by using different types of building materials, taking into account the organizational and technological aspect.

The first variant is foreseen to cover the river of Litva in a sloped profile for the formation of a access platoon, for the purpose of building a mining museum with accompanying facilities (parking space, greenery). This variant with AB concrete slotted profile implies grounding of the foundation and body of the semicircular slope with concrete MB 30.

The second variant is the regulation of the Litva river watercourse reinforced concrete MB 30, installed on site, on the previously prepared substrate.

By choosing cheaper variants of the regulation of the injected watercourse - various II as the ultimate choice we have only a regulated basket.

By Closed Watercourse Regulation - variability and it is possible to reach the water management regulation and get the required and functional space, which in urban conditions can represent a more rational and even cheaper solution

Based on the processed data, it was found that the total price of the works and the price of the works per meter was variable and a more expensive solution for about 50% in the total value of various II.

By the various I - the closed watercourse, a significant area in the urban environment is obtained, which according to the plans is for urbanization of the city. On this surface, a museum of mining on the surface with a parking space for Banovići and museum mines is foreseen.

By closed water regulation, an access platoon plot is provided for which plot is planned.

Specifically, including for the creation of variators and watercourse regulation, the market value of the land is undeniable that this type of regulation performance is profitable in the first variation, ie directly during the construction of the works.

Likewise, in the long run, with regard to the usability of land in the urban zone, and in relation to the lifespan of the facilities envisioned by such an approach, it also brings the necessary profits.

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Scientific Paper

EARLY ONTOGENY OF MIDDLE MIOCENE DREISSENIDAE FROM PLASKOVAC FORMATION NEAR JELOVIK (CENTRAL SERBIA)

Gordana Jovanović[1], Jovica Jovanović[2], Nadežda Krstić[3]

SUMMARY

In this paper, early postlarval and juvenile growth stages of middle Miocene mytiliform bivalves are described for the first time. Location of one of these rare findings is in the territory of village Jelovik south of Mountain Bukulja (central Serbia). The shells originated from the lacustrine deposits of Plaskovac locality (Plaskovac formation). We present data on shell morphology, derived from scanning electron and light micrograph sequences of shell, that allows discrimination among two-stage development of these bivalves (early postlarval and juvenil stages). The taxa is left in open nomenclature, and the observed morphology features are similar to structures seen in extant bivalves of family Dreissenidae.

Key words: Dreissenidae, ontogeny, middle Miocene, Plaskovac formation, central Serbia.

INTRODUCTION

The mode of larval development of gastropods and bivalves is very similar, regardless of the fact whether they are inhabited in marine or freshwater environments [5]. However, recognizing the different stages of development of fossil and modern bivalves is much more difficult than in gastropods. When fossil bivalves are concerned, the findings of fossilized shells from their early development were quite rare and related mainly to marine species. Significant contribution was made to the knowledge of the development of larvae of tertiary Ostreoid [16]. Data for some species of the genus *Mytilopsis* from the Western Parathesis (Lower Miocene, Ottnangian) [13] are available, while the development of modern invasive species is studied in more detail. The most commonly described species belong to the genus *Dreissena* [1], [19], *Mytilopsis leucophaeata* and *Mytilopsis sallei* [23], [25], [12], [10], while more detailed descriptions of the development of other representatives of this family are rare [23], [9], [12]. Several guidebooks [5], [25] have been written to assist in distinguishing some recent taxa of Dreissenidae, however, different terminology has been used to describe the developmental stages of shells [18]. Analysis of settlements, distribution or environmental impact analysis require the correct identification of species, especially the larval and early postlarval stage [2]. In addition, larvae of bivalves can be of great importance for monitoring the formation of shells and speciation [18]. Moreover, fossils of larval shells specimen are useful tool in stratigraphy [8].

As well as many other bivalves, representatives of neogene draissenids during ontogenetic development pass through several stages before developing into an adult shell. Since they have a rich fossil record, they are often used to study evolutionary processes, but literaturedata on their early development is very limited. One of the few finds of fossil shells of shells is recorded south of the mountain Bukulja, in the wider area of the village Jelovik (Location Plaskovac, central Serbia). (Fig. 1).

The shells are preserved in clayey alevrite which is assumed to be the late middle Miocene (Lower Sarmatian) age, [14], [15]. According to the data of the curator of the Natural History Museum Velimir Miloševic, who collected the material during 1971, this formation was called Plaskovac formation. The material is stored in the Natural History Museum in Belgrade, collection number K 6471. This is the first palaeontological description of larval and juvenile specimens of the family Dreissenidae.

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Figure 1. Geographical position of the site with studied material.

GEOLOGICAL SETTING

The site with the described fauna belongs to the Kačer-Jasenica lake neogene basin, west-east direction route. Its north border represents cleavage of mountain Bukulja, while mountain Rudnik represents its south border. Sediments are presented by two formations, the older one lies below, and the younger above andezite and can be observed on natural sprouts as well as in boreholes in the Middle Hill in Jelovik and other localities. The Plaskovac formation composed of the breccia - conglomerate intercalated of sand and alevrite [14]. Plaskovac deposits are younger than sediments with *"Kosovia"* [24]. The genus of *Kosovia* is considered as a younger subjective synonym of the genus *Bulinus*, which was found in the Middle-Miocene lakes of Serbia [21]. Unlike early Middle-Middle Miocene (Badenian) and Upper-Miocene sediments, in the Sarmatian deposits of Serbia, representatives of Dreissenidae are rare. Based on the fauna of this and other sites in the extension of this basin, the Lower sarmatian (Late Middle Miocene) age of Plaskovac formations is assumed. Plaskovac formation is separated from the older (Lower Badenian) deposits by a dry land phase lasting ca. 3Ma.

MATERIAL AND METODS

In total, more than 50 harder and very small thickly, compacted, relatively well-preserved aragonite shells have been preserved in the sediment surface less than 1 cm^2, followed by more scattered individual shells in the sediment and several damaged larger specimens. Figure 2.

We have used the combined digital camera Olympus Z4001, attached to a binocular magnifier Biooptica 1000 and scanning electron microscopy (SEM) techniques to identify, describe and discriminate the early postlarval and juvenile stage of the studied shells from Plaskovac formation. The photos of the specimens were made with BIOOPTICA 100 stereomicroscope with attached OLYMPUS Z4001 camera and Electron Microscopy. SEM photographs were made in the Laboratory for Scanning Electron Microscopy at the Faculty of Mining and Geology of University of Belgrade. The publications related to the discrimination of the shells in larval, postlarval and juvenile stages of recent Dreissenidae were of great help [5], [1], [2], [25], [18]. The taxonomic decisions in this work were guided by study of Carter et al. [4].

PALEONTOLOGICAL PART

The Middle-Miocene sediments of Plaskovac formations contain a large number of shells of different shapes and dimensions. The shells are accumulated and densely compacted in the sediment, which prevents more precise examination of their features in peripheral parts (Fig. 2).

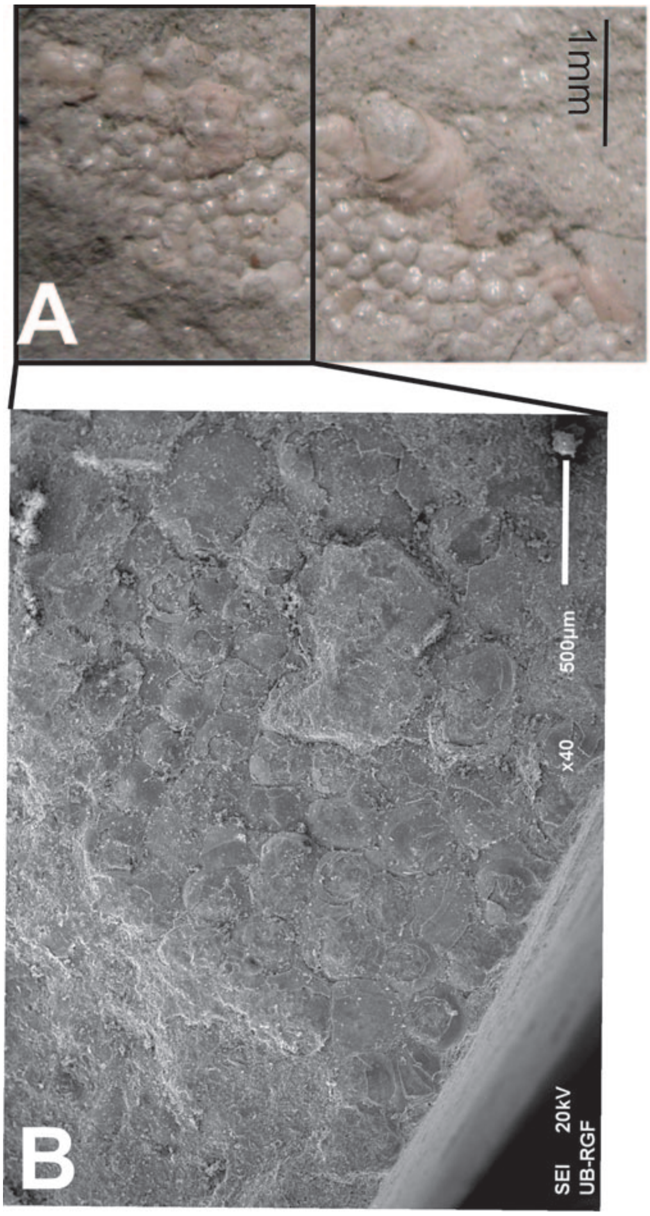

Figure 2 (A, B). Microphotography of group Dreissenidae shells from Plaskovac formation (central Serbia). A. Group photography (a combination of the Olympus Z4001 digital camera connected to the Biooptica 1000 binocular magnifier); B. Detail of picture A (Detailed SEM photos of shell bivalves from Plaskovac formations). The numbers in the images show the dimensions in mm (A), and in µm (B).

SYSTEMATIC PALEONTOLOGY

Class Bivalvia Linnaeus 1758
Subclass Autobranchia GROBBEN, 1894
Superfamily Dreissenoidea J GRAY, 1840
Family Dreissenidae J GRAY, 1840

Dreissenidae indet.

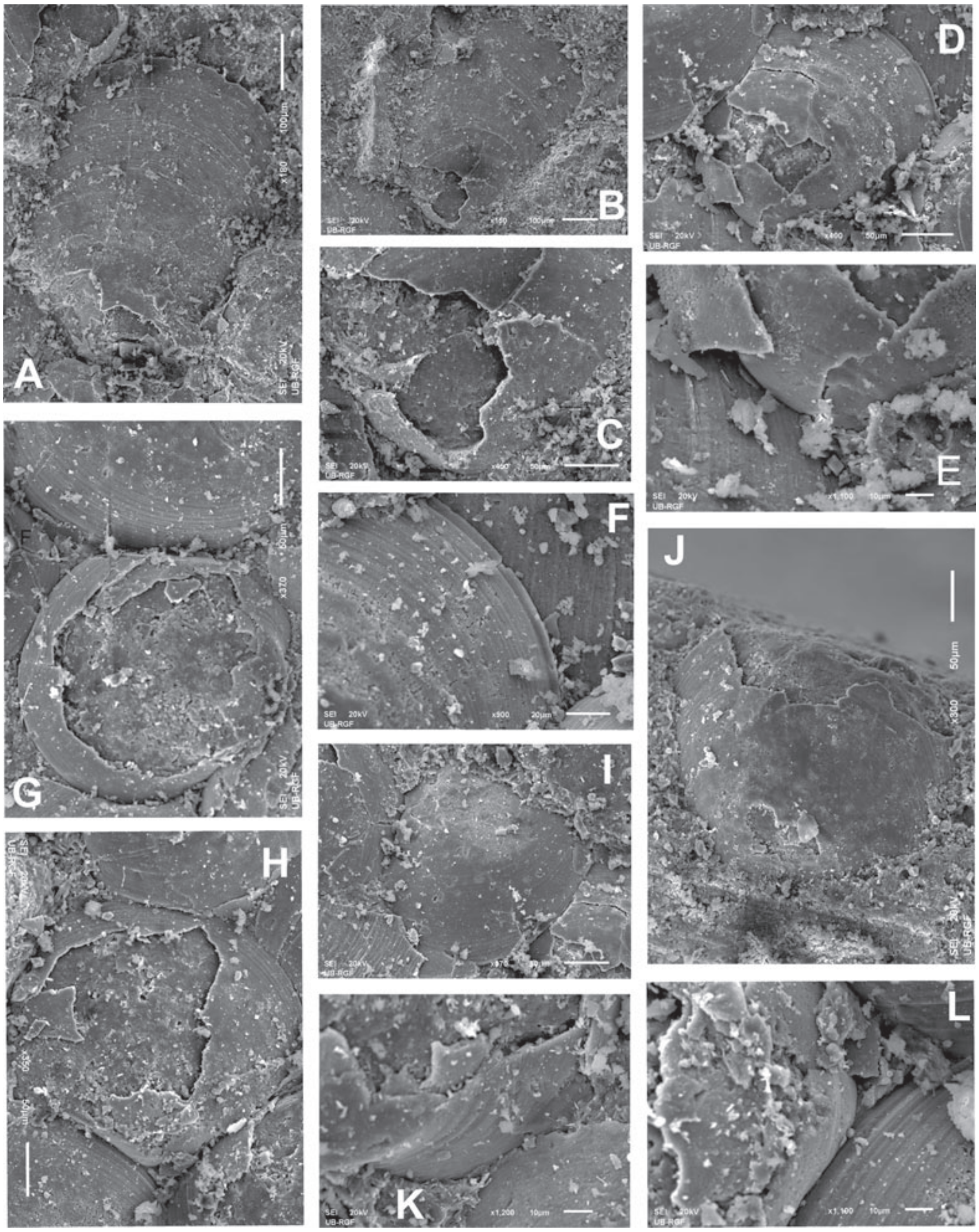

Fig. 3 (A-L)

Figure 3 (A-L). Detailed SEM photographs of bivalves shells from the Plaskovac formations display differences in shape, size and morphometry of the shell (the number in each specimen shows the maximum length of the shell in µm). Detailed SEM photographs of the juvenile growth stage for the specimens: A, B (C is a detail from the Fig. B and shows a prodisoconch image). Fig. 3 (D-L) -detailed SEM photographs of the early postlarval stage for the specimens: D, E (E-detail of Fig. D, shows the prodisoconch), F (F-detail from Fig. D, shows the edge of the valve); G, K (K-detail from Fig. G); H, L (L-detail of H), the image displays the fragments of two specimens, on the left specimen the smooth prodisoconch is visible, and on the other, the edge of the valve with the commarginale lines of growth (right corner of the image).

The shells of the early stages of bivalves development are thin and relatively inflatted, slightly of unequal sides, with almost circular outlines, Fig. 3 (D, E, G, H, I, J, K, L). Proportions of these specimens, such as the relation of shell length to shell height are similar. Prodisoconch (umbo) is small, slightly inflatted. The most of the specimens are more or less damaged. In the better preserved specimens, prodisoconch area is clearly distinguished and slightly bent towards the ventral part of the shell (Prosogyrate). The sculptures on the prodisoconch PI and the prodisoconch PII are clearly distinguished on some specimens. Prodisoconch PI is smaller than prodisoconch PII. The outer surface of described shells appears smooth in the prodissoconch I stage, whereas the prodissoconch II displays regular commamrginal growth lines, and smooth edge, Fig. 3 (D, E, H). The transition to the P II is gradual. Prodisoconch P I and PII are separated by a poorly visible boundary (Fig. 3 D). In prodisoconch area, some specimens are in a bad state of preservation, Fig. 3 (E, H, I, J, K). On the specimen, Fig. (3, G), the protoconch crosses the anterior edge of the shell. The commarginal growth lines are observed on the periphery of the shell. These lines are more strongly developed at the periphery in smaller specimens, Fig. 3 (D, E, F, L). Early disoconch (nepioconch) contains thick, commarginal lines of growth, Fig 3 (H, L). The hinge apparatus is not visible.

Two specimens are slightly elongated to the mytiliform shape, Fig. 3 (A, B, C), slightly inflated above relatively small, but clearly separated rounded prodisoconchs. Prodisoconch PI and PII are partially damaged. The commarginal lines of growth are poorly observed on the PII, while on the surface of the remaining parts of shell those lines are thin and correctly arranged and mark the onset of disoconch. On a smaller specimen (Fig. A), along the periphery of the shell, some lines of growth were slightly thickened. The edges are smooth, ventral rounded. On a larger specimen, the growth lines are very thin, while densely concentrated on the periphery, Fig. 3 (B).

DISCUSSION

So far known species of fossil Dreissenidae have been described and identified exclusively on the basis of morphology of adult shells, except for several species from the lower Miocene [13]. Identification of shells from early ontogeny is very difficult, even in modern species, because they are morphologically very similar and show high morphological plasticity in response to environmental conditions. Therefore, studies are increasingly based on the features of larval forms and phylogenetic relationships. It is difficult to identify and discriminate larval and early postlarval specimens of this species from those of other bivalves that co-exist in freshwater and oligohaline environments. This is particularly true at the early (straight-hinge - the shell hinge is elongated in a straight manner) larval stage, but become clearer with each successive developmental stage. However, there are slight differences in the larval part of the mollusk shell that can be observed and used to make conclusions, including a way larvae live, their identification and classification of larval and post-larval stages [11], [5], [2], [18], [25].

Representatives of the fossil Dreissenidae were more diverse than modern ones, from the aspect of taxonomy. Recently, the new subfamilly Congerinae [21] has been described. Even if Dreissenidae are very common in Miocene sediments, their evolution and origin have not yet been sufficiently studied, so in literature we find different data [22], [9], [3], [7]. Some genera have completely extinct, the genus *Congeria* is almost completely extinct until the end of the Miocene, only three species have survived because they have adapted to life in humid habitats beneath the soil [3]. Several genera evolved in the lake environments of Europe, their numerous species recorded in the Miocene lakes of Serbia, Croatia, Bosnia and Herzegovina, whereas *Dreissena* is extremely rare. *Congeria* and *Mytilopsis* are separated from oligocene to early miocene [17]. *Congeria* differs from *Mytilopsis* by its special form of shell, microstructure and different reproductive strategies [20]. Therefore, we consider that the presence of shells from the Plaskovac formation can give a significant contribution to the knowledge of the early ontogeny of the fossil representatives of this family.

