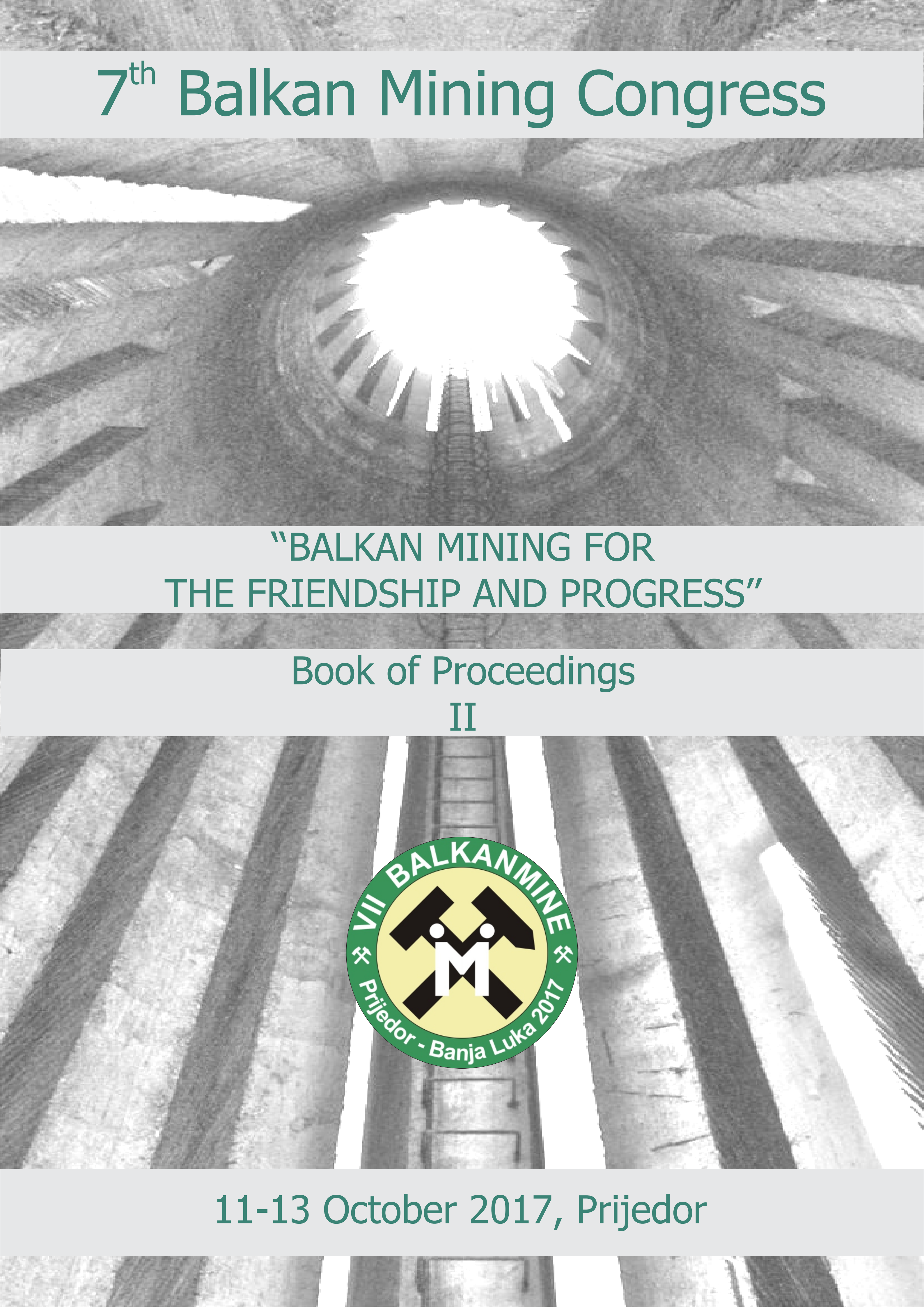

7th Balkan Mining Congress

"BALKAN MINING FOR THE FRIENDSHIP AND PROGRESS"

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October 18-20, 2011.
Ljubljana, Slovenia
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V Balkan Mining Congress

September 18-21, 2013.
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VI Balkan Mining Congress

September 20-23, 2015.
Petrosani, Romania
President of the Balkan Coordinating Committee:
Prof.dr. Nicolae Iliaş

IN MEMORIAM

Assistant professor Tomo Benović was born on January 06, 1958 in Bogutovo Selo in Ugljevik. From 01.02.1982.Tomo Benović was employed in Rudnik i termoelektrana Ugljevik in the following works: trainee, shift manager, technical manager of coal production, assistant director (for mines and technical business), manager for mining and geological service, director of RiTE Ugljevik, coordinator for coordination with Regulatory Authorities, Team Leader of Project Implementation and realization of investments and projector for the mine. Tomo Benović was the first Mayor of Municipality Ugljevik and in the period 2000-2002 he had been a member of the National Assembly of Republic Srpska. Tomo Benović had been in the following scientific and professional organizations and associations: the Chairman of the Alliance of Engineers and Technician of Mining - Geological and Metallurgy Profession, the membership of the International Coordination Committee of the Balkan Mining Congress from Bosnia and Herzegovina in two mandates.

At the Senate of the University of Banja Luka session, held on August 25, 2016, Tomo Benović PhD in mining was elected as Assistant professor for scientific research - Surface exploitation of the mineral raw materials. Assistant professor Tomo Benović tragically died on 27 November 2016 in a traffic accident.

Preface

Dear Colleagues,

On behalf of the University of Banja Luka, the Faculty of Mining Prijedor and the International Coordination Committee of the 7th Balkan Congress, we welcome you as respected and dear guests of the University and Faculty, Prijedor, Republic Srpska and Bosnia and Herzegovina. The 7th Balkan Mining Congress has a motto **"Balkan mining for the friendship and progress"**, which speaks enough about the basic idea of organizing and holding this event. This Conress has been held biennial in the Balkan countries.

This international meeting is an opportunity for Congress participants - authors of works, sponsors, exhibitors, representatives of institutions and companies to meet each other, exchange experiences in solving problems and issues related to the development of mining, geology, and the work of companies. Every opportunity to hear something new, something that is applied in other countries and conditions is the chance to find a chance in this transition period which is difficult for the work and development of mining companies. The exploitation of mineral resources could be beneficial, for the producers themselves,and for local communities and countries where are these mines located.

In contemporary trends in the mining and geology development, there are dilemmas to reconcile certain, at first sight, completely opposed and incompatible activities: mining, environmental protection, optimal economic effects of mining activities for the concedents and concessionaires. The Balkan Mining Congress is a unique opportunity to talk about these issues, exchange experiences, find solutions and align certain models of more rational solutions.

Wishing to feel comfortable and pleasant in Prijedor, and after the end of the Congress, you go home happy and with the view that it was worth being here, I greet you in my personal name and the name of the University in Banja Luka-Mining Faculty Prijedor and others co-organizer of the Congress.

Prijedor, October 2017.

Assoc. prof. Vladimir Malbašić

Chairman of the Organizing Committee
of the 7th Balkanmine Congress

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GEOLOGICAL ACTIVITIES AND ECONOMICS OF MINERAL AND RAW MATERIALS COMPLEXES

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2017 – 135 YEARS OF SYSTEMATIC GEOLOGICAL EXPLORATION OF MINERAL REGION OF LJUBIJA

Ranko CVIJIĆ[1], Aleksandar GRUBIĆ[1], Aleksej MILOŠEVIĆ [2]

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APSTRACT

After the occupation of Bosnia and Herzegovina in 1878, the Austrian authorities have declared all mineral resources in Bosnia and Herzegovina like state property. They had approached to research activities in Ljubija ore area, in order to determine reserves and examine the possibilities of exploitation. Generations of geologists have conducted explorations and changed known hypotheses, intensity of research and concepts. The question is whether the beginning of the explorations was the period between 1882 and 1885 (135 years ago), when the government and mining consultants Vogt and Wolter had recorded the state of the raw material base in these areas for the first time, or when the first iron ore explorations started in 1907 (110 years ago). Geological explorations have been conducted with interruptions and passed through various phases, different in intensity depending on the interest of mining production and the best methodologies of the time were applied. The paper represents the history of explorations, applied methods, detailed and regionally researched areas and the volume and intensity of research for each of the applied methods. There is a critical review of applied research methodologies, achieved exploration level and reliability of available data on previous explorations and the degree of field exploration evaluation.

Key words: Ljubija ore area, Republic of Srpska, the history of geological explorations, applied methods, results of research.

1. INTRODUCTION

Geological explorations of Ljubija ore area started in the late 19th century and continue to this day. The volume and intensity of explorations and known hypotheses have been changed during the time. In recent decades the concept of explorations was based on metallogeny.

Ljubija ore area spreads to the front of Sana overthrust in the south, the Jurassic-Cretaceous boundary in the east, the inner ophiolite belt of Kozara Mt in the north and to the tectonically predetermined direction of the Una River, deeply engraved in the relief in the west [1]. This is very interesting geological area with many discovered and potential deposites of iron ore and other mineral raw materials. At the same time this is an important part of mineral raw complex of the Republic of Srpska.

Iron ore in Ljubija ore area were exploited during prehistory, probably even in the period of the Younger Iron.The intensity of explorations had changed during the Medieval Period and the rise started again in the period of the Ottoman Empire. The first expert explorations of iron ore occurrences in this area started with the Austro-Hungarians.

There are some important dates:

- Austro-Hungarian occupation 1878;
- Regulations prohibited free explorations;
- The Law on Geology provided the use of ores and coal exclusively for Austrians and Hungarians 1879;
- Three Viennese geologists were sent to Bosnia and Herzegovina to create a geological map; Mojsisovics, together with Pilar, was responsible for Ljubija ore area
- The Government mining advisors Vogt and Wolter examined the mines 135 years ago (1882-1885) and Fulan and Nobesk prepared the geological map of a part of Ljubija ore deposites;
- Based on these analyses the first investigations of iron started in 1907 (hundred years ago);
- During World War I (1914-1918) Austria needed large amounts of iron, so for five months they had invested great efforts in logistics (18 km of the railroad) and started the exploitation of iron ore in Ljubija 1916 (one hundred years of mining).

Due to the increasing needs of former Yugoslav ferrous metallurgy, the explorations of Ljubija ore area were very intensive in the second half of the previous centur. The exploration included all current geological disciplines. The correctness of this approach had been proven during the discovering of new deposits and the increasing of iron ore deposits. New deposits were discovered in some areas and stratigraphic levels which previously were not supposed to contain any ores.

2. OVERVIEW OF APPLIED RESEARCH METHODS

In order to present the overview of geological explorations, applied research methods and their contribution to the genesis of Ljubija ore area it is necessary to analyse four separated time segments:

- period from the first rudimentary geological explorations to the end of World War II,
- period from the end of WWII to 1965,
- period from 1965 to 1986,
- period from 1986 to nowadays.

Each of them differs in research characteristics and methods.

Although the data on exploitation and smelting outreach into ancient history, there are no written geological data. Abundance of deposits in the surface of the terrain did not require any geological researches. Geological mapping was the first step made by Austrian geologists. The result was the first geological map of Bosnia and Herzegovina with Ljubija ore area [2]. This was the first time to use the term the Sana Palaeozoic in geological literature. It was an attempt to determine the time of the creation of Ljubija sedimentary series that certainly had not been created at the same time. Stratigraphy was a new brunch of geology used in geological analyses. That was the time of Industrial Revolution in Europe, so the needs for iron increased, and attitudes to the explorations, production and ore deposits changed.

A large number of ore occurrences known today had been registered in the period between 1910 and 1918. [3,4,5]. Appropriate laboratory tests regarding the chemistry and mineralogy were performed, the varieties of oxide ores determined as well as the basic carriers of carboniferous iron ores.

Paleontological research data were used regarding further stratigraphic division of the rocks. Despite the fact that some new geological disciplines were used, the available data were not enough to determine the criteria for detailed explorations. The explorations were dependant on the experts' observations.

A geological map at a scale of 1:25000 was prepared just before WWII as a basis for the explorations of mineral deposits [7], using the tectonic analyses to clarify the structural setting of the central deposits [8].

After the war, intensive works started together with deep drilling in order to determine new reserves. Until 1952, there were 8498 m mining exploration works, about 25000 m drillings in iron deposits and 2800 m in manganese deposits. Geophysical methods were used in order to find and determine new iron deposits in the central and southern area. Those explorations should be the pattern according to which further explorations could be performed. Due to the low sensitivity of used instruments expected results were not obtained. New geological mapping at a scale of 1:10 000 [9], included some parts of the Sana Palaeozoic near Blagaj, Central deposits and Budimlić Japra. Geological mapping was followed by petrographic, mineralogical and chemical explorations. Structural features of the terrain were analysed in details, in order to clarify tectonic relations, important for the deposits origin. These explorations included dozens of analyses and examinations. This period was characterized by detailed explorations of deposits. There were microscopic, X-rays, thermo-gravimetric and differential-thermal investigations of oxide and carboniferous deposits. At the same time the mapping of explorations were performed. The results improved the prospection and planning. The amount of deposits was increased [10,11,12].

The period after 1965 was the period of the expansion of geological explorations on the whole deposit area. The geological map of the region was prepared at a scale of 1:50 000, and the draft was prepared at a scale of 1:10 000. This map was used as a basis for the Basic Geological Map of SFRY at a scale of 1: 100 000 for the territory of Northwest Bosnia. A lots of detailed pertographic, sedimentary, mineralogical and stratigraphic explorations had been performed, as well as a detailed tectonic investigation of the complete area [11]. Geochemical examinations, based on micro and indicative elements with their geochemical correlations, were included in order to obtain the patterns for differentiation of the series of the lower and middle Carboniferous, a key moment for further explorations [13].

Based on the results obtained from these explorations, the sediments of the Palaeozoic, Devonian, Carboniferous and Permian age were defined, as well as the sediments of the Mesozoic with detailed stratigraphic differentiation of the Triassic, Jurassic and Cretaceous sediments. Mineralogical setting of carbonate and clastic sediments was completely determined for all geological periods. For the first time the igneous rocks had been defined within the carbonate sediments. Tectonic analysis of the area determined main geological settings and stratigraphic belonging of specific types of deposits. Besides iron deposits, there were also the deposits of barite in the whole territory. All those data are useful not only for iron depostis, but also as the contribution to the determination of complete geology of SFRY.

The discovery of iron deposits in the area covered by the Pliocene - Quaternary sediments initiated geophysical explorations of Omarsko-prijedorskopolje (1970, 1971, 1972, 1983, 1984), as well as on the locality Bojići-Tomašnica (1982). Further explorations were performed by the Ljubija Iron Mine. The drilling was aimed at geophysical anomalies. Unfortunately, geophysical investigations did not help to discover new deposits. An exception was Niševići deposits near Omarska, but it was less prospective anomaly. One of the aims was to define the paleorelief of secondary allochthonous oxide deposits. The second aim was to define the spatial layout of Carboniferous carbonate series, as the carriers of primary siderite-ankerite deposits.

The explorations, together with deposit categorisation and calculation, were performed in order to prepare uncovering of deposits, using mathematical methods to decrease the costs. Explorations became more complex including geology as a science.

A very important type of explorations is the current exploration during the exploitation. Mining-geological methods of the deposits monitoring within the process of projecting and exploitation gave the data on exploitation losses, dilutions and depletion of the ore. Based on these parameters, together with exploitation explorations (instrumental geological mapping, additional drillings) and other activities, the preparation of the annual plans of exploitation and long-term developments plans were performed. The parameters obtained during these explorations gave the elements for the basis for a clear picture of deposits genesis, tectonic and mineral settings of ores [14]. Analyses, monitoring and the comparison of the parameters obtained from the surface mines with those given in the projects, elaborates and studies, enabled the evaluation of expert and scientific conceptions and their correction [15,16].

In the period between 1986 and 1990 the explorations had become more complex on the basis of the utilisation of metallogenic analyses, as it was presented in numerous studies [17,18,19]. Basic elements of the metallogenic analysis were the examination of the deposit creation and accompanying mineralisation, mechanisms and their mobilisation from the primary sources, the origin of the mediums for their transport etc. It required the implementation of new methods: examination of isotope relations of lead, sulphur, hydrogen, oxygen and strontium, within the minerals which creates accompanying overburdens, as well as the examination of gaseous-liquid inclusions and the determination of the deposits age using stable isotopes. This approach became more important because all deposits with the outcrops on the surface had been explored and the focus is on those undiscovered.

All documentation, reports, studies, elaborates, maps, laboratory analyses, published domestic and foreign studies had been collected during the period between 1986 and 1987.

The analysis of Carboniferous carbonate sediments in the south deposits represented the basis for the estimation of its potentiality. The main focus was on mineralogical-petrographic examinations and petrologicallitophacial analyses given in Zarić's studies [21,22,23]. Those analyses were the basis for further sedimentological examinations.

The analysis of the setting and siderite genesis was conducted for Adamuša deposits in order to estimate the potentiality of adjacent terrains. Siderite-ankerite paragenesis was determined in details, as well as sulphide complex, silifications and temperatures of crystallization. An important lithofacial and sedimentological uniqueness was found regarding other adjacent deposits (absence of barecarbonates). The deposit was under multiple hydrothermal transformations with rearrangement of the ions of Pb, Zn, Cu, Sb etc.

Some specific features were discovered and defined within the deposites of JužnaTomašnica. They reflected in the continuous transition of carbonate deposits into oxide autochthonous getite-limonite formations. Comparative explorations of carbonate facies throughout the microscopic, macrochemical and geochemical analyses enabled forming of the models of the genesis of different types of carbonate deposits.

Geochemical prospection of the terrain south from Tomašnica and Omarska deposits was conducted in the area of 40 km^2 along the basic hydrographic network [24,25]. This terrain was chosen due to numerous ore occurrences and mineralisation. The method had never been applied in these terrains. Obtained results were important not only for Fe, but also for Pb, Zn, Cu and $BaSO_4$.

The preliminary mapping determined the occurrences of igneous rocks and barite-quartz veins. Detailed mapping and the interpretation of the results should be continued. The results were presented in the form of 7 temporary reports.

The explorations of the Carboniferous carbonate formations had been continued during 1988 and 1989 in the field of sedimentology. During 1988 Karamata et al. had performed the explorations of igneous rocks in the area of Trnova near Sanski Most and in the zone of Volar north-west from Ljubija. The investigations were conducted in order to determine metallogenic relations within those igneous complexes and iron deposits. It was determined that they were complex volcanic mechanisms built of magma flows with veins and small intrusions. The rocks consisted of granite-diorite to granite-porphyry composition with minimal transition to trachyte or syenitefacies. The examination of isotopic composition of Pb and Sr it could be concluded that those igneous rocks belongs to earlier phases of rifting, and their metallogenic features made them similar to keratophyre-quartzkeratophyre to porphyry (andesite) rocks in Montenegro. Due to the small amounts of igneous rocks in the area of Ljubija and Prijedor it was possible that they could heat environment and immersed waters and triggered the mobilization of the most mobile components (Fe, Mn) with minimal transition of Pb, Zn and other heavy metals [26,27].

Based on the satellite imagery the study on structural-tectonic examinations of the terrain of Ljubija ore area was prepared in 1989. Achieved results raised doubts about the relations between tectonic and the distribution of ore bodies of that time, the ore zones and potentiality of some prospective areas [28].

The content, character and distribution of the association of the elements in Ljubija ore area were processed within the geochemical explorations, as well as their metallogenic importance. This study [29], dealt with lithostratigraphic correlation among the packages of Ljubija ore area, common arrangement of microelements within the ore bodies and adjacent rocks and changes of their content within different types of ores. The distribution of micro and macro elements in ground waters was examined, as well as the analyses of stable isotopes and monomineral fractions. One of the possible models of iron genesis was given in accordance with geochemical features.

Detailed metallogenic explorations had been conducted during 1988 and 1989 for the deposites Buvač (drillings), JužnaTomašnica, Jezero-Omarska, Vukulja “A”, Kozin-Bjeljevac and Adamuša. The results were shown in the reports in 1990. It was determined that oxide ores were different in facias development because of different primary carbonate ores and different geological, hydrogeological and geochemical conditions within which they had been transformed. It could be possible to distinct the limonite of Jezero, Tomašnica, Brdo, Južna rudišta and other types, which was very important for prospection. Systematic explorations of the depostis within clastic and carbonate rocks were conducted. That was the extension of the explorations [20,21,27]. The explorations showed that there were significant facial differences among some types of carbonate ores as in Jezero, Tomašnica, Adamuša, Južna rudišta, Niševići etc.

Structural studies were performed in 1990. A study on all previously performed geophysical explorations [30], with the proposal for further explorations. The structural analysis of extended area of Omarska was finished and the program of the preparation of a wider area map created and partly implemented (Sasina and Eljdišta area). The explorations of the Devonian sediments near Blagaj determined undeniable content of ores (the borehole DV-1). The explorations of the tectonic border between the Palaeozoic formation and the high karst zone of the External Dinarides started in the zone of Budimlić Japra. This tectonic border had the features of a reverse fault. There were serious indications that it was not a usual nape, which was confirmed by the analyses of satellite imagery, filed explorations and drillings on the locality Poljak near Sanski Most, Budimlić Japra and Vrapčevine. These explorations were supposed to be continued in 1991.

Regional explorations of the Devonian formation were planned and explored in 1991, as well as the Palaeozoic sediments of the Sana nape area and its tectonic features and further geological explorations. The preparation of structural analysis (the structural drilling of Omarska ore area) was planned based on the results of geophysical explorations. The observations indicate higher mineralisation of the north-east and west parts of Omarska area. It was planned to examine the ring structure of the locality Ljujića brdo in Sasina area. Planned geological mapping of a wider area of Sasine and Eljdište have never been continued.

The explorations of mineralisation in Adamuša and JužnaTomašnica mines had been conducted in the period between 1997 and 2002. [31]. A new strategic approach was applied on the complete Ljubija ore area. Previous metallogenic explorations were unfinished and poor and used methods limited. The data were outdated and inadequately interpreted even with relevant and correct elements. An example was Javor ore formation. Many explorers did not recognized a typical flisch formation. That fact is the most important regarding metallogeny of the region. Filed explorations in Adamuša and their correlation to the Palaeozoic in western Serbia and Buk Mt in Hungary proved that the geological column was not uniform. The analyses of metasediments enabled the separation of several specific units, revealed the conditions of their creation and provided new modern ways of interpretation. New geological information and modern metallogenic interpretation of Adamuša and JužnaTomašnica mines became the basis for further explorations of Ljubija ore area [32].

Grubić, Cvijić, Milošević and Čelebić worked on the preparation of a metallogenic map of Ljubija ore area in the period between 2013 and 2016. [33,34,35]. Based on all relevant exploration and exploitation works the Geological background for metallogenic map Ljubija ore area 1:50 000 were prepared and then the Metallogenic map and Prognosis Map of Ljubija ore area 1:50 000. The first and main task was to examine geochemical features of stratimorphic siderite ore bodies.

Spectrochemical analyses from Adamuša proved the content of rare elements was identical to all hydrothermal metasomatic deposits. This was the most important evidence for abandoning the hypothesis of sedimentary, marine and carbonated genesis of siderite and ankerite (Table 1). There were primary carbonate iron ores (siderite and ankerite) and secondary oxide iron ores (limonite). The second ones originated from the first in the process of oxidation under hypergolic conditions at the depth of about 300 m. There were also the sulphides of Pb, Zn, Cu and Hg, then Ag and Au, and fluorite and a significant amount of barite. It was a unique siderite-polysulphide-barite ore formation consisted of three sub-formations: a) siderite-barite, partly limonite, b) polysulphide and c) barite-fluorite[35].

Based on the basis of mutual relations of mentioned sub-formations in the field conditions, their creation should be in the following phases:

1) siderite and ankerite, created by hydrothermal metasomatism within carbonate olistolite blocks, at moderate depths and the temperature of 246^{0}C;
2) sulphides, generated as vein deposits in almost all parts of the geological column. Vein siderites were created simultaneously;
3) barite, created in all areas except the Neocene formations.

These were the basic data for Metallogenic map of Ljubija ore area 1:50 000 [35].

Table 1. Genetic models of deposits of Ljubija mining area

Volcanogenic - sedimentary genesis	Metasomatic - hydrothermal genesis
Jurković (1961), [37]	Katzer (1925), [6]
Jurić (1971), [13]	Cissarz (1951), [40]
Šarac (1981), [38]	Nöth (1952), [41]
Grubić, Cvijić (2003), [39]	Palinkaš (1985,1988, 1990, 2003), [42,45,43,44]
	Grubić, Cvijić (2003), [39]
	Borojević, Šoštarić (2004), [46]
	Grubić, Cvijić, Milošević (2016), [34]

The drilling (18 boreholes) had been conducted from 2014 to 2016 (Arcelor Mittal Prijedor). The aim was to examine ring geophysical structures, interspaces with potential mineralisation and faults as channels for mineralisation. The results were mostly negative but insufficiently processed to be used in further detailed field defining.

3. EVALUTION OF THE TERRAIN EXPLORATION LEVEL

Generally, the level of exploration was very good, taking into account the types and quantity of the exploration works. On the other hand, the arrangement of the exploration works was not appropriate. The highest concentration of the works was related to the locations of ore deposits and ore fields. Between the deposits and the fields the explorations works were minimal.

However, numerous explorations of iron in Ljubija ore area had been provided in different conditions and periods. The explorations were frequently uncompleted and non-systematic. It was the reason why many results were not useful. Within the metallogenic area 3500 boreholes were drilled. The most of them were drilled in the aim of delineation of ore bodies and calculation of the reserves (requested distance between boreholes was 50 m). The number of regional boreholes was 600. The conclusion about high level of exploration of the area should be taken with reserve. The second problem was the fact that boreholes were finished after leaving the ore body, because of the misunderstanding of today’s model of ore genesis.

Geophysical explorations were performed in restricted areas and obtained results were not satisfied. This kind of exploration had been performed with interruptions from 1948 to 1984.

The types of applied explorations were: experimental – with the aim of testing the application of different geophysical methods in known deposits; regional – with the aim of obtaining the data on structure-geological conditions and delineation of perspective areas; detailed – for the delineation of ore zones. The following methods were applied: aeromagnetic (in the area of 500 km^2), geomagnetic, gravimetric, specific electric resistance and induced polarization. The spontaneous potential and seismic methods were applied in a smaller degree, in several separated locations. These explorations were not important for the exploration of iron ores.

In the study Repeated interpretation of gravimetric and geomagnetic explorations in Ljubija, Omarska and Prijedor area [36] the results of the gravimetric and geomagnetic explorations from 1974 to 1990 were reinterpreted. There were also digitalised data from 12 smaller localities with the results of gravimetric explorations as well as 6 localities with geomagnetic anomalies. It was also proposed that gravimetric and geomagnetic measurements should be provided by modern equipment in one well-studied deposit. After the measurements it would be possible to conclude whether this kind of exploration could be reliable for determination of iron ore deposits.

4. CONCLUSIONS

Geological explorations of Ljubija ore area have started in IXX Century and last even today. The intensity of explorations was various in time as well as methodologies and hypothesis that geologist used in the past. The results of all explorations were documented in about 300 studies. About 130 were published and the rest of them represented different reports and elaborates. Metallogenic studies from the period 1987-1990 were given in 17 reports.

So many detailed explorations of the ore deposits used for classification and categorisation of the iron reserves had been conducted, as well as regional explorations. These explorations were directed to examine geophysical anomalies and to register mineralisation with the aim of detecting of iron deposits.

The number of exploration works and their types were very well but spatial distribution of the works was not appropriate. The exploration works were mostly related to the areas of deposits and ore fields. Except them, the explorations were minimal. Geophysical explorations were conducted also with interruptions and low distribution.

The geological setting, tectonic, the conditions of sedimentation, magmatism and metamophism processes, genesis and genetic types of deposits were determined based on the results of comprehensive geological and metallogenic explorations of the Ljubija ore area, in the period of 135 or 100 years,.

The results of explorations were numerous detected mineralisations, iron occurrences and few iron deposits (siderite, limonite, ankerite). It could be visible from 80 occurrences and more than 30 deposits in exploitation today. Some of these deposits are very huge and more that 110000000 t or the ore was excavated in the past. Total amount of explored reserves is more than 400000000 t.

In the last decades, the concepts of the explorations have become based on the metallogenic principles. Metallogenic explorations, accompanied with analyses of formations, provided conditions for delineation of metallogenic regions as well as smaller metallogenic units, based on the results of complex investigations of geologic-structural, geochemical and geophysical features; definition of rules of creation and distribution of iron ore bodies and accompanied

mineral resources in space and time, based on the role of the main effecting factors of mineralisation (litholgical, stratigraphic, magmatic and structure).
The results of explorations indicate that Ljubija ore area is very reach in mineralisation, occurrences and deposits of iron ore. In that sense, future investments in finding new iron deposits are fully justified.

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CONTEMPORARY SALT KARST

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ABSTRACT

Waters in contact with salt rocks do their dissolute to the extent where it can come to a complete disappearance of salt rock layers. Movement of underground waters can be natural or directed by human for the purpose of exploitation of salt water. Natural process take place gradually through geological history, so occurrences that happened due to such process do not have greater significance on terrain surface nor are noticeable. At artificial directing of underground waters movement occur phenomena with significant consequences on terrain surface.

Dissolution of salt rocks creates new geological environment, that depending from accompanying rocks can be cracked or karst, mostly cracked karst. There are no significant data in literature about existence of karst in salt rocks, although many authors say that with dissolution of salt rocks occur the creation of larger cavities, ie empty spaces. Process research of terrain subsidence due to salt water exploitation on deposits of rock salt in Tuzla, defined zones of salt rocks dissolution during natural movement of underground waters that differs from artificial directing of underground waters. Duration of one or more periods characterizes development of karst process. First is called old (ancient) salt karst, and the second contemporary salt karst.

Development of karst process was different depending from the aggressiveness of underground waters, smaller during their natural movement, and significantly larger after their directing. Size of created empty spaces as a result of rock mass deficit due to dissolution of salt rocks is determined from specially constructed diagram for those purposes.

Key words: salt karst, salt, cracked and karst zone, diagram

1. INTRODUCTION

Salt exploitation from salt deposits is familiar throughout the history of human civilization evolution, but there are no enough records about the way and consequences of such exploitation. Fact is that those were smaller amounts of salt waters taken from sources or excavated wells that had no unwanted effects on immediate environment. Such exploitation was slightly different from natural process of exploitation that took place due to movement of fresh waters next to salty rocks.

Period of Middle Ages is characterized with more intensive pumping regime of salt waters, whereby is disrupted their natural movement regime, but not to the extent that it created certain consequences on the terrain. With industrial development in the World begins more intensive exploitation of salt waters, to the extent that disrupt their regime, and in time leaves consequences on terrain surface. Such exploitation was conducted mostly in rural parts, and its effects from the aspect of surface terrain endangerment were not in particular analyzed. In the fifties of the XX century in World began controlled exploitation of brine by forming certain chambers in salt rocks, without appearance of impact on terrain surface. However in one city area of city Tuzla was continued pumping of underground waters as before, with increased capacity, whereby the consequences on terrain surface were manifested with terrain subsidence over 10 m and with destroying of several thousands of construction objects of different sizes and purposes [1,2,3,4,5].