The main developmental stages are embryonic, larval, metamorphosis and postlarval stage (juvenile to adult), and are the easiest to distinguish on the basis of the development of soft parts of the body [17]. For *Dreisesene polymorpha*, e.g. pediveliger is the last larval form [1], while the stage in which the foot develops represents the phase between the larval and the juvenile stage. To identify and discriminate the development stages of Dreissenidae from the Plaskovac formations, the morphological parameters necessary for identifying and determining the stages of the development of recent Dreissenidae were used: the dimensions and shape of the shell, the features of the prodisokonch, the outlines of the valves, etc.

Just like identification of the recent shell, it's difficult to identifylarval and juvenile fossil specimens.The early ontogenesis of fossil Dreissenidae was developed probably similar to that of modern ones.

In this paper, we used the characteristics of the shells to make conclusion in which stages of development they were before they were covered by accumulating sediment. It is known that the differences in the shape of the shell of recent Dreissenidae become clearer after metamorphosis (larval transition in an adult) to the transition into benthic life phase, but it is difficult to describe them by standard methods used to describe adults [17]. In bivalves, the initial part of the shell formed before the metamorphosis is marked as a Prodisoconch, and corresponds to the more familiar term "larval shell" or "veliger" [11]. Prodisoconch consists of embryonic shell (prodisoconch PI) and larval shell (prodisoconch PII), and represent different stages of growth of shell larvae [5], [1], [25]. It is known that the differences in the shape of the shell of modern Dreissenidae become clearer after the metamorphic processes transform the planktonic pediveliger into a postlarval benthic mollusk (larval transition in an adult).

Dreissenidae belong to Autobranchia [4], many representatives of the Autobranhia in the prodisoconch area display a very fine commarginal lines of growth. Described shells from the middle Miocene of Plaskovac reveal that the prodissoconch in this taxon is small (exceeding 25 µm) (see SEM photo (Fig. 3, D), and ornamentation consisting of commarginal growth lines. Thin commarginal lines of growth are observed in all Dreissenidae. The presence of prodisoconch PII suggests the planktotrophic development of the larvae [1]. In *Dreissena polymorpha*, this transition is very pronounced [19]. *Mytilopsis sallei* also has a smooth outer surface on the prodisoconch PI, and PII is indicated by the formation of commarginal growth lines [10]. The planktotrophic development of the larva was noted for the contemporary genera *Mytilopsis* and *Dreissena*, which are easily distinguished by the hinge apparatus [22]. After the metamorphic processes transform the planktonic pediveliger into a postlarval benthic mollusk, differences in the shape of shell valves becomes more marked. In both, in *Dreissena* spp. and *Mytilopsis leucophaeata*, the shell grows mainly along the posterior ventral edge, which leads to an increase in its height (the maximum dimension from the beak to the ventral margin). The shape *Dreissena* spp. differs from *M. leucophaeata* on the anterior edge that is quite straighter and the posterior margin is more angular than in *Mytilopsis leucophaeata* [2].

The size is not a reliable distinguishing larval characteristic, there is, however, a difference in shape which becomes more explicit as the individual develops [5], [1], [25]. Dimensions and shape of the shells from the Plaskovac formation display that it is easy to distinguish at least two stages of development: a) the dimensions in most shell of the bivalves are about 250 µm (Figs. E, F, G, H, I, J, K, L); b) in several samples dimension are over 500 µm (Fig. 3, A, B, C). Analogous to recent Dreissenidae [5], [18], smaller shells due to their characteristic shape and hardnes correspond to the end of the larval stage, i.e. the early postlarval stage. At this stage, a foot is formed. The larger specimens correspond to the early juvenile growth stage.

The damage observed on the studied material is most pronounced in the prodisoconch area, as well as on the central parts of shells. They were formed after burial, most probably under the compression of the sediments. This allowed identification only to the level of the family. According to the diagnostic characteristics shown in the literature [1], [2], [5], [10], [19], the shape of the bivalves the most correspond more closely to the representatives of the genus *Mytilopsis* than *Congeria* and *Dreissena*. This last species was not found in the middle Miocene sediments of the Jelovik region and other localities. *Congeria* differs from *Mytilopsis* and *Dreissena* by its quadrate to rhomboidal shell. Since the Miocene bivalves shells from Plaskovac formation were generally assigned to *Mytilopsis* or *Congeria*, we consider that some of the shells described in this paper most likely may also be attributable to the genus *Mytilopsis* Conrad 1858. More precise taxonomic affiliation was not determined due to the lack of information about the structure of the hinge apparatus, as well as the high degree of damage in the most valves, especially in the prodisoconch area. For the purpose of more precise identification, it is necessary to study other examples and to make a detailed comparison of their morphological characteristics with other mytiliform species. Unfortunately, the early fossil bivalve shells have been largely neglected in taxonomic descriptions, to a much larger degree than for recent, so that a sufficiently comprehensive comparative database does not yet exist. The existence of some other genera should not be ruled out also, as certain differences in the shells morphology are noticed.

CONCLUSION

Very few findings of the fossil bivalve larvae have been published, relating mainly to marine species. One of the rare findings is noticed on the terrains of Serbia, not far from the village Jelovik (south of the mountain Bukulja, central Serbia). The material originates from the middle Miocene deposits of the Plaskovac formation. The studied material is identified by prodisoconch markings and general shape. The taxa is left in open nomenclature, and the observed morphology features are similar to structures seen in extant bivalves of family Dreissenidae.

The data on the dimensions and the morphology of the valves, especially their prodisoconch, obtained on the basis of SEM photographs, enabled identification of the material to the level of the family (Dreissenidae), and the definition of at least two stages of the development of shells. Preserved shells bivalves from the middle Miocene clay alevrolite deposits of Plaskovac formation reveal that the Pconch (prodisoconch I and PII) in this taxon is small and characterized by poor inflatted area with thin commarginal lines of growth. These diagnostic features allow discrimination among the early postlarval and juvenil stages of bivalve species collected in Plaskovac formation.

The morphology of these early parts of shells can be of great importance for the evolution of this group of molluscs, including better understanding processes involved in shell formation. Consequently, this paper constitutes the important contribution to our kowledge of early ontogeny of the Miocene Dreissenid bivalves. The study of early ontogenetic shells is particularly important for fossil bivalve and it may be of particular interest to study species which are adapted to life in freshwater and brackish habitats of the Miocene lakes. For the purpose of definite identification, detailed comparison of morphological features among mytiloid bivalves is required which is quite problematic given the paucity of published studies containing larval and postlarval descriptions.

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Scientific Paper

CLASSIFICATION OF LABELS AND POINTS OF NON-METALLIC MINERAL RAW MATERIALS BY PAN-EUROPEAN RESERVES & RESOURCES REPORTING COMMITTEE –PERC

Damir Baraković[1]

SUMMARY

The paper discusses the application of the results of geological exploration of deposits and the occurrence of non-metallic mineral raw materials, and in the first place geological data on the basic properties of deposits and their applicability, as well as the quantity and quality (resources and reserves) of the relevant mineral raw materials that are of great importance for mineral projects. These geological data, together with other relevant data (primarily technical and economic), are used as the basic parameters in the documentation of mineral projects. Since the success of the exploitation and research projects depends on the reliability of the applied data, special attention is paid to the procedures, is the estimated and established reserves of certain mineral raw materials that contribute to achieving an adequate level of reliability of these data.

Key words: geological explorations, deposits, non-metallic mineral resources, projects, mineral resources and reserves.

INTRODUCTION

An important application in the mining results are geological deposits exploration solid mineral raw materials (non-metallic mineral raw materials), but first of all geological data (including their interpretation) on the basic properties of the examined bearings and the variability of these characteristics as well as the quantity and quality (Resources and Reserve) associated mineral raw materials, which are of great importance for mineral projects.

These geological data, together with other relevant information (in particular the technical and economic), used as the basic parameters in the documentation of mineral projects (in the broad sense): mining enterprise aimed at the mining of mineral deposits. Since the performance of external mineral projects depends on the reliability of applied data, special attention is paid to methods contribute to achieving an adequate level of reliability of these data, such as:

- gradually performance of projects in two stages (first, geological, and mining exploitation or phase)
- to find the optimal solutions in the design and construction of geological exploration, aligned with the basic properties of the studied deposits and variability.
- the real number estimation of mineral resources and reserves in the study bay as a geological task. When considering the above problem have been used world-contemporary standards [1, 2, 3,] and Practice, domestic laws [4], the requirements [5], traditions and practice, and as data of the Doctoral Dissertation of D. Barakovića [6].

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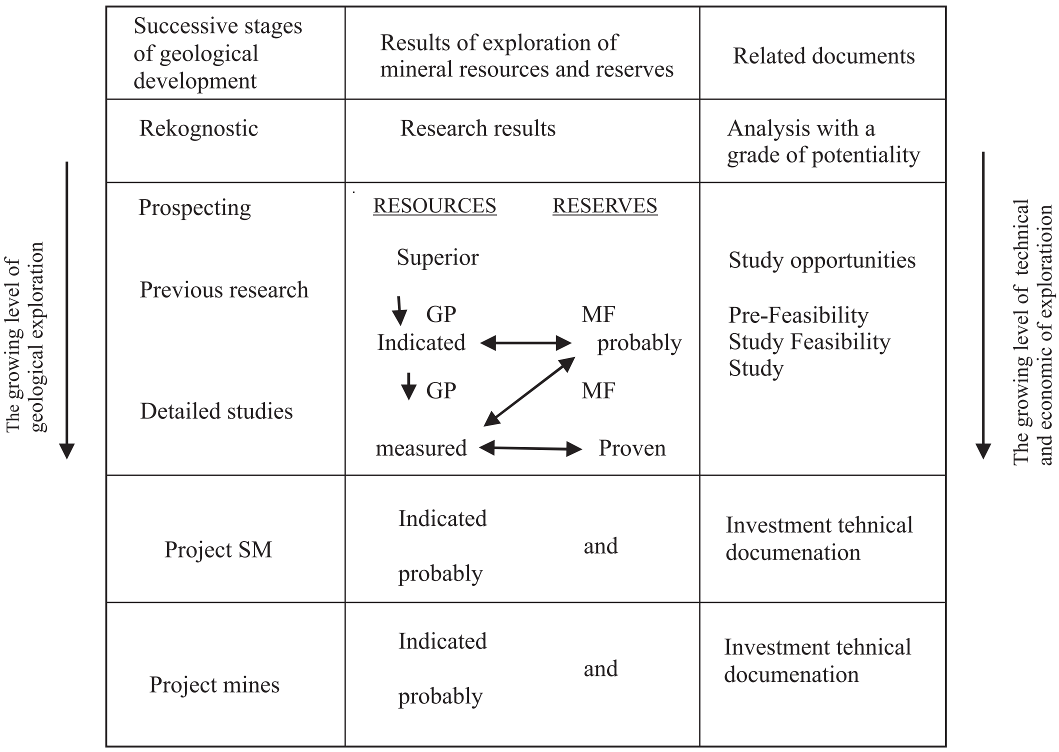
1. DEVELOPMENT STAGES OF GEOLOGICAL PHASE

Many years of practice (and in our country and world) indicated that the largest the performance of external (with an adequate level of reliability) mineral projects achieved by their gradual execution in two phases and the larval stages. The first (or geological exploration) phase has four stages of development (stages reconnaissance prospecting, previous studies and detailed study) and the second (or investment mining exploitation) stage has three stages of development (the stages of design and operational Geological Research).

Giveaway geological phases (as well as mining phases) on the developmental stages of not only the most scientifically correct, but also technically and economically most appropriate because it allows obtaining the necessary data on the investigated reservoirs in the shortest time with the least expenditure of material and labor and with minimum risk. By presenting new research works, in any stage of geological receive new data (geological and other - mainly technical and economic) that contribute to a fuller consideration of geological, technical and economic characteristics of the studied deposits.

At the end of each stage of the geological separated and examined by the competent (or competent) of the person, the most significant geological data which, in the documentation of mineral projects, are applied as the basic - geological parameters. The said geological parameters include data on the basic properties of the bearing (form, seam depth, structure, composition, - its chemical and mineral, bulk density) and exploitation these properties as well as the quantity and quality (Resources and Reserve) of mineral raw material in the examined bearing. Based on the review of geological data, competent person identifies, evaluates and classifies mineral resources (in the superior, indicated or measured), based on the consideration of modifying factors, competent person converts not exploitatione mineral resources (indicated and measured) in exploitable mineral reserve s (probable and proven) - Picture 1.



Picture 1. The general relationship between the results of the research, of mineral resources and mineral reserves Codes: GP - geological data; MF - modifying factors.

It should, however, bear in mind that the established mineral reserves (proven and probable) may be due to changes made in a modifying factor, the loss of the former status and must be retroactively converted into resources (measured or indicated) - Picture 1. The data obtained as the result of geological exploration in successive geological stages mineral projects, are considered and are evaluated in the respective analyzes and studies: in the geological analysis of potentiality (at the end stage of reconnaissance) form the technical and economic studies: study on the potential (in the end stage of screening), a previous study the feasibility of (at the end stage of previous studies) and a feasibility study (at the end stage of detailed research).

These results are shown in the corresponding statements in the official (annual, final) reports (or study), dedicated to the military authorities and public reports, to investors.

To the documentation of mineral projects, as the basic parameters, apply the data on Mineral Resources and Reserve, obtained as a result of the corresponding geological following investigation of mineral deposits.

Mineral resources are determined, are estimated and classified (in the superior, indicated and measured) based on the consideration of geological data from a competent person (or competent persons), at the end stage of screening, and the previous detailed exploration. Mineral reserves (probably and proven) are prepared by converting the (conversion) of mineral resources (indicated and measured) on the basis of considerations of modifying factors of a competent person (or competent persons), at the end stage of the above and the detailed research.

Qualification and competence of competent persons are defined by international standards [1, 2, 3] and our by the [4]. According to our current Regulations [5], "reserve" of solid mineral raw materials A, B and C1 categories are "calculated", while the "buffer" C2 category "estimated", a D1 and D2 of the category "assumed." It should, however, bear in mind that this categorization and associated terminology outdated and not in line with modern international standards. Thus, the mineral reserves based on PERC standard [2], corresponding to only mineable reserves the applicable Rules [5], mineral resources correspond to "reserve" A, B, C1 and C2 categories, and the results of investigations (geological) in turn correspond to "reserve" D1 and D2 categories.

<table>
<tr><td rowspan="2">Classification according to PERC</td><td rowspan="2">results of the survey</td><td colspan="3">Mineral resources</td><td colspan="2">Mineral reserves</td></tr>
<tr><td>Assumed</td><td>Indicated</td><td>Measured</td><td>Probable</td><td>Proven</td></tr>
<tr><td rowspan="3">Applicable Rules</td><td colspan="6">The reserves of solid mineral resources</td></tr>
<tr><td rowspan="2">potential
D_2 and D_1 category</td><td rowspan="2">potential
C_2 category</td><td colspan="2">Identified (off-balance sheet and balance sheet, geological - in situ</td><td colspan="2">Exploitation (balance, minus losses and dilution in the exploitation)</td></tr>
<tr><td>C_1 category</td><td>A and B category</td><td>C_1 category</td><td>A and B category</td></tr>
</table>

Picture 2 - The correlation and conversion map "reserve" of solid mineral resources from the current Rules and mineral deposits, mineral resources and research based on the PERC standard

Of balance (economic exploitability) "reserve" of mineral raw materials by us are, according to Regulation [5], establishes a technical-economical rate, and in the world - the consideration of modifying factors. The experience acquired by the research of a large number of deposits of solid mineral resources, both worldwide and in our country, conclusively showed that the determination of resources and reserves in mineral deposits of more important geological rather than mathematical factors, and this is primarily a geological rather than mathematical task.

Thus, the estimate of resources / reserves far less influence than geological concepts and appropriate methodology of deposit exploration (which should be consistent with the basic properties of the reservoir and changes these properties), the design of research work, their performance (including sampling), trial taken rehearsals and, finally, the geological interpretation of the data obtained, but the mathematical methods and techniques appropriate 'budget' reserves.

Therefore, in practice, the weight of these deposits to research receive more reliable information and to make a more credible as their geological interpretation, and that is then applied as simple mathematical methods and techniques "budget". Bearing all this in mind, it can be concluded that the correct term estimation (and not a "budget") mineral resources. The above research experiences have also shown that the biggest mistakes in assessing the mineral resources occur due to incorrect second measurement (in the field or on the corresponding graphic appendices) - Length (primarily the thickness of the deposits and ore bodies) and the surface (the plans and profiles), due to incorrect sampling (choice of type and schedule rehearsals, their uptake and processing) and tests taken sample (content helpful and / or harmful components, bulk density) and, in particular, due to incorrect interpolation and extrapolation of data obtained from research. The sum of these partial mistakes makes a single (overall) error estimate reserves. According to our rules [5], the permissible error in calculation of the „reserve" is as follows: for category A ± 15%, for category B and ± 30% for C1 category of ± 50%.

In contemporary practice world permissible error in assessing the mineral resources are: for measured resources and proven reserves of ± 10-15% (the same as for the feasibility study) for the indicated resources and reserves probably ± 20-30% (the same as for the previous feasibility study) and inferred resources of 30 ± 50% (the same as for the feasibility study).

2. POTENTIALITY OF NON-METALLIC MINERAL RESOURCES WIDER AREA BY GRACANICA BY PERC

In the wider area of Gračanica in a relatively small area, there are deposits and occurrences of non-metallic mineral resources such as technical structure stone, ceramic, refractory and bentonite clay, quartz sand, thermal mineral water, asbestos and talc. This mineral raw material have been subject to certain geological and mining exploration during most of the 20th century. On some reservoirs was organized exploitation of some of the mineral deposits.