Processes that happened in the zone of movement of underground waters next to salt waters changed the natural state of the environment where it was formed a new environment called cracked – karst. Zone quickly changes in the function of human time, where underground water aggressively attacks salt rocks, dissolute them and waters become brines, and marl rocks that are interlayers of salt stay in place and form a karst zone. In hinterland, or on place where the process of dissolution of salt rocks is finished, gradually consolidation of newly created geological environment that can be called after karst zone, takes place.

2. NATURAL SALT KARST SHAPED DURING TIME

Existence of salt karst in nature was disputed for a long time, since there were no significant literature data. In second half of the XX century Russian authors wrote about it, but it was not enough to attract wider audience of world expert public. There are no particular literature nor published articles, but can be found some documents that show that at that time something was written. Even can be found some photos that are similar to those that follow karst terrains in carbonate rocks, figure 1.

Figure 1. Karst shapes in rock salt

Salt deposits follow underground waters from their origin [6,7,8], whether they are in salt rocks as old elisione waters or move at rim, dissolving them gradually during geological history. Aggressiveness of underground waters that are in contact with salt rocks on rim parts is different, depending from the speed of water movement and their saturation [9,10,11]. Those are in general concentrations from several mg/l, rarely dozens of mg/l.

Movement of underground waters and ruination of salt rocks lead to development of salt karst [1,7,12,13,14]. Depending from environment conditions where processes took place, salt karst can be clearly expressed as on figure 1, or less as on figure 2. In natural conditions process takes place progressively, that is dissolving ability decreases with increased concentration of salt.

In near surface part water has less mineralization, and movement is faster so it has better dissolving ability. Formed are certain crack systems that are new directions of underground water movement. It still moves through crack systems and empties through sources that are called salt sources. Greater dissolvent of salt rocks creates empty spaces, that are during time increased till the limits when roof salt rocks do not have a stable backing, whereby occur collapsing of rocks or sudden bursting (cracking) [3,7,15]. On certain parts of the terrain depending from the size of empty spaces and depth on which they appear, can occur consequences like subsidence of terrain surface.

Terrain subsidence is in forms of funnel or well dents that in certain periods of year are accumulations for temporary surface waters. If collapsing of sediments or sudden bursting of certain parts of the terrain, and sometimes even movement of blocks is more intense, cracks by vertical till the depth of empty spaces zone are formed. Surface water is directly infiltrated in salt rocks and increases intensity of their dissolution, and with that also accelerates the development of salt karst.

Conditions for development of salt karst are dissolubility and water permeability of rocks, and dynamic movement of underground waters. At salt deposits that have high plasticity, or no cracks, dissolubility is smaller. If water do not get in contact with salt rocks, or is closed within salt rocks and there are no movements, there are no conditions for natural development of salt karst.

Contact of waters at rims, roof and subsoil part of salt rocks leads to their faster dissolubility, and marl interlayers stay the skeleton of newly formed karst zone, figure 2. With larger dissolution of salt rocks occur larger empty spaces, or cavities that stay like that till they can no longer be a stable backing for roof sediments. The same one collapse and gradually consolidate forming in that way the new geological environment, slightly changed from autochthonous, that can be called after karst zone.

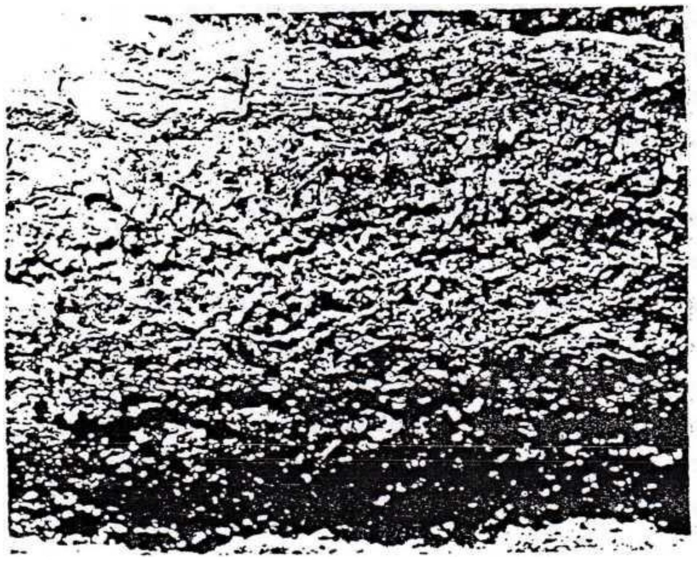

Figure 2. Karst shapes in rock salt after flooding of pit of Salt mine "Tušanj", Tuzla
(Foto: Zabuš S. 1979)

Dissolution of salt rocks due to movement of slightly mineralized underground waters represents the process of karstification, and phenomena that occur in that process are included with term salt karst [16]. Occurrences that appear during forming of salt karst have affect on change of lithological characteristics of sediments, structural-tectonic, hydro geological, hydrodynamic and other characteristics of roof salt rocks.

3. CONTEMPORARY SALT KARST AS A RESULT OF HUMAN IMPACT

Change of regime of underground water movement due to their pumping, increases the dissolubility of salt rocks. Process is uncontrolled and different water movement directions dictated by the pumping intensity and characteristics of salt rocks are formed [1,7]. Presence of cracks and different cavities of karst shape increases, which leads to change of existing geological environment and creation of a new one that represents karst zone. In time karst spaces are filled with collapsed material and consolidated till the boundary of water impermeable rocks. Areas that include cracks and karst zone are called an aggressive zone of karst, and consolidated areas are analog to areas at natural consolidation and are called after karst zone.

The most important human impact on creating of contemporary salt karst is related to deposit of rock salt in Tuzla. Century-old exploitation of brine from salt deposit with deep wells from terrain surface on very small area created different karst cavities by size and shape, on depth greater than 250 m [9]. Such zone is called cavity – karst zone [17], that during exploitation changed its boundaries horizontally and in vertical direction.

Greater aggressiveness of slightly mineralized underground waters on salt rocks accelerates the process of karstification, and in hinterland where dissolution of salt rocks is already finished occurs process of consolidation [4,7,18,19,20]. In that way is finished circular process of salt rock dissolution, creating of cracked and karst porosity, ie an aggressive zone of karst and at the end consolidation of area where occurred deficit of rock mass due to dissolution of salt rocks, figure 3. Termination of human impact on regime of underground waters and way of exploitation od salt water, establishes gradually approximate natural balance state. Cracked – karst zones are consolidated also during time, gradually going from an aggressive zone of karst into after karst zone.

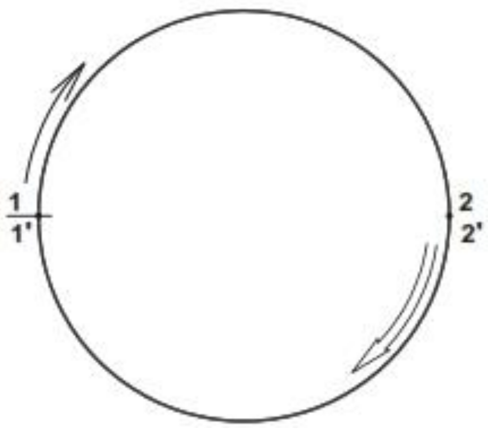

Figure 3. Schematic view of circular process of dissolving salt rocks and consolidation free spaces
1. beginning of dissolution, 2. termination od dissolution, 2'. begining of consolidation, 1'. termination of consolidation
(Đurić N. 1987, supplemented by 2017)

Detail geological research and analysis of borehole core can define state of aggressive zones of karst and after karst zones. In that way are allocated zones on deposit of rock salt in Tuzla, where are clearly separated after karst zones from aggressive zone of karsta created in period of pumping of brine in deep wells, figure 4. In time spatial position of aggressive zones of karst changes, slightly higher by vertical because of subsidence of roof part of rock massif.

Time of occurrence of salt karst can be determined with stratigraphic comparison of an aggressive zone of karst rocks with rocks that are deformed under the influence of karst. Salt karst on rock salt deposit in Tuzla is very hard to define from aspect of its occurrence, but we relate it to the beginning of occurrence of salt sources on terrain surface [16]. Geomorphological analysis of relief of surrounding terrain showed that morphological development started 500 000 years ago. For that period is related the occurrence of salt sources, and with that the activity of karst process.

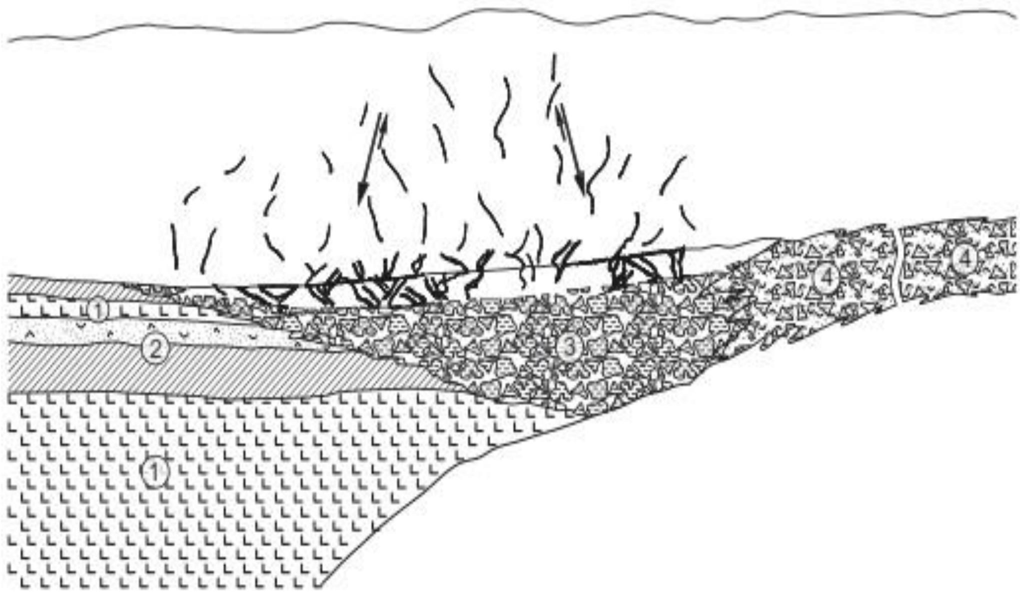

Figure 4. Terrain profile on salt deposit in Tuzla
1. salt rock, 2. supporting rocks, 3. aggressive zone of karsta, 4. after karst zone
(Đurić N. 1987, supplemented by 2017)

Total activity of karst process is determined from relation of volume of dissolved salts that goes with the water and volume of an aggressive zone of karst massif for certain time. According to researches of N. Đurića in 1987 total activity of contemporary karst process on rock salt deposit in Tuzla, in previous period in average is 78% [16]. This size refers to complete dissolution of salt rocks within salt deposit. In previous period of natural and artificial directing of underground water movement, indicator of contemporary activity of karst process was changing. In period of natural movement of underground water, salt dissolution was gradual and complete, while at artificial uncontrolled directing of underground waters, dissolution of salt rocks was uneven.

With termination of artificial directing of underground water movement and exploitation of brine, on salt deposit is established natural regime of underground waters in new conditions. Water movement towards salt rocks is more even and slower, dissolution of salt rocks is less, level of underground water increase and returns in earlier close original state.

4. DETERMINATION OF EMPTY SPACES SIZE DUE TO DISSOLUTION OF SALT ROCKS

At salt karst that originated from dissolution of salt rocks due to aggressiveness of underground waters are no real empty spaces. Those are spaces in which are marl fractions left after dissolution of salt and clayey muddy material that originated due to aggressiveness of waters on marl rocks, whether they are layered or broken in the way of fractions. At determination of total empty spaces, besides exploitation of brine and concentration of salt, is necessary to put in the presence of marl rocks. In 1987 N. Đurić constructed a dependency diagram of brine production, brine saturation and izluženih spaces [21]. Same diagram N. Đurić in 2017 had done in digital form as a dependency diagram of brine exploitation, salt waters saturation and created empty spaces, figure 5. Defining of listed sizes can determine the size of karst zone, but it is hard to separate boundary of an aggressive zone of karst from after karst zone.

Use of diagram is simple if are known sizes, brine exploitation and its concentration. In points 1 and 2 are given values of brine production for different salt concentration, and size of empty spaces as a chamber of regular and irregular shape. With knowing of percentage presence of marl component in such spaces can be determined the volume of karst zone in which salt component completely disappeared.

5. DISCUSSION

Topic processed in work is continuation to earlier studied legality of karst process development on salt deposit in Tuzla. It started from natural exploitation to today, with processing all stages of underground waters aggressiveness on salt rocks. With geomorphological shaping of the terrain started natural dissolution of salt rocks, and water with certain percent of salt concentration appeared on terrain surface as salt sources. Dissolution of salt rocks left "empty spaces" that in beginning phase had characteristics of karst shapes. From today's time distance that is called old (ancient) salt karst. During time it consolidated and created new geological environment that separated as a special environment with partly new types of rocks from marl layers.

This process took place arond 500 000 years, with gradual development of karst zone, its transition in an aggressive zone of karst and after that in after karst zone. Human impact on regime of direction of underground waters accelerated the process of dissolution of salt rocks. Phases of development and termination of karst process stayed the same, only occurred faster in time.

Dependence of water aggressiveness on salt rocks and effects of that are given on diagram in logarithmic ratio. Diagram have application at studying of karst processes, industrial brine exploitation and chemical processes at dissolution of salt rocks.

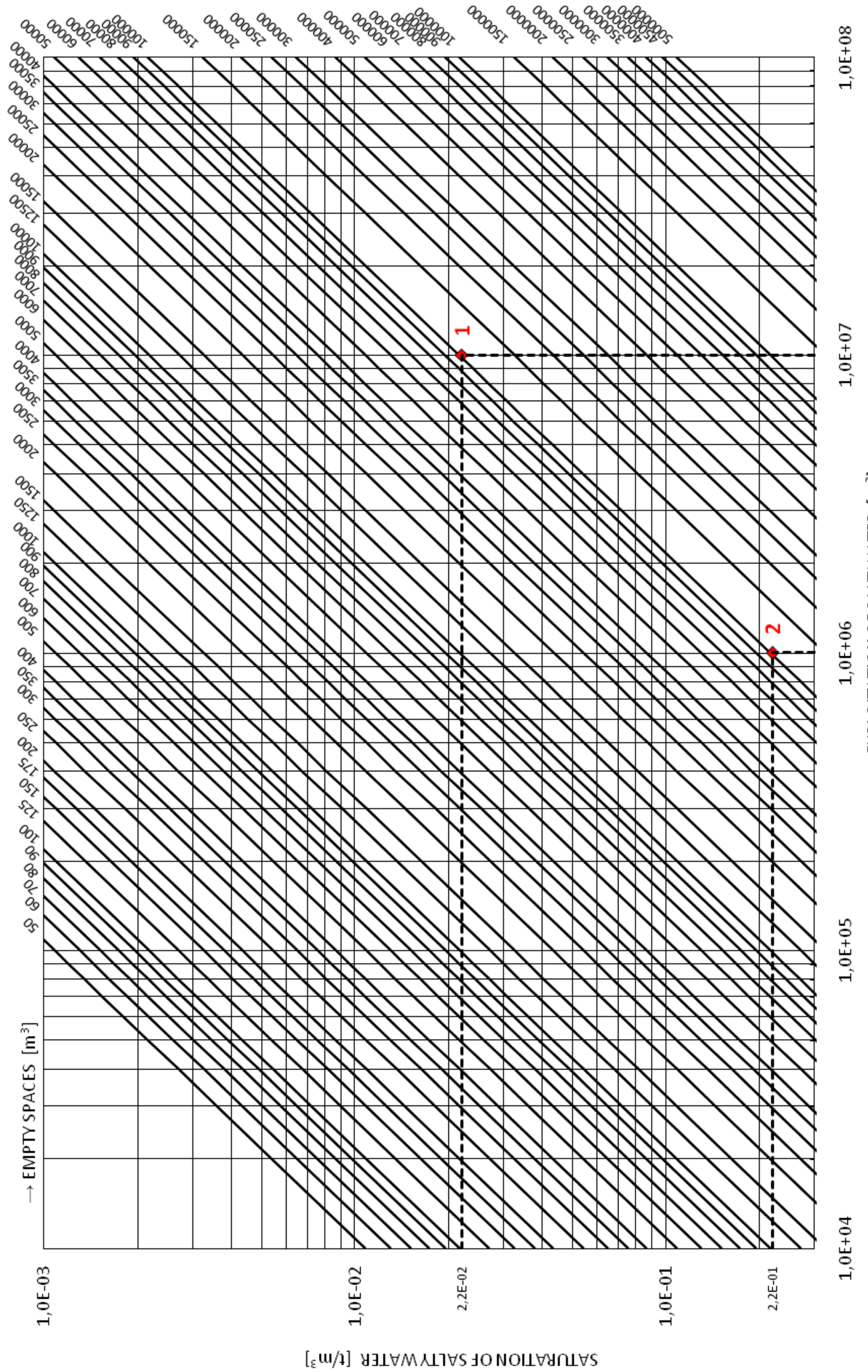

Figure 5. Diagram of dependence exploitation of salt water, saturation of salty water and created empty spaces (Đurić N. 1987, supplemented by 2017)

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IRON ORE MINING IN LJUBIJA MINING REGION

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ABSTRACT

For decades iron ores in Ljubija mining region have *exceptionally big influence on whole social reproduction on area of Prijedor town* , RS, B&H, which is closely connected to constant renewing and intensifying of production process. Systematic geological researches have been conducted over 135 years and exploitation with certain stoppages over 100 years. Because of that Prijedor region and institutions of RS have been interested for present data on state of ore resources/ reserves of iron ores, to asses state of raw material base , economically significant mineralization , evaluation of realistic justification of further geological research and exploitation in this area, and consider strategy of further development of mining in the Region. Present resources/reserves need to be optimally activated with the goal of achieving of commercial value of investment done but also those that need to be invested and certain expected national benefit. In this papier we are traying to evaluate realistic justification of further geological research and exploitation in this area and strategy of further development of iron ore mining .

Key words: Ljubija mining region, iron ore, ore resources/reserves, geological research, exploitation, development.

1. INTRODUCTION

In Ljubija ore region , which covers parts of Prijedor, Novi Grad, Sanski Most, Banja Luka and Oštra Luka, with different intensity for almost two millenniums there was research and exploitation of iron ore. In new age, systematic geological research has been lasting for over 135 years, and exploitation with certain stoppages for over 100 years. This historical fact has been transformed long time ago in a haze mythical experience of collective and unconscious for generations which have been growing and dying in this area. Generations of this century are not freed of this, on the contrary, everyone believes that there is a lot of ore in this area, although they are not exactly sure why, then, they can be successfully exploited and finally, decent living can be provided . So it is not strange, that AcelorMittal d.o.o., Prijedor, region and Institutions of RS are interested to analyse present data, asses of state of raw material base, economically significant mineralization of iron, evaluate realistic justification of further geological research and exploitation in this area, as well as consider strategy of further development of mining in this region.

2. ORE RESOURCES/ RESERVES

With analysis of ore bearing and ore formations of Ljubija ore region , their level of knowledge and exploration of ore bodies and occurrences , defined are individual ore fields and ore beds based on quantity and quality , their position in ore bearing formations , perspective for uncovering of new iron ore beds as well as possibilities of its capturing.

Iron ores of Ljubija iron region for decades had huge influence on whole social reproduction on area of the town Prijedor, RS, B&H, which is clearly connected with constant renewing and intensifying of production process. Based on this, you need to have in mind that iron ores as exhaustible and non-renewable resource, cannot be observed only from this small aspect, as explored reserves of certain category, meaning mechanically brought to the roll of work subject in exploitation process , but much wider, as object of commercial value and as well as national value. In this regard, this mineral resource must be observed in material sense , first of all , as potential and researched reserves, than as active ore beds and build up mining capacities with plant for preparation and primary processing of ore as well as parallelly trough continual research and defining of iron ore reserves and their adopting and available man power and its reproduction. Because of all that, mineral raw material base or iron ores of Ljubija ore region, overviewed on complex manner, consists from [1]:

a. Researched iron ore beds Omarska, Ljubija and Tomašica;
b. Discovered ore occurrences (registered and individually researched), and
c. Defined perspective areas of different degree of potential.

Here, for information, we need to have in mind difference between ore resources and ore reserves of iron ores as well as other definitions. Ore resources of iron are, with adequate geological research, determined mineralization of iron on certain areas which are present in such quantity and with such quality that there are rational potentials for eventual financial exploitation. Mineral resources are commercially nonexplainable because of insufficient research level, meaning is not proven technical efficiency and financial efficiency of their exploitation. Based on geological information and reliability they are divided on assumed, indicated and measured. Ore reserves are, through adequate geological research mineral resources on ore bed, which are present in quantities and with such quality that technical efficiency is proven, as well as financial efficiency and ecological acceptability of exploitation Ore reserves are commercially exploitable part of measured and indicated mineral resources from which are deducted planned losses and dilutions which occur during exploitation.

So in ore resources of iron ores of Ljubija ore region we have for now researched ore beds on ore fields in Omarska, Ljubija and Tomašica, uncovered and partially researched ore occurrences and potential areas for uncovering of potential resources [3]. The way it looks is shown on table1:

Table 1.

State of ore resources and ore reserves in Ljubija mining region (million tons)			
Ore filed	Ore type	Ore resources	Ore reserves
Omarska	oxide	80	16
	carbonate	15	-
Ljubija	oxide	32	13
	carbonate	163	14
Tomašica	oxide	6	-
	oxide pelitoid	47	-
Total	oxide	167	29
	carbonate	178	14
	total	345	43
Note: In Omarska till now it is produced 39,5 mil.tons of oxide ores , in Ljubija 23,7 mil.tons of oxide and carbonate ores, in Tomašica 24,5 mil.tons oxide ores . Explanation: *ore resources* are commercially nonexplainable because of insufficient level of research; *ore reserves* are sufficiently researched resources with proven technical efficiency , financial efficiency and ecologically acceptable exploitation. Present ore reserves cca 43 mil.tons are enabling projected exploitation till 2032			

Researches which have been conducted on priory developed concepts, gave good results regarding determined reserves. Determined ore reserves are result of high productivity of ore bearing formations and metallogenetic epochs. Biggest reserves are determined within ore bearing formations of younger Palaeozoic from Permian-Triassic and Triassic metallogenetic epochs and belong to hydrothermal- metasomatism formation type of carbonate, basic and hydroxide ores. Continental ore beds , occurred within Paleogene- quaternary ore bearing formation and Styria rodan phase of alpinic metallogenetic are much more modest . If it is totally overviewed till now, productivity of ore bearing formations and metallogenetic epochs, than total geological reserves need to be increased for 91,5 million tons of ore concentrate , which is app 180 million tons till now used geological reserves , so total productivity of ore bearing formation is over 500 million tons of geological reserves of iron[2].

Based on detailed analysis of ore bearing formations and analysis of conditions of localisation of ore formations and rules of their distribution within, assessed is big potential of Ljubija ore region for locating of new ore reserves mostly hydrothermal- metasomatism formation type and secondary continental formation type.

In the World exploited is mostly (over 90%) ore of hematite and magnetite from which is received very qualitative concentrate with 62 do 68% Fe content. Ljubija ore bodies ores are different types limonite, siderite and other carbonates, than brand with low Fe content that is very unfavourable for receiving of adequate concentrates (table 2). So, in Omarska are excavated limonite ores with over 42% from which we receive market concentrate from 50 to 53% Fe content [5], and plan is to excavate in Ljubija limonite ore with over 40% and carbonate with over 25 % iron content where market product shall be much more lower quality [7]. It is reality now and this needs to be confirmed with adequate feasibility studies.

Table 2.

QUALITATIVE CHARACTERISTICS OF IRON ORES											
TYPE OF ORE	Fe (%)			Mn (%)			SiO_2 (%)			$BaSO_4$ (%)	CaO (%)
	min.	max.	average	min.	max.	average	min.	max.	average	average	average
LIMONITE	26,80	55,16	43,60	0,42	2,34	1,58	3,58	29,05	17,89	-	-
BARIT+ LIMONITE	5,10	37,58	18,16	0,56	2,41	1,39	1,80	25,55	7,82	42,20	-
SIDERIT + ANKERIT	24,72	40,62	30,43	2,10	0,89	1,42	2,33	12,70	7,91	-	-
LIMONITIC LIMESTONE	28,49	45,14	35,90	1,13	1,88	1,57	4,48	10,05	7,65	-	-
LIMONITE - BRAND	24,75	42,70	35,95	1,43	3,07	2,20	16,46	34,85	23,67	-	-
BRAND	31,90	47,57	37,57	2,45	3,51	2,80	8,54	25,85	20,64	-	-
CLAY BRAND	28,79	30,92	28,84	2,47	2,81	2,79	25,15	29,30	25,87	-	-
BASIC ORES	11,96	25,87	23,43	0,77	1,26	1,15	1,65	4,31	3,27	-	19,90

3. TIME DURATION OF RESERVES

Reserves in Omarska Mine Surface pit Buvač based on projected production can last till the end of 2025 [5], [6], [7],.

For now logical activities are geological, technical-technological and financial activities in ore bed in Ljubija (carbonate and oxide ores). Carbonate ores are problematic because of low Fe content and unfavourable technical conditions of exploitation. Biggest ore bed of oxide ores in Ljubija Vidrenjak is problematic because of content of barite and technical-technological conditions of separation/enrichment need to be resolved [7]. With dynamical, expert and other activities this needs to be resolved based on predicted dynamics given in next table, and later intensive expert activities for exploitation after 2032 needs to take place. (table 3).

Table 3

Plants /type of ore	Planned production based on years (million tons) of concentrate															total
	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	
Omarska limonite	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5								12,08
Ljubija limonite									1,5	1,5	1,5	1,5	1,5	1,5	1,5	10,30
Ljubija carbonate	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	5,6
Total Concentrate	1,5	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1,7	27,98

Note: based on world standards to be able to open one surface pit it is required 5 – 7 years, and pit with plant for ore preparation 12 –15 years; Shown is one of the options of prolonging of life of the Mine with on important condition , and that is that carbonate ore can be mixed only with limonite ores from Omarska and Ljubija in quantity of 30%. Analysis are showing that it is required as soon as possible to activate exploitation for carbonate ores.

4. TECHNOLOGY OF PREPARATION

World practice of evaluation of iron ores quality is very different. General tendency of application of very rich and pure ores is conditioned with [1]:

- Strict financial norms in iron production , which are the most important for total economy of Steel plants
- Very high requests of iron purity based on oligo elements, because that is pre condition for satisfaction of more and more strict requests by the buyers of qualitative steel products.

Without prior preparation ore can not be used in production programs of steel plants and such ore was used till 1970.

Variety of mineralogical ore content (represented with different types of limonite, siderite and brand, relatively unfavourable structural-texture characteristics) has conditioned technological solutions of preparation which are in application today. Every ore has requested suitable and individual treatment. Main characteristics of applied procedures is physical separation of iron ore from filthiness, with which we receive adequate effects. With this is enabled qualitative sintering in the Blast furnace. In Mines "Ljubija" Prijedor applied is: washing technology, classification and gravity-magnetic separation of fine particles of limonite ore in Omarska Mine; washing and classification for oxide and carbonate ores in Mine "Ljubija"; as well as draying and classification of limonite-brand ore in Mine "Tomašica". Grain size of the product is 10 – 100 mm for direct usage in blast furnaces and from 0 – 10 mm for agglomeration. For procedure of draying used is fuel oil.

Ores from Mine "Ljubija" are relatively pure ores , because content of pure mineral from limonite ore, from theoretical (62-63%) is as follows :

- Lump ore - limonite 88,0%,
- Fine ore - limonite 87,3%,
- Fine ore - siderite 81,8%.

Natural mineralogical content is made more difficult with higher degree of concentration, which is now most often over 90%. Based on economy of metallurgical processing common for ores of Ljubija region which are exploited and enriched with present technology, limited is application of payable technologies of deep enrichment and relatively low Fe content in final products (table 4). But, with other qualitative advantages and with this level of Fe content final product is competitive on the Market.

Table 4

CHARACTERISTICS OF ORE FROM LJUBIJA ORE REGION BASED ON PREPARATION AND METALURGICAL PROCESSING ASPECT		
ORE TYPE	PREPARATION	METALURGICAL PROCESSING
LIMONITE	Excellent characteristics for preparation with simple methods: crushing, washing, classification and high intensive magnetic separation. Received is limonite concentrate with 50 - 56 % Fe , 5-8 % SiO_2. **Fe recovery in metal is over 90 %.**	Good characteristics for direct melting in blast furnace ; For reduction and other processes and production of agglomerate for blast furnace. Low content of bad elements in raw iron .
LIMONITE + BARITE	Favourable physical-mechanical characteristics for enrichment. It is very complex enrichment technology. Result are concentrates with 50 % Fe, 7-8 % SiO_2 and 3 % $BaSO_4$ and concentrate $BaSO_4$ with 96% BaSO4. **Recovery of metal Fe of 80-90 %.**	It can not be used for direct melting in blast furnace. Very good characteristics for agglomerate production where is removed over 60 % S from $BaSO_4$. Marginal content of bad elements in raw iron.
SIDERITE + ANKERITE	Excellent characteristics for preparation with simple methods: crushing, washing, classification and high intensive magnetic separation. Received is concentrate of siderite and ankerite with 38 % Fe, 5-7 % SiO_2 and 15-16% carbonate. **Fe recovery of metal 90-95 %.**	It can not be used for direct melting in blast furnace . Excellent characteristics for agglomerate production . Content of harmful elements in raw iron is marginal.
LIMONITE + BRAND	Good characteristics for enrichment with simple methods crushing , draying and high intensive magnetic separation . Received is concentrate with 44-48 % Fe, 8-12 % SiO_2. **Recovery of metal Fe from 85-90 %.**	Good characteristics for direct melting in blast furnace . Excellent reduction and other characteristics . Very good characteristics for production of agglomerate for blast furnace. Marginal content of harmful elements .
BRAND	Bad characteristics for enrichment . Ore preparation is done only with draying . **Received is dry ore 44-46 % Fe.**	Good characteristics for agglomerate production for blast furnace . Marginal content of harmful elements.
BRAND + CLAY	Bad characteristics for enrichment. **Received is ore with 40 % Fe**. Very expensive enrichment with small effects .	Very expensive metallurgical production , low extract from blast furnace . High coke consumption.
BASIC ORES	Preparation of these ores is possible with enrichment and refinement. Enrichment is done with methods crushing, washing classification and high intensive magnetic separation, improving of basic ores is done with oxide fraying . Received is concentrate with 43-50 % Fe, 2-4 % SiO_2, 25 % CaO + MgO. **Recovery of Fe 95 - 100%.**	Excellent characteristics for production of agglomerate for blast furnace . Marginal content of harmful elements. Increased productivity of blast furnace .