This fact and the current market and economic conditions prevailing in the region, it will take much more organized efforts of the interested domestic and foreign investors, in order to use the natural resources of the wider area of Gračanica. It should be noted that when evaluating the potentiality of thought primarily to geological potentiality rather than the direct possibility of opening new deposits. Were not considered nor socio-social aspects of potentiality - is the potential area spatial plan allowed the exploitation or not.

2.1. CRITERIA PROGNOSTIC SCORE MARKS POTENTIALITY

Prognosis any solid natural mineral resources a given area, including the non-metallic raw materials in a wider area Graçanica is based on certain types of specified characteristic bearings which are located in the area or its vicinity, and similar geological and geotectonic conditions. Ore general criteria on basis of which the mineragenetic - prognostic rating defined Jankovic (1994) and are mainly developed for the purpose of forecasting of metallic mineral resources.

However, some of these criteria are used for the assessment and the forecasting and non-metallic minerals (Simic, 2004; Božović and Simic 2015; Božović, 2016), and hence the carbonate raw materials. Criteria mineragenetic - assess the prognostic resources of non-metallic mineral resources have so far been generally considered poor. From the point of non-metallic minerals resources extracted are other important prognostic criteria:

- Stratigraphic
- Lithologically
- Palaeogeographic
- Structural
- Technology
- Geological – economic

The stratigraphic criteria

Appearance of deposits of non-metallic mineral in an area related to the certain of the stratigraphic units, or certain periods of time in the geological history, when there were particularly favorable conditions for the formation of such deposits. According to the age of certain geological formations, can be often predict mineral potential of these areas. For example prospecting technical - construction stone in the area of Gracanica for its perspective and productivity stand out massive and thick layered limestone Paleocene-Eocene, where he discovered several deposits and occurrences technical - construction stone. The situation is similar with other investigated mineral raw materials, which are linked to either ophiolitic belt (diabase), of any neogenic sediment (clay, quartz sand). Bauxite occurrences are related to the Paleocene-Eocene limestone.

Lithological criteria

This criterion is based on the spatial and genetic association of individual deposits with certain lithological units. Prognostic evaluation of mineral potentialities of certain areas on the basis of lithological criteria are based essentially on the definition of the relationship between the composition and terms of creating lithologic formations and reservoirs whose education is related to these areas. Their formation and their appearance is mainly dependent on the particular arrangement of control lithography geological formations in space and time.

Paleogeographical criterion

Paleogeographic criterion is closely related to stratigraphic criteria, and indicates the distribution of individual lithostratigraphic units in certain time periods. Creation of different sediments, as well as carbonate sediments, condition different physical and geographical conditions in certain areas.

Structural criteria

Create and spatial distribution of mineral deposits is closely related to the process of shaping a structured environment. Structural (tectonic) criteria may be regional or local character (Simić, 2004). Regional structural criterion applies to establishing relationship of deposits and major metallogenic units with structural elements of a given area. For certain tested materials, this factor is of great importance, especially for asbestos and talc, wherein the fault zone mainly mark hydrothermal changes that lead to the formation of asbestos-free talc.

Many technological criteria non-metallic mineral raw materials, especially those whose application is based on the physical and technical characteristics, are characterized by a specific technology preparation and processing or treatment. Under the technological criteria refer to all mineralogical, chemical, physical - mechanical and technological characteristics of carbonate raw materials that define the possibility of their application in the industry. Therefore, for example ceramic clay Sočkovac can be treated to be promising as a raw material regardless of the relatively small residual reserves because their technological characteristics of the minutiae.

Geological - economic criteria

Geological - economic criteria based on relevant factors and geological indicators - economic assessment, based on the results of geological research. Geologically-economic criteria is important when forecasting method for using analogies and quantitative character, ie a number of known and researched phenomenon corresponding deposits or deposits of carbonate raw materials entails a greater potentiality of the territory in which the deposits or occurrences are.

2.2. CATEGORIES INVESTIGATED THE POTENTIALITY OF NON-METALLIC MINERAL RESOURCES

In determining the category of potentiality study area wider environment Gracanica have to remember that this area has not been systematically explored in terms of non-metallic materials, but also in investigative work started from the already well-known phenomenon in the field and then approached a detailed research. Therefore, no level of exploration of non-metallic raw materials is not the same, neither the same nor their potential.

Based on the review criteria prognostic evaluation the following are the categories of potentiality wider area of Gračanica:

1. Areas of great potentiality,
2. Areas of medium potentiality, and
3. Areas vague potentiality.

In the field, which is characterized by great potentiality certain mineral raw detail is aware of how genetic conditions of the foundation, as well as technological features, and there are open bearings and the appearance of these non-metallic materials.

The terrain that is characterized by secondary potentiality of non-metallic mineral resources allocated on the basis of knowledge primarily lithologic and stratigraphic criteria evaluation of potentiality, based on the analogy with the known deposits and occurrences of certain raw materials. Areas with a vague potentiality isolated as such because there is no data on the preliminary and detailed investigations, nor the quality of the raw material (for example bauxites Stjepan polje or shoots a hostage around Petrova).

The following table gives an overview of the potentiality of the non-metallic mineral of the wider area of Gracanica, divided into two parts, those which are located north of the Spreča fault zones belonging to a chalk-tertiary rock complexes so-called "inner ophiolitic tectonised melange", and others, are located to the south of Spreča fault zones belonging to the volcano-sedimentary rock complexes Ultramafite and the so-called "central ophiolitic mélange".

All deposits and occurrences, are deployed within oleate denominated raw mineral resources of the wider area of Gracanica, and are shown in Table 1. The raw material of non-metallic mineral resources of the wider area of Gračanica classified by PERC standard.

MINERAL RESOURCE	TYPE OF RESOURCES		LOCATION	GEOLOGICAL CHARACTERISTICS	GENETIC CHARACTERISTICS	ORE RESERVES
	Occurr.	Deposit				
Chrysotile asbestos 		+	Delić Brdo – Brđani Petrovo	J (lherzolite, harzburgite, dunite, piroksenite, gabbro, amphibolite, serpentinite) $J_{2,3}$ DRF (diabase, sandstone, cherts, conglomerates, schistose clay, marl, limestone tabular) Tc (granite, rhyolite albite-lamprophyre, quartz- carbonate rocks, talc-carbonate rocks, talc rocks) Pl_1 and PlQ (conglomerates, sands oolitic and other clay)	The product of alometamorphic serpentinization of tectonized periodotites by hydrothermal at, medium temperatures and moderate depths	Measured 56.300.000 t ore with 1.130.030 t asbestos fibre
		+	Bjeljevine Jovanovići-Njivice Kakmuž			Probable 2.000.000 t ore
Talc 		+	Mušići Porječina	J (lherzolite, harzburgite, dunite, piroksenite, gabbro, amphibolite, serpentinite) $J_{2,3}$ DRF (diabase, sandstone, cherts, conglomerates, schistose clay, marl, limestone tabular) Tc (granite, rhyolite albite-lamprophyre, quartz- carbonate rocks, talc-carbonate rocks, talc rocks) Pl_1 (conglomerates, sands oolitic and other clay)	Hydrothermal-metasomatic deposits of dunite-lherzorites-harcburgite formations; type of ore iron-ore talc rocks, talc rocks subtype „medvjedovski“	Probable 2.200.000 t ore with 550.000 t talc Probable 900.000 t ore with 220.000 t talc
		+	Žarkovac Porječina			Probable 2.400.000 t ore Probable 1.850.000 t ore
			Rustina Petrovo			Research results Talc outcrop 50 x 10 m perspective
			Tešanovići Boljanić			Research results Zone of talc 500 x 100 m perspective
Clay 		+	Kečkovac Sočkovac	$J_{2,3}$ (ophiolite melange), Tc (quartz-carbonae rocks), Pl_1 and Pl_1Q (polymineral ceramic clay, sand, gravel, coal)	Autochthonous clay deposits formed by dissolution and chlorite sericite phyilitic shales, weathering factors surface or ground water and a hydrothermal rich with dissolved CO_2	Proven 2.467.157 m^3 or 6.340.593 t
		+	Lipovac-Brezici Karanovac		Sedimentary autochtone deposit formed by decomposition of tectonized ultrabazite, in chemical complex processes	Proven 760.270 m^3 or 1.870.264 t
	+		"Džebe" – Stjepan polje	Bentonite, sediments of Jurassic ophiolitic melange, Paleocene Lover Paleocene and Miocene.	Monomineral pelitic formations, made of montmorionite	Research results 340.000 m^3
	+		Stjepan polje	Clay Pl_1Q (polymineral ceramic clay, sand, gravel, coal	Sedimentary autochtone deposit	Proven 2.300.000 t
		+	Pribava			Proven 2.260.000 t
		+	Žarkovac Porječina			Proven 3.220.000 t

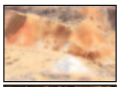
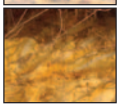
MINERAL RESOURCE	TYPE OF RESOURCES		LOCATION	GEOLOGICAL CHARACTERISTICS	GENETIC CHARACTERISTICS	ORE RESERVES
	Occurr.	Deposit				
Quartz sand  		+	Kečkovac Sočkovac	J (lherzolite, harzburgite, dunite, piroksenite, gabbro, amphibolite, serpentinite) $J_{2,3}$ DRF (diabase, sandstone, cherts, conglomerates, schistose clay, marl, limestone tabular) Tc (granite, rhyolite albite-lamprophyre, quartz- carbonate rocks, talc-carbonate rocks, talc rocks) Pl_1 and PlQ (ceramic clay, olitic clay, sands, gravel, coal)	Formed by transferring, perfused, mechanical and chemical decomposition of the surrounding rock containing quartz, and depositing materials in relief forms. The irregular shape of quartz grains and a small degree of curvature grains indicate relatively small length of transport. Very frequent cyclic shift ceramic clay and lignite coals with quartz sands. Expressed heterogeneity and anisotropy of reservoir conditions in space.	Proven 540.121 m^3 or 1.134.254 t
		+	Lipovac – Brezici Karanovac			Probable 5.500.000 m^3 or >11.000.000 t
	+		Mušića rijeka, Lužani, Kojići, Gušte Porječina			Resarch results Outcrops and zones of dm and ha in size
	+		Bisići – Šešlaci Petrovo			
		+	Pribava			Probable 3-5 milions t quartz sand
		+	D. Lohinja			
Lime stone 		+	Karabegovac Lipac	Pc, E_1 (massive and banded, to banked limestone) Pl_1 and PlQ, (al - gravel, sand and clay), (e - "in situ" sediments of humus, clay and clayey fragments of karstification lime stone), (nm - a fill and deposited material antropogenic character)	Marine sedimentary formations. Organogenic lime stone clastic character, high energy in environment	Proven 4.597.369 m^3 C_2+D_1 11.570.146 m^3
			Orlovača Lipac			Proven 1.219.332 m^3
		+	Drijenča			Proven 3.777.813 m^3
		+	Sklop			Proven 3.252.182 m^3
Technical building stone		+	Greblje			Proven 1.246.345 m^3
Bauxite 	+		Stjepan polje "Džebe"	Upper Cretaceous sediments at these sites include sandstone and marl and jagged appearance of bauxite, breccia and marly, dark red colors.	Deposited on karstificated Upper Jurassic limestones	Research results 340.000 m^3
Dijabase 	+		Donja Lohinja "Durać"	In diabase-chert formation of igneous rocks occur diabase, and ophiolite melange; the Cretaceous conglomerates, breccia-like limestone, marl, marly limestones and conglomerates with some limestone, different types of Tertiary sediments.	Hipoabisal (subsurface of wire) volcanic rock	Research results 400.000 m^3

Table 1. Overview of the mineral potential of non-metallic mineral raw materials of the wider area of Gračanica by PERC

3. CONCLUSIONS

The work was conceived in order to present complex parameters of potentiality and qualitative characteristics of deposits and the appearance of nonmetal mineral raw materials of the wider area of Gračanica according to PERC classification.

The systematic approach to the processing of this topic, using the most recent research and relevant data obtained on field, laboratory and industrial geological investigations over the last few years and using a new conceptual approach, defined a higher degree of research of qualitative and quantitative characteristics of deposits and the appearance of non-metallic mineral raw materials determination of the potentiality and reserves of mines according to the classification of PERC and 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 protection of nature and environment.

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Scientific Paper

OPTIMIZATION OF RESERVOIR SPACE WITH ASPECT OF RATIONALIZATION OF WATER SUPLY SYSTEMS

Jasmin Hrnjadović[1], Anadel Galamić[2], Mufid Tokić[3]

SUMMARY

Water supply system is a collection of objects related to functional unit with the primary aim of ensuring sufficient quantities of good quality water as economically as possible.The aim of this paper is to analyze the several alternatives, establish functional dependence of certain parameters of the system , and to reach optimal variant that from a technical and economic point of view gives the most acceptable solution. In this regard, two variants of the pressure pipeline of the water supply system have been analyzed, with an emphasis on finding the optimal variant solution from the aspect of the rationalization of the reservoir space.

The first variant is the existing water system of Sjenina village near Doboj, with a threeway pumping water from water supplies (existing reservoirs neighboring village) to reservoirs R1 , R2 and R3 , that are used in gravity water supply to villages. Another variety of a treated water supply considered similar system but with a two stage pumping water to the zone of the reservoirs R1 and R2. Therefore omitted one tank which seeks reduction of the initial cost of building the system.

Keywords: water supply system, pressure line, reservoir, pumping station

INTRODUCTION

Among many branches of modern techniques aimed at increasing living standards, urbanization of settlements and industry development, water supply occupies a significant place. Supplying the population with clean and quality water is primarily of great hygienic importance as it protects people from various diseases that are transmitted by water. Ensuring and bringing enough water to the inhabited place allows the lifting of the general human standard of living and the regulation of its environment. Water consumption is even greater if water is available. In order to meet the needs of modern multi-million cities, significant amounts of water are needed, which are measured daily by millions of cubic meters. Considering that the construction of a water supply system requires significant investments, and very often the operating costs themselves can be quite large (for example, in the pressure system), the selection of an optimal water supply system is an important step in the realization of such projects. It is therefore necessary to carry out detailed preliminary research and extensive analysis in order to arrive at a variant solution that, with minimum initial investment and operating costs, provides a technically satisfactory solution. In this paper, an analysis of the part of the water supply system, which treats a pressure line, will be carried out, by which water from the water intake is transported to the reservoir. The goal is to come up with an optimal solution from the aspect of utilization and rationalization of the reservoir space.

1. GRAVITY WATER SUPPLY SYSTEM

In gravity systems, the flow of water is primarily carried out under pressure, (Fig. 1), or combined (under pressure and with free water face). Thus, the pressure regime is most common in gravity water supply systems and must be provided for functional reasons in the main distribution and distribution pipelines,

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while in the main supply pipelines, if the topographic characteristics permit, the leak can be with a free water face (although for health reasons, if it is open channels, it is not desirable). The advantages of the gravity system are reliability and minimum operating costs (without electricity consumption). When displaying a scheme of such a system (which will also apply to the following ones), the water conditioning device is not marked, because the multiple possibilities of its accommodation would only multiply the display of the water supply system, but without significant drive differences. The location of the conditioning device is dictated by topographic conditions and the size (capacity) of the device, and is mandatory before the reservoir of clean water. Depending on the height relationship in the system, interpolation of intermittent chambers (Fig. 1 (b)), between water intake and reservoir, or between the reservoir and the consumer, can be interpolated to regulate the pressures (if the pressure is exceeded allowed). Then a system with several height zones is obtained, i.e. zonated water supply system. In a gravity system, a case may arise that consumers (settlements) are between water intakes and reservoirs, (Figure 1 (c)). Then a system with a counter tank is obtained, where the water in the tank touches and flows out of the tank with the same pipeline. As we see with the mentioned image, and in this case, it is possible a system without an interrupt chamber, (Fig. 1 (c1)), or with an intermittent chamber (Fig. 1 (c2)).

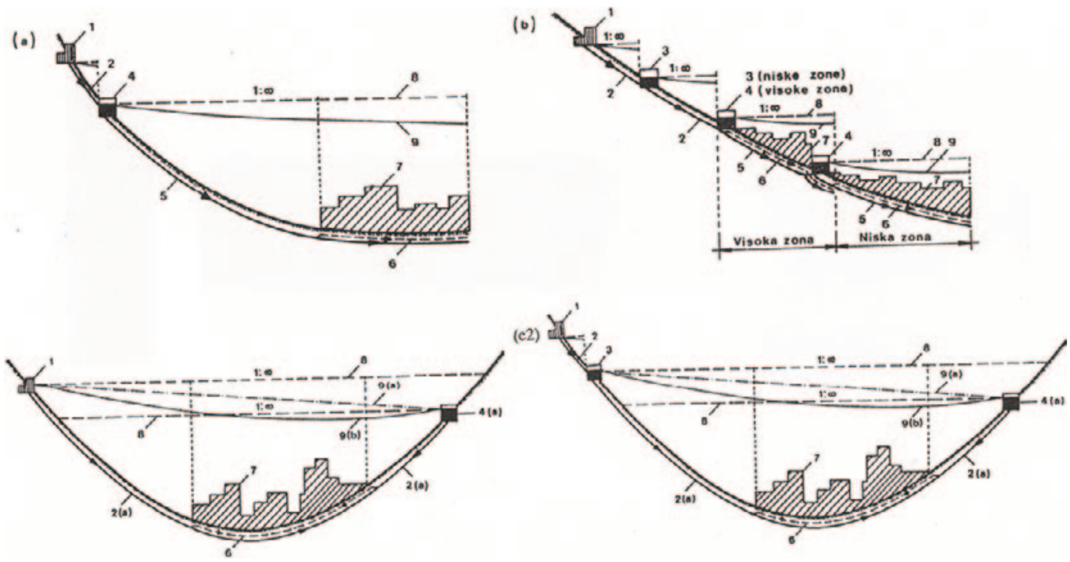

Figure 1: Schemes of gravity systems of water supply
(a) a typical gravity system; (b) a zoning gravity system; (c) a gravity system with a counter tank
1 - water intake; 2 - main supply pipeline; 2 (a) - main supply - supply pipeline; 3 - interrupt chamber; 4 - tank; 4 (a) - counter tank; 5 - main supply pipeline; 6 - split network; 7 - consumers; 8 - line of hydrostatic pressure; 9 - line of hydrodynamic pressure; 9 (a) - the line of hydrodynamic pressure in the hour of least consumption; (b) - the line of hydrodynamic pressure in the hour of highest consumption

2. PRESSURE WATER SUPPLY SYSTEMS

With the pressure system (Figure 2), water is pumped directly from the source to consumers by consumers. The advantages of such systems are primarily reduced initial costs (system construction costs) due to the reservoir and the length of the pipeline being avoided. These systems are mainly applied to smaller settlements, extremely rare for larger ones, primarily due to significant operating costs due to the almost continuous operation of the pumps.

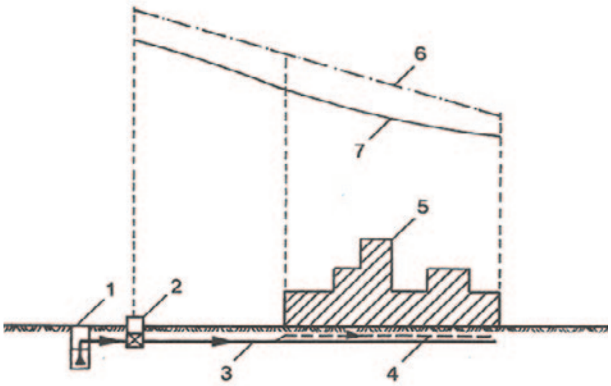

Figure 2.: The scheme of the pressure water system
1 - water intake; 2 - pump station; 3 - main supply pipeline; 4 - split network; 5 - consumers;
6 - the line of hydrodynamic pressure in the hour of least consumption;
7 - the line of hydrodynamic pressure in the highest consumption watch

3. COMBINED WATER SUPPLY SYSTEMS

For combined systems, (Figure 3), different subsystems are possible, but the flow of water is always under pressure.

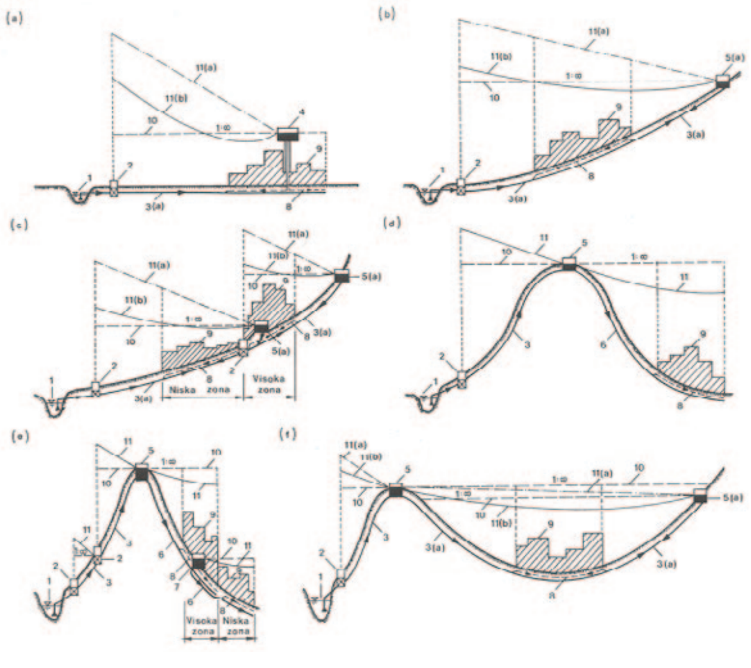

Figure 3: Schemes of combined water supply systems
(a) combined water system; (b) a combined system with a counter tank; (c) a zonated combined system;
(d) a combined indirect system; (e) a combined combined indirect system; (f) combined indirect system with counter tank 1 - water intake; 2 - pump station; 3 - main supply pipeline;
3 (a) main supply - supply pipeline; 4 - watercourses;
5 - tank; 5 (a) counter tank; 6 - main supply pipeline; 7 - interrupt chamber;
8 - split network; 9 - consumers; 10 - line of hydrostatic pressure;
11 - Hydrodynamic pressure line; 11 (a) - line of hydrodynamic pressure in the clock least consumption; 11 (b) Hydrodynamic pressure line in hour of highest consumption

In practice, there is a common combination of pressure and gravity systems with water (Fig. 3 (a)), where all quantities of water should be pumped as the water catch at lower altitudes from the settlement. The primary function of the watertight is to compensate consumption in relation to the selected pump station mode. This is a more reliable scheme than the pressure system, as water can be provided (short-term) with water in case of pump failure. In addition, this is a system that is cheaper than a pusher, because due to the partial equalization of water consumption from the watercourse, the required capacity of the pump station decreases and allows for its more economical drive in periods of cheaper electricity.

4. ANALYSIS OF RESERVOIR SPACE - VARIANT I

The reservoir space is dimensioned based on the maximum daily water consumption, taking into account the consumption regime, as well as the regime of the inflow of water into the reservoir space. The water supply regime in the reservoir space depends on the operating mode of the pump station. For the considered plumbing system, the design task is defined the coefficient of equalization of the reservoir space kr = 0,35 which will be used in the further analysis of the variant solutions of the water supply system.

In the first variant (implemented water supply system), according to the topography of the terrain and population conditions, three water supply zones were formed. The lower zone (zone I) is 35% $Q_{max, day,}$ mid zone (zone II) 30% $Q_{max, day}$ and upper zone (zone III) 35% $Q_{max,day,}$

In addition to the working volume of the tank, the amount of fire extinguishing water should be provided within the tank space for a minimum of 2 hours of fire.

It is also necessary to add a spare volume of 25% of the collection of fluctuating and fire volume.

The total volume of the tank is calculated according to the form:

$$V_{tot} = V_f + V_p + V_r$$

V_f - fluctuating volume
V_p - fire volume
V_r - spare volume

Table 1 shows the values obtained by analyzing the water system with three-stage water pumping.

height zones	$Q_{max,day}$ (l/s)	(%)	Consuption by zones $Q_{max,day}$ (l/s)	V_f (m³)	V_p (m³)	V_r (m³)	V_{total} (m³)	$V_{adopted}$ (m³)
(zone I)	**12,65**	**35**	**4,43**	**133,96**	**72,00**	**51,48**	**257,44**	**2x125=250**
(zone II)	**12,65**	**30**	**3,80**	**114,91**	**36,00**	**37,73**	**188,64**	**2x100=200**
(zone III)	**12,65**	**35**	**4,43**	**133,96**	**36,00**	**42,49**	**212,45**	**2x125=250**

Table 1: Demonstration of required and adopted volume of tank space

5. ANALYSIS OF RESERVOIR SPACE - VARIANT II

In the second variant, a water supply system is considered, formed in two water-supply zones. According to population conditions, it is estimated that 50% $Q_{max, day}$ and 50% $Q_{max, h}$.

All other input parameters for the budget are the same as in the first variant solution.

Accordingly, the total volume of the tank is calculated according to the form:

$$V_{tot} = V_f + V_p + V_r$$

V_f - fluctuating volume
V_p - fire volume
V_r - spare volume

height zones	$Q_{max,day}$ (l/s)	(%)	Consuption by zones $Q_{max,day}$ (l/s)	V_f (m³)	V_p (m³)	V_r (m³)	V_{total} (m³)	$V_{adopted}$ (m³)
(zone I)	**12,66**	**50**	**6,33**	**191,42**	**72,00**	**65,86**	**329,28**	**2x165=330**
(zone II)	**12,66**	**50**	**6,33**	**191,42**	**36,00**	**56,86**	**284,28**	**2x150=300**

Table 2: Demonstration of required and adopted volume of tank space

6. OPTIMIZATION OF THE RESERVOIR SPACE

The first variant solution treats three-stage pumping of water from the source (existing reservoir) to the consumer. So this system contains three reservoirs. The tank R_1 has a capacity of 2x125 = 250 m^3, a reservoir R_2 volume of 2x100 = 200 m^3 and R_3 a total volume of 2x125 = 250 m^3 (Figure 4).

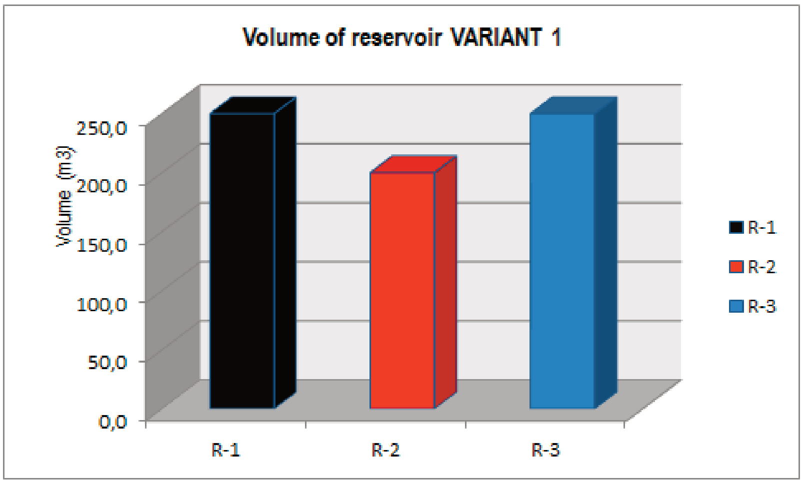

Figure 4: Display of tank space for variant 1

The total useful volume of the tank space for the first variant of the water supply system is:

$$V_{tot} = 250 + 200 + 250 = 700,00\ m^3$$

In the second variant solution, one tank is omitted so that a system with two-stage water pumping is provided. The first tank R1 has a capacity of 2x165 = 330 m^2, while the R_2 tank is a volume of 2x150 = 300 m^3 (Figure 5).

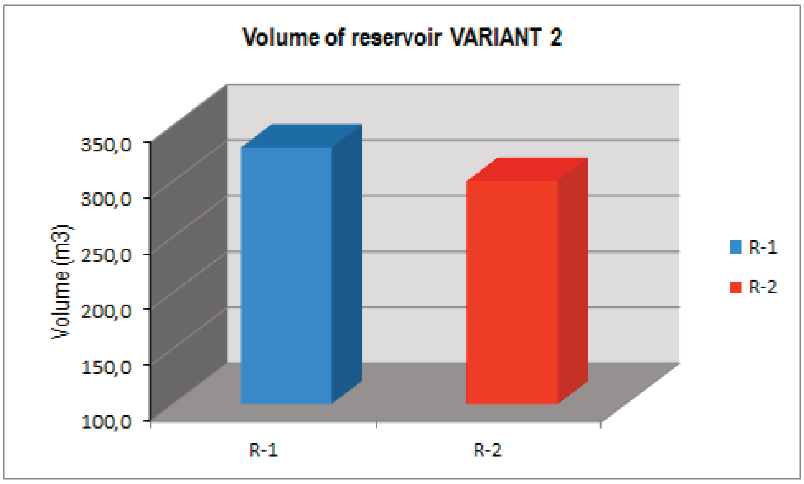

Figure 5: Display of tank space for variant 2

The total useful volume of the tank space for the second variant of the water supply system is:

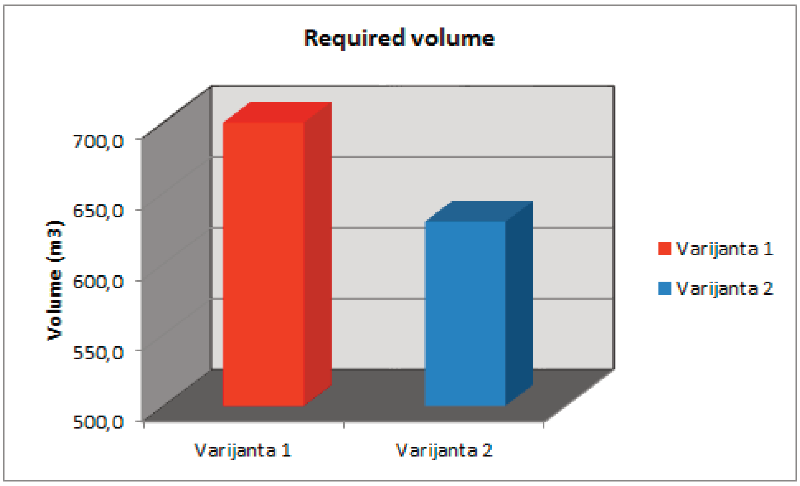

Figure 6: Required reservoir space for the considered variants

Based on the above, it is evident that for the second variant solution of the water supply system, a smaller reservoir space of 70 m^3 is required in relation to the first variant, i.e. it is possible to achieve savings of about 10% of the total cost of building a reservoir. Of course, in addition to the initial construction costs, there is considerable savings in the costs of maintaining the system. In variant 2 we have one tank less, one pump station less, which would also mean reduced operating costs of the system, ie maintenance costs of the pump station.

CONCLUSIONS

In the previous chapters, two variants of the water supply system of the settlement were analyzed. As the basis for the analysis, the existing water supply system of the rural settlement Sjenina and Sjenina Rijeka was selected in the area of Doboj, where the existing water supply status was analyzed as the first variant solution of the water supply system. This variant solution treats three-stage pumping of water with a pressure pipeline to the reservoirs R_1, R_2 and R_3 at different elevation angles, from which the water supply of the settlements is carried out by gravity.

In the second variant solution, one tank and a pump station is omitted so that two-stage pumping of water to the reservoirs R_1 and R_2 is obtained, from which the water is gravity transported to the consumer as in the first variant.

The aim of the research in this paper was to provide an in-depth analysis of all the influential parameters of the optimal pipeline and accompanying facilities (reservoirs, pumping stations, pipeline equipment, etc.) in order to consider the possibility of finding a more favorable solution of the water supply system for the settlement.

In this regard, an analysis of several parameters has been carried out which significantly influence the technical and economic characteristics of a water supply system. By analyzing the required reservoir space, it was concluded that the second variant solution is more favorable because it requires less useful volume of all reservoirs, which, from the economic point of view, saves about 10% of the investment in the construction of the reservoirs in the system. It is also important to note that the maintenance costs of the system are lower in the second variant because it contains one tank less.

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Scientific Paper

DETERMINATION OF CIRCUMSTANCES AND CAUSES OF METHANE IGNITION IN CHAMBER WORKINGS USING CFD SIMULATION OF GAS-VENTILATION PARAMETERS

Jelena Marković[1], Rijad Šišić[2], Zvjezdan Karadžin[3]

SUMMARY

This paper deals with an accident that took place in 2009 in „Stranjani" underground mine, an operation of Zenica brown coal mines, when methane ignition occurred during the sealing of chamber workings in which oxidation process was in progress.

Analysis of accident scenario from the moment of oxidation process occurrence until the ignition of methane was carried out using CFD simulation of gas-ventilation parameters to determine circumstances and causes of methane ignition. Methane ignition was induced by roof caving into the top section of chamber workings that caused propulsion of methane layer into the zone of an active oxidation process. Seven workers were injured, being at the moment in the exit room from the working face, i.e. situated in the direction of flame wave spreading. One worker died while other six suffered heavy injuries.

Key words: oxidation process, methane ignition, CFD simulation, chamber workings, roof caving.

1. INTRODUCTION

Causes of coal self-combustion, and resulting endogenous fires in Stranjani mine are directly connected with complex natural conditions, including complex geological conditions, significant methane content in coal seams and propensity of coal to self combustion. Giving the natural propensity of coal to self-combustion and influence of technological factors, oxidation processes frequently take place in old chamber workings due to their ill- timed isolation/sealing upon the mining phase.

Furthermore, it is worsened by layer faults, with displacements of 0.5-12 meters and striking direction are usually set diagonally to striking of coal seam. Apart from diagonal faults, there is a series of small faults striking in the dip or striking direction of coal seam. These faults create uneven parquet structure of the main coal seam, that require more complex face development works, reduces the coal layer recovery, and causes a number of problems that affect the efficient conduct of planned mining method. Excavation direction is from ventilation toward haulage road, approximately close to dip of the seam, therefore the mining front in the panel develops in seam striking direction.

Ventilation of chamber face in conducted using flow ventilation system connected in serial connection with development faces. Air is introduced into workings by haulage road and roof incline, and driven through chamber face or gob into ventilation road.

Methane is usually released into mine rooms in the form of escalation and a number of „blowers", creating a gas compound with mine air. Occurrence of mine fire causes much more complex gas composition of mine air, containing certain percentage of carbon monoxide and other gasses resulting from incomplete combustion of coal caught by the fire. Thereby a complex gas mixture is created, whose ignition mainly depends on content of combustible components in mine air, oxygen content and existence of ignition source [4] .

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Gas content of the deeper part of the coal seam, were accident occurred, was not analyzed but frequent occurrences of methane blowers during the excavation is evident, along with high absolute (2630,8 m3CH4/shift) and relative methane release (35,15 m3CH4/t) [5].

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2. ACCIDENT CHRONOLOGY

On March 14, 2009 at 10 am occurrence of local methane ignition in a chamber face (KO-13) took place. whereby seven workers suffered injuries and one worker died.

At the moment workers were conducting sealing of an old chamber workings, creating a water-sand plug 109 at the exit side of chamber workings in the ventilation road no 53[2]. Location of the workings KO-13 in the active part of the mine is shown in Figure 1.

Location of the oxidation process in the safety bridge KO-13 was detected in the floor part of the face were excavation of the roof coal seam was carried out. The room in the roof part was drifted earlier aimed to create a ventilation connection for the working panel.

That room was in a longer contact with air and it lead to conditions for development of oxidation process. Water splashing was carried out to prevent oxidation process in each shift.