Future endeavours and finding solutions must be taken in following directions:

- In present production it is necessary optimization of present state, which considers maximal usage of qualitative possibilities of ore bed and available plants in the Mines but in Steel plants as well,
- Valorisation of solutions received with present technological research on ore preparation ,
- Long term arrangement with buyers, because over 90% iron ore makers in the world have preciously defined buyers and adjusted technologies.

Processing capacities can be used on achieved level of exploration as follows:

- Omarska 25 mil tons of oxide ores and 7 mil tons of carbonate ores [5], [6];
- Ljubija 13 mil tons of oxide ores and 14 mil tons of carbonate ores [7];
- Tomašica 13 mil tons oxide ores for now are not exploitable form aspect of quality and adequate technological solution of preparation [8].

Mutual attribute of qualitative characteristics of researched mineral resources of iron ores in Ljubija ore region is:

- Quality level is not achieving top world standards, which limits wider possibilities of processing based on quality ,
- Almost with all types of ores is not achieved maximum of qualitative possibilities, and realization needs to be in direction :
  a) Introduction of new technologies of preparation and enrichment,
  b) Usage of different forms of selective exploitation ,
  c) Geological research for finding of ore beds within available potential,
  d) Necessary is very tight connection with ore processors .

5. FORECAST OF RESERVES (METALLOGENETIC STUDY)

Iron ores in Ljubija ore region have been exploited continually over 100 years . In this period is extracted over 90 million tons of ore. *Now we have a serious question of further perspective of these terrains ? What nature has made is it uncovered and mostly excavated or there are still more hidden iron ore bodies?* We are traying to answer on this question with help of metallogenetic research , meaning metallogenetic analysis and following evaluations of region potential. Metallogenetic analysis have shown [3]:

- Ore bearing formation makes deep see javoric flysch, which is for sure middle to upper carbonic age;
- In javoric geological formation you can extract raw of well marked members ;
- Mineralization of iron occurs in form of ore sub formations: siderite-limonite and ankerite-limonite.
- Two ore sub formations are spatially divided and there is difference in manner of origin.

This analysis represents good context and for now it already gave its maximum, based on present data. Further selection of perspective areas for research needs to be done based on geophysical research, obligatory followed with geological interpretation for purpose of finding of ore bodies. Distribution of ore bodies and occurrences, changes surrounding the ore body. geochemical analysis , elements indicators, minerals indicators, dislocation and ring structures, geophysical anomalies and all forms of old mining and using of furnace, indicate eventual possible presence of new reserves and iron ore body with over half of billon tons.

6. RESEARCH ACTIVITIES – FOR FINDING OF RESOURCES/RESERVES AND DEVELOPMENT

Done is metallogenetic map of Ljubija mining region with explanation. First we overviewed all present data on research and exploitation works in mining region and based on it done is "Geological base for metallogenetic map of Ljubija region 1:50.000". In second phase first is finished "Metalogenetic map" and, than, based on it and "Forecast map of Ljubija region 1:50.000".

Research drillings were done on checking of ring geophysical structure, checking of interspace for which there was indication on presence of mineralization, as well as checking of mining shifts as inflow channels for mineralization.

We have done experimental geophysical research works based on program, in the report given is description of geophysical methods which were applied and showing of results of performed data analysis (2017.g.) [11]. Expert discussion was conducted and on this discussion were represented following information from final report of geophysical research :

- It is possible to determine a model which would be applied in future research for successful localisation of ore bodies.
- By combination of max and min values of gravimetric and geomagnetic anomalies certain areas can be located which could indicate presence of ore mineralization.

Based on detailed analysis of ore bearing formations and analysis of conditions of ore formation localisation and rules of their distribution within, it is assessed that in region, meaning research area further geological research has sense for finding of new ore reserves mostly in javoric ore bearing formations of siderite-limonite and ankerite -limonite sub formation type outside of researched ore fields and on bigger depths.

Research occurrences, which are used for predicting of eventual presence of mineralization, as prospect indications are all geological markings which indicate eventual possible presence of occurrences and beds of mineral raw materials.

In mentioned sense, already in first phase on basic research, on researched area were considered all main categories of prospection indication. In prospection indications, basically, included are seven categories of geological characteristics. That is data on: (1) ore grafts, (2) occurrences surrounding ore, (3) elements of indicators, (4) mineral indicators, (5) geophysical anomalies, (6) geomorphologic forms and (7) traces of (old) mining.

All mentioned prospection indicators are proving without a doubt that research area between ore fields as well as Ljubija ore region is rich with mineralization, ore occurrences and iron ore beds, on the first place. In that regard is totally justified further search for new potential ore beds of that raw material. It needs to be started from basic research, when they are realised, we should have an answer on question, in which direction we should direct further research in the region?

On research area of the region for now planned is to be executed main geophysical research on area of 240 km^2 in two phases (I phase on area of 80 km^2, phase II on area of 160 $km^{2)}$ to check position of olistostromic member which is bearing iron mineralization , than research drilling app 1 000 m. Drill holes would be located depending on results of geophysical measuring and analysis of mentioned prospection indications [10] (table 5).

Table 5.

Geological research for purpose of finding of new ore reserves								
	2017	2018	2019	2020	2021	2022	2023	2024
Geological research	+	+	+	+	+	+	+	+
Main research	+	+						
Detailed research	+	+	+	+	+	+	+	+

There is a justification of permanent geological research for purpose of deeper recognition of geological characteristics of the terrain, better knowledge of iron ores and tougher requests of the market. This means that, first of all, we need to look for markets that give better and more qualitative indicators and better exploitation conditions.

7. INFLUENCE OF MINING ON FINANCIAL POWER OF THE REGION

In accordance with iron ore production projection of Ljubija ore region and rational usage of available and potential resources with strategy of protection and improvement of life and working environment , total significance of mining can be indicated as [1].:

- Achieving of continuance in iron ore production for needs of black metallurgy in this area;
- Achieving of profit from production as pre condition for investing of own means in development , growth of standard personal and general etc.;
- With achieving of profitable production of iron ore made are precondition for development of other accessory activities (traffic, tertiary and activities outside of industry);
- Analysis are showing that on one employee in iron ore production and similar industry achieved is in other activities outside of industry, infrastructural and other activities in the region employment of 15 to 20 workers. Also every employee ensures existence for 3 – 4 members of his family ;
- With production of iron ore achieved are realistic conditions for further growth of life standard and human and social wellbeing. Schooling of larger part of community on higher education levels has consequently growth of productivity of work and increase of total positive financial effects of the region and RS.

8. WHAT NEEDS TO BE CONDUCTED SO MINING IS MORE SIGNIFICANT FOR THE REGION

Executed metallogenetic and other analysis of certain metallogenetic units of iron ore in Ljubija ore region without a doubt are indicating significant potential against increase of present mineral -raw material base in quantitative as well as qualitative sense : with increase of present iron ore reserves , transformation of occurrences in profitable ore beds or finding of new ore beds.

Resources /iron ores are requesting permanent geological research. It is necessary for purpose of renewing of reserves which are excavated during work of the mine, transforming of resources into reserves and transforming of reserves in higher category of research.

Terrain fur further research was identified based on conducted metallogenetic research with application of form analysis when it is done : contouring of ore region, meaning smaller metallogenetic units , based on results of complex research of geological-structural, geochemical and geophysical character; analysed and defined rules of forming and distribution of iron ore mineralization and other following mineral raw materials in space and time based on the role of main control mineralization factors (lithological, stratigraphic, magmatic and structural) which have caused origination and determine genetic character and areal distribution of all uncovered ore formations; enabled is evaluation of perspective of smaller metallogenetic units for uncovering of certain iron forms and finally, done is metallogenetic and forecast map.

Made forecast map contains ranked areas based on perspective and based on present level of research. Different areas are marked based on perspective , having in mind quantitative (occurrences and size of ore body, excavated mass, potential reserves ...) and qualitative indicators (primarily chemical content of ore), than control factors (stratigraphic, structural, lithological, geochemical, haematogenic and hypergenic) and indication of ore occurrences (ore grafts, occurrences surrounding ore, element indicators, mineral indicators, geophysical anomalies, geomorphologic forms and traces of mining).

Beside mentioned indicators combine with control factors of ore and prospect indicators , for determination of perspective areas it was important achieved level of research received with earlier prospection research, but also applied methods of research and research works. Areas for research are identified based on :

- Study "Metallogenies of Ljubija region" [3], and
- Study "Repeated interpretation of gravimetry and geomagnetic research on wider area of Ljubija and Omarska near Prijedor" [4].,
- Report on gravimetric and geomagnetic researches on test area Buvač near Omarska [11].

Areas for research are categorised based on Forecast map from Study of metallogenies of Ljubija region [3] as follows:

- Areas with perspective for ore reserves increase;
- Areas on which are present direct ore control elements and uncovered ore occurrences;
- Areas on which are present ore control elements and favourable structures, without uncovered occurrences of mineralization or with rare manifestations;
- Areas which not researched enough;
- Areas already researched on elements present in ore region and received are negative results;
- Areas covered with thick neogenic sediment of central part of negenic basin.

9. STRATEGIC PLANS

Within strategy of development of qualitative valorisation of available iron ores in Ljubija ore region it is required:

- Making of favourable social-financial ambiance on level of Republic of Srpska– Legal frames, mineral strategy and politics and required measures.
- Maximal expert engagement for purpose of ensuring of optimal quality parameters, which are satisfying iron ore consumers. Other professions should be engaged as well as institutions specialised for resolving of these problems.

Within strategy of further development of Ljubija mining, as it was done from the beginning of new Century exploitation, there was a high level of justification and certainty of permanent geological research in the region [9]. It is necessary for: deeper knowledge of geological characteristics of the terrain, better knowledge of iron ores itself and for harder requests against ore product quality. Without taking in account of these facts there is no strategy.

This means that is necessary to look for ore beds which give better and more qualitative indicators and better exploitation conditions.

10. POSSIBLE RISKS

In research system and Ljubija iron ores exploitation there are number of types (sorts, groups) of risks. Biggest significance have geological (natural), mining-exploitation, ecological and market (financial) risks. All these risks directly and indirectly relate to professional risk. Direct cause-effect relation is evident against influence of natural conditions on professional risk. But, from investment aspect in complex of research and ore exploitation in Ljubija region especially actual are political risks, which are also in certain correlation with professional risks. Political risks refer to certain specificities of social, financial and political factors of the environment. Level of political risk is determined by: country stability, relations between political parties and character of the party in power, state (constitution) organization, quality of administration , politics against foreign property, characteristics of foreign politics, possible government crisis, instability and non principal tax policy, environment policy, concession policy, level of corruption etc.

11. CONCLUSION-RECOMMENDATIONS

Iron ore beds with relatively well researched mineral-raw material base and with potential to be increased, continue to be in focus of Prijedor Town, region and Republic of Srpska, but based on concept of permanent balanced development and portfolio effects. Occurred is modern social and financially logical need to treat available iron ore resources in accordance with long term and strategically placed goals based on principle of modern Management, as a specific form of widely placed management of resources, people and capital. In this manner placed social problematic and present concrete iron ore resources of Ljubija mining region , represent one of the most important comparative benefits of Prijedor Town, region as well as Republic of Srpska. This comparative benefit is specially obvious in cooperation with world leader in development-production aspect of iron ore and steel, ArcelorMittal, who is strategic partner of Republic Srpska Government. That is why, these resources need to be optimally activated with goal of achieving of commercial benefits of investment in them, but also those that need to be invested, and certain expected national benefit. This requests realization of mentioned geological and other research, which should not represent limitation factor, because without them there is no reproduction of mineral-raw material iron ore, continuity of production and development. All this represents precious strategy of development and making of permanent stabile politics within Republic of Srpska in total, against iron ore resources in Ljubija mining region, and in another word, required is clear attitude of emphasized national respect and respect of these resources.

From presented material following can be concluded:

- Iron ore excavation in Omarska Mine is finished in 2025,
- With timely involvement of rest of ore reserves from Central ore sites Ljubija, mining activity can be prolonged till 2032
- Condition for achievement of prior goal is start-up of production in Central ore sites in 2018,
- To be able to achieve above mentioned, it is required urgent agreement between subjects RŽR Ljubija a.d. Prijedor, Republic Srpska Government and Prijedor Town,
- To be able to continue production after 2032, it is necessary to conduct intensive geological research for purpose of finding of new ore beds.

In case there is no realization of prior activities, it can be expected that in 2025 stops iron ore production in Ljubija mining region.

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TYPES OF SILICA RAW MATERIALS ON THE TERRITORY OF THE REPUBLIC OF MACEDONIA

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ABSTRACT

The Republic of Macedonia, in which structure participate different lithological complexes and various formations of different ages, in terms of minerageny, is rich with different genetic types of silica raw materials. Quartz, quartzite, quartz sandstones and secondary igneous quartzite are treated as a special group of raw materials due to their specificity, application area and the manner and conditions of their formation and the types of deposits in which they appear.

The quality of silica raw materials depends on presence of harmful matters (feldspars, mica, pyrite, limonite etc.).

Studying of silica resources on the territory of Macedonia suggests a promising development of these raw materials, primarily because of their applications in many industries, such as telecommunications, optics, medicine etc.

Key words**:**silica raw materials, classification, types

1. INTRODUCTION

Evolution of the geological structure on the territory of the Republic of Macedonia allowed formation of different types of silica raw materials. In the literature, there is no single classification of silica raw materials. It can be performed according to: [1]

1. Mineralogical – petrographic characteristics
2. The conditions of formation (genesis)
3. Morphological characteristics and
4. Economic significance.

2. MINERALOGICAL – PETROGRAPHIC CLASSIFICATION

According to mineral - petrographic characteristics, the following types can be distinguished:

1. Pegmatite quartz - represents well-differentiated concentrations of pure quartz within the pegmatite bodies. They have almost uniform monomernal composition of quartz crystals. Low contents of mica and feldspars are found locally (almost in all deposits in Pelagon). Locally appear pigmentations in the quartz mass with limonite in the small cracks.

2. Wired quartz - monomineral quartz masses deposited from hot or cold aqueous solutions. The presence of secondary minerals in the composition of quartz wires is complex and is in a certain relationship with the chemical and mineralogical composition of the surrounding rocks.Deposits of wire quartz in Macedonia mainly appear in gneiss - mikaschist formations or granite intrusions. In their composition, it is often possible to find smaller contents of plagioclases, potassium feldspars, tourmaline, rutile, sericite, biotite and kaolin (for example, Umlenna, Preseka, Prevedena, Ribnica, Babuna, etc.).

3. Quartzite - Quartzites are metamorphic rocks in which quartz as the main mineral is represented by more than 80% in the entire rock mass, and some deposits represent mono-mineral rocks made only by quartz. As subsidiary ingredients in quartzite there are: mica, pyrite, chlorite, sericite, dysten, graphite, sillimanite, epidote and organic matter. The pure quartzites are white, but from the impurities can be colored gray - greenish, dark or completely black. Quartzites often have a granoblastic structure, but they can sometimes have the structure of quartz sandstones, i.e. blastopsamitic.The texture is massive, but there are also schistose quartzites. The quartz grains in these rocks are usually rolled together and this gives great hardness on the rock masses. The most important deposits are in Western Macedonia, Skopska Crna Gora and the Veles series. [2]

4. Secondary quartzites - Secondary quartzites (a term adopted by the Soviet terminology) also known as silexes are hydrothermal - metasomatic creations formed from acid and medium acid volcanic rocks. [3] They have a quartz-calcedon mineral composition. Unlike other quartzites, they are characterized by an amorphous structure and high hardness. In Macedonia, such deposits are only in Kratovo - Zletovo Volcanic area and they are Crn Vrv, Plavica and Pester (fig. 1).

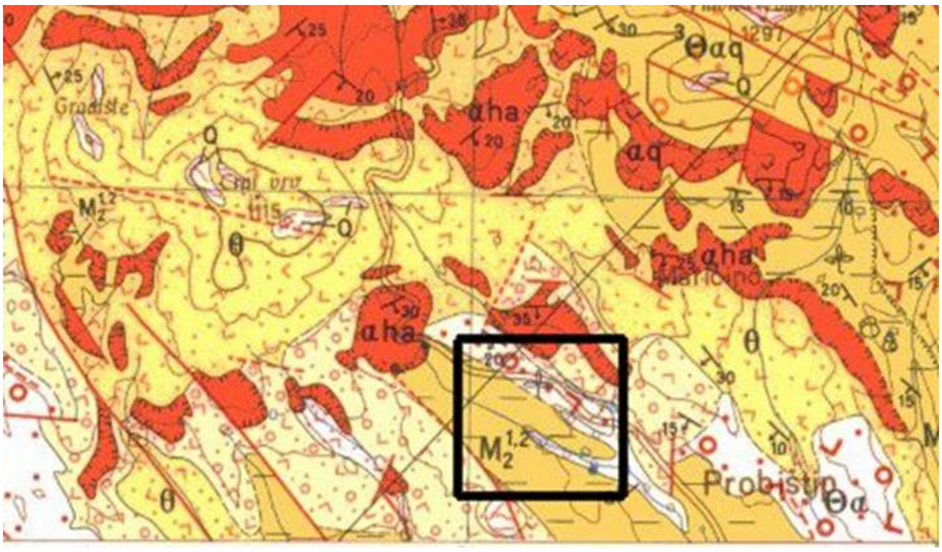

Figure 1. Area of deposits of secondary quartzites [4]

5. Quartz gravel, pebbles and grains - These are actually loosed clastic creations froms of semi-rounded or rounded pieces of monomineral quartz rocks. Depending on their transportation, they can be of different size and degree of curvature. By their composition, apart from quartz, they may contain Calcedone or opal concentrations (for example, deposit Lakvica).Besides quartz, as additional minerals appear mica, feldspar and limonite matter. Deposits of quartz gravles, pebbles and grains are found in several places, almost all over Macedonia (the alluvions of Pchinja, Treska, Babuna, Bregalnica, Kriva Reka, as well as in the Pliocene sediments in Kumanovo, Berovo, Radovish, Veles, Vinica, Kocani, etc.).

3. GENETIC TYPES OF DEPOSITS

According to the conditions of formation (genesis), the following genetic types of deposits can be separated: [5]

1. Magmatogenic deposits
2. Sedimentogenic deposits
3. Metamorphogenic deposits.

1. Within the magmatogenic or primary deposits are separated pegmatitic and hydrothermal.

- Pegmatitic deposits include pegmatiteic - quartz wires and lenses. In these deposits, the zonality is clearly expressed in the layout of individual minerals, so quartz is most often found in the central parts of the pegmatite bodies. Among the pegmatitic deposits can be divided two subgroups of deposits: endocontact and exocontact deposits.

Endocontact deposits are spatially located in granites near contact with surrounding rocks. In these deposits, there is often an increase in the content of potassium feldspars (eg, deposits in Mariovo, Berovo, etc.).

Exocontact pegmatite deposits are located outside the granite massifs, ie in their immediate surroundings within the gneiss - micaschist formation (for example, the deposits in Pelagonia and Veles). Unlike endocontacts, these deposits are much less prevalent and of less economic significance.

- Hydrothermal deposits on the territory of Macedonia are found as hydrothermal quartz wires and lenses and hydrothermal - metasomatic quartzites. Hydrothermal quartz wires and lenses are formed in conditions of medium temperatures. Hydrothermal solutions rich in silica components moving through the surrounding rocks repeatedly leached additional silicon and again deposited from the hot solutions in the form of quartz deposits. Spatially, these concentrations were placed along the crack systems forming deposits in the form of wires, lenses or irregular bodies (eg. Preseka, Prevedena, etc.).This group is associated with the appearance of quartz crystals. Such deposits are formed along the cracks in the granite intrusions where the quartz crystals are formed in the central parts of the wires, where the crystals "grow" on the walls of the cracks in the free or in the favorable environments filled with clay material (eg. the phenomena near the villages Budinarci and Mitrashinci).
Hydrothermal – metasomatic quartzites, mentioned as secondary quartzites, genetically are connected to igneous rocks and are product of hydrothermal metasomatosis on volcanic formations.

2. Of sedimentogenic deposits the most present are alluvial deposits and those deposited in Pliocene shallow lake basins.

Alluvial deposits formed in the areas of water currents and their terraces, as well as on the slopes and platforms near the autochthonous deposits of silica raw materials. They occur in the form of pebbles or grains with different granulometric composition, deposited in alluvial - deluvial sediments or fluvial - glacial sediments. Quartz originates from surrounding rocks rich in quartz wires or other silica raw materials.

Especially important are the sedimentary deposits formed in the Pliocene basins, where the quartz masses were deposited from the quartz-rich rocks or overdeposited from the already formed sediments (for example, deposits Oslomej, Lakavica, Slavishko Pole, etc.).

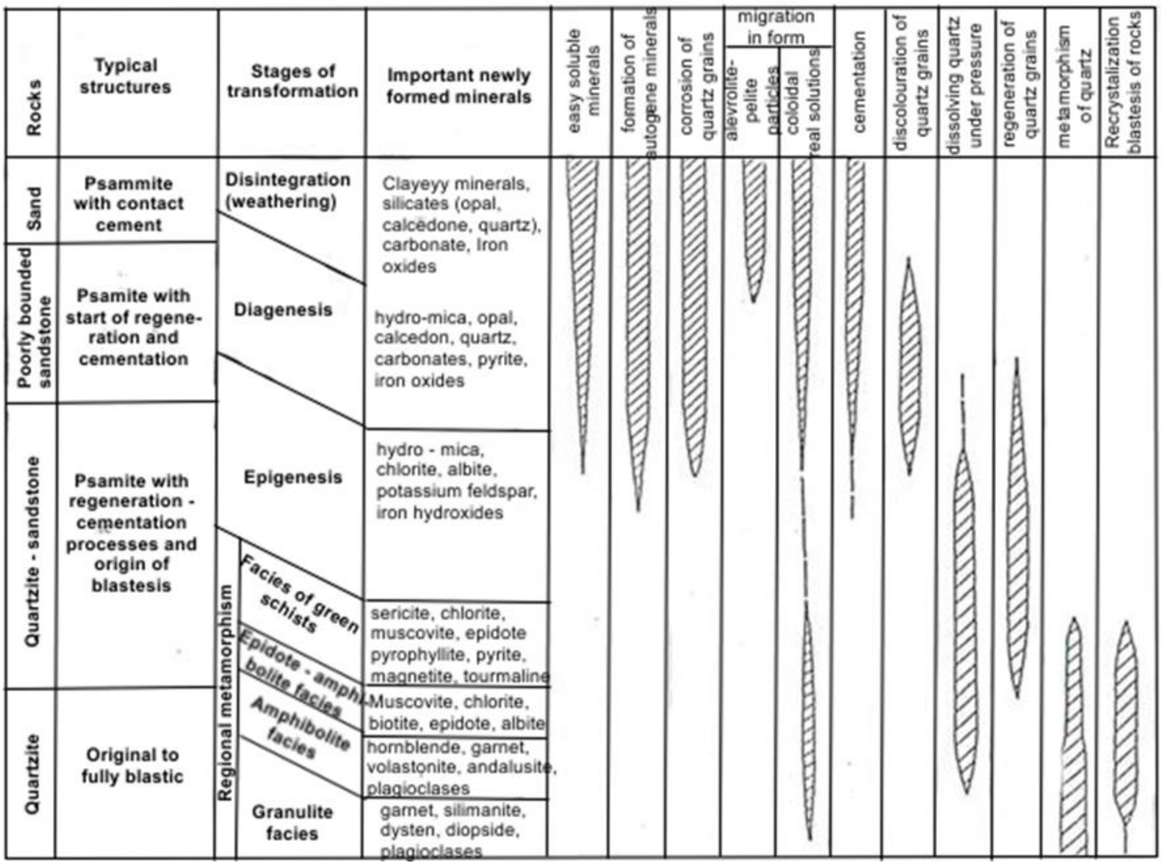

Figure2. Stages of development of quartz sands and transformation in quartzite
(after K. Blazev, 1991) [1]

3. Metamorphogenic deposits formed with the process of regional metamorphism by transforming the quartz sands and sandstones primarily formed in marine environments during tectonically stable phases (quartzite deposits in Vardar zone and Western - Macedonian mass). Their final genetic physionomy was formed by tectonic-metamorphic processes that made significant changes in the structural-textural features in the primary silica sediments.The base mass is composed of quartz grains that are cemented with silicone matter. In the process of quartz formation, four stages are identified (Figure 2): disintegration and weathering, diagenesis, epigenesis and regional metamorphism.

4. CLASSIFICATION ACCORDING TO THE MORPHOLOGY OF THE ORE BODIES

According to the morphology of the ore bodies, quartz deposits can be separated in the following types: [1]

1. Wire ore bodies occur in magmatogenic, pegmatitic and hydrothermal deposits in granite intrusions or old Precambrian formations. They are formed along the crack systems. Their powerthickness is from 30 cm to 10 m, and up to 200 m in length.

2. Lensed ore bodies are found in all types of deposits. In magmagenic, pegmatitic and hydrothermal deposits this type is represented by quartz concentrations along cracked systems or disintegrated zones in the form of lenses with dimensions of 50 - 100 m (deposit Umlena). In metamorphogenic deposits quartzites form lensed ore bodies, but with much larger dimensions compared to quartz lenses.

Sedimentary lensed bodies are formed in alluvial deposits where quartz pebbles are concentrated in the form of lenses (eg. Lakavitsa deposit).

3. Layered ore bodies are most commonly formed in sedimentogenic and metamorphogenic deposits. In sedimentary deposits are layers that are rich in quartz grains. Layers can be at different levels of sediment basins and can be shifted in cycles with layers of sand, clay, etc.They have a different thickness ranging from 50 cm to 5 m, and can be tracked from 200 to 300 m in length (characteristic example is the deposit Lakavica near Shtip). In metamorphogenic deposits layered ore bodies form quartzite in the form of elongated stripes and thin layers with a length of several hundred meters.

4. Irregular ore bodies occur exclusively in hydrothermal and pegmatite deposits. They represent quartz concentrations embedded in the fault zones or where they cross with undefined and irregular shapes of different dimensions. They are most commonly present in granite intrusions and gneiss - micaschist formations (eg. hydrothermal deposits Budinarci - Mitrashinci).

5. CLASSIFICATION ACCORDING TO ECONOMIC SIGNIFICANCE

In separation of the deposits according to their economic significance should be taken into consideration several elements: the belonging of the deposit to a certain ore bearing formation or genetic group, the contribution of the reserves of the given type of deposit in the total reserves of the raw materials and their quality, mining factors in exploitation and market conditions.

Knowing all upper mentioned deposits of silica raw materials, in Macedonia, according the economic significance, can be classified in several groups:

1. Metamorphogenic deposits of quartzites–these deposits are the most present on the territory of the Republic of Macedonia. They are characterized by a very high degree of research, reserves ranging from several hundred thousand tons to several million tons. They are characterized by medium to extremely high quality and very favorable conditions for massive exploitation.

2. Sedimentogenic deposits of quartz are the most important deposits in Macedonia. The most significant are deposits formed in shallow lake basisns (Oslomej and Lakavica), and, also, alluvial deposits of quartz pebbles which appear all over the country.

3. Magmatogenic deposits within which are distinguished pegmatitic and hydrothermal deposits.

Pegmatitic deposits include pegmatite - quartz wires and lenses that are widespread in the domain of the Serbian - Macedonian massif, the Pelagonia and the Vardar zone. They are characterized by the best quality of the raw material, but are least researched because they are in difficult access areas.

Hydrothermal deposits include hydrothermal quartz wires and lenses and deposits of secondary quartzites. They are characterized by quite high quality, but the deposists of secondary quartzites are quite rare. They are only known in the Kratovo-Zletovo volcanic area (Crni Vrv, Pleshenci and Plavica, Fig.1). They are characterized by variable quality of the raw material, from extremely high to very weakand it is necessary to select them during exploitation. Reserves have a high degree of research from several hundreds to several million tonnes. The exploitation conditions are quite favorable.

6. CONCLUSION

The Republic of Macedoniais rich with different genetic types of silica raw materials.In the literature, there is no single classification of silica raw materials. It can be performed according to mineralogical – petrographic characteristics, the conditions of formation (genesis), morphological characteristics and economic significance.

According to mineral - petrographic characteristics can be distinguished deposits of: pegmatite quartz, wired quartz, quartzite, secondary quartzites and quartz gravel, pebbles and grains.

According to the conditions of formation (genesis) can be separated: magmatogenic (pegmatitic and hydrothermal) deposits, sedimentogenic and metamorphogenic deposits.

Based on the morphology of the ore bodies, quartz deposits can be separated in: wire ore bodies, lensed ore bodies, layered ore bodies and irregular ore bodies.

According the economic significance, can be separated three groups of deposits: metamorphogenic deposits of quartzites, sedimentogenic deposits of quartz and magmatogenic deposits. The most important deposits in Macedonia are sedimentogenic deposits of quartz formed in shallow lake basins.

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UNDERGROUND RESEARCH DRILLING FOR THE NEEDS OF DESIGNING EASTERN TUBE IN THE KARAWANKS TUNNEL IN GEOLOGICAL FORMATIONS WITH THE RISK OF METHANE OUTBREAK

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ABSTRACT

Tunnel Karavanke lies on the trans-European transport Corridor X and connects the A2 motorway in the Republic of Slovenia to the A11 motorway in Austria. Existing Karavanke tunnel was built over 30 years ago as a single-tube and is currently a safety problem in the trans-European transport corridor. Based on the Directive of the European Parliament and the Council on minimum safety requirements for tunnels in the trans-European road network, the Republic of Slovenia and the Republic of Austria has decided to participate in the construction of the new eastern tunnel tube and the rehabilitation of existing western tunnel tube until 2019.

In 2016, we started with a drilling research work in the context of the implementation of geological, geotechnical and hydrogeological investigations. We got more than 1000 meters of drilling core. Particular attention during the drilling was in very demanding conditions in the geological layer, which content methane. Some of the geological formation in this area contains a large amount of methane (over 30 %).

In this article, we want to describe the technology that allowed drilling in a manner appropriate to ensure the core of the high degree of security.

Key words: methane outbreak, geological formations, drilling

1. INTRODUCTION

The Karawanks tunnel is located on X. Pan-European Transport Corridor and it connects the A2 motorway in the Republic of Slovenia with the A1 motorway in the Republic of Austria. The existing tunnel was build more than 30 years ago as a single two-way tube tunnel, but it is now perceived as the bottleneck in Pan-European transport corridor. Under the directive of the European Parliament and the Council of minimum safety requirements for tunnels on trans-European road network, the Republic of Slovenia and the Republic of Austria decided to cooperate in construction of new eastern tube and rehabilitation of the existing western tube by 2019.

For the purpose of geological, geotechnical and hydrogeological surveys, the drilling started in 2016. Drilling in Permo-Carboniferous layers was demanding and required special attention. The formation is gas-bearing and contains large quantities of methane (more than 30 %). This article aims to describe technology used for drilling in order to obtain core and also maintain high level of safety.

2. TUNNEL SURVEYS

Good knowledge and understanding of geological, geotechnical and hydrogeological conditions on the future tube route is a precondition for making a quality tunnel construction project. Geotechnical characteristics of the rocks that will be crossed by the new eastern tube still remain unknown, because there is not much known about deformation made while building the western tube. There is also another factor influencing geotechnical characteristics of the rocks, that is the presence of water and water is present in at least four water-carrying zones within Slovenian tunnel area.