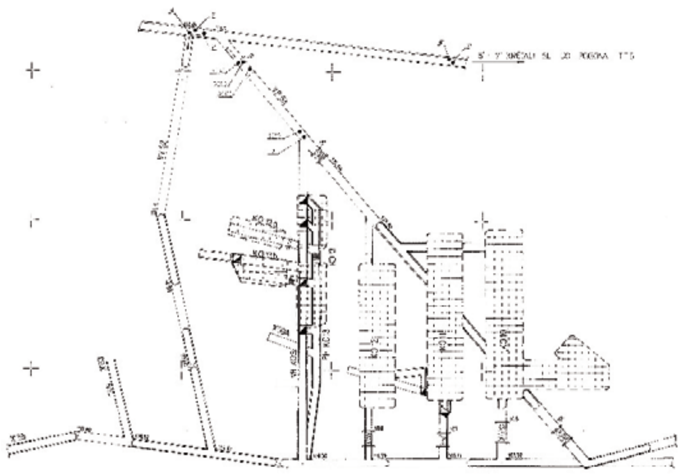

Figure 1. Location of KO-13 in the active part of "Stranjani"mine [5]

Regular daily control of gas status was conducted upon detection of oxidation process on March 3, 2009. Oxidation process resulted in increase of methane and carbon monoxide content in exit air current from chamber face. Concentration of methane in exit air from KO-13 varied between 0.7 and 2.2 percent. Complex tectonic movement within the seam caused a constant roof caving into the old workings KO resulting in increase of methane concentration above the permitted values (in the period March 3 to March 8)

Immediately above the oxidation process is a gob of 2500 cubic meters volume. Methane was released into the collapsed part of KO and the cavity was filled with methane with high concentration. Moreover due to absence of turbulent ventilation layering of methane occured in the roof part.

Increase in temperature and content of carbon monoxide in the exit air from KO-13 was detected on March 13, 2019 and 10 a, when a maximum concentration of carbon monoxide of 0,0105 % was measured.

Based on effects created upon ignition, it can be concluded that pressure developed during the methane ignition was under 0.15 Bar, since no major mechanical destruction of mine rooms take place.

Table 1. Characteristics of various kinds of methane burning [6]

Burning form	Pressure of explosion wave* bar	Velocity of flame spreading m/s
Calm burning	Insignificant	0,5 – 0,6
Ignition	< 0,15	2 _ 10
Explosion	> 0,15	< 330
Detonation	do 40 – 50	> 330 i do 2000 – 8000

*Pressure of explosion wave of 0,15 bar is the lowest pressure at which destruction of mine rooms and human injuries can take place

Seven workers that were in the line of impact wave suffered heavy injuries while one of the workers who was at the time in standing position (based on forensic findings) died. Based on the forensic findings the flame velocity of methane ignition was calculated, of ~15 – 20 m/s [3] [8]. Blood analysis on carboxy-hemoglobin of the worker indicates there was no carbon monoxide poisoning and that methane-oxygen reaction lead to creation of carbon dioxide, i.e. it concerned a full combustion process.

3. CFD SIMULATION OF GAS-VENTILATION CONDITIONS

Simulation model using Finite volume method was developed to determine causes of methane ignition, i.e. simulation analysis using software for numeric calculation simulation of fluid mechanics (CFD-Computational Fluid Dynamics).

Spatial and geometrical inputs were taken from the mine situational plan and other operative-technical documentation (Figure 2) as a basis to develop simulation model.

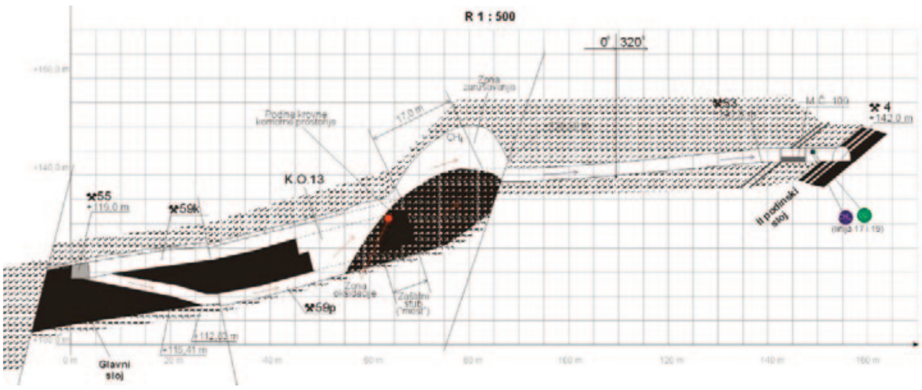

Figure 2. Cross section of chamber working face no. 13

Limits of the model were set to include immediate space in which roof caving (gob No -13), along with mixing of stratified methane with air and ignition occurred.

Input data for numerical simulation of methane ignition were defined based on measuring the gas-ventilation parameters before and after the accident [2] and [5].

Multiple species option was used for modeling the reactive fluid movement used for determining transport of multi-component gas mixture, chemical reaction in volume, interaction of turbulence and chemical reactions. In the frame of the chosen model, sorts and conditions of development of chemical reaction were defined in order to prove possibility of methane ignition occurrence.

Other most important parameters of physical model used for calculation are shown in Table 2.

Table 2: Basic parameters of used physical model

Parametar	
Solver	*Segregational*
Model of turbulence	*k - ε*
Model of reaction	*eddy-dissipation*
Fluid density	*Based on equation of state for ideal gas*

Limit conditions define the kind of limit domain of calculation and relating conditions. Input limit is the entry from the main seam gallery (gallery no 55 K +119.0 m) for which air velocity is defined (v = 0,78 m/s). Exit limit from calculation domain is the exit of gallery KO-13 into the gallery of the IInd floor seam (gallery no 4, K +142,0 m).

Air movement in normal ventilation conditions of KO-13 was from main seam rooms, through development room of KO -13 toward the IInd floor seam. Flow ventilation at the methane ignition occurrence was reduced to minimum, that intensified stratifying of methane in the roof of caving zone due to the reduced intensity of turbulent mixing.

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4. RESULTS OF METHANE IGNITION SIMULATION

Figure 3 shows air velocity through chamber workings immediately before the methane ignition. It is obvious that air velocity in the central part and in the roof of caving zone is closing to zero, that creates favorable conditions for local air recirculation or release and stratifying of methane . Furthermore, narrow passage between the central active part of chamber and safety bridge, i.e. caving zone (gob) above the bridge, caused the acceleration of air current and thus more intense air exchange.

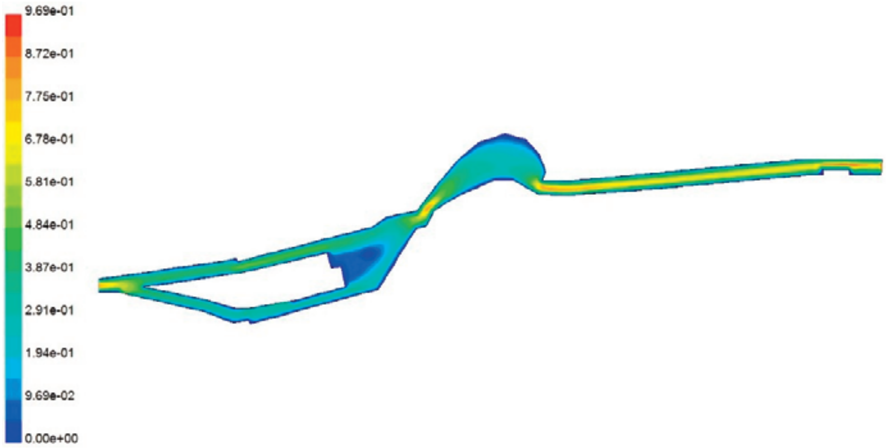

Figure 3: Contour of air movement velocity (m/s) through chamber workings immediately before the ignition

Upon simulation of ventilation conditions present during the construction of water-infusion seal No-109, the conditions favorable for methane ignition were simulated.

Stratified methane in the roof of caving zone was pushed toward the oxidation zone of coal seam in the safety bridge. Methane movement velocity toward the oxidation zone was 0.5 m/s, simulated by the roof caving. Simultaneously with movement of methane toward the oxidation zone it mixes with air. Assumption was that mixture concentration that was ignited by oxidation process were above the upper explosion limit (>15%), a series of simulations were conducted with concentrations ranging from 15 do 50 % of methane. This concentration concerns the one in suppressed methane, before mixing with air. Source of ignition was the oxidation zone, with assumed temperature of 850 K (577 o C)

Analyses of a sequence of simulations with different methane concentration showed that basic physical parameters of methane ignition (static and dynamic pressure, flame velocity, flame temperature) were relatively independent of initial methane concentration, i.e. variations in the final methane ignition were lower than 10 % for each simulated cases. This upholds the fact that limitation factor for ignition development in KO-13 was oxygen content in the air [6] [7].

As a representative sample of conducted simulations, are shown in figures below as the results with mass share of methane of 0.2 kg/kg (approx 0.161 kg/m3) in caving zone. Figure 4 shows velocity of flame wave upon methane ignition at chamber face.

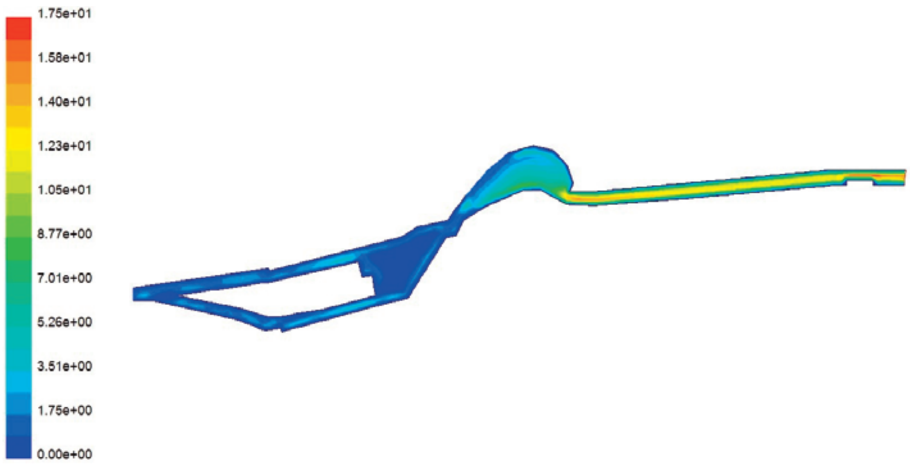

Figure 4: Contours of flame wave velocity upon methane ignition (m/s)

Based on simulation , the maximum flame velocity (vpl = 17,5 m/s) was reached at the working site on water-sand infusion seal No 109., location were workers suffered injuries.

Inspection of the accident site proved there was no major damages on equipment , i.e. there were no signs of high pressures caused by intense deflagration combustion (explosion) of methane.

Numerical simulation showed relatively low increase in static (Δpst = 212 Pa) and dynamic pressure (Δpst = 55,7 Pa).

Figure 5 shows contour zones in which reaction of methane combustion took place. Reaction zone includes front part of caving zone, above the safety bridge. Expanding combustion products are moving toward the free space of the rear part of caving zone, i.e. toward the water-mud infusion seal NO 109 and the room no 4. Narrow passage between the chamber workings and caving zone and a dynamic effects of ventilation additionally conditioned the movement of combustion products toward the place of construction of water-sand infusion seal. No 109.

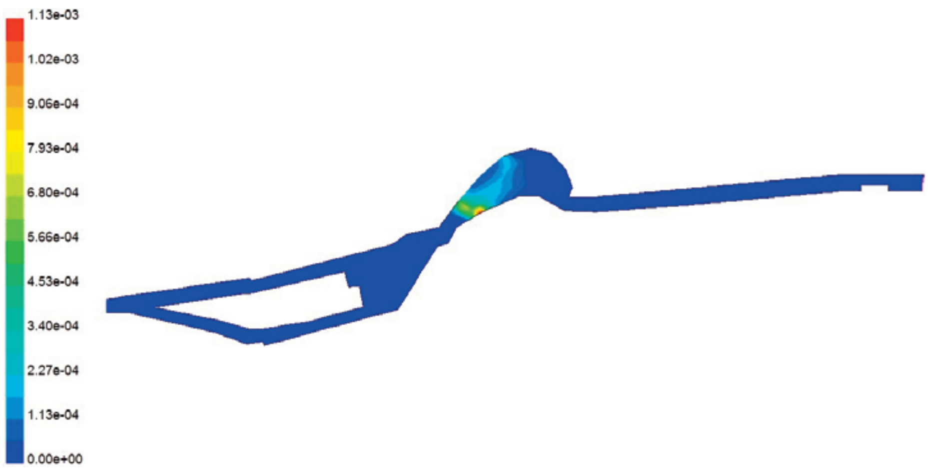

Figure 5. Contour zone of combustion reaction of methane-air mixture
Simulation results indicating achieved temperatures in the reaction zone and the rooms of combustion product movement are shown in Figure 6.

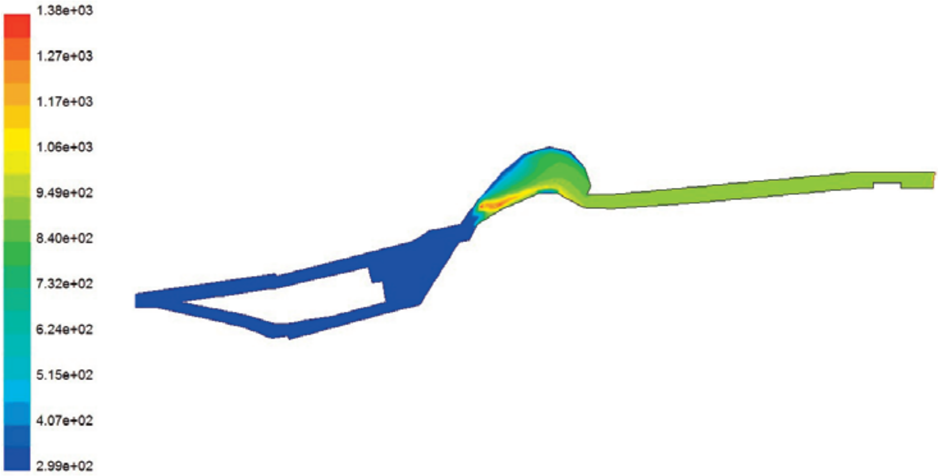

Figure 6. Contours of temperatures during the ignition of methane –air mixture

As shown, maximum temperature is in the reaction zone (1380 K), while temperature of combustion products in the remaining part of caving, gallery and location of water-sand infusion seal No 109 is ranging between 840 and 950 K. These temperatures of flame wave are sufficient to cause burnings, hair scorching (eyebrows and eyelashes), as well as burnings to respiratory tract at workers working at infusion seal No 109.

Figures 7,8 and 9 show mass share (kg/kg) of methane, oxygen and carbon dioxide in chamber workings and exit gallery.

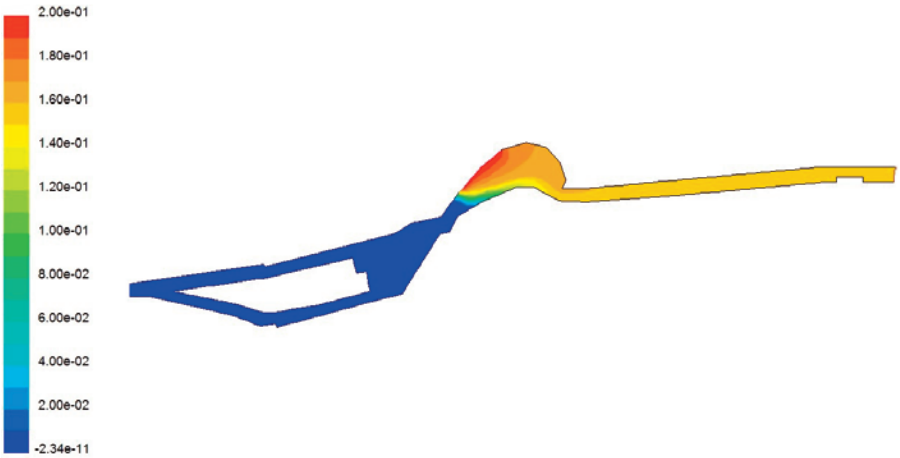

Figure 7. Contours of mass methane share in KO-13 and exit gallery

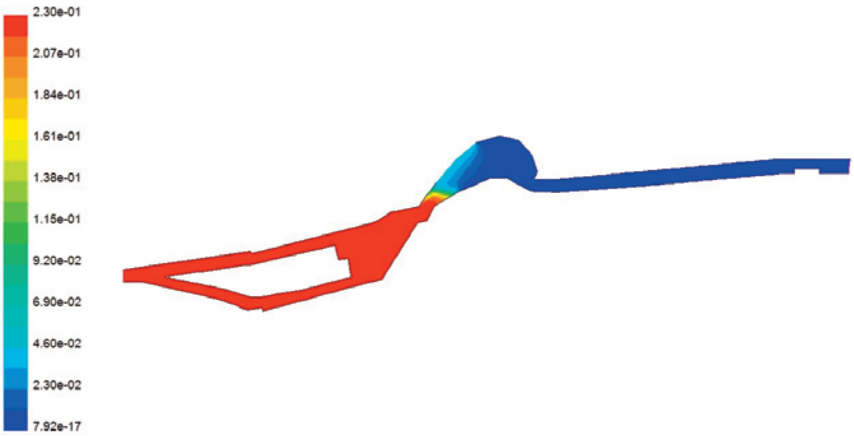

Figure 8. Contours of mass oxygen share in KO-13 and exit gallery

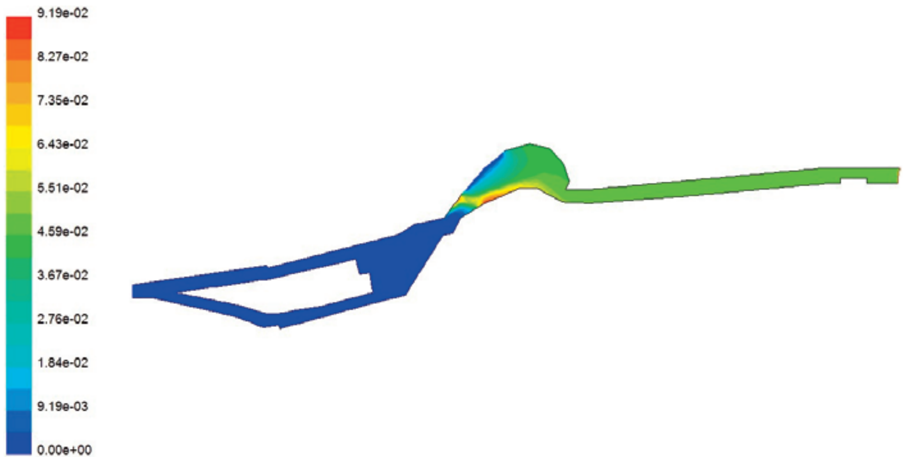

Figure 9. Contours of mass CO2 share in KO-13 and exit gallery

Mass share of oxygen in combustion products is close to zero value (7,9 x 10-17 kg/kg, in relation to 0,23 kg/kg oxygen in atmospheric air), implying that present quantity of air in caving area was limiting factor for accident development. Mass fraction of methane in combustion product was aprox. 0,14 kg/kg, indicating that only 25-30 percent of initially mixed methane reacted during the combustion process. Furthermore relatively high concentration of carbon monoxide was present in combustion products (aprox. 0,05 kg/kg).