The results of geotechnical findings are a necessity, because based on their findings the construction of a new tunnel tube is defined, taking into account temporary and permanent support measures and time needed to build the entry tube. In addition to the geotechnical findings, the impact of constructing a new tube to the existing tube with two-way traffic, will also be defined [1].

The following research work was implemented within the tunnel surveys:

- drilling fourteen horizontal structural boreholes,
- geophysical measurements in the boreholes,
- geotechnical measurements in the boreholes,
- collection of intact samples and implementation of adequate geotechnical, mineralogical and paleontological laboratory tests,
- implementation of hydraulic pouring tests, testing water permeability of soil and pumping tests,
- conversion of some boreholes into metric hydrogeological facilities,
- flow measurements in central drainage system of existing tube by segments,
- re-interpretation of the data collected and the creation of complete 3D geological, geotechnical and hydrological model,
- processing data collected and synthesis.

3. DRILLING – STRUCTURAL BOREHOLES IN THE TUNNEL

For the purpose of geo-mechanical core research, drilling of fourteen horizontal structural boreholes of various lengths was planned. The drilling locations within the existing tube were in the existing blind underground facilities, existing partially-built walking paths (type GQ) and in turning point PBN2, which consists of two trafficked crossbeams (type FQ) and another tunnel tube finished in the pre-construction phase. Transport of drilling units and equipment to specific locations was carried out when the road in the existing tube was completely closed. Construction site preparations consist of drilling unit installation, installation of settling-tanks, electrical wiring and installation of ventilation system. Diesel generator was used as a primary energy source to supply all energy consumers on the site. The generator was located in storage spaces, out of the main tunnel tube. Electrical equipment used for electrical supply on the sites was in accordance with designed project documentation. Building site management was designed in order to give special attention to ventilation system, since the presence of methane and other toxic gases was expected during the drilling.

Therefore separate compression ventilation was established. Fresh air supply was provided from the main tunnel tube. Establishment and use of necessary ventilation equipment was organized in accordance with designed project documentation on building site ventilation.

The drilling was performed by drilling rig DIAMEC 262 (Figure 1a) and CMV MK1400 FG (Figure 1b).

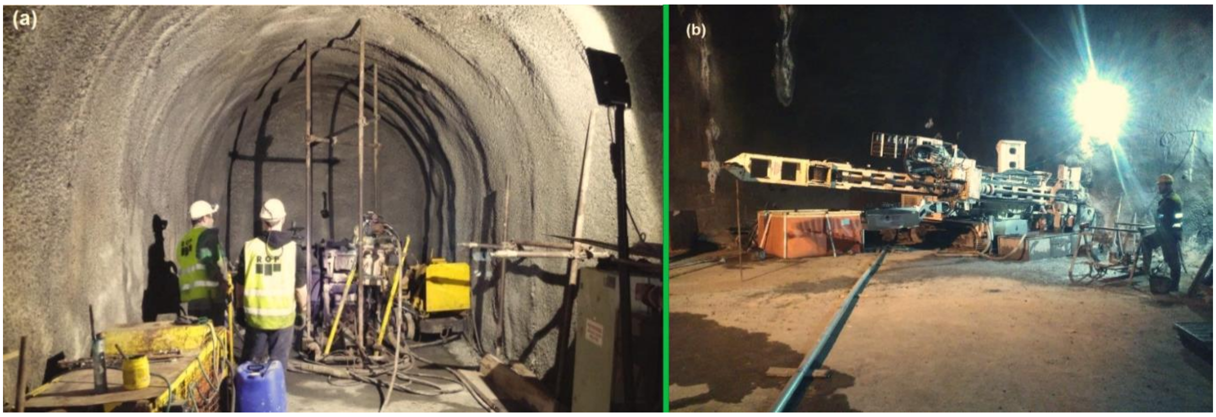

Figure 1: (a) Drilling rig DIAMEC 262 on site, (b) Drilling rig CMV MK1400 FG on site

Two smaller drilling units were used on site PBN2, as with cross-beams type GQ and FQ, and a larger drilling unit could only be used on turning point PBN2, because of its size. At any time during the contractual relationship, the contractor was bound to specific requirements; organizational special requirements, technical special requirements and formal special requirements. In addition, the contractor has undertaken to carry out the drilling in tunnel outside the tourist season and without hindering transport through the Karawanks tunnel.

The biggest challenge was presented by specific technical requirements, such as adequate ventilation with continuous monitoring of toxic gasses presence, or appropriate reaction in case of maximum permitted gases level overrun, and preserving a 100% intact core. In order to preserve a core, the contractor implemented technology using a single coring unit in the area to a depth of 6 meters. Drilling to the final depth was carried out by a double coring unit with inner dividable tube and use of triple coring unit. This technology provides extracting the intact core by extrusion, using devices such as extrusion with water and similar. In the areas, where the core loss had been foreseen or poor geo-mechanical conditions were expected, triple or double coring unit with inner dividable tube was used. The drilling equipment used in this project met the criteria ISO 22475-1:2006 [2]. Directions of boreholes are different, that is in direction of the existing tunnel tube or transverse to the existing tunnel tube. Inclination of boreholes is 5 degrees downwards from the horizontal. Diamond drill bits of different granule sizes were used most of the time (95 %).

4. DRILLING – IN GAS-BEARING LAYERS

As already noted, special attention was given to the process of drilling in the area of gas-bearing layers. Those layers are parts of geological formations from the Precambrian period or contacts between Permo-Carboniferous layers and other geological formations. The presence of methane and other dangerous gases was detected by combined detectors that were installed above the mouth of the boreholes and in various parts of building sites, where lower air-flow was expected. Gas detectors Drager X-am 7000 and Drager PAC 7000 were measuring the presence of oxygen (O2), methane (CH4), carbon dioxide (CO2), carbon monoxide (CO) and hydrogen sulfide (H2S). Detectors were equipped with light and sound signalization, and programmed to trigger an alarm system in case of increased concentration of dangerous gases [3]. In addition to the above-mentioned measures, there was also a preventer in every borehole, ensuring borehole closing in case of dangerous gas intrusion.

While drilling, the contractor met some unfavorable conditions, especially when maximum permitted levels of dangerous gases, methane and carbon monoxide, were exceeded and also exhaled. With the first larger methane exhalation, the presence of this gas had to be measures in the main tunnel tube as well, and consequently, the road through the Karawanks tunnel had to be closed. In order to prevent these kinds of events, the contractor, the tunnel operator DARS and fire brigade GARS Jesenice together established a protocol, which was drawn up to foresee actions in case of dangerous gases occurrence in the construction site itself as well as in the main tunnel tube. When exhalation of methane and/or carbon dioxide was measured and detected, the drilling in such conditions caused many problems to the contractor. This meant that the drilling was performed in atmosphere, where additional ventilation was necessary and the speed of drilling process decreased substantially, due to degasification for boreholes and building site itself. During the gasification of the boreholes, unfavorable geo-mechanical conditions were identified. Due to pressure, those conditions are likely to additionally affect the core collapse. To prevent this situation, the contractor used special pipes, but after the pipes were used, they detected pressures on the borehole mouths and the drilling in safe conditions was not possible anymore. After measuring, presence of dangerous gases was detected, exceeding 10 bars.

While drilling works were in progress, National Laboratory of Health, Environment and Food from Maribor performed measurement of gasometry within some boreholes. The data generated are presented in the following table:

Table 1: Results of gasometry measurements

Parameter	Method	Unit	Cankar KN5B	Cankar KN5D-1	Cankar KN5A	GQ16 KN4B	EQ15 KN3A
O_2	ISO 12039: 2001	vol. %	2,1	5,6	7,5	0,6	16,9
CO	ISO 12039: 2001	mg/m^3_n	<5	<5	<5	<5	<5
SO_2	SIST ISO 7935: 1996	mg/m^3_n	8010	8430	8570	8490	3880
NOx (asNO_2)	ISO 12039: 2001 -extended	mg/m^3_n	<15	<15	<15	<15	<15
CH_4	intern method GC-TCD	vol. %	37,47	35,48	42,35	39,01	5,02
N_2	intern method GC-TCD	vol. %	68,59	63,76	55,42	66,44	80,31
H_2	intern method GC-TCD	vol. %	0,05	0,03	0,13	0,14	0,01
CO_2	intern method GC-TCD	vol. %	0,11	0,08	0,06	0,02	0,16

Further on, all the boreholes were also equipped with safety valves with manometers that monitor and detect pressures of gases. This monitoring is still applied.

5. PROBLEMS WITH DRILLING IN GAS-BEARING LAYERS

Preparation for drilling in conditions where it is expected to encounter dangerous gases is highly challenging for both, the contractor and the design engineer. They both have to place great emphasis on safety of employees and other personnel involved in the project as well as the broader area of the already existing tunnel. Safety and health at work, fire safety and protection of the environment were designed in concordance with safety requirements. The requirements were based to ensure adequate protection of the building site towards its environment, security measures used in drilling, protection against sudden outbreak of water or gases, protection against dust and air pollution, protection of water and fire protection. In order to ensure a high level of safety, the contractor must provide all technical documentation before the project starts (implementation plan, a document operating procedures in case of increased amount of dangerous gases) and prepare a plan of defense and rescue for specific location where the drilling is taking place. All the documentation has to be prepared in close cooperation between the contractor and the design engineer, since it contains information referred to current legislation, technical regulations, specific safety requirements and technology of implementation.

Other similar projects are challenging to the contractor and the design engineer, because there is a possibility to encounter gas while drilling, but it is on the contractor to foresee and carry out all the measurements to ensure the highest level of safety. Preparation of documentation, exploration and drilling in the Karawanks tunnel were implemented in such manner, that when increased levels of methane were detected (detection during constant unsmoked control of dangerous gas presence) on the mouth of the borehole, the methane could not have been diluted under 0,5%. 0,5% was also the level of methane that was set to be the maximum permitted level by which the contractor is still allowed to perform work [3].

A dilemma arises; whether to continue drilling when the amounts exceed concentrations defined in the documentation. To this end, the contractor prepared a cost assessment that includes continuation of drilling in conditions which are applied in hazardous places with methane. It was concluded, that some parts of electrical equipment, preventing explosive atmosphere to form, should be provided. At the same time, the supply of such equipment would have great impact on estimated cost and the project termination date.

6. CONCLUSIONS

Throughout the project cycle, the building contractor has concluded or got confirmation to some previously asked questions:

- Research work concept has to be prepared in close cooperation between the design engineer and the potential contractor. Only close cooperation will ensure achieving results, necessary for constructing underground facilities. The contractor will research technical solutions of the implementation work and the design engineer will study the amount of research work which will lead to quality preparation of documentation for executing the project.
- Research work needs to be carried out in order to reach sufficient level of quantity and quality. Assessment of investment and implementation of investment depend on level of exploration and quality of work performed. Sufficient quantity of research work and its quality determine the accuracy level of investment assessment.
- In the phase of research, close cooperation between the contractor and the investor is needed. It is acknowledged that geological, mining and building projects are of most complex ones, because they largely deviate from original plans. When there are geological surprises, the situation becomes even more complex. The work here needs to be carried out in such a way, that the investor realizes their goals and that the contractor can work in safe environment. That is why, all the possible risks have to be predicted in the research stage. At the same time all measures providing safe and quality work need to be implemented.
- It is necessary that project documentation includes all risks and appropriate measures, that were detected and carried out and on the basis of those provide new ones. New risks and measures need to be carefully specified, because this is the only way to implement the project allowing the investor to use financial resources within the forecast budget and financial implementation will ensure safe and quality performance at the same time.

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EXPLORATION OF UNDERGROUND STRUCTURES WITH GEOPHYSICAL - SEISMIC METHODS

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ABSTRACT

Seismic explorations are based on registration of seismic refraction and reflection of the elastic waves.In the processed geophysical data, obtained during the investigations of the archaeological site "Skupi", seismic explorations were conducted in combination of refraction and reflection. But, this paper presents the results only from refraction method.

During the research, the application of seismic methods is performed using measurement technique slalom by placing more geophones along the investigated area.

Slalom technique is based on registration of the generated elastic waves which spread through the researched area in the setted geophones.Using the moment of registration of elastic waves in a geophone, by adjusting the time it can be assumed as a source of new elastic wave, which with further registration modeling the characteristics of the investigated terrain where it is placed.Through this technique with one generation of elastic waves are produced seismic models for each geophone, and for each subsequent decreases the depth of examination, because it cuts the measuring length of recording of the elastic waves.

Key words: refraction, underground structures, archaeological site

1. INTRODUCTION

The subject of research in the paper is the fence wall the archaeological locality "Skupi". According to the existing data, the wall has a pentagonal shape with a total length of about 3000 m.It is built of stone with basement width of 3 m and height of 4 to 7 m. The aim of the investigations is indication of the shifting of the real spatial position of the wall from initial spatial position and planning uncovering the fence wall and entire archaeological site [1].

Coverage and relatively large length for the detection of the wall by direct digging, justifies the preliminary application of geophysical investigations to locate the wall.

The geophysical approach is based on the initial geomagnetic prospecting of the investigative space, the results of which are standards for investigative geophysical explorations. Combined seismic and geoelectric investigations have been adopted as investigative methods by which, through a complex interpretation of the registered anomalies, potential excavation sites are determined in order to determine the position of the archaeological site.

Seismic tests are carried out through two seismic methods: standard profile refractive researches and reflective seismic studies combined with detailed refraction investigations (only forwards).

2. REFRACTION SEISMIC METHOD

There fractive seismic method studies the propagation of the elastic waves that refract at the boundary surfaces.[2]

There fractive method is performed by placing the geophones from the source of the elastic waves along the measured profile line at a certain distance.Geophones through cables are connected to the seismic apparatus. In the moment when the seismic waves encounter a boundary surface that separates two different elastic environments, they refracted and as such the feedback signals are registered.On the surface of the ground, the installed geophones turn mechanical oscillations into electrical impulses that are transmitted to the seismic apparatus.

The seismographs register the time of arrival of the elastic wave as well as the moment of excitation of the ground. Based on seismographs, diagrams are constructed that determine the dependence between the distance of the geophon from the point of excitation and the time of arrival of the seismic oscillations to each geophon. Such diagrams are called hodochrons.

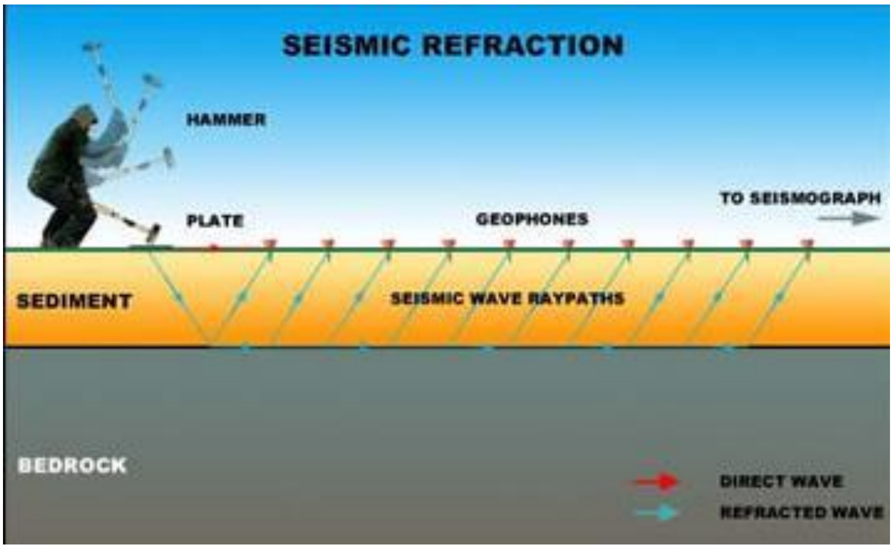

Figure 1. Seismic refraction method

With there fractive seismic method, horizontal, vertical and steep boundary surfaces are successfully determined, but with the condition that in each deeper layer the propagation velocity of the elastic waves is greater than the speed in the previous.

3. GEOLOGICAL COMPOSITION OF THE EXPLORATION TERRAIN

From the previous geological researches performed on the investigative area, the image of the basic geological structure of the same is generalized. Figure 2 presents the basic geological structure of the investigative space with the represent edlithological members [3].

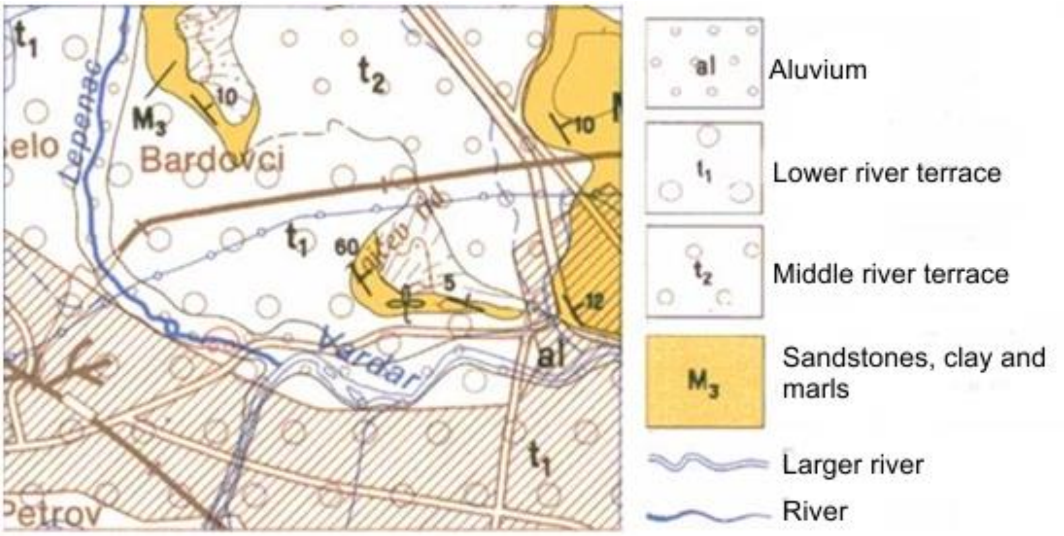

Figure 2. Geological map of the investigated area

Sandstones, clays and marls (M_3). Upper Miocene sediments lye above the basal conglomerates and have large spreading in the northern edge of Skopska valley. Also, determined are along the valley of Lepenec. They are composed of sandstones, clays and marls, and, also, present are marly clays and clayey marls. Marls, marly clays and marly sandstones are directly above the Cretaceous sediments.

Marl series occur in the lower parts of the Miocene basin. Due to its uniform composition shows long time unchanged sinking medium and continuity of the basin. Upper parts which are composed of coarse granular sediments pointed to rapid changes, stagnation of the basin level and filling of the basin, which is associated with the termination of the sinking of the basin and calming of the tectonic processes. This is supported by the fact that immediately over the terrigenous sediments lies a thick complex of Pliocene layers of coarse composition (poorly bound gravels and sands).

Middle river terraces (t_2) are determined on 20 to 30 meters of the alluvium on the rivers Vardar and Lepenec. Slightly inclined towards the river beds. Along the valley of the river Lepenec, similar terraces were developed at 30-40 meters from them odernaluvionon both sides of the river near Kacanik.

Lower river terraces (t_1) are found along the river Vardar, and along the valley of the river Lepenec on height of 10 – 20 meters from the modern alluvium.Lower terraces occupy very large area around the mouth of Lepenc in Vardar and upstream to the entrance to the Kachanicka gorge. In the valley of Lepenec, these terraces are found up stream from Kachanik, in the form of interspersed narrow terraced landscapes that, unlike the higher terraces, are horizontally developed around the river beds.

Alluvium (al). The largest areas under the alluvial and recent river beds are found around the larger rivers Vardar and Lepenec. They are mostly made of gravel – sand material. Around the river Lepenec and its tributaries this material is coarse granular and composed mainly of rounded blocks whose size ranges upto 2 m^3. This material is, infact, redeposited moraine sediments, orfluvial – glacial material where modern river flows on their route eroded and redeposited it.

4. RESULTS FROM THE REFRACTION SEISMIC EXPLORATIONS

On the investigated object were conducted several variants of refractive seismic explorations:

- Standard refractive investigations – with excitation of seismic waves, forward and back
- Detailed refractive investigations parallel to the reflective seismic explorations with excitation of seismic waves only forward – “slalom” technique.

A part of these is micstudies were performed just ahead with the slalom technique as well as there fractive explorations performed with forward – back technique are interpreted individually, and some of the overlapping tests are interpreted through data from both refractive methods [4].

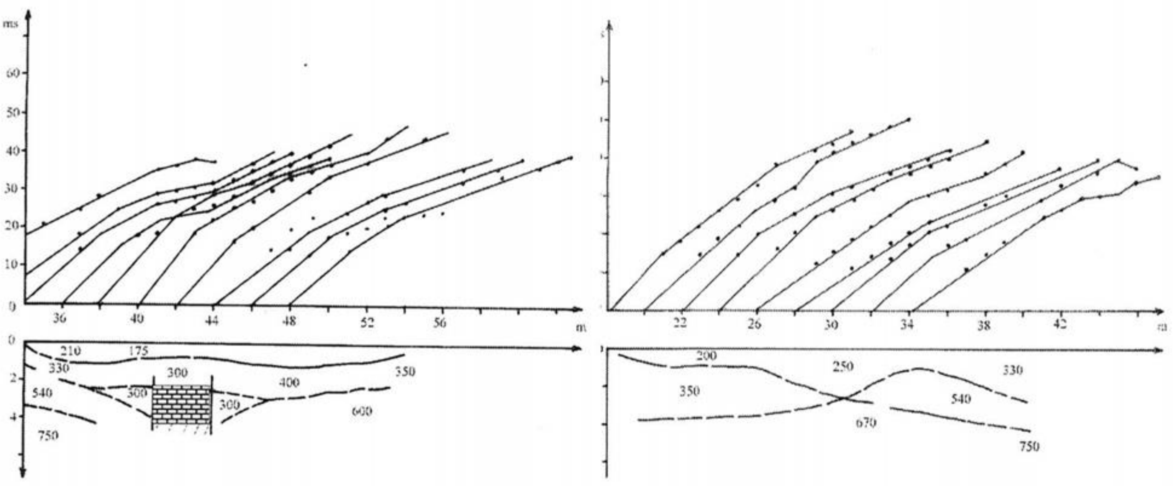

Figure 3. Profile line – 2, Refractive seismic investigations – slalom

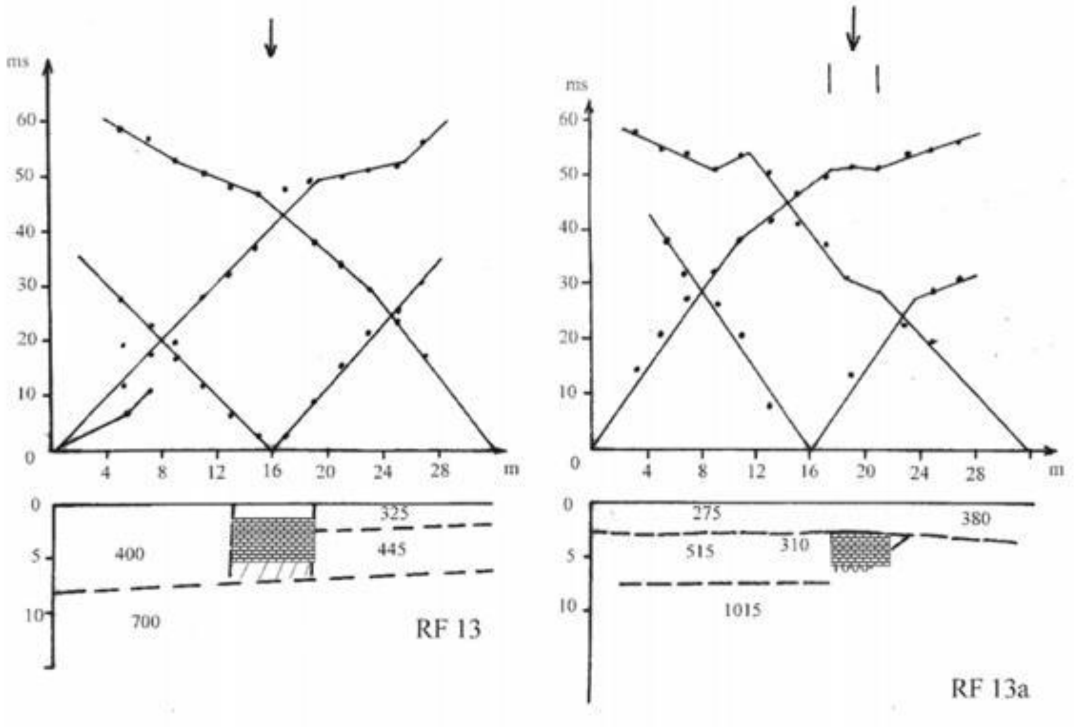

Figure 4. Profile line – 13, Refractive seismic investigations, Forward – Back

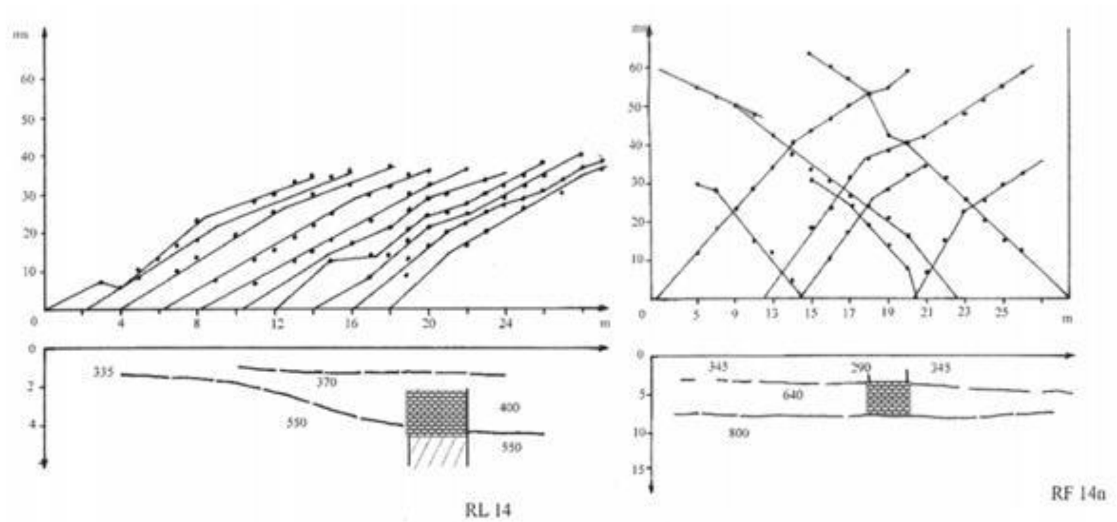

Figure 5. Profile line – 14, Refractive seismic investigations, slalom and Forward – Back

5. CONCLUSION

In the paper, refractive seismic research has been applied as the main investigative method in defining the fence wall of Skupi archeological site.

The complementary use of seismic researches performed through refractive and reflexive methods in determining the fence wall oft hearchaeological site "Skupi" was applied on the basis of the various elastic characteristics of the building stone on the wall and the sedimentary material surrounding it. The main disadvantages in the application of these researches is that the subject under study is on a relatively shallow depth (2.5 - 5 m) with a small width (from 1.5 to 2.5 m), which drastically reduces the efficiency of the used methodology.

Geophysical methods give a complete preview of the entire research area and serve to define exploitational drilling in the extremities of the geophysical model. Geological exploration drilling with core mapping gives precise data on rock masses for the place where they are took, but not for the wide rarea. From this aspect, the combination of geophysical investigations with exploratory drilling at the extreme soft hegeophysical model is the path for the development of a real geological model.

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3D GEOLOGICAL MODEL OF THE BAUXITE BEARING AREA CRVENE STIJENE (JAJCE, BOSNIA & HERZEGOVINA)

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ABSTRACT

3D geological models can be very useful in many geological, mining and other engineering activities. Constructed model should serve as a 3D geodatabase for variety of input data. Study area represents one of the bauxite bearing sites, Crvene Stijene, near Jajce (Bosnia & Herzegovina). Presented methodology includes the integration, digitalization, organisation and visualisation of different types of input data (600 boreholes, geological maps and sections, DEM, structural measurements from the surface and in the tunnels and adits) in the 3D geological database. In the modeling workflow, different types of geological objects were modeled with different interpolation algorithms. Used interpolation algorithm depends on complexity of geological object, character and spatial distribution of input data. The model is interactive which is important because there are constantly ongoing research and exploitation activities: boreholes, underground mining objects, etc. that can be easily imported into the model. 3D geological model represents a basis for planning new scientific research and mining activity.

Key words: 3D Geological Modelling, Ordinary Kriging, Karst bauxites, Midland Valley Move, Jajce

1. INTRODUCTION

3D geological models represent a solid background, not only for the visualization of geological data, but also for data acquiring, processing and organising them into the 3D geodatabase (Wu et al., 2005). The development of the computer industry and software for 3D geological modelling, introduces the opportunity for their application in solving numerous geological challenges (modified after Xue et al., 2004; Kaufmann & Martin, 2008).

Planning mining activities for the exploitation of raw mineral resources, requires defined geological structure of the area, the spatial distribution and geometry of the exploited ore bodies. Insufficiently geologically explored deposits usually lead to various difficulties in the design and construction of mining objects (Vanneschi et al., 2014). The consequences can be a variety of technical and technological problems during construction, such as a threat to human lives, damage to machinery and a regular increase in the cost of mining object. 3D geological models of the study area can be a great help in more efficient planning of research and mining activities, and with enough input data, they can very accurately represent the geological structure of the area (Caumon et al., 2009; Vanneschi, et al., 2014). Models are especially useful when the ore bodies are in geologically complex settings

This paper presents the methodology for constructing the 3D geological model of the bauxite bearing area of Crvene stijene (Jajce, Bosnia & Herzegovina) (Fig. 1). Several decades of research and exploitation of bauxite have provided a large collection of input data: bauxite footwall and hanging wall stratigraphy, detailed geological maps and sections, detailed topographic maps, over 600 drilled boreholes and over 10 km of underground mining objects (adits and tunnels), etc.

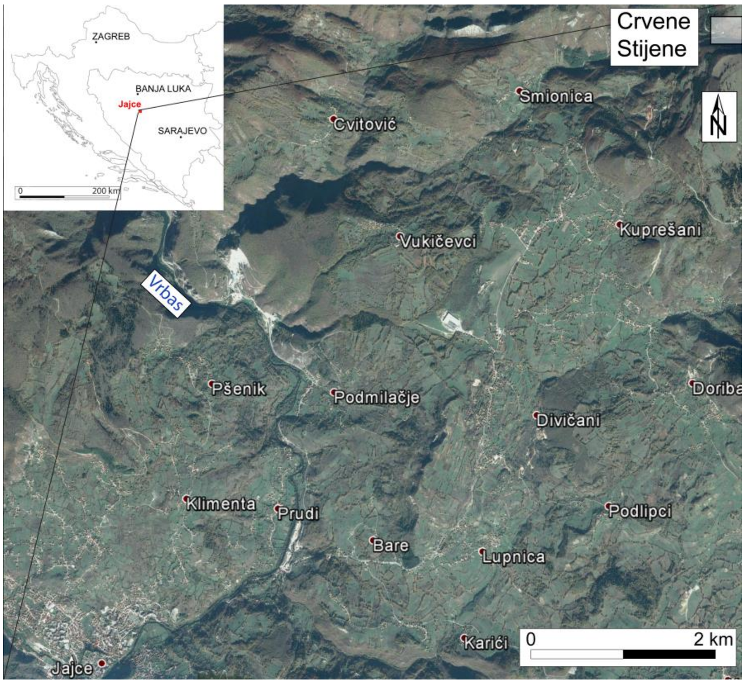

Figure. 1. Geographical location of the bauxite bearing area Crvene stijene, Jajce (Bosnia and Herzegovina) (Pavičić et al., in prep).

2. GEOLOGICAL SETTINGS

The fundamental stratigraphic and tectonic featuresof the study area weredefinedin a Basic Geological Map of Yugoslavia, sheet Jajce, 1:100 000 (Marinković & Ahac, 1975), explanatory notes for the same map, (Marinković & Đorđević, 1975), geological maps of bauxite bearing area Jajce (Dragičević, 1981 and Papeš, 1984) and published and unpublished geological research papers (Dragičević, 1987; Tomić, 1983; Dragičević & Velić, 1994; Dragičević, 1997; Dragičević & Velić,2002 & Dragičević & Velić, 2006, etc.). Geological settings are shown on a geological map in Fig. 2.

The oldest rocks present in the study area are shallow marine, well-layered, and white to grey limestones of Lower Cretaceous age, which end in Albian shallow marine, white - light grey to pink limestones. These rocks are footwall to bauxite deposits. The end of the Lower Cretaceous and the beginning of the Upper Cretaceous on the margin of the carbonate platform was characterized by intense compressional tectonics and emersion of regional impact (Dragičević, 1987; Dragičević & Velić, 2002). The emersion lasted from the Upper Albian to the Coniacian – Maastrichtian, approximately 20 million years when bauxite deposits were formed. The stratigraphic hanging wallof the bauxite deposits in the Crvene

Stijene area is mainly composed of carbonate clastics. Lithologically, they are numerous and diverse lithofacies. The most common types are the carbonate breccia, conglobreccia and conglomerates.

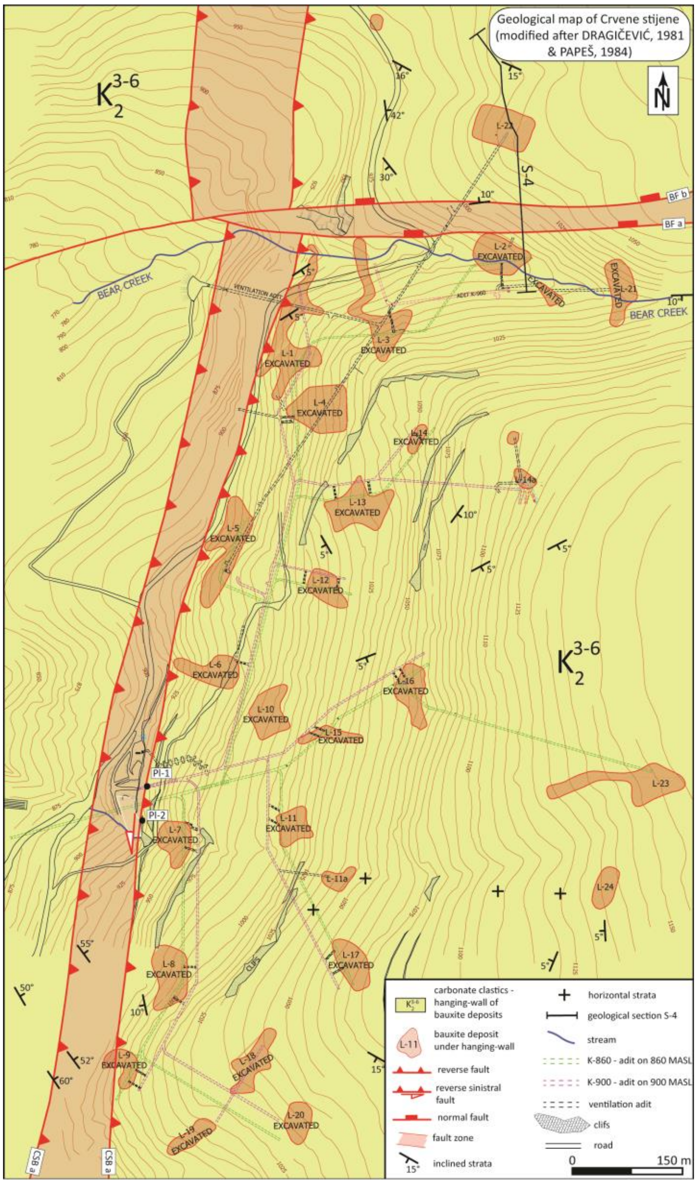

Figure. 2. Detailed geological map of Crvene stijene (modified after Dragičević, 1981 & Papeš 1984). CSB a and b –Crvene stijene-Bešpelj fault zone; BF a, b – Bear fault zone (Pavičić et al., in prep.)

3. METHODOLOGY

The **Midland Valley Move** (http://www.mve.com/) software package was used to build a 3D geological model of Crvene Stijene area. Once all the data was imported into the software, the building of a 3D model could start. Process started with the construction of 46 geological cross-sections and 3 longitudinal sections. Then, fault surfaces, palaeorelief and top of bauxite surfaces could be constructed. The last part of model construction was building solid models of individual bauxite deposits (Fig. 3).

Each of the surfaces was different in character (fault surfaces, palaeorelief surfaces, top of bauxite deposit surfaces) and complexity (Fig. 3). Also, they are defined by a different type, quantity and quality of input data. So, for each type of surface it was necessary to use a different interpolation algorithm. Faults are mostly defined by their surface trace and measurements in the adits, while movements on faults are interpreted based on different depth of horizons in boreholes on both sides of the faults. Palaeorelief surfaces are geometrically the most complex. Palaeorelief is represented with several surfaces and their boundaries are faults and boundary of study area (Fig. 3). Palaeorelief surfaces require the highest amount of input data. So, they were built based on 600 boreholes, and geological sections in areas where there are few or none borehole input data. Top surfaces of bauxite deposits, have relatively small areas and irregular shape in comparison to palaeorelief and fault surfaces. These surfaces are modelled based on two types of input data:

- boreholes which have penetrated the bauxite deposits and imaginary boreholes created for the better interpolation of shape of bauxite top surfaces;
- contours of bauxite deposits from detailed topographic maps (visible in fig. 6), which are digitized and projected onto palaeorelief surfaces.

In order to obtain the geometry, size and volume (in m^3) of bauxite deposits, solid models were created in between palaeorelief surfaces and top of bauxite surfaces (Fig. 3). These solid models show the morphology and geometry of the deposits, so dimensions and volume (in m^3) of individual deposits can easily be calculated.

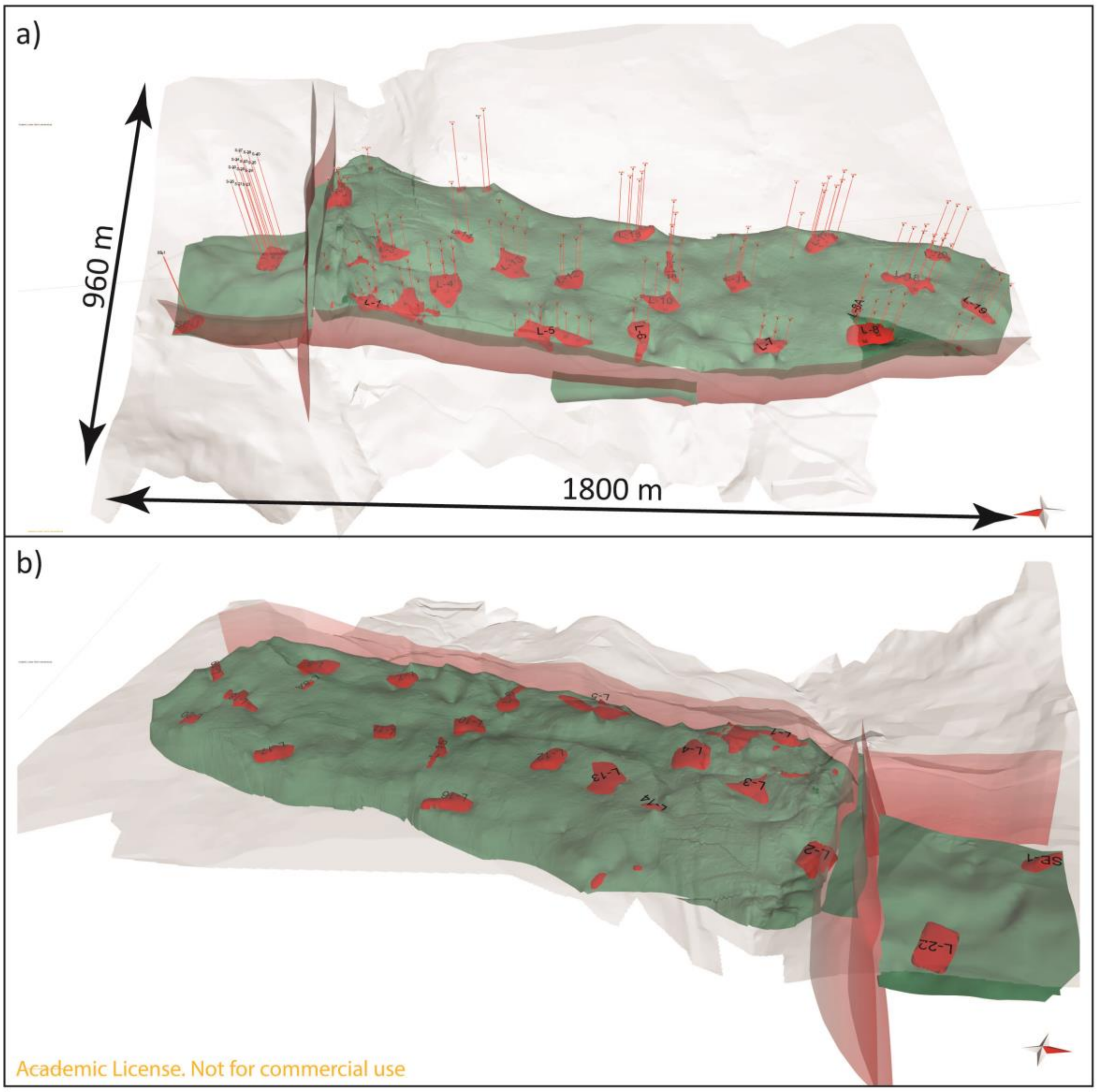

Figure. 3. 3D geological model of palaeorelief surface, bauxites and faults (Pavičić, et al., in prep)

4. DISCUSSION AND CONCLUSION

The paper presentsdeveloped methodology for constructing a reliable 3D geological model based on variety of input data. The methodology includes the integration, digitalization, systematisation and visualisation of different types of data (boreholes, geological maps and sections, DEM, structural measurements from the surface and in the tunnels and adits) in the 3D geodatabase. This is especially useful when there is a large amount of input data (in our example 600 boreholes). In the modeling workflow, different types of geological objects are modeled with different interpolation algorithms. Chosen interpolation algorithm depends on complexity and geometry of geological object, and type, quantity and quality of input data. Therefore, this methodology could be applied in other areas and for other raw mineral resources.The constructed model is interactive and is easily upgraded with new data. This is important because there are constantly ongoing research activities: boreholes, underground mining objects, etc. that can be easily imported into the model. Model is now a basis for planning of ongoing research activity. Furthermore, newly found deposits can quickly be contoured, volumes can be created and calculated.

Acknowledgements

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ANNEXES TO THE KNOWLEDGE OF THE METALOGENIA OF THE LJUBIA MINERAL AREA

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ABSTRACT

Despite the more than a hundred years long history of geological exploration and exploitation of iron ore, the Ljubija ore region continues to be a promising area for locating iron ore deposits. Detailed work on the development of a metallographic map, all the essential knowledge of geology and metallogeny of the terrain was re-examined and interpreted on the principles of contemporary sedimentological, tectonic and metalogenetic theories. The knowledge and legality of the ore genesis and geological evolution of the terrain, defined ore formations and possible models of the distribution of ore masses within certain mineralogical formations were determined. In further research, it is very important to take into account the metalogenetic factor of irregularities, which has been clearly identified for the first timefor this region. The arrangement of carbonate olistolytic bodies in an olistosstrom member is chaotic and hardly predictable, their size, shape, morphology, boundaries, workmanship and metal content are incorrect. Because of this, the ore bodies and deposits have no continuity in providing, as they were attributed to earlier interpretations.

Key words: Ljubija ore region, metalogenetic map, perspective, prognosed map, olistostromian member

1. INTRODUCTION

The Ljubija ore region implies a complete ore territory of about 1500 km^2. It is part of the Dinaric metalogenetic province characterized by identical geological conditions and the development of ore formations and types of economic deposits of iron and other mineral resources.

The Ljubija ore region is defined on the south front with Sana thrust, on the east with border of the Jurassic-Cretaceous unit, on the north with ofiolyte zone of the Kozara and in the west with the tectonic predetermined direction of the river Una, deeply engraved in the relief. This is a very interesting geological phenomenon and area from the standpoint of the known and potential deposits of iron and other mineral raw materials. It is at the same time an important segment of the mineralno-raw material complex of Republika Srpska [1].

Geological explorations of the ore region begin at the end of the 19th century and continue to this day in continuity. However, over time, the intensity of the research, their scope and the working hypotheses for which geologists have served have been changed. In the last decades, the concepts of research have increasingly been based on the foundations of metalogenia.

In 2013, in cooperation with the geological service of Arcelor Mittal and the team of the Instituteof mining Prijedor, under the leadership of academician A. Grubić, the entire preparation for the completion of the metalogenetic map of the Ljubija region was completed in the scale of 1: 50,000 [3]. All existing data on research and exploitation works are examined. The final result of the work on the metallurgy of the Ljubija ore region is Explonation, which is accompanied by three maps: geological, metalogenetic and prognosis. They also show the potential of certain geological formations in terms of finding new deposits and ores of iron, which imposed the definition of: geotectonic evolution of the ore region with particular reference to the processes that led to the education and spatial distribution of ore deposits, the control factors of the arrangement and the creation of deposits within the ore formations and the definition of perspective spaces for detailed research.

The degree of exploration of the region

The degree of exploration of the Ljubija ore region was considered by M. Šarac [3,5]. According to this criterion, the author developed the perspective of the region and distinguished four categories of terrain: (1) detailed researched, (2) less explored, (3) insufficiently explored, and (4) terrain without investigative works [2].

The well-studied terrain includes areas with known mining deposits in exploitation or whit deposits which are prepared for this and their narrow environment. These groups are located in three groups: central, southern and eastern deposits. The extent to which these deposits have been investigated in detail is the fact that in the group of central and southern deposits only 1000 different exploration drillholes were made, while in South Tomasica 520.

The less explored terrain includes areas located in the wider area of the exploitation sites and partly between them. In these terrains a smaller number of necessary research works were made than in the first category. These are two spacious terrains: the western and eastern, which, in fact, surround the terrains of the first category. Insufficiently explored are those terrains in which only rare informative exploration drills, geophysical works or scattering were performed, and in the unexplored there is none of it. These two groups include all the remaining terrain of the ore region.

It can be concluded that the research of the Ljubija ore region is quite good according to the amount of work performed and their diversity, but the density of the works is noticeably unevenly distributed. Their higher concentration is predominantly related to ore deposits and ore fields. Between them, research is minimized. The results of all types of research are registered in 300 different papers. Out of that, 130 papers were published and 170 reports and elaborates of various volumes and purposes. Seventeen reports on jobs carried out between 1987 and 1990 have been dedicated to metalogenetic studies.

2. GEOLOGICAL CONSTRUCTION AND GEOTECHNICAL EVOLUTION OF THE TERRAIN

On the basis of all the studied materials and field tests, it is reliably established that the area of the Ljubija ore region and its frame had a complex evolution in the carbons, permus and triads. The geological pillar of the Ljubija ore region consists of: carbon javoric flysch, permo-triassic clastite, triassic tergene-carbonate, vulcanogeno-clastic terigens and carbonate formations, and neogen-quaternary lake crevices.

For the metalogenia and genesis of the ljubija ore, the javoric formation is particularly important, and its olistostromic member as the carrier of numerous primary and secondary autochthonous deposits of iron. In the javoric flysch there are members: overfleis and lowerflies, olistostromic crevices and the upper flush (Fig. 1). Tectonic is accumulated in the upper carbon when it is rupturefully intensely damaged. From the detailed studies of the javoric formation in Adamuša and South Tomašica, the impression that it is possible to extract more units in it has become apparent. Thus members are described: lower flies, siderite-limonite, wild flysch, olistostromic and upper flysch [4]. Considering the possible application of this division to the entire Sana paleozoic, however, has shown that it is too detailed and therefore difficult to carry out throughout the ore area. In addition, the basic metalogenetic concept of mineralization of iron has been changed, so the working hypothesis about the sedimentary origin of primary siderite and anchorite has been abandoned. In relation to the earlier division, the biggest change occurred in the olistostromic member. This member now includes a Siderite-Limonite member, wild flysch and middle flysch. Among other things, this change agrees well with the thickness of the olistostromic member, which, according to new data, can be 300 m (for example, in Vukulja).

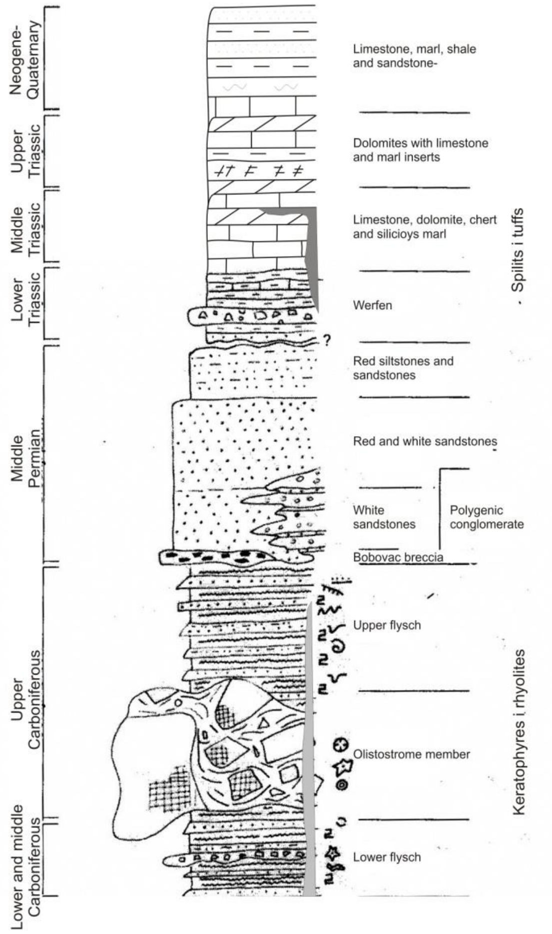

Figure 1 The geological column of the Ljubija ore region [2,3]

The olystromic member forms the middle part of the javoric formation. Below overflown flies and the bottom flush member and through it comes a member of the upper flush (Fig.1 and 2). It was created in deep sea conditions. In the mining region it was discovered in the middle parts of the Sana paleozoic, right in the core of the alpine Sana antiforme. This article has an extremely complex composition dominated by four groups of rocks: flysch matrix, carbonate olistolite blocks, autoclastic melancholy and partially or completely stiff bodies. Synthetic, ankerite, sideridic and ankerite carbonates are involved. Sometimes the entire olistolite body has been replaced, and sometimes only partially altered and limonitised. Particularly emphasized are the major replaced stratiform bodies, whose genesis has long been controversial. The thickness of the member is 100 to 300 m.

The permotrian clastic formation lies across the Javoric formations in a discordant and transgressive manner. It was developed and, due to erosion, only preserved. It was formed in continental, lagoon and sublotal conditions. It is made of white and red quartz sandstone, conglomerate and clay slate. Red rocks are prevalent. Mystically there are hollow dolomites and siderite wires up to 40 cm. It is up to 150 meters thick.

In the triassic, through transgressive colorful and slippery verphic layers, first, limestone and dolomite lie, then ladin vulcanogeno-sedimentary porphyrin-rosy formations. From the younger sediments there are only lake neogen-quartar creations. Of the magmatic rocks in the region, only Triassic riolites and lesser trachits are more important, then granite-potfires and sini-porphyries.

The tectonics of the studied terrain is very complex because it was created as a result of hercine, chimeric and alpine deformation phases. Hercine and chimeric structures are delicate, and alpine are busy. The Herzegic events left a trace only in the Javoric formations, in the form of a set whose B axes have an azimuth of 10 to 400. The dispersion of the B-axis is a consequence of the Alpine overfill [3].

Sana dislocationis has oldchimerian age, which was the result of riftogenesis in the peripheral parts of Apulia. According to its provision of the NW-SE, it belongs to the southwestern, accompanying raises of the rift opening of the dinaric ophiolitic belt. She crossed the lithosphere to the wrapper and was followed by lateral rupture systems. It left a trail in Javorica but also in younger formations. Through later events, it influenced the change of the Hertzian structural plan of the terrain in the Alpine region. The accompanying lateral rupture systems in the study area predominantly have the direction of providing NE-SW. They were well expressed in the field and in metalogenia they played the role of distribution channels, which were important for the circulation of hydrotherms and the present arrangement of ore deposits and the appearance of ore and ore fields [3].

In the alpine tectogenesis, the formation structures with the B-axes of the SZ-JI direction (130-140) and corresponding longitudinal, transverse and diagonal ruptures were formed. Sana dislocation was converted by a reverse transport into a cavity. Alpine disintegration and cracking systems have opened downburst pathways to descendent atmospheric oxygen-rich waters and gradually oxidized siderite and ankerite over time.

Based on this geological column, the tectonics and the areas in which its parts were formed, the evolutionary path of the studied terrain was reconstructed. In the Carbon, this area was an integral part of the oceanic basin on the bottom of deep-sea flysch sedimentation. During the intensive hercene collection, the basin was converted into land. In the middle and upper perm, this space was covered with a shallow sea with carbonate, clastic and evaporative sedimentation. Early intracontinental rifetogenesis was then started [6]. The clastite and carbonate precipitation continued in the triassic. In the middle of the triassic, however, this area was found in the zone of well-defined (internal) dinaric riftogenesis with transitional scaling, followed by appropriate vulcanism and extensive hydrothermal processes. This led to the de-mineralization in several phases, which were primarily affected by the lower, paleozoic parts of the geological pillar because they were at an appropriate depth and tectonically damaged during the time of hercegic tectogenesis. In part, however, hydrotherms also came to the dislocated Permian and even Triadian formations, especially verfenic. They also produced wire iron ores (Volar, Southern Tomašica, Okreč).

The oldalpine and youngalpine gatherings, between albeit and oligocene, also affected this area. Then there were cracks, creases, faults and new cracks systems. All of this enabled the intensive circulation of descending oxygen-rich waters through the top parts of the lithosphere and the formation of "iron hats" on carbonate iron ores [3].

Judging by everything, this area was definitely becoming landlocked very early, and it was exposed to long-lasting erosion and hypergenic influences. It was only in the younger neogen and quaternary that lakes formed in which clastic sediments had been accumulated with porcine from the adjacent ore terrains. They also formed young overgrown iron ore bodies.

3. GENESIS OF LUBIJA MINERALIZATION

The first fundamental iron researcher in Ljubija F. Kacer [7,8] noted that the ore is predominantly hydrothermal metasomatic, but also has sedimentary phenomena. After this, all authors advocated hydrothermal metasomatic genesis. It was not until the sixties that M. Jurković firmly claimed that all ores of iron in the Ljubić region of sedimentary origin [9,10]. He made a number of evidence for this. For him, this view was also represented by the authors of two doctoral dissertations M. Šarac and M. Juric [4, 11].

In the nineties, after detailed studies of Adamuša and Južna Tomašica, A. Grubić and LJ. Protic [3] considered that there are two metalogenions in the region. Older, carbonic hydrothermal sedimentary, siderite, and younger, triassic hydrothermal metasomatic, anchorite and polymetallic followed by sulphides. With the help of field, sedimentological, petrographic and ore-microscopic methods, it was impossible to do any more. For more reliable reasoning, very detailed and complex geochemical analyzes and interpretations were to be carried out. In the end of the first decade of this century, Croatian geochemists took it for their own needs.

S. Strmić-Palinkaš et al. analyzed, in Swiss laboratories, sixty samples from Adamuša, South Tomašica and other mines on: main elements, rare elements, isotopes of oxygen, sulfur and carbon and hydrocarbons [12]. All the results, and in particular the content of the rare elements, indicated the hydrothermal metasomatic iron genesis. Particularly indicative are Cerium (Ce) negative and European (Eu) positive anomalies that testify that ore can not be sedimentary origin. These results were confirmed by V. Garašić and I. Jurković [13], but they left open the question of the genesis of stratiform deposits.

In the mining region of Ljubija there are primary carbonate iron ores (siderites and ankerites) and secondary oxide (limonite). Others formed from the first long-term oxidation in hypogenic conditions to a depth of about 300 m. Apart from iron ore in the region, there are sulphide Pb, Zn, Cu and Hg, Ag and Au, fluorite and a considerable amount of barite. It is a unique "siderite - polysulfide - barite ore formation", consisting of three subformations: a) siderite - anchorite, partly lemonitis; b) polysulphide and c) baritic-fluorite. Based on the mutual relations between the members of the aforementioned subformations in field conditions, their formation should be in the following phases: In the first phase, siderites and ankerites with hydrothermal metasomatosis were formed in carbonate olistolite blocks, at moderate depths and at temperatures around 246 ^{0}C [12]. In the second phase, sulphides are generated by depositing in the form of wires in almost all parts of the geological column. As it looks, in parallel with them, wire rods (at temperatures of about 186 ^{0}C) were formed. Finally, in the third phase, there was a barit in several places in the region in all environments, except in unethical creations.

Factor of irregularities and shedule of Ljubija deposit

The geological structure of the terrain, its formation and all the collected data on the processes show that the main mineralogizing factors in the Lubija ore region were: stratigraphic and structural, lithological and geochemical, followed by magmatogenic and hypergene.

In the geological column of the ore region there are two ore formations: Javoric with its olistostrom member and the Neogen-Quaternary of the Prijedor Basin. In the first, there are primary siderite and ankerite parts of limonite ore, and in the second, only the overgrown limonite. Iron ore occurs in other formations, but these are wires that have no relevance for economic exploitation, which means that it is a "stratigraphic control" of the deposit.

In the lithological view of the ore is found in carbonate olistolite blocks. In limestone it is siderite and limonite, and in dolomite ankerite and limonite. The entire olistolite or only their parts can be replaced by the rudiment. When in some carbonate body there is siderite and anchorite, this means that its composition was partly limestone and partly dolomite. In clastics there is also siderite and ankerite, mostly in wired form, but also as impregnations in the matrix of rocks. The deposits of stratiform morphology were created from the lens bodies of carbonates, which previously led the researchers into a confusion in the interpretation of the iron genes in the region.

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Magmatic rocks do not have much distribution on the ground. They were recorded in the wider Volar region, in the north, and in Trnava, in the south. They are especially isolated, although they are usually part of the Triadian, or Ladin Vulcanogeno-clastic formations. Certified are diets, diabases, keratophores and riolites were found to make effusive members of the Porfirith-Rosemary formation [14]. In Dinarides this formation is a very important magmatical control factor of polymetallic mineralization with specialties on mercury, iron, lead-zinc and manganese [15].

The structural factors for mineralization in carbon rocks were mostly directly influenced by their tectonic cracks. This is especially true for limestone olistolite blocks. A dense network of ruptures in them, formed in the process of rhytogenesis, has broadly opened the roads to later hydrotherms. They were circulating in large quantities through the systems, causing metasomatic processes and mineralization. Indirect but significant importance for mineralization throughout the Ljubićki ore region had dislocation systems that played the role of inlet and distribution channels with hydrothermal melt and solvents. From all the data we have, we slowly discover and reconstruct these important ruptures, although they are rather masked by subsequent geological processes. In Adamuša and South Tomašica, paleopucto-decimetric dimensions, filled with siderite and siderite with silicon, have a completely identical orientation with a regional rupture mega-assembly. Two of their conjugated systems were provided with NW-SE and NE-SW [3]. The younger generation of the system of alpine cracks and faults has allowed hypergene oxidation processes, ie conversion of primary siderites and anchorite into lemons. In carbonate rocks, in which there was a high coefficient of cracks, especially with the participation of gagging cracks, limonitis penetrated deeper and broader into the terrain.

The hypergenic control factor significantly influenced the formation of oxide iron ore. Depending on the depth of the terrain, which was penetrated by oxygen-rich surface waters through the system of young cracks, the extent of the primary carbonate iron ore (siderites and ankerites) was converted into oxide ores (compact and powdered limonite).

In the ore bearing of the olistostromic member, there are several irregularities significant for the methaloenia of the region. First, the arrangement of carbonate olistolite bodies in a member is irregular, that is, chaotic, which is very important because of the special importance of their commercial rudeness. Second, extremely uneven and diverse are the size, shape and morphology of these bodies and their boundaries, and when they are primary and when they are tectonic. Changes in the thickness of the ore body range from several tens to 100 m and are mostly abrupt in terms of thickening and thinning. The lateral ore bodies gradually move into the surrounding rocks, crawl or suddenly break off. Only extremely ore bodies have statiform morphology and inner texture. Thirdly, not all of the olistolite bodies have been plastered, but only some of them. In addition, two adjacent bodies can both be bored, but also one can be brazen and the other completely without mineralization. Fourth, olistolite bodies can be completely or only partially processed, and they are only minimally mineralized (up to the level of ferrous limestone or dolomite). Because of this, both the ore bodies and deposits "do not have continuity but appear isolated" [4]. In addition to all of the above, "The content of metals in carbonate ores of iron and their secondary products varies at wide intervals."

Ore bearing of this ores ore makes ore minerals in the deposits, such as bauxite and antimony, in which the degree of risk in investigative works on blind ore bodies is very high. The above-mentioned gross irregularities, however, are not characteristic of the overgrown dust limonite ores in the lake sediments of the quaternary quaternary. These ores appear in the form of more or less regular lenses of various dimensions in which the quality of the ore is somewhat worse but persistent. The amount of iron decreased (40 to 50%) and the increased content of SiO_2 (16-17%) and Al_2O_3 (6-8%).

Regionalization and classification of area

The basic tasks and goals of the development of the metallographic map of the Ljubija ore region were: determination of the type and contour of the region within which the ore zones, ore nodes and ore fields are defined, then analyzing and presenting the basic principles of formation, spatial and temporal distribution of deposits and phenomena of iron and other mineral raw material, and finally the terrain pitching for the detection of deposits of iron [16].

First, a geological basis was created, on which geological units and structural data were separated, adapted to the metalogenetic situation of this area. This means that on the surface, the geological elements that they have and can play the role of ore control factors on the surface are the most complete and, if necessary, especially emphasized while the rest are given at the required level.