5. CONCLUSION

Numeric simulation of gas-ventilation parameters using CFD software, along with analysis of all events occurring in the chamber workings, proved as a very useful method for determining circumstances and causes of methane ignition. Presented simulation results undoubtedly point that roof caving caused movement of methane layer in the caving zone (top of chamber face) into the safety bridge zone of chamber face were the source of ignition was situated (intensive oxidation process). Giving the fact that roof caving in the chamber workings induced mixing of methane layer with air already containing methane in concentration above the upper explosive limit it finally caused methane ignition. Kinetics of this reaction depended on oxygen quantity in chamber air.

Analyzed case indicates to a sequence of interconnected events (intensive oxidation process, creation of methane layers, roof caving) that can lead to mining accidents with fatal consequences. In order to prevent such accident it is necessary to improve ventilation in chamber workings to eliminate creation of explosive mixtures or methane layers. Whereas special attention has to be dedicated to monitoring and prevention of endogenous oxidation processes, and timely decisions on sealing of old workings upon their exploitation.

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Scientific Paper

DESIGNING OF THE DEPOSITIONAL MASSES CONSOLIDATION EFFECT

Mevludin Avdić[1], Izudin Bajrektarević[2], Frljak Zijad[3], Božana Barušić[4]

SUMMARY

Deposition of the masses from the coal seam, or construction of embankments on the building objects are subject to consolidation. In this paper, it is given an estimate representation of consolidation of the waste dump, which is built on the ground slope. Data that are used are from earlier physical-mechanical researches, geodetic data and engineering - geological profiles, made by Coal mine Kakanj. The paper does not show the representation of stability calculations, which were done using the Janbu and Bishop method.

Key words: consolidation, depositional masses, designing

INTRODUCTION

The waste dump „Čobin Do" was built in the 1980s and was used for the deposition of the mullock from the coal seam „Vrtlište". By ending of masses deposition, cracks and mass sliding occurred, but they were partly remediated, according to the project documentation. Needs for the deposition of the new masses have emerged, so it was necessary to do an estimate, not just of stability analysis, but also of the depositional masses consolidation effect with stability calculation.

Earlier deposition of masses was done on unprepared ground slope.

PROBLEM DESCRIPTION

Deposition of masses from the coal seam creates a new layer, which is not homogeneous in any part. Actually, depositional masses are composed of several lithologic units, which can be connected, but in general, those are individual blocks-pieces, which are not connected.

While depositing, there are also significant factors, such as incoherence, heterogeneity and the occurrence of cracks-spacing between individual pieces. All this affects the exact definition of the geomechanical parameters at the landfill. At the very beginning of deposition (the eighties of the last century), geomechanical testing is done, and the new examinations are made in 2018, on depositional material. In the last twenty years, there was no any deposition at the location in question, so we considered the stationary state of consolidation in the analysis. Also, geodetic points have been set up as the starting point for observing the terrain. No geodetic observation was performed in the last period, so we decided to do the consolidation estimate based on the visual observation and new parameters of the depositional material by the method of investigation hall. The position of the considered profiles and the situation map are shown in the text below. Geomechanical parameters are shown in Table 1.

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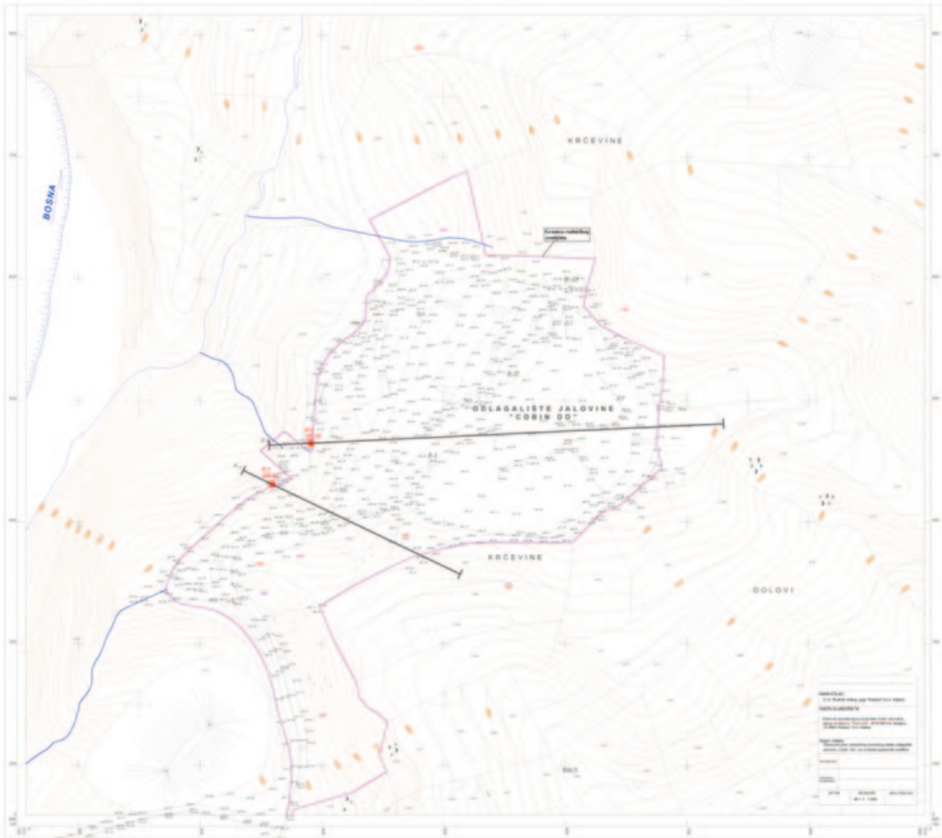

Figure 1. Situation plan of the recorded current state of waste dump "Cobin Do", with investigation hall and profile position

Table 1. Geomechanical parameters

Material	Bulk density, γ (kN/m^3)	Cohesion, c (kN/m^3)	Angle of internal friction, φ (^{o})	Bulk modulus, M_v (N/cm^2)	Humidity, w, (%)
Sandy clay	19.85	2.5-25.5	15.5-21.5	390-980	21.36
Sandy marl	21.36	5.0-45.5	19.5-23.5	590-990	15.37

DESCRIPTION OF THE CONSOLIDATION THEORY

The time-dependent effects of the stress condition and the influence of fluid in the bores signify consolidation. The problem can be described by using the partial differential equation, the so-called parabolic equation. If the problems describe non-homogeneous layers, differential equation changes shape [1]. In time-dependent problems, it is necessary to give initial conditions that define initial or starting conditions for the body. In the time interval, we have a domain division in the coordinate system that we are working in. This can be solved by applying finite differences or the finite element method. In the finite element method, the coefficients are given by the terms:

$$[\mathbf{k}_\alpha] = A\int_{x_1}^{x_2}[\mathbf{B}]^T\alpha[\mathbf{B}]\,dx$$

$$[\mathbf{k}_\mathrm{t}] = A\int_{x_1}^{x_2}[\mathbf{N}]^T[\mathbf{N}]\,dx$$

$$\{\mathbf{Q}(t)\} = \overline{q}\int_{x_1}^{x_2}[\mathbf{N}]^T\,dx$$

$[\mathbf{k}_\alpha] =$ matrix element of hydro diffusion

$[\mathbf{k}_t] =$ matrix element for time dependence

$\{\mathbf{Q}(t)\} =$ an element of node vectors, force or flux of parameters that are time-dependent

CALCULATION OF THE DEPOSITIONAL MASSES AND TERRAIN CONSOLIDATION

The calculation is done based on the parameters which are given in the estimate list for two profiles. Previously, the slope stability calculation was performed, based on the tested samples and geodetic backgrounds:

	X	Y		Start Point	End Point	Length	Angle	Stress /Strain Boundary
Point 1	0 m	0 m	Line 1	1	2	200.6 m	10.1 °	
Point 2	197.48994 m	35.16238 m	Line 2	2	3	20.593 m	90 °	Fixed X
Point 3	197.48994 m	55.75516 m	Line 3	3	4	17.117 m	5.96 °	
Point 4	180.46494 m	53.97805 m	Line 4	4	5	7.0597 m	5.51 °	
Point 5	173.43789 m	53.29976 m	Line 5	5	6	2.5914 m	11.8 °	
Point 6	170.9011 m	52.7707 m	Line 6	6	7	2.172 m	2.15 °	
Point 7	168.73058 m	52.68931 m	Line 7	7	8	1.5675 m	23.5 °	
Point 8	167.29262 m	52.06528 m	Line 8	8	9	6.2049 m	-2.38 °	
Point 9	161.09308 m	52.32303 m	Line 9	9	10	3.6223 m	-0.644 °	
Point 10	157.47103 m	52.36373 m	Line 10	10	11	6.3353 m	0.245 °	
Point 11	151.13583 m	52.3366 m	Line 11	11	12	3.0457 m	6.65 °	
Point 12	148.11067 m	51.98389 m	Line 12	12	13	6.5541 m	14.4 °	
Point 13	141.76191 m	50.356 m	Line 13	13	14	8.4889 m	14.4 °	
Point 14	133.54107 m	48.23975 m	Line 14	14	15	9.2683 m	4.62 °	
Point 15	124.30281 m	47.49363 m	Line 15	15	16	8.9834 m	15.9 °	
Point 16	115.66144 m	45.03823 m	Line 16	16	17	15.872 m	16.6 °	
Point 17	100.45425 m	40.49371 m	Line 17	17	18	2.4867 m	22.8 °	
Point 18	98.16164 m	39.53055 m	Line 18	18	19	4.2844 m	27.9 °	
Point 19	94.3768 m	37.52282 m	Line 19	19	20	2.8235 m	-9.96 °	
Point 20	91.59583 m	38.01118 m	Line 20	20	21	8.4656 m	0.643 °	
Point 21	83.13081 m	38.10614 m	Line 21	21	22	1.6461 m	8.53 °	
Point 22	81.50292 m	37.86196 m	Line 22	22	23	3.9898 m	50.5 °	
Point 23	78.96613 m	34.78254 m	Line 23	23	24	3.235 m	47.2 °	
Point 24	76.76848 m	32.40854 m	Line 24	24	25	2.0032 m	5.44 °	
Point 25	74.77432 m	32.21862 m	Line 25	25	26	4.6125 m	-0.505 °	
Point 26	70.16197 m	32.25931 m	Line 26	26	27	5.2334 m	5.5 °	
Point 27	64.95273 m	31.75738 m	Line 27	27	28	14.376 m	3.3 °	
Point 28	50.60018 m	30.92987 m	Line 28	28	29	8.4391 m	9.25 °	
Point 29	42.27082 m	29.5733 m	Line 29	29	30	1.1512 m	21.4 °	
Point 30	41.19913 m	29.15276 m	Line 30	30	31	1.7145 m	15.1 °	
Point 31	39.54411 m	28.70509 m	Line 31	31	32	1.8967 m	32.4 °	
Point 32	37.94335 m	27.68766 m	Line 32	32	33	3.0282 m	25.2 °	
Point 33	35.20308 m	26.39892 m	Line 33	33	34	3.7671 m	17.4 °	
Point 34	31.60816 m	25.27296 m	Line 34	34	35	2.2162 m	34.3 °	
Point 35	29.77678 m	24.02491 m	Line 35	35	36	2.9449 m	1.58 °	
Point 36	26.83302 m	23.94352 m	Line 36	36	37	4.0517 m	-3.84 °	
Point 37	22.79043 m	24.21483 m	Line 37	37	38	1.437 m	7.59 °	
Point 38	21.36603 m	24.02491 m	Line 38	38	39	6.145 m	8.51 °	
Point 39	15.28858 m	23.11601 m	Line 39	39	40	4.414 m	20.9 °	
Point 40	11.1646 m	21.54238 m	Line 40	40	41	11.204 m	4.79 °	
Point 41	0 m	20.60635 m	Line 41	41	1	20.606 m	90 °	Fixed X
Point 42	197.48994 m	0 m	Line 42	1	42	197.49 m	0 °	Fixed Y
			Line 43	42	2	35.162 m	90 °	Fixed X

REGIONS

	Material	Points	Area
Region 1	Embankment	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27, 28,29,30,31,32,33,34,35,36,37,38,39,40,41	4,372.1 m²
Region 2	Subsoil	1,42,2	3,472.1 m²

Color	Name	Category	Kind	Parameters
	Fixed X	Stress/Strain	Force/Displacement	X-Displacement: 0 m
	Fixed Y	Stress/Strain	Force/Displacement	Y-Displacement: 0 m

Color	Name	Model	Young's Modulus (E) (kPa)	Unit Weight (kN/m³)	Poisson's Ratio
	Nasip	Linear Elastic (Total)	9,900	19.8	0.45
	Podtlo	Linear Elastic (Total)	9,900	24	0.45

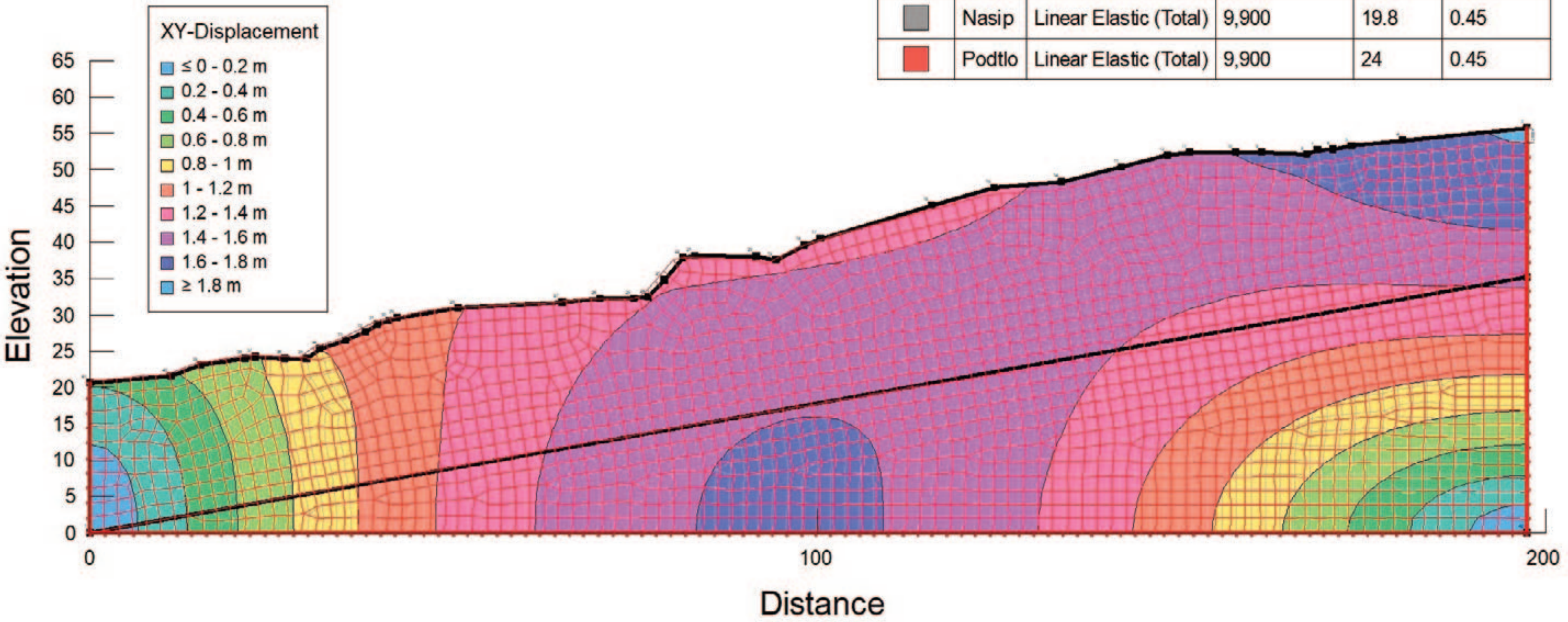

Figure 2. Calculation model for terrain consolidation with vertical and horizontal shifts for profile P-1

	X	Y		Start Point	End Point	Length	Angle	Stress /Strain Boundary
Point 1	319.26725 m	33.034217 m	Line 1	1	2	316.57 m	3.64 °	
Point 2	3.33438 m	12.932646 m	Line 2	2	3	6.9899 m	14.6 °	
Point 3	10.09842 m	14.695106 m	Line 3	3	4	12.573 m	17.3 °	
Point 4	22.1022 m	18.434379 m	Line 4	4	5	5.1303 m	21.8 °	
Point 5	26.86561 m	20.339741 m	Line 5	5	6	5.1286 m	3.19 °	
Point 6	31.98627 m	20.625546 m	Line 6	6	7	1.5063 m	34.7 °	
Point 7	33.22475 m	21.482959 m	Line 7	7	8	6.2758 m	17 °	
Point 8	39.22664 m	23.31687 m	Line 8	8	9	4.7589 m	5.17 °	
Point 9	43.96623 m	23.745576 m	Line 9	9	10	3.5754 m	2.29 °	
Point 10	47.53879 m	23.888478 m	Line 10	10	11	3.6014 m	25 °	
Point 11	50.80172 m	25.412768 m	Line 11	11	12	2.457 m	16.3 °	
Point 12	53.1596 m	26.103462 m	Line 12	12	13	3.2231 m	10.6 °	
Point 13	56.32727 m	26.698888 m	Line 13	13	14	9.8499 m	6.39 °	
Point 14	66.11607 m	27.794471 m	Line 14	14	15	3.7928 m	-11.6 °	
Point 15	69.83152 m	27.032326 m	Line 15	15	16	11.271 m	7.65 °	
Point 16	81.00171 m	28.532799 m	Line 16	16	17	8.9831 m	13.3 °	
Point 17	89.74256 m	30.60488 m	Line 17	17	18	2.7867 m	0.49 °	
Point 18	92.52915 m	30.628697 m	Line 18	18	19	4.207 m	7.81 °	
Point 19	96.69713 m	31.200306 m	Line 19	19	20	4.7104 m	22.3 °	
Point 20	101.05565 m	32.986583 m	Line 20	20	21	18.751 m	24.2 °	
Point 21	118.15627 m	40.679483 m	Line 21	21	22	1.9768 m	0 °	
Point 22	120.13309 m	40.679483 m	Line 22	22	23	11.045 m	4.95 °	
Point 23	131.13655 m	41.632164 m	Line 23	23	24	12.761 m	3.1 °	
Point 24	143.87866 m	42.322858 m	Line 24	24	25	21.206 m	4.19 °	
Point 25	165.02818 m	43.870964 m	Line 25	25	26	6.7426 m	27.1 °	
Point 26	171.03007 m	46.943361 m	Line 26	26	27	6.4657 m	-3.38 °	
Point 27	177.48449 m	46.562288 m	Line 27	27	28	7.1566 m	-3.24 °	
Point 28	184.6296 m	46.157399 m	Line 28	28	29	1.9928 m	-24.7 °	
Point 29	186.43969 m	45.323803 m	Line 29	29	30	0.50636 m	-48.8 °	
Point 30	186.77313 m	44.942731 m	Line 30	30	31	20.697 m	0.198 °	
Point 31	207.47013 m	45.014182 m	Line 31	31	32	15.125 m	0.722 °	
Point 32	222.59394 m	45.204718 m	Line 32	32	33	12.147 m	0 °	
Point 33	234.74062 m	45.204718 m	Line 33	33	34	4.986 m	-3.29 °	
Point 34	239.71838 m	44.918914 m	Line 34	34	35	6.6148 m	6.41 °	
Point 35	246.29188 m	45.657241 m	Line 35	35	36	12.982 m	-0.841 °	
Point 36	259.27216 m	45.466705 m	Line 36	36	37	20.825 m	1.7 °	
Point 37	280.08824 m	46.085948 m	Line 37	37	38	4.7396 m	-0.288 °	
Point 38	284.82783 m	46.062131 m	Line 38	38	39	11.348 m	-2.53 °	
Point 39	296.16473 m	45.561973 m	Line 39	39	40	4.9889 m	-3.83 °	
Point 40	301.14249 m	45.228535 m	Line 40	40	41	4.5218 m	-31.4 °	
Point 41	305.00085 m	42.870649 m	Line 41	41	1	17.329 m	-34.6 °	
Point 42	0 m	13.051731 m	Line 42	42	2	3.3365 m	-2.05 °	
Point 43	323.76867 m	33.177119 m	Line 43	1	43	4.5037 m	1.82 °	
Point 44	356.70762 m	34.725226 m	Line 44	43	44	32.975 m	2.69 °	
Point 45	368.09216 m	35.01103 m	Line 45	44	45	11.388 m	1.44 °	
Point 46	368.09216 m	21.942598 m	Line 46	45	46	13.068 m	90 °	Fixed X
Point 47	0 m	0 m	Line 47	46	47	368.75 m	3.41 °	
Point 48	368.09216 m	0 m	Line 48	47	42	13.052 m	90 °	Fixed X
			Line 49	46	48	21.943 m	90 °	Fixed X
			Line 50	48	47	368.09 m	0 °	Fixed Y

REGIONS

	Material	Points	Area
Region 1	Embankment	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27, 28,29,30,31,32,33,34,35,36,37,38,39,40,41	4,618.1 m²
Region 2	Subsoil	42,2,1,43,44,45,46,47	4,930.4 m²
Region 3	Hard clay	47,46,48	4,038.4 m²

Color	Name	Category	Kind	Parameters
	Fixed X	Stress/Strain	Force/Displacement	X-Displacement: 0 m
	Fixed Y	Stress/Strain	Force/Displacement	Y-Displacement: 0 m

Color	Name	Model	Young's Modulus (E) (kPa)	Unit Weight (kN/m³)	Poisson's Ratio
	Nasip	Linear Elastic (Total)	9,900	19.8	0.45
	Podtlo	Linear Elastic (Total)	9,900	24	0.45

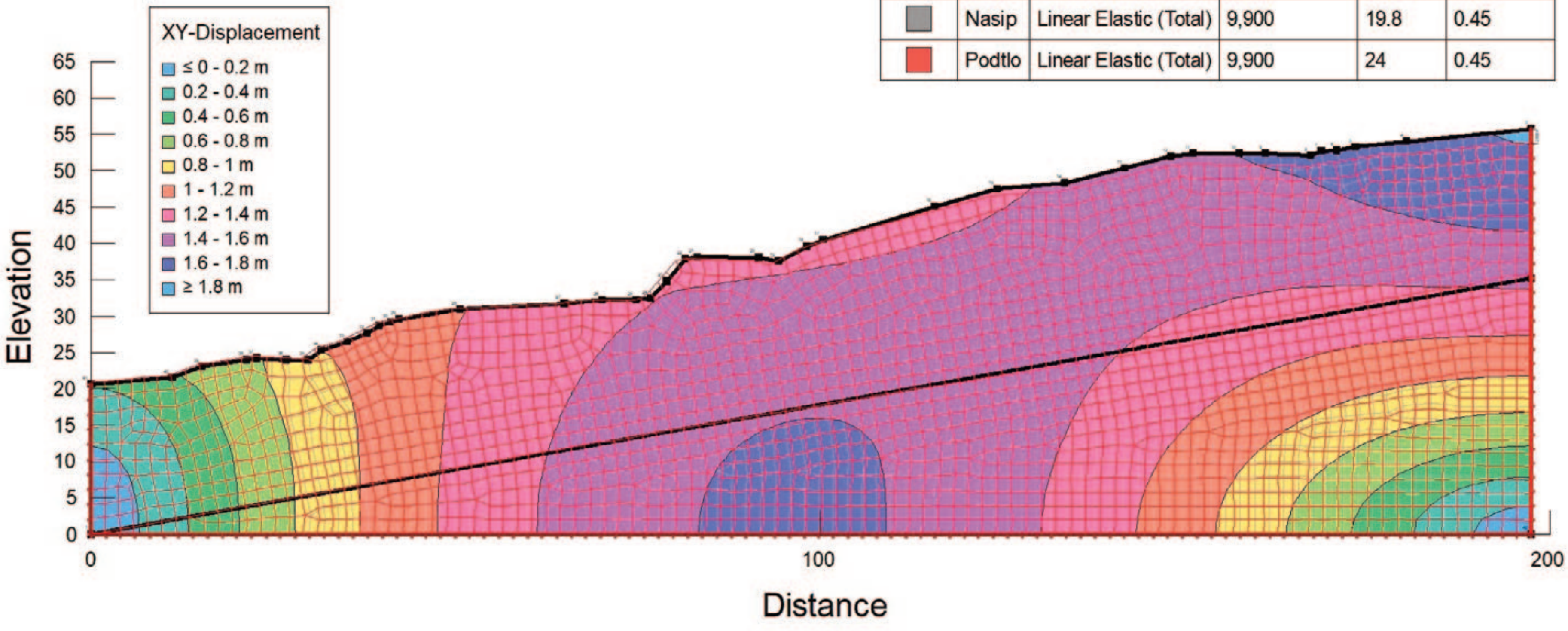

Figure 3. Calculation model for terrain consolidation with vertical and horizontal shifts for profile P-2

CONCLUSION

Based on the consolidation estimate of the depositional masses, which were transformed from the coherent to the incoherent material due to the disturbance, with modified geomechanical characteristics, material consolidation data was obtained after a long period of time. Consolidation parameters are shown in Figures 2 and 3. Based on the obtained data, mass consolidation values ranged from 1.4 to 1.6 m (Figure 2) and from 1.8 to 2.0 m (Figure 3). Better results can be achieved if we know groundwater levels, as well as geodetic monitoring of benchmarks, that are built into and around the waste dump.

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Original Scientific paper

THE WIDTH OF THE PAVEMENT FLOOD IN RELATION TO THE CROSS SLOPE

Zahid Bašić[1], Nedim Suljić[2], Anadel Galamić[3]

SUMMARY

The drainage of surface water from the pavement construction is an important parameter for preserving the planned period and safety during the exploitation of the pavement. This paper presents the investigation of the relationship between the width of the pavement drainage of the pavement depending on the transverse inclination. Proper selection of transverse inclines and collecting rainfall from the sloping surface of the road increases the safety of exploitation conditions itself. Changing the transverse inclination also changes parameters in terms of water velocity, drainage efficiency and relevant surface water quantities. During the analysis, hydrological parameters for the locality of the subject stock are taken into account in this paper.
By analyzing this paper, it is to be shown that the proper selection of transverse tilt of the pavement can be of crucial importance for efficient drainage of surface water from the pavement to provide high security under exploitation conditions.

Key words: cross slope, width of flooding, pavement, exploitation conditions, rain runoff

INTRODUCTION

Efficient road drainage is very important for ensuring the stability of the lower and upper road machines as well as for comfort and safety under exploitation conditions. (Basic, 2014) The basic task of fulfilling these conditions is to keep all forms of water under constant control and take the shortest route to permanent or occasional natural watercourses. The correct choice of geometry of the upper machine and drainage system achieves faster drainage, and in this connection the degree of traffic safety increases. In order to examine the results of the investigation of the surface water drainage from the road, the section of the road with length L = 100.0 m is treated in the work. The conveyor section is constantly decreasing by 3%, while the transverse inclination is varied by variants. The initial transverse incline is 1.5% and the final 2.5%. The transverse inclines are increased from the initial to the highest with the step h = 0.25. For the purposes of this research, the area of the hull of the pavement was determined and the time of the concentration of the basin for each transverse inclination was calculated. [2] [6]

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3 Anadel Galamić, "GPP Banovići" d.o.o. Banovići, Armije BIH 36, Bosnia and Herzegovina, galamicanadel@gmail.com

HYDROLOGICAL CALCULATION

The amount of rainwater in direct dependence on the intensity of the precipitation, the size, the type and the inclination of the surface from which the runoff is carried out. The calculation of the quantity is based on the adopted rainfall values from IDR curves for KS Tuzla, for a 5-minute rainfall and a 5-year return period.

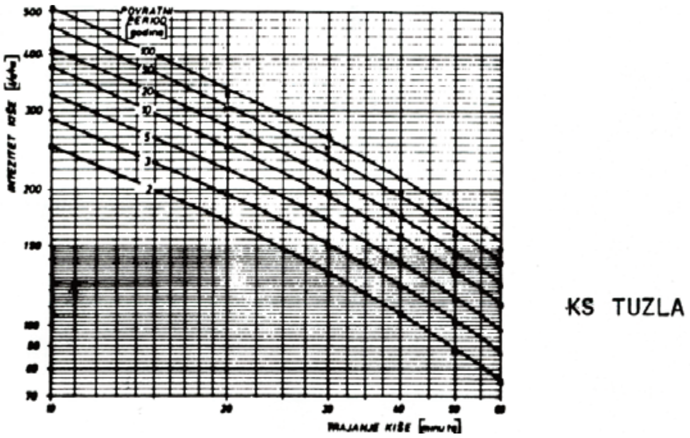

Figure 1. The graph of the dependency of the "intensity-duration-return period" according to the peak method

Table 1. Calculation of the time of concentrations of the watershed section l = 100,00 m

Cross slopes	C	L (m)	S sr. (m/m)	tc. calc. (min)	tc. adopted (min)
Cross slope 1.5 %	0.85	100	0.015	7.09	7.50
Cross slope 1.75 %	0.85	100	0.018	6.73	7.00
Cross slope 2.0 %	0.85	100	0.020	6.44	6.50
Cross slope 2.25 %	0.85	100	0.023	6.19	6.30
Cross slope 2.50 %	0.85	100	0.025	5.98	6.00

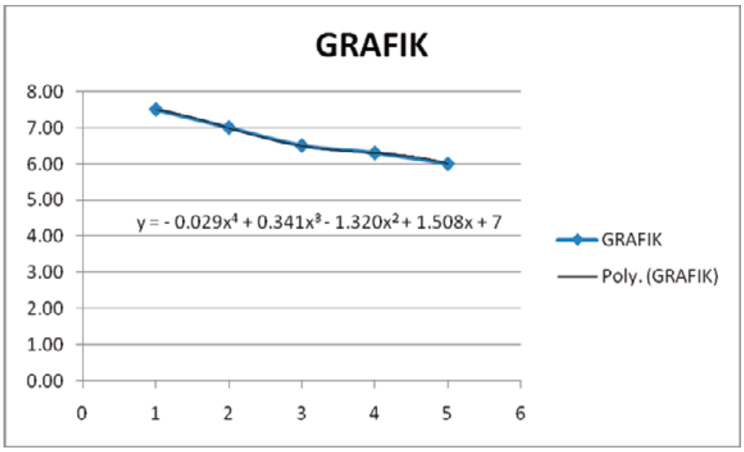

Figure 2. Runoff speed function relative to the transverse inclination of the pavement

Figure 2. shows graph of watershed concentration functions depending on the transverse inclination of the pavement, with a mathematical expression for the calculation of the concentration of the basin for any transverse inclination of the pavement.

THE WIDTH OF THE PAVEMENT FLOOD IN RELATION TO THE CROSS SLOPE

Based on the calculation of the rainfall parameters of the slope surface and the obtaining of relevant droplets, the velocity of the flow determined the width of the pavement floating in relation to the values of the transverse inclination. [4] [5]

Table 2. Hydraulic calculation values for treated cross slopes

Cross slope	Qi (l/s)	Q (l/s)	Qb (l/s)	b1 (m)	b2 (m)	b_s (m)	v_a (m/s)
1,50%	11,57059	17,26953	5,698945	1,126503	1,70722	1,434	0,703
1,75%	11,68553	17,44109	5,75556	1,026834	1,556172	1,307	0,732
2,00%	14,61713	21,81661	7,199482	1,027331	1,556925	1,308	0,801
2,25%	11,85236	17,69009	5,83773	0,882254	1,33706	1,123	0,783
2,50%	11,91519	17,78387	5,868677	0,827668	1,254335	1,053	0,805

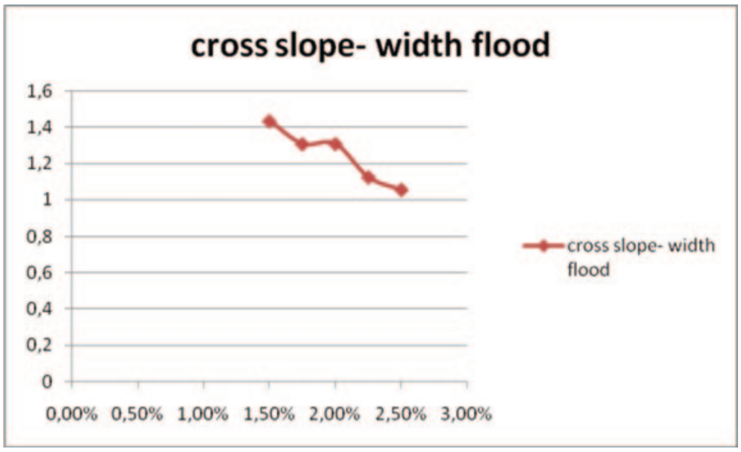

Figure 3. The float width function of the pavement as compared to the cross slope

Figure 3 shows the float width function of the pavement as compared to the cross slope.
It is clear that for the treated section of the cargo structure, and with certain relevant rainfall parameters and rainfall amounts, the pavement width of the pavement decreases with the increase of the cross slope.

CONCLUSIONS

In this paper are presented the research of the relationship of the transverse inclinations of the pavement to the width of the pavement floating in the collecting of the rainfall.
At the concrete site for which the influence parameters were made, the calculation of the deflection parameters from the sloping area of the lenght of l = 100.0 m and the width b = 11.5 m was made.

Given that the results of the research are shown graphically, Figure 3 shows the dependence of the floating width of the cantilever convection of the transverse inclination. From Figure 3 it is clearly seen that by increasing the slope of the cross section of the pavement, the width of the flooding decreases when collecting the rainfall for the observed rainfall period.

Table 2 shows the values of the hydraulic calculation for the treated lateral inclinations.

It is clear from the table that increasing the lateral inclination of the pavement increases the speed of swelling from the sloping surface of the pavement.

As the ultimate result of this research, ie the analysis of the transverse inclination ratio on the width of the floating pavement, we have the dependence of the transverse inclinations on the speed of swelling from the traffic lanes and the width of the bleeding.

Work is a good basis for further research in terms of proper selection transversal tilting of pavement structures for the efficient drainage of surface water with road structures, determination of the distance of the drainage troughs on the carriageway construction, preservation of the planned period and safety under exploitation conditions same pavement construction.