The geological basis was based on the Basic geological map and using all available geological maps of larger scale and other geological documentation. Geophysical and geochemical data were used. Data on absolute age and isotopic relationships have been analyzed for the magmatic rocks for which the genetic link with labor is assumed. The structural elements on the basis of which the region and the smaller metalogenetic units have been separated, as well as those who played or could play a role in the arrangement and localization of the mineralization of the iron and the accompanying mineral resources are adequately represented on the geological basis. Also, the structural elements that characterize mutual relations and the greater deformation of rock masses are also sufficiently detailed.

The basic mineralogical elements are adequately represented on a geological basis and represent the basic content of the metalogenetic map. The main mineragenetic elements are ore deposits, ore and mineral phenomena. Also, other mineragenetic elements are especially shown: endogenous changes in rocks related to the processes of mineralization and mineralization, breeding holes, geophysical anomalies, magmatic rocks, ore formations, ie their divisions and horizons, exogenous creations resulting from the transformation of ore mines or representing the decay of the ore.

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The prognosis map represents the ranking of perspective surfaces at today's level of research. Until now, two or three more serious maps of this area have been published. One of them is the map of M. Šarac [2], where the phenomena and deposits of iron are deposited within, in his opinion, productive all the carbon deposits of the Una-Sana paleozoic. According to the aforementioned author, they are perspective surfaces, and non-perspective would be all those peripherals that are built by other stratigraphic units.

The prognosed map was prepared according to the Instructions for the production of metallographic map 1: 50000, although other instructions and methods of making such maps are similar. Different areas are marked according to perspective, taking into account quantitative (appearance and size of ore bodies, excavated masses, potential reserves ...) and qualitative indicators (primarily chemical composition of ore), then control factors (stratigraphic, structural, lithological, geochemical, magmatogenic and hypergens) and indication of mineralization (minerals, circumstantial changes, elements indicators, minerals indicators, geophysical anomalies, geomorphologic forms, traces of mining).

In general, 3 major categories are shown on the map, and these are: perspective areas where research is justified from four groups of terrain, from those first degree to insufficiently researched, areas on which no additional research is required at this moment, whether it was already examined at elements present in the ore region and obtained negative results or surfaces whose geological structure according to known data is unsuitable for the education of economic concentrations of ore elements, and the third - unpredictable surface outside the mining zones and nodes. The selected areas are the most commonly geologic whole according to the degree of research, and can be further reclassified by further research into units of different perspective.

4. CONCLUSION

1. The Ljubija ore region is part of the triadian, regional, internal metalogenetic zone of the Middle Dinarides. It is located approximately in the middle of this larger metalogenetic unit and has many common features with its other parts. It implies a complete ore territory of about 1500 km2 characterized by identical geological conditions and development of ore formations and types of economic deposits of iron and other mineral resources. This striking zonal regularity is obviously not accidental, but it is related to the geodynamic development and the accompanying structures formed in this dinaric segment of the Earth's crust.

2. The geological structure of the terrain, its origin and all the collected data about ore show that the main mineralogizing factors in the Lubija ore region were: stratigraphic and structural, lithological and geochemical, accompanying magmatogens and hypersensitivity. Amongst these, they stand out stratigraphically because the main concentration of the oleic ore and the appearance of iron is found almost exclusively in carbonaceous materials, especially in the olistostromic member.

3. It is very important, in further research, to take into account the metalogenetic factor of irregularities, which for the region has been clearly identified for the first time. The arrangement of carbonate olistolite bodies in the member is chaotic and difficult to predict, their size, shape, morphology and boundaries are incorrect. Then, not all olistolitic bodies are labor and the work is diverse: sometimes complete, sometimes partial or minimal, often irregular and rarely stratiform and, most importantly, with considerable variation in the content of metals. Because of this, mining bodies and deposits have no continuity in providing, as they were attributed to earlier interpretations on the profiles in the calculations for the reserve budget. This is the reason why the risks in their search and research are quite pronounced. The abovementioned irregularities, however, are not characteristic of the overgrown dust limonite ores in the neogen-quartar.

4. The main recognized prospecting indications are: laying of ore deposits and phenomena, circumstantial changes, geochemical analyzes, elements of indicators, minerals indicators, dislocation and ring structure, geophysical anomalies and all forms of old mining and smelting, indicate the possible existence of phenomena and deposits of mineral raw material.

5. In order to minimize the risk, further research on primary iron ores should be directed exclusively to the search for carbonate olistolytic bodies in the carbon olistostromic member of the javoric formation, whether discovered on the surface or in the underground. Iron ore should be searched only in the Neogen-Quarter of the Prijedor-Omarska Basin. Mostly in his southern half.

6. Due to the fact that most of the known and exploited deposits were at least partially detected on the surface, in further searches for underground ore bodies, the prediction should be given to new geophysical studies and systematic structural drilling.

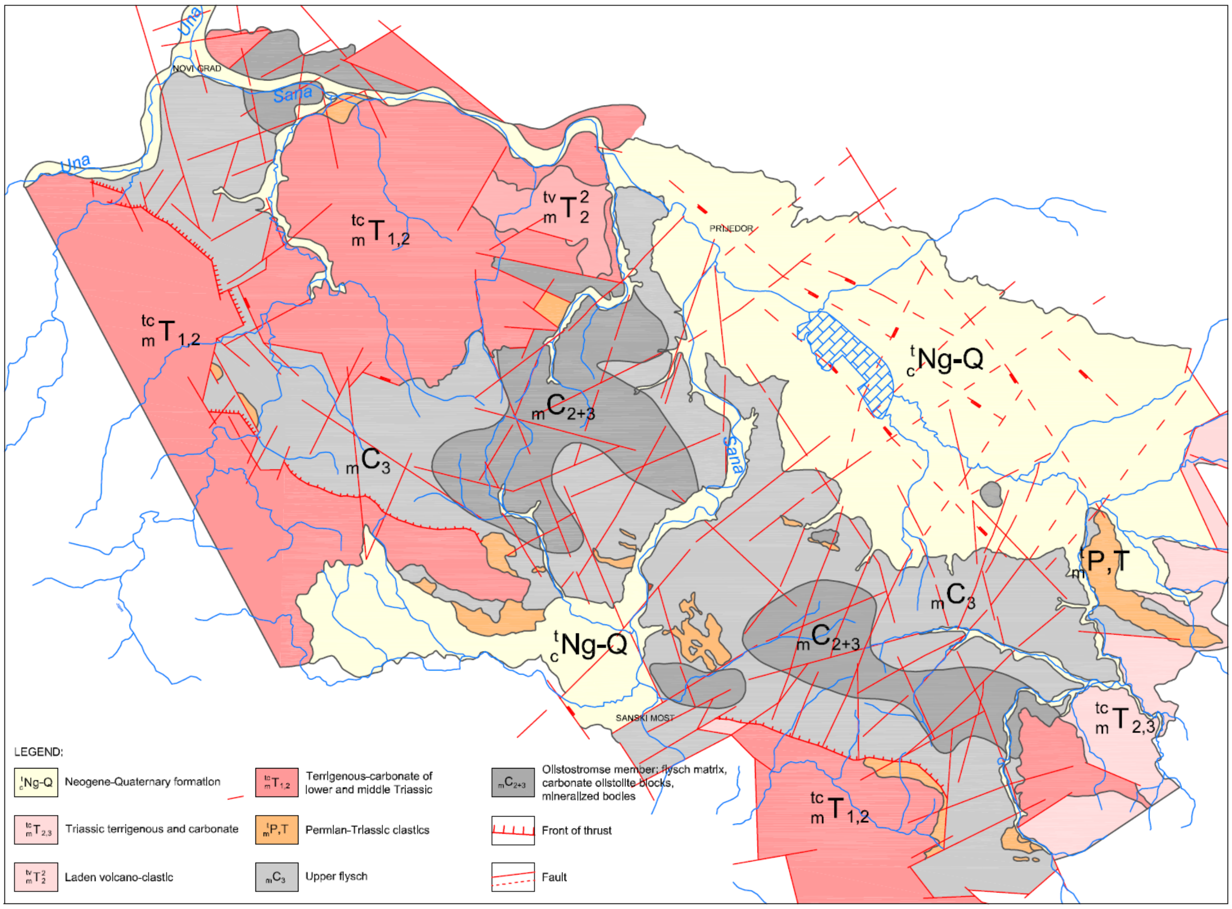

Figure 2 Schematic representation of the geological base for metallogenic map of Ljubija area [2,5]

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ACTUALITY OF APPLYING GEOLOGICAL-ECONOMIC EVALUATION IN MANAGEMENT ACTIVITIES IN THE MINERAL SECTOR

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ABSTRACT

Modern management activities in current working and business conditions in the mineral sector and mineral economics of Serbia require the utilisation of various management tools in order to prepare, bring about and implement necessary business and expertise decisions. Given the revitalisation of work and business market criteria in the mineral sector, economic evaluation and the issue of the feasibility of mineral raw materials geological exploration, its exploitation, preparation and processing until being sold on the market are of special significance. The geological-economic evaluation is an extremely useful management tool, containing key data and information concerning economic conditions and geological exploration feasibility, the utilisation and market valorisation of mineral raw materials. The geological-evaluation's structure, factors and indicators ensure that the manager's activities, which are important for productive business management as well as success in the mineral sector, are successful, efficient and effective, in accordance with the adequate business policy and development strategy.

Key words: geological-economic evaluation, mineral raw materials, management, manager.

1. INTRODUCTION

Further transitional alignment of Serbia's economic activity is particularly linked to the need to accelerate the production of materials, ensuring basic economic growth and an increase of the country's GDP. The mineral sector and mineral economics play an important role in that process, given the fundamental role that numerous mineral raw materials play in production and the accompanying dependency of the working and functioning of a range of branches of the industry on them[1]. Despite the dual feasibility of mineral raw materials, commercial and national feasibility [2], also present in the mineral sector is the application of market criteria of deposit economic evaluation as well as determining the feasibility of acquiring and exploiting mineral reserves. In accordance with that trend, which impacts the geological, economic, financial, legal and other conditions of geological work, there is a need for the faster introduction of efficient geomanagement [3], as well as more efficient planning, programming and realisation of market justified geological exploration. In addition, especially pronounced is the need for the complete assessment, study and market definition of geological-economic properties of Serbia's mineral resources [3].

Experience concerning mineral reserve economic evaluation which is several decades long and has been applied in countries with free-market economies and developed mineral economics (the USA, Canada, Australia, the countries of the EU etc.), has yielded valuable methodological and practical solutions for the advancement of economic geology and modern practice in the economic evaluation of mineral deposits in Serbia. Adequatedirectivefor geological and management work in the mineral sector were especially significant in the temporary, transitional period of Serbia's mineral economics.

Unlike earlier periods when classic commercial feasibility studies were not utilised in Serbia, geological explorations of mineral resourcesin the current period deal with metallic, non-metallic mineral raw materials and energy resource deposits primarily as a basic economic category. The presence of foreign, competitor exploration companies necessitates additional high-quality geological activities regarding all aspects of geological exploration management and mineral resource management. With the gradual increase in economic activity, the need for larger amounts of certain mineral raw materials has also risen in Serbia, which also means the larger scope of geomanagement and geological project activities, entailing a qualitatively higher and more competitive level of geomanagement in general.

The issues that this paper deals with are in small part based on some basic economical-geological postulates and management expertise elements [4-9]. More importantly, it represents the continuation and advancement of thorough analytical-synthetic, induction-deduction and systematic, studious,specialised research conducted thus far in the domain of geological-economic evaluation, mineral resource consideration and in the domain of geomanagement [10-18]. Overall, the main goal of this paper is to draw attention to the applicative significance of geological-economic evaluation as a methodological procedure which considerably facilitates management activities by assessing all relevant geological-economic evaluation factors and indicators, especially regarding the economic rationale for investments and mineral reserve utilisation profitability.

2. CURRENT GEOLOGICAL-ECONOMIC EVALUATION OF MINERAL RESOURCES

Given the prior expert, socioeconomic and political specificities of the development of the Belgrade school of economic geology in Serbia [19], the existing model of deposit economic evaluation was considerably altered, rounded out and modernised at the beginning of the 21st century.A change that was of particular importance was the practical introduction of market criteria of evaluation and the definition of three key elements in economic evaluation: (a) mineral raw material quality, (b) mineral raw material reserves and (c) mineral raw material value i.e. profit that could be gained from the mineral raw material. Methodologically speaking, in contemporary economic evaluation of mineral reserve feasibility and work carried out on exploration, exploitation and valorisation of mineral reserves from explored deposits, the following three types of evaluation are the most utilised [13, 17]: (a) prefeasibility study/analysis; (b) feasibility study/analysis; and (c) geological-economic and technical-economic evaluation. These evaluations stem from practically identical basic elements and use the same models for determining deposit value, though they compose factors and evaluation indicators differenly. In countries with developed market economies, prefeasibility and feasibility studies (analyses) have been used for decades to evaluate the economic significance of deposits. In many Eastern European countries, geological-economic evaluation used to represent, and partially still does, an integral component of the process of geological exploration. It should be noted that at the end of each stadium of geological exploration, geological-economic evaluation represents the basis for the rational planning of exploration, its economic effectiveness evaluation, commencement of further exploration as well as timely and effective discovery of mineral resources.

In Serbia, in the Belgrade school of economic geology, the geological-economic evaluation of the occurence and deposits of mineral raw materials was developed and conducted. However, despite its numerous advantages, it did not fully take off in the practice of programming, projection and mineral resource exploration [19]. In Serbia, the issue of the content and necessity of geological-economic evaluation at the end of individual stadia of geological exploration is neither consistent nor regulated precisely. In existing legislation, instead of geological-economic evaluation, the term technical-economic evaluation is primarily used, representing a modified and, to a certain degree, narrowed term for geological-economic evaluation. Overall, the geological-economic evaluation has, with its existing factors and indicators, a broader and more inclusive scope than the prefeasibility and feasibility study and represents the basis for choosing priority directions in geological exploration, optimal assessment of results achieved within the individual stadia of geological exploration and the basis of granting concessions and assessing capital value. In future geological-economic work, advancements in the model quality of its individual elements of the prefeasibility and feasibility study await, with special emphasis placed on the renaming of the existing technical -economic evaluation into the geological-economic evaluation.

By using a systematic-analytic approach, the geological-economic evaluation of mineral resourves can be represented as the hierarchically highest system consisting of subsystems expressed through concrete factors [13]: metallogenetic, geological, mining, technological, market, regional, social-political-economic-strategical, legislative-legal and geoecological. Evaluation indicators, significant for the completeness of the depiction of the subsystems, can be grouped into natural, economic and synthetic. Economic and synthetic indicators are especially valuable for the market since they, when linked to the natural indicators, play a key role in determining the possibility of profitable utilisation of evaluated mineral reserve.

Geological-economic evaluation is particularly important as the basis for making geomanagement decisions if the resulting evaluation regarding further exploration is positive or, should the evaluation be negative, in making the geomanagement decision for the timely cessation of any further exploration activities i.e. the permanent or temporary cessation of geological activities and investments into certain geological exloration projects and mineral resource acquisition. Utilising a modern geological-economic approach in expert, exploration and engineering work has yielded a significant improvement in the methodology of the geological-economic evaluation through the application of modern and market methods of economic evaluation such as the Discounted Cash Flow method, NPV, IRR, the Benefit-Cost analysis etc. [13]. The economic evaluation of the results of geological exploration and the market definition of identified, determined and proved reserves of mineral raw materials is particularly significant for the geological exploration of metallic, non-metallic mineral resources and energy resources.

3. GEOLOGICAL-ECONOMIC EVALUATION AND GEOMANAGEMENT ACTIVITES

After adjustments in the social, economic and political system in Serbia, the demands and circumstances of geomanagement activities and the further development of geomanagement implicitly conditioned the need for responsible, expert and professional geomanagement and orientation in complex transitional conditions. For the further development of Serbia's mineral economics and the conditions and way of functioning of its mineral raw material complex, the issue of mineral resource management becomes a particularly important question, with three key components [3]: (a) the successful definition of geomanagement bases which is, among other things, reflected in the definition, adoption and implementation of mineral policy and mineral strategy, including the strategy of sustainable mineral resource use and its practice in the relevant functions of management; (b) the assessment, definition and structuring of geomanagement work, functions and tasks; and (c) the geomanagement activity of capable, efficient and effective managers with the adequate skills, knowledge and abilities.

Geomanagement activities realised in geo-organisation include management work, functions and tasks. From the aspect of management, all works related to the planning, preparation and execution of geological activities and accompanying works, can generally be divided into two basic groups [3]: (a) management and (b) nonmanagement work. The first type of work includes determining work tasks, organisation, coordination, direction, monitoring, control and lessening employees' work load in geomanagement by the manager, while the other deals with concrete work processes and operations directly executed by operatives. Unlike nonmanagement work, management work is carried out at a higher level of the organisational hierarchy, above the first operative work level. At those levels, managers, ranging from the top to the bottom of the hierarchy, coordinate, direct and facilitate employees to work with the aim of realising concrete work tasks i.e. through delegated tasks, all in accordance with the aims of organisation. Apart from the director and his/her assistant geomanager, that title is also held by, for example, heads of sectors, heads of work groups/crews/teams of classic tasks and/or concrete projects of geological exploration, including the heads of field crews etc.

Being based on providing information, the factors and numerous indicators it contains, geological-economic evaluation is of direct significance for management work and indirectly significant for nonmanager work. The concrete plan activities and tasks are linked to the intial, geological-economic evaluation forecast which marks areas of potential interest regarding certain metallic, non-metallic or energy mineral raw materials. The preliminary processing of metallogenenetic and geological factors of the geological-economic evaluation, along with the monitoring of mining, technological, market and other factors, directly impacts the planning of adequate geological exploration projects according to the determined area, mineral raw material and degree of exploration. A certain conception and methodology of geological exploration, application of certain systems of exploration, exploration method and the definition of individual types and scopes of exploration works stem from this sort of geological-economic evaluation, especially the economic projections i.e. the financialrationale of a project. Based on the aforementioned, we can directly derive the specification of the type and scope of exploration works which are the basis for the definition of individual work tasks of geologists/crew members/team members i.e. the jobs and work activities of the manager's subordinates.

Within the scope of their regular management activities, responsibilities and authority, geomanagers carry out management duties which are do not coincide with company functions. The manager’s functions are treated differently and are separated into different development phases of management, with five distinct manager functions being distinguished in the modern approach [11]: (a) planning; (b) organisation; (c) employment; (d) influence and (e) control. At each level of the organisational hierarchy, the manager performs all of the specified management functions, regardless of the way they have been classified and defined, the size of the organisation (small, medium or large) and the type of organisation (public, private, PPP company, economic or non-economic). These functions are simultaneously standard functions, also performed by geomanagers in organisations which are linked to the management of mineral resources through analyses, activities, work and decision-making.

The greatest illustration of the importance of the geological-economic evaluation in geomanagement activities is during the assessment of the utilisation of evaluation results in order to conclude the economic rationale of planned geological exploration works and the accompanying geomanagement decisions based on such an evaluation, be it positive or negative. In the case of a negative geological-economic evaluation, when expenses exceed the cost price, the geological-economic evaluation retains its positive aspect, directly representing the basis fot a management decision concerning the discontinuation of investments and further exploration and, depending on individual reasons, the temporary or permanent cessation of geological exploration. Should the evaluation be positive, it becomes possibleto assess expected financial gains and, based on that, to prepare adequate arguments for securing investments into exploration as well as to plan the temporal scope and intensity of geological exploration, preparatory activities until the beginning of exploitation and the final valorisation of the explored mineral raw material and financial return on investment. In that way, the geological-economic evaluation acts as a high-quality basis for the manager's decision-making and communication, two important characteristics that all managers have in common. In geo-organisations and the work of geomanagers, the geological-economic evaluation can be beneficial when making all three types of decisions [3]: (a) strategic; (b) operational (tactical) and (c) administrative decisions. The geomanager has a variety of modern tools which facilitate decision-making at his disposal, among which operational research is worthy of mention, with techniques such as the network analysis, risk analysis, statistical decision theory etc. and in relation to individual geomanagement functions [11] the SWOT analysis, TOWS analysis, BCG analysis etc.

4. CONCLUSION

After the socio-political and economic changes which have occurred in Serbia, the working conditions of geomanagers have changed considerably. In the upcoming period, the concept of systematic management work on geological exploration, economic evaluation the mineral resource study is highly important for the successful working and functioning of geo-organisations and the successful management of Serbia’s mineral resources.

Currently, geomanagement in Serbia's mineral sector requires an urgent shift toward broader and more profound adoption of the management concept, as well as the induvidual assumption of management responsibility and duties based on geological-economic information. When carrying out numerous management work, functions and tasks, geomanagers must mostly focus on theirresponsibility of high-quality geological-economic information preparation and the laying the groundwork for decision-making, direct decision-making and the responsibility that such a decision bears on the working, functioning, development, success and profitability of the company as well as the work results of the manager's subordinates who carry out operational work tasks.

The comprehensive and complex activities regarding the study of the place and role of geological-economic evaluation in geomanagement in the management of Serbia's mineral resources will commence in further, diligent scientific research and applicative work. A part of the activities will especially be focussed on detailing and the multimodel study of geological-economic evaluation relations – individual functions of geomanagers, in order to place information concerning economic geology and geological-economic information into the active function of geomanagement and decision-making in the successful management of mineral resrouces and the further development of Serbia's mineral economics.

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GEOLOGICAL-ECONOMIC MODELLING IN CURRENT CONDITIONS OF ORE DEPOSIT EXPLORATION

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ABSTRACT

Current working conditions and mineral sector functioning inSerbia's mineral economics necessitate a higher degree of economic analysis and an evaluation of the profitability of mineral reserves in ore deposits. Therefore, it is of the utmost importance that ore deposits be well defined both geologically and genetically in the basic part of geological exploration as initial geological objects, in addition to the quantitative and qualitative definition thereof. Further in the research, the economic component, in addition to the geological, is especially emphasised, with the market criteria of profitability of the total geological, mining and technical work on the subject ore deposit included. Encompassing and depicting the set of a large number of factors and indicators regarding the geological-economic evaluation of the deposit in modern economic geology is done by performing geological-economic modelling of the deposit. It enables the creation of partial submodels and their integration into a complete geological-economic model with the aim of a total and systematic encompassing of all geologically and economically significant properties of the ore deposit.

Key words:economic geology, geological-economic modelling, ore deposit.

1. INTRODUCTION

The successful functioning of a country's mineral sector, mineral economics and other numerous branches of the economy directly depends on geological exploration, exploitation and the market valorisation of a multitude of metallic, non-metallic and energy resources. Depending on the ore deposits present in the country and the degree to which production is engaged, one part of the mineral resources required by the economy is supplied domestically and the other through imports. Economic geology plays a significant role in defining profitability when performing market valorisation of subject ore deposits. The existing transitional and economic trends of mineral resource economics are focussed on market-oriented principles and criteria for the planning and realisation of the production of required mineral resources. Accordingly, there is a pronounced need to introduce and implement efficient geomanagement [1], the concept of sustainable development [2] and the necessary thorough study, assessment and market definition of key geological-economic properties of ore deposits [3] in the mineral sector.

In developed economies such as the USA, Canada, Australia and the countries of the EU, the economic evaluation of deposits is primarily conditioned by profit and commercial value of the reserves exploitable from the deposit, which could later be processed and successfully financially valorised. Practically, there are three key elements present in these evaluations [3]:(a) the quality of the mineral raw materials; (b) mineral reserves and(c) the value of the mineral reserves, the profit that could be made.

The decades of experience regarding implemented and verified economic criteria and evaluation methods from these countries [4-9], have been very useful in furthering domestic economic geology [10], and current practice in geological-economic evaluation of domestic mineral resource deposits.

The complex geological-economic evaluation of deposits in Serbia has recently been improved and modernised significantly, which has, among other things, led to the domestic introduction and development of geological-economic deposit modelling [3], considerably facilitating systematisation, processing, interpretation and ultimate depiction of numerous geological and economic information [11,12]. By implementing the current model approach, the values of different factors and indicators of geological-economic evaluation are depicted in a number of individual submodels and a complete geological-economic model of the deposit. The aim of this paper is to emphasise the place, role and significance of geological-economic modelling in current conditions of ore deposit exploration as a valuable methodological approach which considerablyfacilitates geological-economic monitoring, consideration and the lucrative eval
uation of ore deposits.

2. GEOLOGICAL-ECONOMIC MODELLING WITH SYSTEM STRUCTURE

The development of economic geology and the trends of expansion and improvement of modern scientific and theoretical knowledge, including practical implementations have facilitated a suitable transformation and improvement of geological-economic evaluation [13,14]. In the past two decades, the form and direction of its development was most significantly impacted by economic and market conditions, the utilisation of the modelling method and system analysis i.e. often-utilised systems engineering. The incorporation of the modelling method into geological-economic evaluation resulted in geological-economic modelling, while the introduction of the modern systematic, analytic and synthetic process has yielded additional quality regarding the model's system structure. The system approach to the elaboration of initial theoretical bases and practical implementation of geological-economic evaluation is necessary for the examination and processing of the whole geological-economic problems of the deposit.

Geological-economic modelling represents an integral way of depicting corresponding elements and the stages of geological-economic evaluation of ore deposits as an analytical and synthetic process and procedure, through the creation and functional implementation of different types and structures of the pertaining submodels [14]. When aligned with the model of geological and economic indicators and elements, geological-economic modelling, consisting of two components, is based on several basic principles [13]: (a) the principle of uniqueness; (b) the phase principle; (c) the principle of being temporary; (d) the principle of analogy; (e) the principle of multiple parts; (f) the principle of model evolution; (g) the principle of convergence and (h) the principle of representativeness.

The geological-economic modelling of the deposit which, up to a certain point, represents the implementation of the analogy method on a combined geological, economic and mathematical level, between the deposit as a geological-economic object and the set model, represents a complex and comprehensive issue, initially requiring a large amount of data and information. Depending on the encompassed scope of geological-economic information, two general groups of geological-economic models can be distinguished [13,15]: (a) partial and (b) integral.

The geological-economic evaluation of ore deposits, being the complex process and analytic and synthetic procedure that it is, is represented by a set system with characteristic groups of factors as subsystems and indicators as elements. They can be depicted by corresponding models i.e. submodels acting as constituents of a lower order. This systemic approach allows the geological-economic evaluation to be depicted hierarchically as a classic relation between part i.e. with a general structure: system-subsystem-elements. Consolidating the parameters into subsystems and the subsystems into a system makes it possible to determine characteristic groups of data regarding the evaluated deposit and creates the conditions for a total, systematic and all-encompassing geological-economic study of the deposit as the object of economic evaluation.

The geological-economic evaluation of the deposit, which is the highest hierarchical system depicted by the model, consists of subsystems expressed through submodels which, in their complete form, can be [3]: metallogenetic, geological, mining, technological, legislative-legal, market, regional, social-political-economic-strategic and geoecological. The significant elements for depicting these systems fully can be grouped as natural, economic and synthetic. Among the numerous indicators of economic, natural and synthetic properties which are the basis of the geological-economic evaluation and its factors, there are close correlative and functional dependencies and they need to be grouped into certain subsystems i.e. submodels within the complete geological-economic evaluation system. The number of these subsystems varies depending on the type of mineral resource, degree of deposit exploration and investigation i.e. the stage of exploration after which the geological-economic evaluation is carried out. Geological-economic modelling of ore deposits in Serbia with this sort of system structure and form has existed for some time. However, an integral geological-economic model has only been created for the polymetallic deposit *'Rudnik'*, while partial geological-economic models have been created for a range of smaller deposits [3].

3. ACTUALITY OF GEOLOGICAL-ECONOMIC MODELLING

In current trends of more extensiveimplementation of project standards from countries with developed economies, especially important is a professional overview of the relation between geological-economic evaluation and the prefeasibility and feasibility analyses. The geological-economic evaluation and the geological-economic model are significantly more comprehensive and all-encompassing, containing data and information based on which elements needed for carrying out either analysis can be singled out and regrouped. From that aspect, in the final stadium of preliminary geological explorations the geological-economic evaluation, as has been conducted thus far in Serbia, corresponds to the prefeasibility analysis content-wise and corresponds to the feasibility analysis at the end of detailed geological explorations [15]. Therefore, geological-economic evaluation may justifiably be utilised in the future, especially for improvement through geological-economic models of mineral resource deposits with existing inclusion of new market methods of geological-economic evaluations of mineral resources. Additionally, in order to successfully carry out all of the work related to the geological-economic analysis, it is also crucial that the numerous elements of organisation [16], economics [17], management [18], marketing [19], geoecology [20], computer science etc. also be included in the complete geological-economic analysis.

An especially practical aspect of the geological-economic model of deposits are the accompanying research functions which offer possible additional and more detailed geological and economic analyses and include [13]: (a) exploring the geological-economic model itself; (b) exploring the modelled deposit and (c) advancing and improving geological-economic knowledge of the modelled deposit. The aforementioned research functions are especially important for increasing the reliability and representativeness of the created model and its qualitative upgrade whose ultimate goal is more efficient and effective research and exploitation and more profitable work.

Autor's research and analytic activity conducted thus far on geological-economic modelling of mineral resources in Serbia has had three phases. The first, initial stage included the collection of needed data and information in order to perform initial assessments and choose strategically high-priority mineral resources and deposits which are in the interest of Serbia's further economic development. The second phase included a thorough study of international discoveries regarding geological-economic evaluations and geological-economic models in the past decade, so as to implement the latest scientific expertise and geological-economic scope and positive experiences from abroad in Serbia concerning further geological-economic evaluation and geological-economic modelling. Currently, there is an ongoing broad and comprehensive analytical phase dealing with the study of the properties of certain mineral resources and the most significant ore deposits, along with the elaboration of a complex synthetic model of chosen 'benchmark' deposits according to individual mineral resources. The upcoming elaboration of geological-economic models is of particular importance, especially in the part concerning geological-economic parameters for deposit evaluation, in accordance with modern transitional conditions and market criteria, similar to developed mineral economies.

When economic geologists are performing complex procedures under current research conditions, a geological-economic evaluation of a deposit is an integral part of their work activities. The geological-economic evaluation is also referred to as a technical and economic evaluation in the part of legislation concerning the ore reserve study. The temporary nature of a geological-economic evaluation, meaning the cross-section of time in which its factors and indicators are valid, necessitates geological-economic monitoring of changes in the evaluation's elements and, should a change occur, making a new evaluation. There are two aspects of particular importance in geological-economic monitoring:(a) geological; and(b) economic.

The geological aspect of geological-economic monitoring primarily refers to the state of mineral reserves i.e. their amount, the quantityand quality variability in the area of the deposit. Monitoring this aspect is conducted by monitoring the state of geological, balance, exploited and industrial reserves and their ratio. This data is considerably easier to monitor operationally in the corresponding parts of the deposit's geological-economic model, especially its geological part.

The economic aspect of geological-economic monitoring refers to economic indicators i.e. indicators of value, among which the following are the most significant: (a) the production cost of 1t mineral raw materials with the complete structure and amount of expenses included; and (b) the selling price of 1t of extracted mineral raw materials which depends on market conditions i.e. supply and demand as well as domestic and stock market prices. Based on the relation between the aforementioned value indicators, the balance of mineral reserves and profitability of the entire geological-mining-technological work on the valorisation of the subject mineral raw materials can be determined.

With the geological and economic aspects of the geological-economic model presented, the deposit's most essential characteristics in the geological-economic work in the mine have been included, which is why it is necessary to intensify the practice of making appropriate geological-economic models and their practical implementation. Their implementation is also significantbecause of two important reasons: (a) practical; and(b) economic reasons.

The practical reasons are: facilitated monitoring of the state of mineral reserves, the planning of exploitation geological exploration, making plans for follow-up exploration of deposits and mineral reserve and resource management of the deposit.The economic reasons are: monitoring the work profitability on the valorisation of explored and extracted mineral resources, cost management, company resource production management, efficiency and effectiveness of geological exploration and business economics. That being said, there are numerous, justified reasons for intensifying efforts to implement geological-economic modelling in the practice of geological exploration in order to ensure more successful production and economic management of companies which are the bearers of exploration, exploitation and valorisation of the subject mineral raw materials on the contemporary market both at the level of individual deposits and the level of the mineral sector and mineral economics.

4. CONCLUSION

Within the scope of the modern geological-economic approach, especially significant in the work on deposits in economic geology are the following: (i) geological-economic evaluation in various forms and stages of exploration; and (ii) geological-economic modelling of the deposit. Recently, the complex geological-economic evaluation of deposits in Serbia has been considerably advanced and modernised which is, given the circumstances in the country among other things, resulted in the introduction and development of geological-economic modelling of deposits.

The implementation of geological-economic models is significant because of practical and economic reasons. In the altered economic conditions in Serbia, geological-economic modelling of mineral deposits must function as a tool for the appraisal of real geological-economic significance of deposits and the generation of profits from mineral raw materials, by incorporating commercial and national feasibility as well as respecting the demands of geoecology and the elements of sustainable use of Serbia's mineral resources. Therefore, there are justified reasons for intensifying efforts to implement geological-economic modelling in geological explorationboth at the level of individual deposits and the level of the mineral sector so as to secure the prerequisites for the successful economic management of companies which are the bearers of exploration, exploitation and valorisation of the subject mineral raw materials. All of the aforementioned serves to augment the functioning of Serbia's mineral economics in the forthcoming period of its social and economic development.

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SPATIAL GEOINFORMATION SYSTEM FOR MINERAL RESOURCES

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ABSTRACT

The paper provides an overview of the information system of the mine that was designed with the intention of achieving the database of geological and mining data and monitoring exploitation as a basis for the development of mines and research that tell us that geological, mining planning and programming are of great importance as information that would lead to further exploitation to ensure the highest level of mineral resource utilisation.

All of these parametres were observed and analysed according to the most up-to-date studies and methods that regulate this problem.

This paper presents the structure of the database as the basis for the development of the mines.

Therefore, the paper discusses the advantages and disadvantages of this method of modeling geological and mining data that would lead to technology development and their applicability.

The idea behind it is to develop a model of achieving exploitation and geological data as information that we need to show how important it is and how much it affects the efficiency and future of exploitation.

Key words: mineral resource, geoinformation system, research methods

1. INTRODUCTION

The municipality of Milici is a medium-developed part of the Republic of Srpska. A significant contribution to finding ways and possibilities to invest in new development projects, that is, detailed geological research in the above mentioned municipalities, is given by AD "Boksit" Milici.Geological explorations in the field of ore were carried out during the 1900s and until 2016.

By realising this study of geological explorations, the investor will learn more about the reserves (type, quantity, quality, position of the ore body) mineralogical and petroleum composition, the genesis of the mineral resources, as well as the possibility of preparing mineral raw materials and its applicability, about the economy and profitability of production for the market, and other parameters important for the work of future mines.

2. BAUXITE ORE IN AREA OF MILICI

Bauxite deposits of this area lie between Gunjak in the southeast (the border with the municipality of Srebrenica), through Rupovo Brdo, Stedra, Polom, Vrsin to Gerovi in the northwest. They are form one relatively narrow zone of 2-4 km in width, about 13 km long.

This area administratively belongs to the municipality of Milici and the exploitation of bauxite is carried out by "Boksit" Milici. The exploitation of bauxite in this area began in 1959 at Gunjaci site and soon after it spread to the site of Palez, where the exploitation took place until 1965. The deposits in Palez were exploited with interruptions for more than 40 years.

There are now untouched deposits of bauxite within this area: Podbracan - Bracan, Crvena stijena and Gerovi.

2.1 Red bauxite ore deposit Bracan

The red bauxite ore deposit Bracan is located near Milici. The study on the classification, categorization and calculation of geological reserves and quality was accepted by the Audit Committee, i.e. the reserves and quality were verified as of 30th September, 2008, as shown in the table 1.

Table 1. Balance reserves and chemical composition of red bauxite, ore deposit Bracan near Milici (state on 09 September, 2008) (Todorovic, 2008)

Category of reserves	Quantity of reserves	Al2O3 %	SiO2 %	Fe2O3 %	TiO2 %	CaO %	G.Z. %	Mod.
A	**665 683**	51,85	6,51	27,98	2,71	-	10,12	7,96
B	**706 856**	52,00	6,62	28,82	2,80	-	10,37	7,85
A + B	**1 372 539**	51,95	6,58	28,81	2,75	-	10,24	7,87

2.2 Red bauxite ore deposit Podbracan

The red bauxite ore deposit Podbracan is a continuation of the ore deposit Bracan, which together cover an area of about 523,000 m^2. The study on classification, categorization and calculation of reserves was accepted with verified geological reserves and quality as of 31st October, 2007, as shown in tables 3 and 4.

Table 2. Reserves of red bauxite, ore deposit Podbracan near Milici

Balance reserves (t)

А category	*296.134 t*
Б category	*5.469.810 t*
Total А+Б	*5.765.853 t*

Off-balance reserves (t)

А category	*24.723 t*
Б category	*1.968.087 t*
Total А+Б	*1.992.810 t*

Table 3. Chemical composition of red bauxite, ore deposit Podbracan near Milici with the average chemical composition of the bauxite ore:

Composition	%
Al_2O_3	52,48
SiO_2	6,79
Fe_2O_3	26,38
TiO_2	2,63
CaO	0,17
Loss by annealing	11,35

Due to the great depth of the deposit and the elevation height (about 400 m) of the roof deposits, at the current exploitation stage, overburden coefficient of about 1/6 has been reached so it is planned to reach the deeper parts of this deposit by the pit exploitation.

2.3 Bauxite ore deposit Crvene stijene

Bauxite ore deposit Crvene stijene is located between the villages of Pomol and Lukici, at an altitude of 564 m above sea level and it is not far from Derventa near Milici.

The bottom of the bauxite deposits is medium-sized limestone and in the peripheral northern part, on the smaller surface, there is Paleozoic limestone as determined by deep drilling (Buric & Zivaljevic, 1979). The surface of the bauxite deposit, which is determined with studies, amounts to 140,000m^2 with an average bauxite thickness of 16 m. The research of this deposit was carried out in 1960 and 1964, and with small interruptions until 1971. Bauxite is of variable chemical composition and the content of Al_2O_3 ranges from 41-59%, SiO_2 from 1-23%, Fe_2O_3 from 21-39%, TiO_2 from 1.55-2.90% and loss by annealing from 11-12.50%. Studies have proven that the reserves of bauxite of about 5,000,000 t with an average content of Al_2O_3 of 47.63% and SiO_2 of 13.26% (Buric & Zivaljevic, 1979).

Exploitation of this deposit started in 2005. An elaborate study of red bauxite deposits was prepared and geological reserves and quality were verified as of 31st December 2002. (tables 5 and 6).

Table 4. Geological reserves of red bauxite, ore deposit Crvene stijene (state on 31st December 2002) (Todorovic, 2002)

Category of reserve	Quanity (t)
Balance reserves (A category)	2.404.107
Balance reserves (B category)	2.423.702
Total(A + B)	4.827.809

Table 5. Average chemical composition of red bauxite,ore deposit Crvene stijene (Todorovic, 2002)

Components	$Al2O_3$	SiO2	$Fe2O_3$	TiO2	CaO	G.Z.	Module
Content (%)	50,57	7,98	27,67	2,80	0,10	11,23	6,337

3. STATISTICAL SIGNIFICANCE OF THE SPATIAL GEO-INFORMATION SYSTEM OF MINERAL RESOURCES OF THE MINES

Linking the locations of the GEOINFORMATION studies (images, graphic cross-sections, topographical plans, engineering and geological environments, etc.)

This burden of geoinformation research is of great importance in the modeling of functions and ranges to finding out the of the described and selected data of the highest criterion.

Goals and concept of the paper

As can be seen from the previous paragraph, the aim of this paper is to try to provide quality information regarding the remaining parts of the ore deposits predominantly meant for surface and underground exploitation, in the near future.

According to the concept of this paper, it is intended to implement such technical and technological solutions in order to meet the following objectives:

1. Continuity of production, that is, exploitation in accordance with the development programme of the mine;
2. Introduction, it could be said, of so far not used manner of exploitation (underground exploitation) which will be the basic manner of production in the mine in the near future;
3. Flexible and modern technical and technological solutions for further excavation of ore;
4. Economically justified mineral resource production.

4. SPECIAL PART OF THE GEOINFORMATION SYSTEM 2016

DESCRIPTION AND SELECTION OF INFORMATION
GEOLOGICAL INFORMATION
MINING INFORMATION

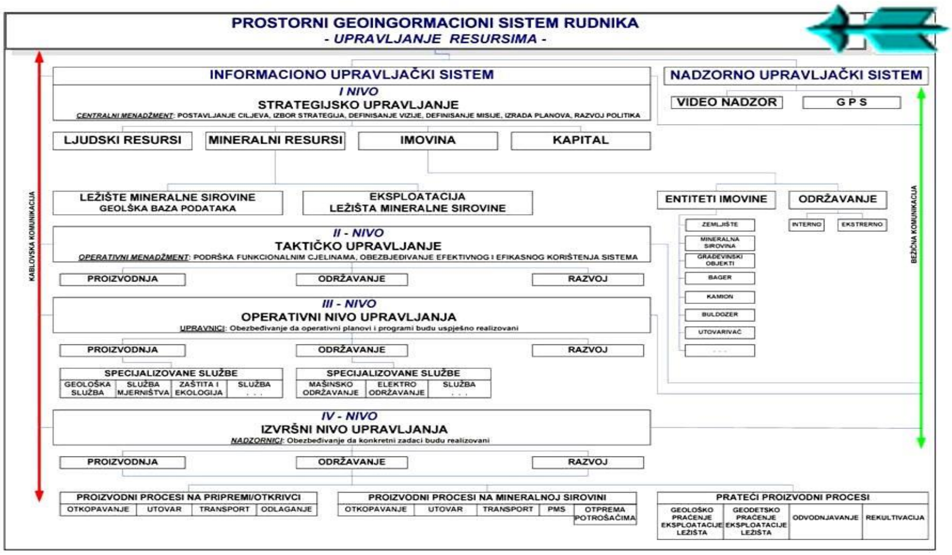

Figure 1. Spatial Geo-information System of the mine

5. CONSTRUCTION OF MINERAL RESOURSE INFORMATION SYSTEM

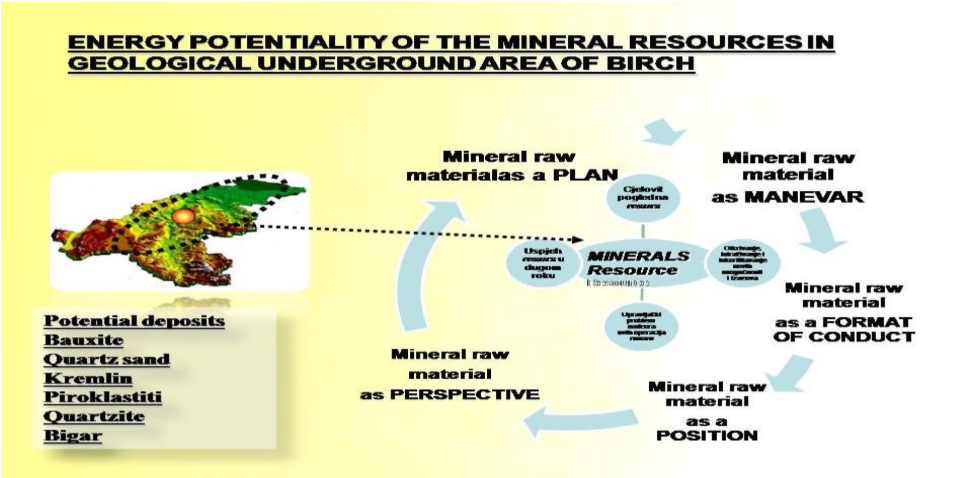

Figure 2. Areas for determining the main objectives of the S G S Mine

6. CONCLUSION

Based on the results obtained from the research, it can be concluded that this paper gives all relevant indicators from the domain of geological and mining research as well as its effects.

All known mineral resources - ore deposits and important phenomena in the territory of Milici are covered and shown. For each mineral, the geographical position, degree of research, chronological, stratigraphic superposition and reserves in detail researched ore deposits are shown.

As a result of intense geological explorations, carried out in the twentieth and beginning of this century, numerous deposits of metallic and non-metallic mineral have been identified and defined. The ore deposits of the mentioned mineralogical formations are defined.

The mineral potential of Milici is great. There are large available, explored resources and a good prospect of potential mineral wealth. The largest part of minerals noted in the area, and which are not classified as deposits, was rated as promising for further geological research of certain geological formations of zones and areas. The energy potentials make Milici one of the richer regions in Republic of Srpska.

Geological exploration changes the direction of scientific knowledge, geological and economic assessments and they are directed towards determining the economic profitability of the exploitation of the ore body. Findings and examinations done in this paper show us that research, planning and programming are of great importance as data that could lead to further research in order to utilize mineral resources as much as possible.

All the mentioned parameters were observed and analysed in accordance with state-of-the-art principles and methods that regulate this issue.

Finally, the offered mode of the INFORMATION MANAGEMENT SYSTEM, which will be some type of experiment, which, when it turns out to be justified, has its absolute perspective and possibility of application at other localities.

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INDUSTRIAL DUSTS AS POTENTIAL SOURCE OF EXPLOSION HAZARDS

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ABSTRACT

The biggest catastrophes in coal mines were due to explosions of coal dust or methane. These disasters occur in coal mines as well as in plants where coal is processed and continues to be treated (crushed, transported, deposited, etc.). These disasters should be warned by industrial plants to implement measures to protect against explosive dust. This involves regular testing and control of explosive dusts. In this paper explosive characteristics (flour, sugar and coffee) are presented and data comparative analysis with coal dust is presented.

Key words: explosion, dust, coal

1. INTRODUCTION

The first written note on possibility for explosion of mixture of coal dust and air is dated in 1803 with regard to explosion in the Wallsend mine in England. Since then started the intensive research on theoretical interpretation of explosion of mixture of coal dust and air. On the basis of the events from practice it was understood that explosions of the coal dust in mines have much more destructive effects and substantial consequences in comparison with other types of underground explosions.

Against threats of explosion of coal dust cannot be excluded the industrial buildings where the coal is processed both, in the procedure of processing or consumption.

It must be particularly pointed out that mot only coal dusts under certain condition are of capacity to explode, but many other industrial products, such as: dust of starch, grain, flour, dried milk powder, cocoa, sugar, powder of various detergents and soaps, paints and varnishes, oxide dust o various metals, and other.

According to data in literature may be noticed that no one country has been spared of explosions occurred in industrial facilities. These explosions cause victims and serious injuries with considerable material damages of facilities and equipment including loss in production.

2. SO FAR INVESTIGATIONS OF EXPLOSIONS OF COAL AND OTHER DUSTS

The Mining Institute in Belgrade deals with such investigations last 45 years starting in 1972. The research results were published scientific journals and presented in scientific conferences in the country and abroad. This work gives comparable review of explosive characteristics for the coal dust in the cave *Mramor* in BiH with dusts of sugar, flour and coffee (randomly selected).

3. CONDITIONS FOR DUST EXPLOSION

The main conditions that enable explosion are the following:

- Dust in explosive concentration
- Oxygen
- Ignition source
- Floating state of dust.

All conditions must be met at the same time for realization of an explosion, or simultaneously created.

Lack of any parameter will not prevent explosion of the dust. The natural dust ability toward explosion is determined by its physical, chemical, ignition, and explosive features.

Experiments on explosivity have been performed in the vessel of 40 liters.

4. TESTING RESULTS

In tables 1, 2, 3, and 4 are illustrated features of explosivity for coal from the cave Mramor, shaft Marići (1), flour (2), coffee (3), and sugar (4), randomly selected in the retail.

Table 1: Testing results of explosive characteristics for coal sample from cave Mramor, shaft Marići

Coal					
Measuring	Concentration [g/m^3]	Pmax [bar]	Pmax/Δt [bar/s]	dp/dt [bar/s]	Ek [bar/s]
Average	60	0,124	4,145	0,000	0,000
Average	125	3,506	9,818	14,605	11,947
Average	250	6,166	30,133	73,978	47,122
Average	500	7,320	55,994	123,653	82,996
Average	750	7,473	60,547	166,205	100,303
Average	1.000	7,316	57,218	132,577	87,016

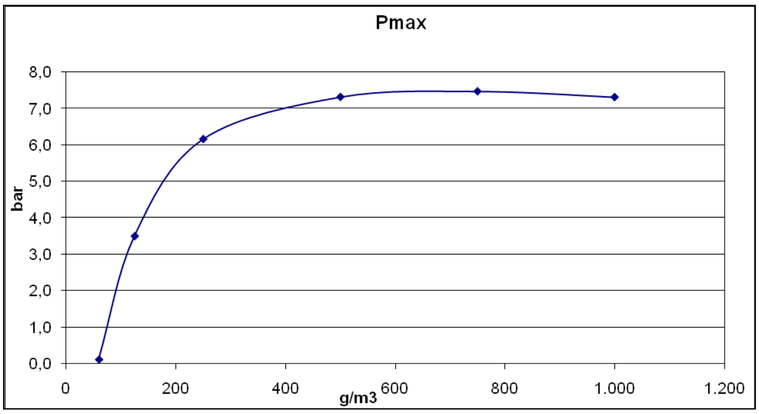

Figure 1: Graphic view of pressure increase

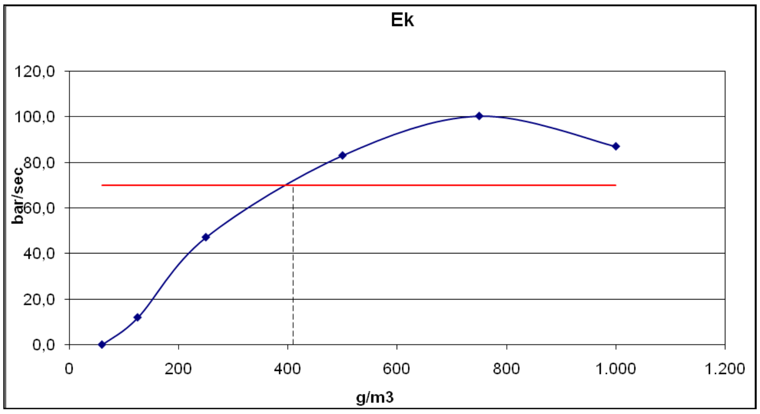

Figure 2: Graphic view of explosive characteristic change

Maximum pressure of explosion P_{max}=7,473 bar
Maximum time increase of pressure dp/dt=166,205 bar/s
Explosive characteristic – explosion coefficient K_{st}=57 bar*m/s

Table 2: Testing results of explosive characteristics for flour sample

Flour					
Measuring	Concentration [g/m^3]	Pmax [bar]	Pmax/Δt [bar/s]	dp/dt [bar/s]	Ek [bar/s]
Average	125	2,946	6,741	14,468	9,875
Average	250	5,116	20,881	54,012	33,583
Average	500	5,775	23,288	58,835	37,016
Average	750	6,314	25,458	79,090	44,872
Average	1.000	7,436	38,934	111,883	66,000
Average	1.250	6,982	34,215	94,118	56,747

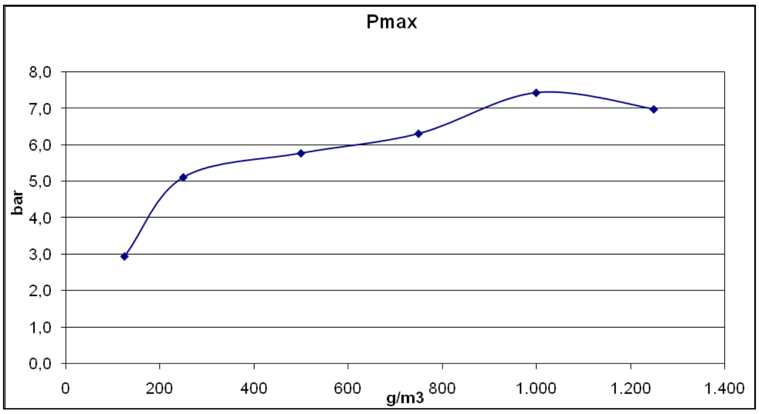

Figure 3: Graphic view of pressure increase

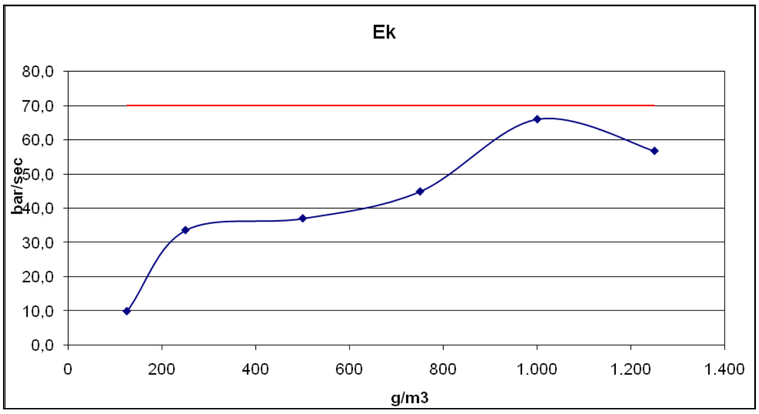

Figure 4: Graphic view of explosive characteristic change

Maximum pressure of explosion P_{max}=7,436 bar
Maximum time increase of pressure dp/dt=111,883 bar/s
Explosive characteristic – explosion coefficient K_{st}=38 bar*m/s

Table 3: Testing results of explosive characteristics for coffee sample

Coffee					
Measuring	Concentration [g/m^3]	Pmax [bar]	Pmax/Δt [bar/s]	dp/dt [bar/s]	Ek [bar/s]
Average	125	4,045	9,939	20,255	14,188
Average	250	4,427	11,559	22,184	16,013
Average	500	6,235	35,214	69,784	49,572
Average	750	6,712	47,120	78,994	61,009
Average	1.000	6,478	40,268	65,478	51,348

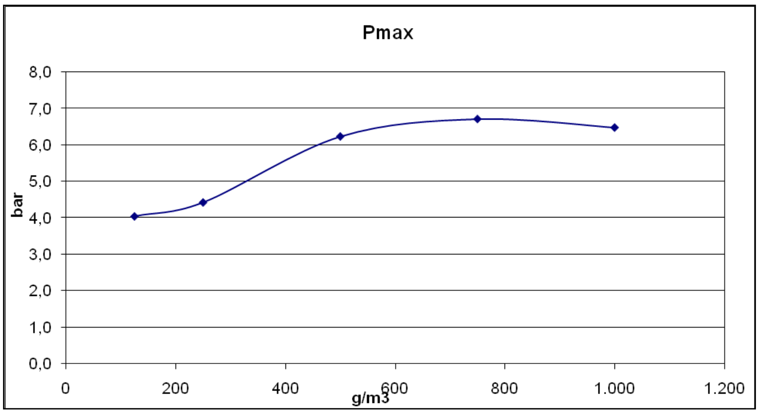

Figure 5: Graphic view of pressure increase

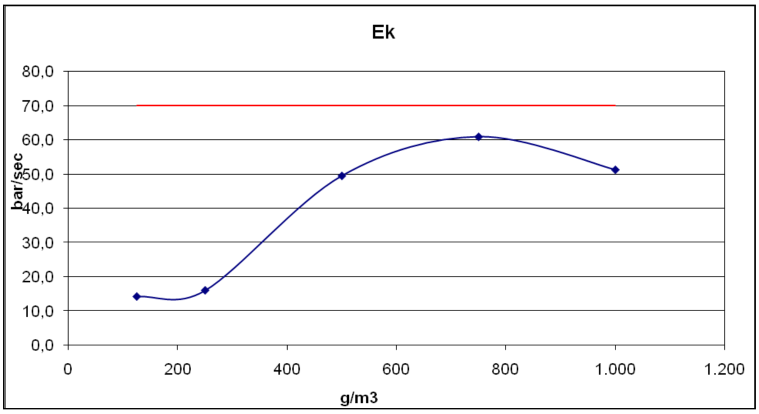

Figure 6: Graphic view of explosive characteristic change

Maximum pressure of explosion	P_{max}=6,712 bar
Maximum time increase of pressure	dp/dt=78,994 bar/s
Explosive characteristic – explosion coefficient	K_{st}=27 bar*m/s

Table 4: testing results of explosive characteristics for sugar sample

Sugar					
Measuring	Concentration [g/m^3]	Pmax [bar]	Pmax/Δt [bar/s]	dp/dt [bar/s]	Ek [bar/s]
Average	125	2,251	4,321	10,610	6,771
Average	250	4,334	13,056	28,935	19,436
Average	500	6,146	30,275	79,090	48,933
Average	750	6,578	39,478	102,477	63,605
Average	1000	6,349	29,547	89,264	51,356

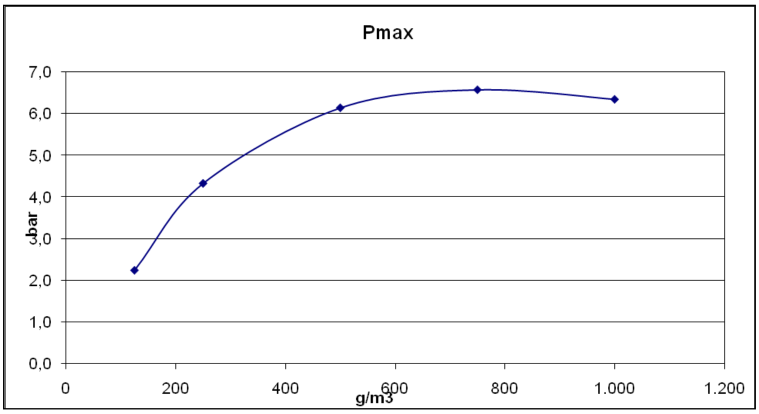

Figure 7: Graphic view of pressure increase

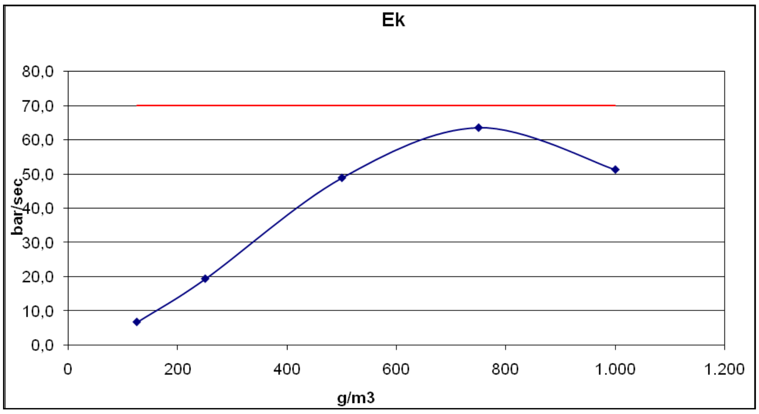

Figure 8: Graphic view of explosive characteristic change

Maximum pressure of explosion	P_{max}=6,578 bar
Maximum time increase of pressure	dp/dt=63.605 bar/s
Explosive characteristic – explosion coefficient	K_{st}=22 bar*m/s

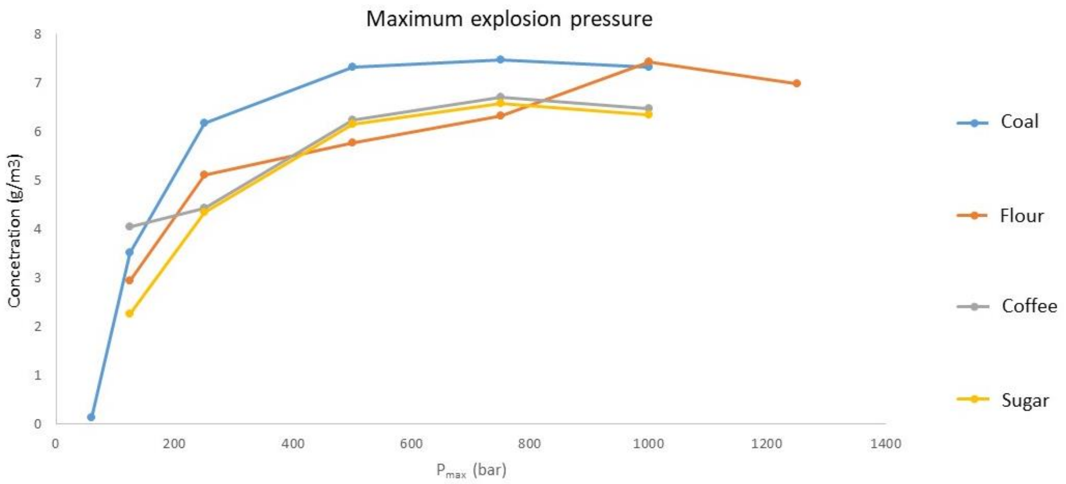

Figure 9: Maximum pressure for coal, flour, coffee, and sugar

EXPLOSIVE CHARACTERISTIC $E_K=\sqrt{\frac{Pmax/\Delta t}{dp/dt}}$

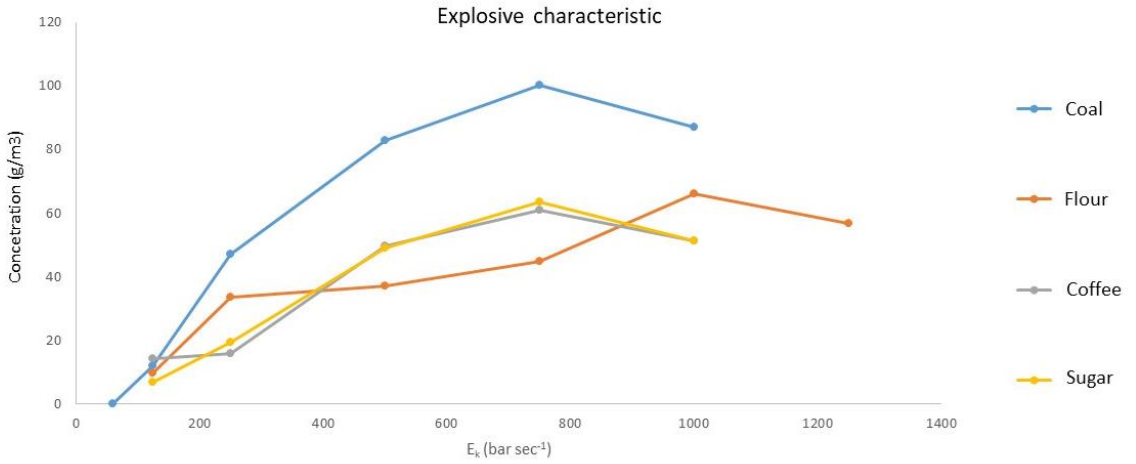

Figure 10: Explosive characteristic for coal, flour, coffee, and sugar

According to these results of maximum pressure it is possible to conclude that all dusts showed pronounced explosive ability. These and similar examinations have been published in the professional literature fifty years ago. This research was not given respective importance and corresponding protective measures were not implemented.