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Scientific paper

GEOMORPHOLOGICAL CHARACTERISTICS OF TUZLA'S BASIN AND ITS LOCAL INFLUENCE ON GROUND-LEVEL AIR POLLUTION

Alen Lepirica[1]

SUMMARY

This paper is focused on the relief structure of the Tuzla's basin and influence of this geomorphic landform on the local climate urban area of Tuzlacity. The researched area is situated mostly in the northeastern part of the Bosnia and Herzegovina, in the zone of the Internal Dinarides, which were geomorphologically reshaped on different lithological substrate. Based on the terrain researches we were concluded that the geomorphic landforms and bigger and higher objects in the Tuzla's basin have strong influence on local climate elements such as local wind and temperature. The results obtained by terrain monitoring of air polution in the colder period of year, showed that, different concetration air pollutants in a very small distances in Tuzla's urban area.

Keywords: Tuzla's basin, landforms, gemorphological influence, local climate, air polution.

1. INTRODUCTION

The basin is depression with leveled bottom, surrounded by hilly and mountainous slopes from all sides. The Bosnian basins are faulted- tectonically predisposed relief depressions, geomorphologically and polygenetically shaped, most often in erodable, cenozoic deposits. The lowest positions of these basins in the Inner and Central Dinarides are represented by relief structures of the shallow meandering river beds (local erosion basis). Along the riverbeds, the elongated, flattened fluvial forms of the floodplains are provided. Somewhat above, there are usually three elevation levels of planation forms of low river terraces as a fluvial geomorphological expression of climatic fluctuations and neotectonic uplifting (A. Lepirica, 2013.). The basic geological specificity of the Tuzla area is the deposits of coal, salt and appearance oil on a geographically small area, which is rarity in the world. Urban and industrial development of Tuzla and its environment, for centuries, was based on the mentioned natural attributes of Tuzla's neogenous basin marked with thick deposits of coal and salt. One of the most important parts of the energy sector related to the exploitation of coal resources is the Tuzla thermal power plant, the largest thermal power plant in Bosnia and Herzegovina. The analyzed area of the Tuzla's basin (Fig. 1) was created within the Tuzla's neogene basin, which is the tectonic unit of the Inner Dinarides of Bosnia and Herzegovina. "The Tuzla's basin, in the narrow sense, has been subsidence throughout the whole neotectonic period, and thus, built from neogene deposits, whose thickness according to geophysical data is about 4,000 m"(S. Čičić et al., 1988.).

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Figure 1: Tuzla's basin – The area of research (Stjepić Srkalović, Ž., 2015.)

According to a Basic Geological map, sheet Tuzla (BGM 1 : 100 000) it can be concluded that geologically, 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 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 sediments (Fig 2). 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(Stjepić Srkalović Ž., Babajić E. et al., 2017.). Geologically, the youngest Quaternary formations cover the bottom and cower sides of teh basin. Therefore, the Quaternary formations can be found as alluvial, proluvial-alluvial and proluvial-deluvial depositions. The deposited semibinded and binded fluvial terrace and alluvial sediments (sand and pebbles) are dominateing at the basin bottom (Fig 2).

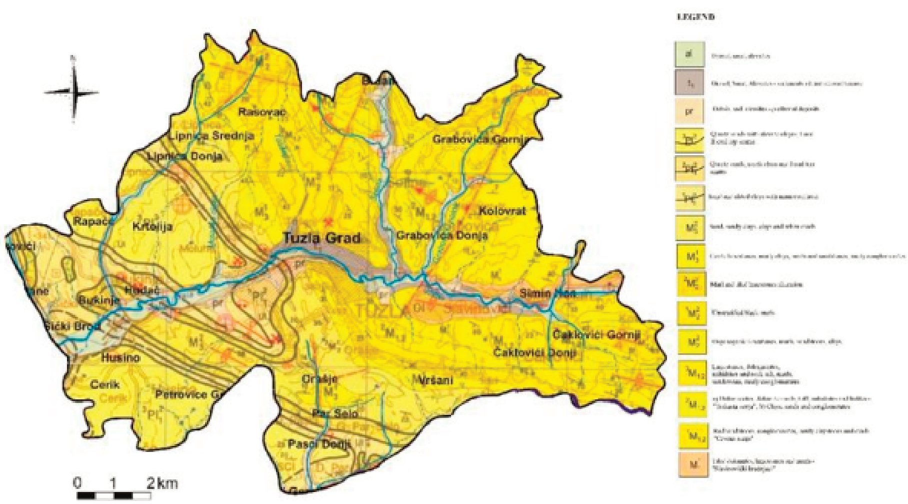

Figure 2: Geological map of Tuzla's urban area (S. Čičić, 1988)

According to authors of Basic geological map, the primary geological structure here is anticline Jala – Požarnica in the upper part of Tuzla's basin, with Oligocene sediments in its core. By Požarnica fault, the Oligocene sediments of anticline development are in contact with miocene deposits on the right Jala bank

(Fig 2). For these structural forms are probably bonded the appearances of oil in Požarnica and Simin Han (Čičić et all, 1988). Also, within the Jala - Slavinovići fault, the thermomineral springs are probably activated. Based on this, we can coclude that newer fault movements disrupted former Tertiary folded structures which resulted by unconform, inverse valley were incised in the older positive geological antiforms.

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) . 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. (Fig 3.)

At first, the morphological analysis of the orographic structure, hypsometric relations, slope inclinations and energy relief were done. Finally, on terrain, we were analysed the impact of geomorphological landforms and higher and bigger objects on climate elements – temperature and wind streams in colder periods of year.

3. RESULTS AND DISCUSSION

3.1. BASIC GEOMORPHOLOGICAL CHARACTERISTICS OF TUZLA'S BASIN

The Tuzla's basin with an area of 5.9 km^2 is the depression in relief of the Dinaric mountain morphosystem. The analysed area is located in the northeastern part of Bosnia and Herzegovina. Thus, in the geomorphologically-regional sense it belongs to the Geomorphic macroentity of "Low mountains and hills, valleys and basins of northern Bosnia" (A.Lepirica, 2013). The basins, as highlighted, represent the polygenetic depressions of a leveled bottom, surrounded by hillslopes from all sides. Accordingly, the Tuzla's basin is extending from the Požarnica to the Šići settlement, at a length of 14,950 m, and it is by all its sides surrounded by the hillslopes of the South Majevica hills. The basin bottom is mostly flattened by lateral fluvial erosion of the Jala and Požarnica (in the upper part) with gently inclines, an average of 6 ‰ on the total length of 14.95 km. In the Požarnica and Simin Han, in its eastern part, the average width of the basin is about 250- 300 meters and about 275-300 meters high above sea level. The bottom of the basin, in the area of the Tuzla's city center, on the Mejdan - Slatina is about 600 meters wide. At the mouth of the Mramorski potok in Jala, at an absolute height of 203 m, there is the lowest point of researched area. Right here, at the bottom, the basin is the widest - about 1 km wide. The mentioned microlocation is located not far from the Šići settlement, where the Tuzla's basin is morphologically connected with the wider intramontane basin of Donja Spreča.

The analysed slopes of Tuzla's basin with relatively low altitudes of about 70-80 m, de facto express the lower slopes of the surrounding South Majevica foothills. Basically, the valley sides are of complexed longitudinal profiles. Morphologically the highest parts of the basin, generally coincide with the upper limit of the radiation fog layer, which at the winter anticyclones reaches heights of about 70 meters above the basin bottom. Thus, according to the results of the field observations of S. Gutić (2015), the height of the inverse layer above the Tuzla's basin is about 290 m n/a.

The morphotectogenesis of this basin morphostructure is linked to the neotectonic uplifting of the South Majevica foothills and the narrowing of the former, spacious, Tuzla's neogenous basin, which stretches from Srebrenik to Zvornik. It should be noted that the South Majevica foothills, according to the vertical movement of the Geodetic leveling data from map of Earth crustal vertical velocity (P. Jovanović, 1971), are affected by a neotectonic uplifting of 0 - 2 mm per year. The upper part of the relief dent of the Tuzla's basin, elongated, irregularly shaped along the Jala – Slavinovići fault by the E-W direction and in about 6.5 km length.

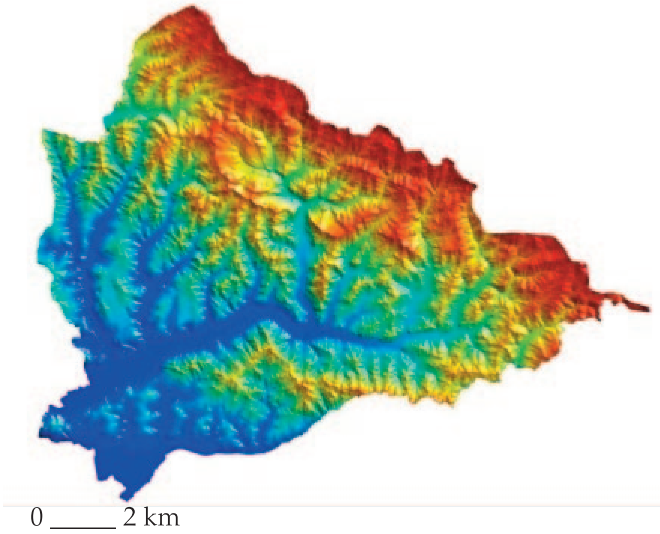

Figure 3: Tuzla's basin (S. Gutić 2018. DEM)

The analysed basin landform, somewhat downstream, in the area of Zlokovac to Tušanj, about 2 km in length, tectonically changes the direction of orientation to NW-SE. The lower part of the basin, from Tušanj to the mouth of the Mramorski potok at Šićki Brod, is generally elongated in NE-SW direction (Fig. 1. and 3.). Therefore, the basin is neotectonically, predisposed by fault. The Tuzla's basin is morphologically enclosed from all sides, with a hilly range, vertically overhanging it for about 200-250 meters. Orographically it is open only toward the southwest, where it is tectonic-morphologically connected to the morphostructure basin of Donja Sprečawhere the Jala river outflows (Fig. 1. and 3.).

3.2. THE IMPACT OF RELIEF ON LOCAL AIR CIRCULATION AND POLLUTION IN TUZLA'S BASIN

Thus, the above mentioned geomorphological characteristic of the orographic enclosure of the basin has resulted in significant annual silences - calms (periods without wind) with significant absence of more intense ground wind circulation, which affects the increased pollution of the ground layers of troposphere (Šegota, Filipčić, 1996.). The aforementioned negative meteophenomenon of the ground radiation fog layer with increased concentration of aeropolutants is particularly emphasized in the colder part of the year at the time of the anticyclonal activities, when many fireplaces are activated in the urban area of Tuzla. Wind currents are closely related to local relief and plastic of terrain i.e. orographic obstacles - elevations and notches, which is strongly confirmed by the wind-roses for the newer period 2009-2016., which is constructed according to the data of the Tuzla's meteorological station. It is the Tuzla's meteorological station Bukovčić (305 m n/v) located on the southern slopes of the foothills, at altitudes of about 60 meters above the basin bottom, i.e. the strict center of the Tuzla. Besides the calms or silences at the Bukovčić meteo-station, the dominant winds throughout the year are those who blows from the northeast quadrant with a total of 37% (NNE with 21.3%, E with 8.3%, NE with 7.9%). In the local wind circulation, there is a significant proportion of those from the southwestern quadrant, with a total of 24% (WSW with 12.8%, W with 11.2%) reaching the lower parts of Tuzla's basin which is also directed by WSW-ENE (Fig 3.).

Here dominates the angular type of drainage network with valleys, subperpendicularly directed to the Tuzla's basin, which was influenced by the neotectonic fault activity (Fig.2. and 3.). Those are the stream valleys of: Kovačica, Grabovica, Solina, Moluška rijeka, Joševica and Mramorski potok, which represent the right tributaries of Požarnica and Jala. The wind circulation from these valleys, especially at night, has a somewhat microlocation role of the urban zone polluted air cleaner. This is actually a daily, local wind circulation, when the night wind (noćnik), due to the higher atmospheric pressure blows from the higher south Majevica foothills and cleanses the ground troposphere of the lower basin area, where is lower atmospheric pressure. "According to the data obtained from five measuring stations located in Tuzla and the surrounding area, it can be noticed that the concentrations of the pollutants are increased during the winter period, especially in parts of the city with the busiest streets (Skver) and residential buildings (Bosnian – Cultural Centre). The sulfur dioxide and dust concentrations often exceed high values" (S. Gutić, 2015.).

We can conclude that, it is certainly necessary to carry out more detailed aeropollution monitoring in the Tuzla's basin with modern mobile meteorological stations in an urban zone, that could determine the quantitative parameters of air pollution and their differences in the concentration of aeropollutants per microlocalities as it was done in Hamburg, Germany at the end of last century (Šegota, 1985.).

In the geomorphologic-morphogenetic sense, the lowest part of the basin is represented by fluvial forms of meandering rivers Jala, Požarnica and their tributaries, which are narrowly subdivided into alluvial-proluvial deposits. In the center of the Tuzla's urban zone, these are the concrete river beds of the regulated rivers Jala and Solina. From the geomorphological aspect, the bottom of the basin is mostly presented with the planes of the first and youngest river terrace where, mostly residential and industrial buildings with supporting urban infrastructure were built. The margines of the basin bottom are covered with semibinded fluviodenudational proluvial-deluvial fan landforms that have been deposited by leaching, torrenting and creeping from the surrounding slopes. Some morphogenically older, the second river terrace, is seen in the left sides of the basin, at altitudes of 20-30 m above the riverbed of Jala. These are, de facto, terrace fragments, where are the smaller plains with Mejdan school, the muslims cemetary at Donje Brdo, the part of the Kula settlement, the hospital for the pulmonary patients and heart center in Slavinovići and the river terraces above the Požarnica settlement. Above the basin bottom, the slopes of the surrounding South Majevica foothills uplifting, that are orographically represented by several sides of the Tuzla basin. The steep slope fans of the average slopes (6° -31°) prevail, intersected with dells, gully, ravine and hanging valleys. The slopes of this basin are polygenetically shaped in the Quaternary by derasional slope processes: leaching, torrenting, landsliding and creeping. Wavy slope profiles, in described area, point to the landsliding activity. The appearances of active, temporarily stable and fossilized landslides are frequent in this area. In the Tuzla municipality, according to the Civil Protection Service latest dana, from the of 2013., a total of 1313 landslides were recorded. Recently, especially around settlements, the number of active sliding surfaces has considerably increased.

The gently inclined slopes above basin bottom represent the accumulation forms of glacis and erosion forms of strath terraces of average inclination of 5° -11°. "Unlike pediments, glacis represent the foothill stairs created by accumulation processes, i.e. joining a series of torrential flood-fans and conical clusters or deluvial cones, related to denudation "(A. Bognar, 1997). The lower glacis surfaces are more evened (slopes 5° to 6°), while the tip edges are somewhat steeper (slopes 9°-11°). They often appear in series such as Ilinčica (452 m above sea level) over the town of Tuzla. On this slope, this linked fossil and semibinded fans with built infrastructure of low private house objects, geomorphologically mark the Ši-Selo, Dragodol, Donje and Gornje Brdo, Zlokovac et others. The third, highest level of planation in the basin slopes, morphologically represent a rocky terrace or fluviodenudational floor. This oldest level of planation is mostly visible in the right sides of the basin, at about 50 – 60 m above the basin bottom. It is actually a paleoplanational fragment of Pleistocene level of planation in the slopes, reliefly characterized by microlocalities of Kicelj, Gradina with cantonal hospital complex, erosion-degraded fluviodenudational floors above Paša Bunar, Stare Moluhe, then western of Hudeč and Šićki Brod - the microlocality of a thermo-power plant landfill at Talijanova šuma.

4. CONCLUSION

Accordingly, the Tuzla meteorological station "Bukovčić" because of its geographic and hipsometric position, above the city center and due to vegetation and surrounding with green grass covering cannot be representative in the case of the analysis of the air pollution of the Tuzla's basin.

Relief is a significant factor but also a climate modificator. In the case of the Tuzla's basin, the anthropogenic-technogenous relief of the urban zone has a very big impact. This primarily applie to the city geometry, as well as to the high and large urban objects such is the Mellain building, skyscrapers, and long buildings that primarily influence the formation and channeling of local wind routes circulation of a specific urban wind. Recently, intense terrain sinking in the central part of the Tuzla urban area, caused by the exploitation of salt, influenced the changes in the morphology of the basin relief. Also, the surface mining of the Kreka and the Bukinje mine are included in this category of technical relief of the Tuzla's basin. Anthropogenic-technogenous relief (buildings, chimneys, factories, their hights, spatial sizes) as well as construction materials of city facilities and city traffic significantly affect as the climate modifiers. Larger residential and industrial buildings have influenced the occurrence of local urban wind and its channeling, direction and intensity. The microclimate of settlements is generally characterized by poor air circulation in the underinversion layer and the occurrence of local urban wind. Therefore, here along with the established ground-level local air circulation in the town of Tuzla, we have local winds from neighboring stream hanging valleys of Solina, Grabovica, Joševica, Mramorski potok, from the southwestern majevica foothills that partially purify the ground troposphere of some microlocalities in the city. The mentioned meteo phenomena is apparent in the Tuzla microlocality of the Banja, where the flow of clean colder air is more often. A similar case is also with Skojevska Street, characterized by channeled wind circulation. It is important to mention the changes of the town's microclimate in direction of concrete Jala river-bed. Mostly, lower wind speeds characterize the urban area in comparison with neighboring areas of bigger relief depression such as Gornjosprečka (Kalesija, Živinice) or Donjosprečka valley (Gračanica, Puračić). The distance between the city center of Tuzla from the thermal power plant Tuzla (7 km) and Ugljevik (25 km) and coke (koks) factory in Lukavac (11 km) is also important from the air pollution aspect in the Tuzla basin, which influence should be determine by more suitable methods.

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