In the underground exploitation mines they have realized the explosive coal dust hazard which was followed with regulations in which each cave is categorised upon the level of danger of the coal dust while it is defined by the Standard SRPS B.Z. 063/1990.

In the economy Regulations and the Rule Book are brought ordering to make classification of endangered spaces in all objects where the dust produced and deposited in order to determine hazardous zone for explosion and fire. In industrial objects where occurs production and depositing of dust, which has inflammable and explosive features, the standards SRPS EN 60079-10-2/2011 *Inflammable atmosphere of dust* is implemented on the basis of which the hazardous zones are established.

5. CONCLUSION

Testing of explosiveness and flammability of deposited dust has to be performed in order to conduct *classification of endangered space.* On the basis of gained results is possible to establish hazardous zones in objects. According to the law on fire protection all economic subjects dealing with production where dust occurs should have detailed reports on classification and hazardous zones of deposited dust. The Mining Institute as the only one institution in Serbia dealing with research of explosive and inflammable characteristics of dusts, so far has not received any request for testing of any dust except for needs of the mining organizations.

There is a question imposed: How is possible to determine hazardous zone if dust is not tested on explosive and inflammable characteristics?

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LOGISTIC PROCESSES AND ECOLOGICAL EFFECTS

- LOGISTIC PROCESSES -

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MINE SURVEYING OF LARGE OBJECTS AND SUBSIDENCE IN EXPLOITATION AREA OF VELENJE COAL MINE

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ABSTRACT

With underground longwall mining method,Velenje Coal Mine is causing subsidence of the surface above mine pits. The influence area of mining in the exploitation area of Velenje Coal Mine is subject to constant changes of the surface. The size and the location of the mine influence on surface area is changing according to the location and the size of the mining panels. Surface movements and deformations are observed on over 300 measurement points in mining area and its vicinity using mine surveying monitoring system including tachymetry, geometrical levelling, GNSS, TLS and aerial photogrammetry. The Velenje Coal Mine's mine surveying monitoring system is complex and can be classified as an extended geodetic monitoring system. The extended geodetic monitoring system is constantly upgraded with new measurements and the latest measuring equipment.

Key words:underground coal mining, mine surveying, subsidence, geodetic monitoring system

1. INTRODUCTION

TheVelenje Coal Mine (VCM) is located in the Šaleška Valley between the city of Velenje and the town of Šoštanj and spreads on 1104 hectares(Figure 1).The VCM mining area is subject to constant subsidence of the terrain and the lakes' bottoms that emerged as consequence of coal excavation.In the VCM coal is excavated at a depth of more than 400 meters according to the Velenje Mining Method (VMM) with continuous caving-in of the hanging wall layers [1]. The length of longwalls is from 80 m to 210 m and the length of the panels varies from 600 m to 800 m.

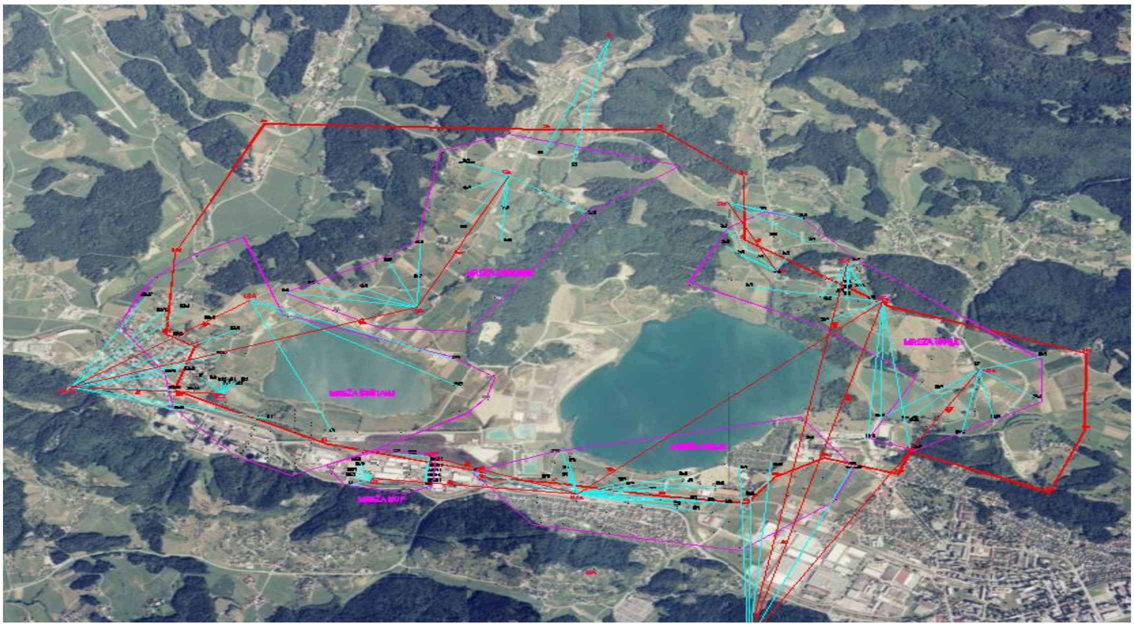

Figure 1. Mining area (inside redpolygon) and scheme of the VCM's observation networks.

The size and the location of subsidence is changing according to the location and the size of the mining panels in the excavation sites of the mine. One of the mine surveying tasks are to predict subsidence, asses potential impacts, advise on methods to manage potential impacts and to monitor coal mining influence and advise during mining.The VCM's mining area geodetic monitoring system is complex and is classified as an extended geodetic monitoring system [2]. The surface movements and subsidence are observed in mining area and its vicinity. Monitoring the surface movements and subsidence covers measurements of geodetic observation networks, dams between lakes and the bottoms of lakes, furthermore monitoring of nearby industrial buildings, residential buildings and terrain of mining by using classical surveying methods (tachymetry, geometric levelling) and GNSS (Global Navigation Satellite System) surveying. The extended geodetic monitoring system is constantly expanding and upgrading with new measurements and use of new surveying methods like terrestrial laser scanning, automatic GNSSmonitoring system and aerial photogrammetry.

2. VELENJE COAL MINE EXTENDED GEODETIC MONITORING SYSTEM

Classic geodetic measurements are used for determine subsidence and movements of observation points of the observation networks. The observation networks of the VCM consist of over 300 observation points on surfaceas shown in figure 1. Observation of points in observational networks are performed with classical terrestrial surveying methods, which result in three-dimensional coordinates (Y, X, H) in the national Gauss-Krüger coordinate system. For a more accurate determination of point'selevation, the method of geometric levelling is used. Measurements of observation networks are generally performed at least once a year, in some cases, even several times per month. GNSS measurements are also part of standard geodetic techniques and it is used for measurements of basic observation network.

The depth measurement data of the Šalek lakes is essential in monitoring the subsidence areathat is filled with water [3, 4]. In VCM theReason NaviSound 110 sonar has been used for measuring the depths since 2010, as it enables connection to a computer and GNSS device;

the results of the measurements are points with given Y, X, Z coordinates and the depth. Based on models of the lakebed structure from each year, subsidence areas under the lakes can be seen.A comparison of results measurements with previous measurementsprovides insight into the changes that have occurred within one or more years. Figure 2 shows equipment for bathymetry that we use, resulting bathymetric map and 3D model of lakebed structure.

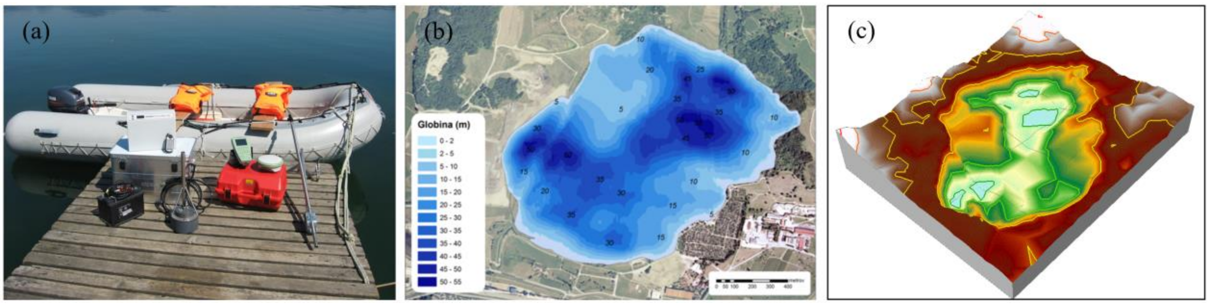

Figure 2. (a) Equipment for bathymetry, (b) the bathymetric map and (c) 3D model of lakebed structure.

One of the more modern method of observation is an establishment of real-time GNSS automatic monitoring system, which has been placed on the cooling tower of Unit 4 of the Šoštanj Thermal Power Plant(TEŠ). Monitoring system consists of three GNSS observation points (GMX N, GMX S and GMX E), which are located at the circumference at the top of the cooling tower of Unit 4, two observation points with inclination sensors (Nivel n and Nivel s), which are located on the circumference on the ground of the cooling tower of the Unit 4 and a reference (stable) GNSS point (GRS O), located outside of potentially influenced area(Figure 3a). Continuous real-time monitoring enables fast and efficient response to critical emergencies such as displacements or deformations of the monitored structure. Throughout the whole observation period, we monitored any potential changes in position of points on-line. On figure 3c the results of 20-minute interval measurements on every 24 hours, which gives us the maximum accuracy, are presented. By setting up a system for continuous monitoring the movements and deformations of the cooling tower of Unit 4 in TEŠ in real-time, stable conditions and safety are provided [5, 6]. Data obtained in real-time are essential for both optimal preventive action as well as the proper curative treatment.

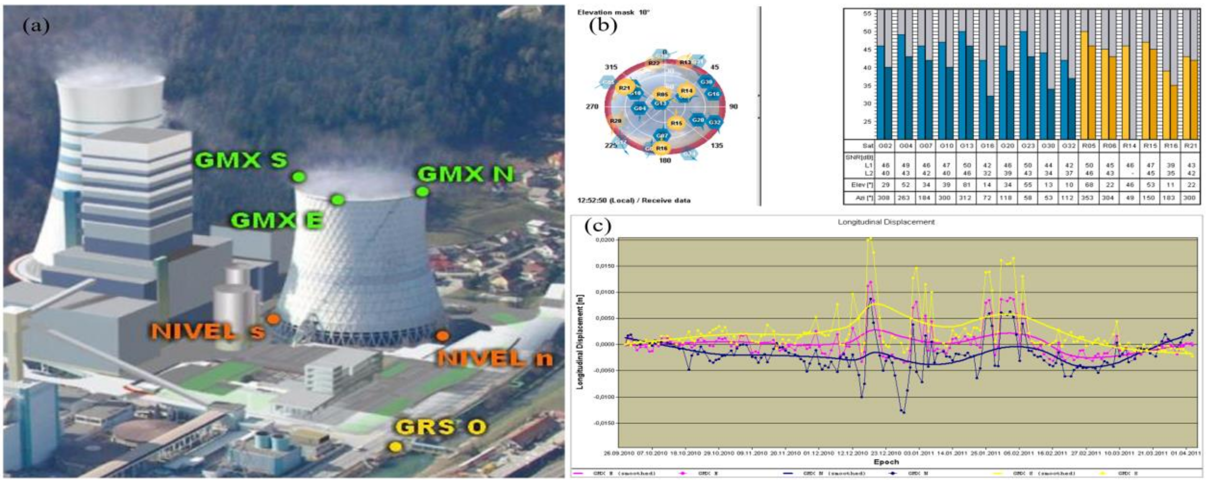

Figure 3. (a) The position of the measuring points of the automatic GNSS monitoring in TEŠ, (b) GNSS satellite constellation and (c) point displacement real-time diagrams for observation points in X coordinate direction with corresponding regression functions.

3. USING DRONE TO MONITOR MINING SURFACE AREA

Aerial photography for mapping terrain is in use for several decades. Development in the field of optics and Unmanned Aerial Vehicles (UAV) – drones has enabled technologies that can already compete in accuracy with traditional geodetic measurements of the terrain. Use of photogrammetry in combination with drones enables high-quality 3D terrain and objects modelling that can be used in mining industry for projects plans, monitoring of mining operations and construction works.The VCM uses drones for surveying of the mining area to produce 3D models of terrain, furthermore to detect subsidence caused by mining and to calculate the volume of subsidence and the volume status of the coal depot[7].

Field measurements involve the installation of ground control points (GCP) - targets for which exact coordinates need to be determined, usually done with the GNSS method (Figure 4a). These GCP are important for geo-referencing obtained aerial photogrammetry data [8]. Furthermore, computer processing involves the import of 2D images and GCP locations, resulting in creation of a point cloud. Since the point cloud represents points with given XYZ coordinates, we can then construct a digital elevation model, or by filtering individual points, a digital surface model. By combining the DOF and the digital surface model, we create a 3D image model [9]. Figure 4b shows 3D model of settling basins in mining area, created from drone’s aero photogrammetry measurements. Moreover, by calculating the difference between two successive measurements, volume changes of terrain can be obtained (Figure 4c).

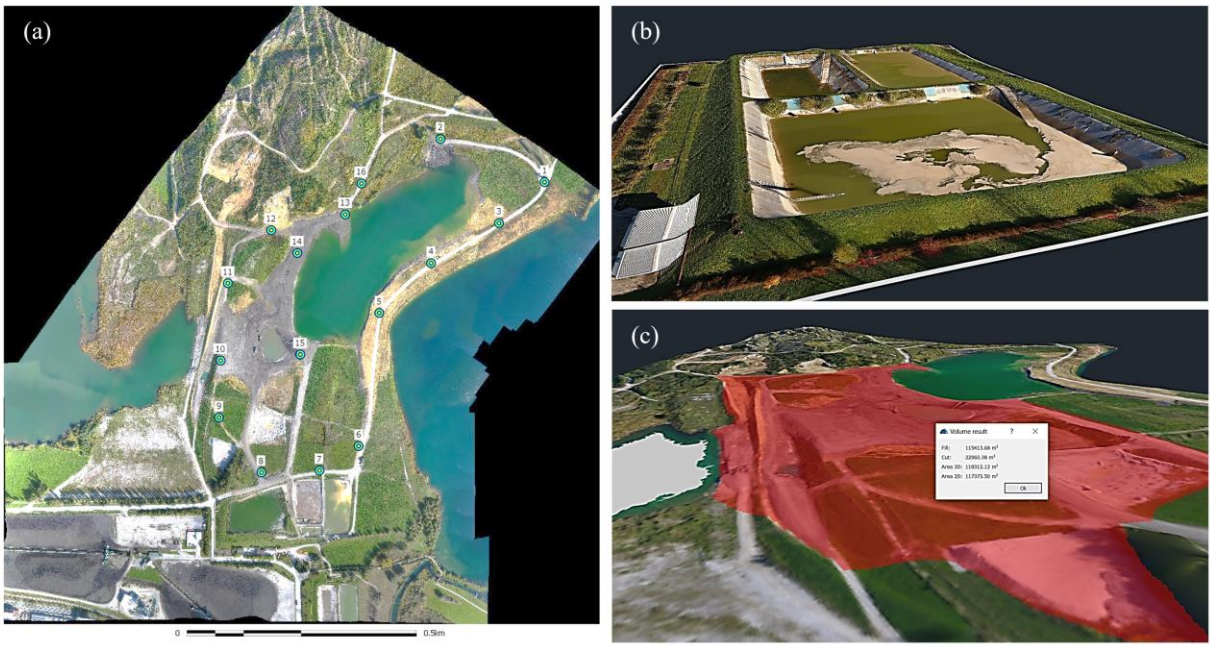

Figure 4. (a) Digital orthophoto of observed part of mining area with marked Ground Control Points (numbered dots), (b) 3D model of settling basins and (c) digital 3D model of mining area with DOF display and calculated volume of subsidence of certain area (red transparency).

As drones proved to be very suitable for monitoring important structures in the mining area, on figure 5 the drone measurement results of protective embankment of the lakeare shown. The main advantage, in addition to 3D visualization, is the simple way to extract the 2D profiles needed in ordinary engineering design as shown on figure 5d.

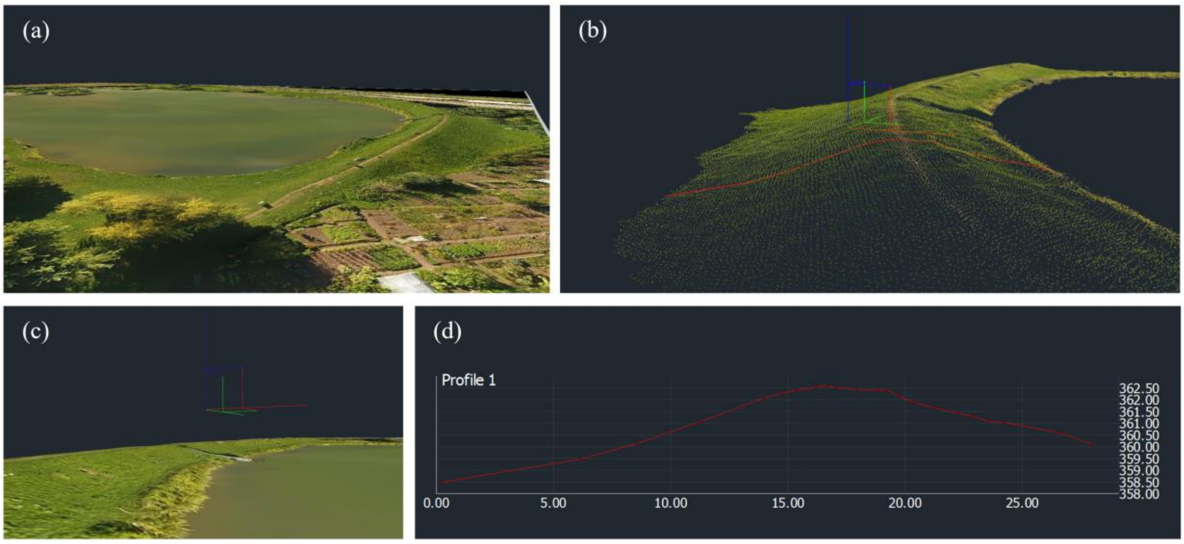

Figure 5. (a) Digital 3D model with DOF of protective embankment, (b) point cloud of individual area, (c) 3D model with DOF magnification of individual areaand (d) corresponding extracted 2D profile

The monitoring of coal depots is important for ensuring and coordinating coal consumption for the production of electricity [4]. The method described allows both the acquisition of a digital orthophoto image at the desired time, as well as the calculation of the volume of coal located at the depots. Figure 6a in b shows the axonometric view of the digital cloud of the captured coal depots points. Based on this point cloud, volume of individual coal depot is calculated (Figure 6c) and the location of the parallel profiles used to calculate the volume by the profile method are extracted (Figure 6d).

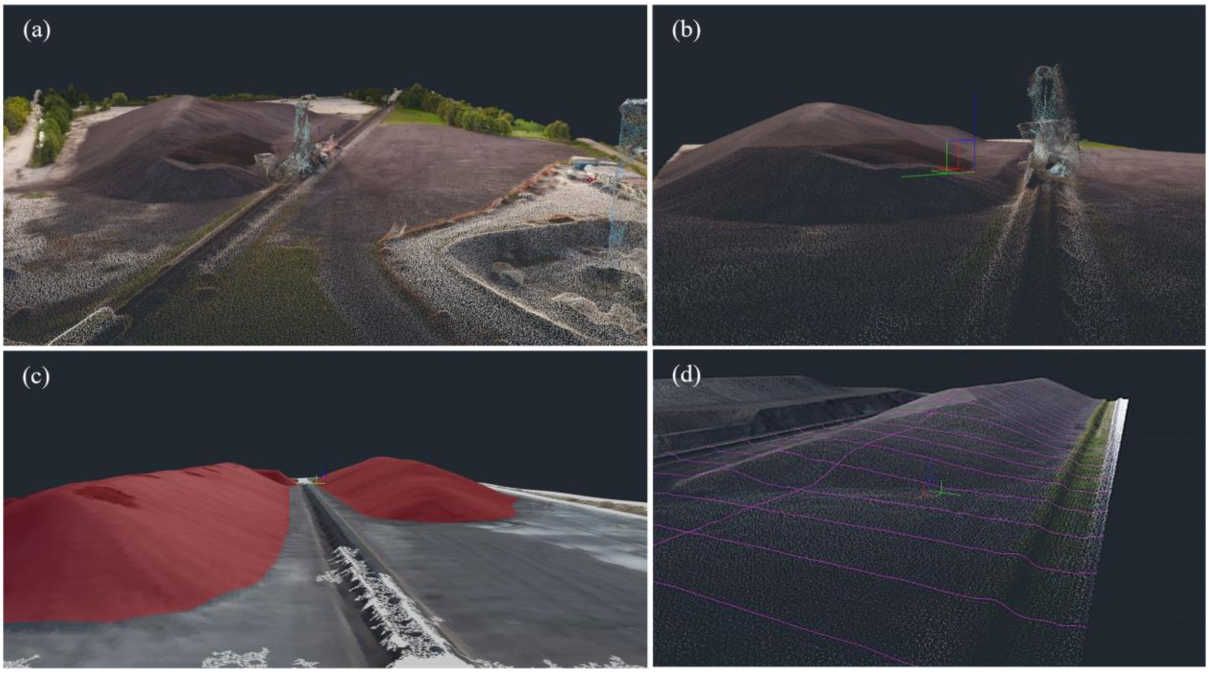

Figure 6. (a) Digital 3D model of coal depots, (b) magnification of individual area, (c) calculated volume of individual coal depot and (d) corresponding extracted 2D profiles

4. CONCLUSION

With underground longwall mining method Velenje Coal Mine is causing subsidence of the surface above mine pits. Before 1990, network measurements were conducted only by a combination of triangulation and trilateration for the plane network and a geometric levelling for the height network. However, with the development of satellite technologies and the GNSS system, at the Velenje Coal Mine an observation network based on GNSS measurements was established. Such points represent a much better basis for establishing the coordinates of the mining observation networks main points, which we then use for measurements of the observation networks. However, surface movements have a negative effect on all neighbouring facilities. By monitoring these movements and the deformation of close industrial and residential facilities, we are able to provide safe working and living conditions. Moreover, we are able to calculate position changes of surface points and facilities in any given time frame using these observations.

Recent methods include remote data capture techniques, which include drones, planes and satellites. The use of drones in the mining industry is on the rise as it offers the possibility to use in various engineering fields. Surveying methods of large areas with drones combined with corresponding computer programs already outperforms traditional surveying methods. Using drones to observe mining area shortens measurement time and consequently reduces costs and increases productivity.

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NOISE LEVEL MEASUREMENTS AROUND THE SURFACE MINE FILIJALA IN BEOČIN

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ABSTRACT

In this paper the results of measurement of the overall noise level in the environment during execution of the open pit "Filijala" in the course of the execution of works by additional exploitation of marlstone mining design-first stage. Measurements were taken at two sites from 2012 to 2016 and were conducted in the normal course of work with the equipment provided for the project.

Key words: NOISE, ENVIRONMENT

1. INTRODUCTION

On the basis of the Study on Environmental Impact Assessment of the Additional Mining Exploitation project on Surface Marl Mine "Filijala" in Beočin - Phase I there is surveying of urban noise in the external environment in the vicinity of the surface mine conducted at two measuring points distributed on opposite sides of the building in the direction of inhabited objects. Residential objects were taken as a noise-threatening area, and measurements were made in the day and evening regime in the period from 6AM to 10PM.

2. NOISE MONITORING FORESEEN BY THE STUDY ON ENVIRONMENTAL IMPACT ASSESMENT

During the exploitation in the surface mine Filijala the noise level increases due to performance of equipment and load transportation by the heavy trucks. The Rule Book on the acceptable noise level in the environment defines methods of measurements, selection of measurement points and time intervals. If there are appeals on excessive noise level during the work performance than it is necessary to control noise level additionally. Within the noise monitoring framework during the exploitation the following would be demanding: to execute measurement of the zero condition.

In the case when the permitted noise level is significantly exceeded during the work performance, there should be undertaken necessary protection measures. Measurement points are defined by the presence of inhabited objects and national park Fruška gora in the vicinity due to noise manifestation which will be at maximum grade regarding distance of the same from the source. Position of measurement points are illustrated in the Figure 1.

Figure 1: Position of measurement points for determination of instant *zero* condition

It is predicted the monitoring at 2 (two) measurement points, B1 and B2, providing that measurement point 2 will be positioned at the south-east side of the surface mine to monitor noise impact in direction toward the national park Fruška gora, or location Čakorske livade. He highest permitted noise level in the inhabited environment is prescribed by the Directive on noise indicators, limiting values, methods for the assessment of noise indicators, disturbing and hazardous noise effects in the environment (Official Gazette of RS no. 75/10).

3. NOISE LEVEL MEASUEMENTS IN THEVICINITY OF SURFACEMINE FILIJALA

Measurement results are showed via noise indicators – Relevant noise level. The basic measurement parameters were equivalent, minimum and maximum instantaneous noise level. Measurements for the zero noise level have been performed in compliance with the Study planned for the location Čakorske livade, and according to results here were no off limits noise values, or measured values are quite below those permitted by the regulations. Due to the inaccessibility of the terrain where it was measured, as well as the lack of the inhabited facilities to which the noise would be negative, it was decided that further investigations would be conducted near the closest objects in which people live and to which the noise could have a negative impact. At the place Čakorske livade as endangered object was chosen camp house, illustrated in the Figure 2, as potentially endangered by noise. It was not spotted anyone living there but it was aimed for camping. The nearest houses were sheltered on the other side of the hill as opposed to the surface mine, so it was naturally protected of any noise from the surface mine Filijala.

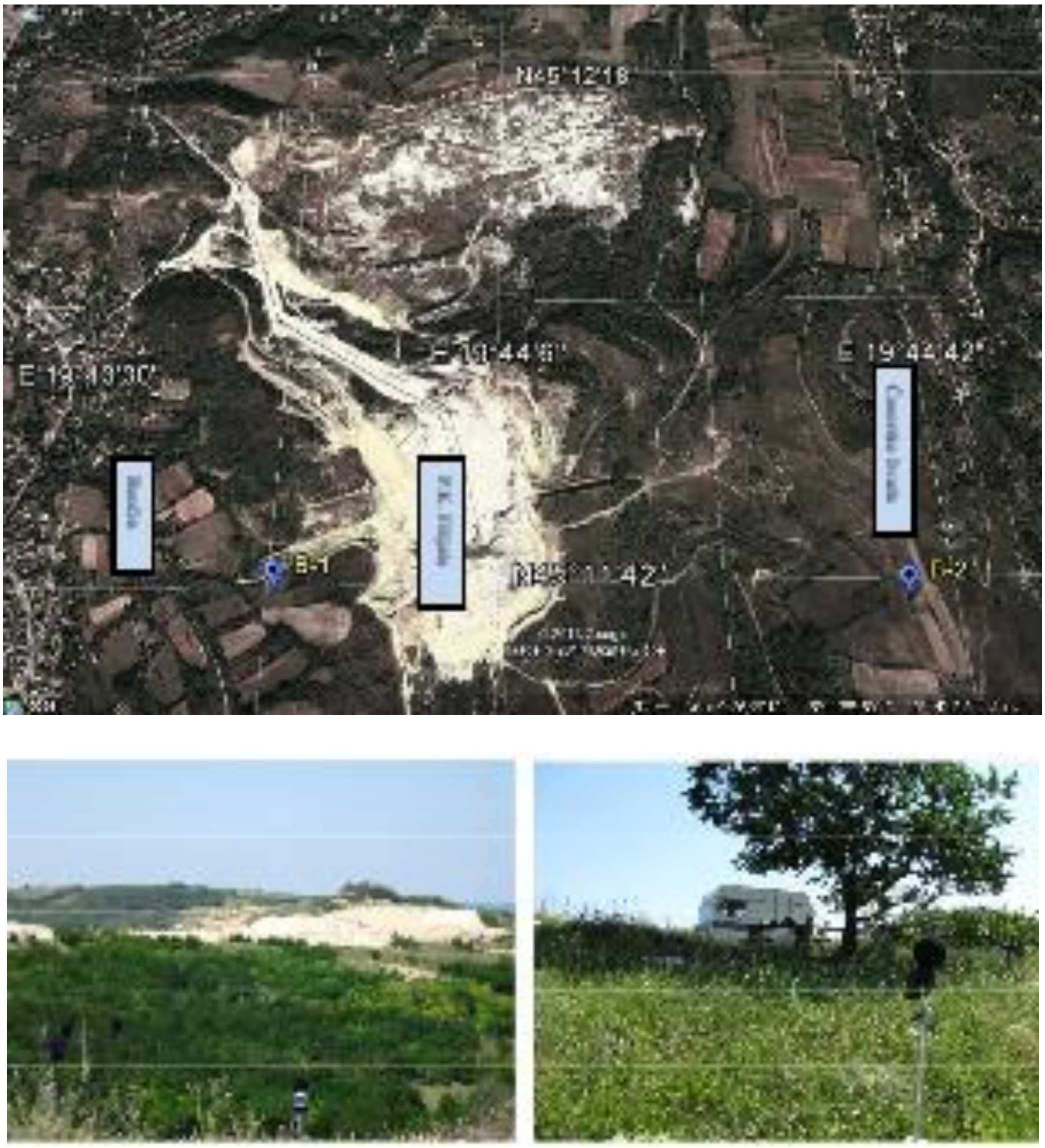

Figure 2: Position of measuring point Čakorske livade

Applicable noise level for day regime was 41dB (A) and evening regime was 31B (A). Regarding the fact that surface mine continues in depth operation there should be no danger of the noise level increase at Čakorske livade in the following period of the surface mine work; the further monitoring of noise continues at spot where the instant condition had been measured in 2012. In further presentation it will be taken to compare MM-2 tests for 2014, 2015 and 2016.

4. NOISE MEASUREMENT RESULTS

Surface mine Filijala makes a set of large number of single sources of noise: stationary, moving, doted, and linear sources. The location diagram of the measurement points is given in the Figure 1 and Figure2. The noise is very audible at the mine itself in the moments of work, where the most dominant is the noise by bulldozer when working. Mechanization and transport by conveyor belts affect the most the noise level. At measuring points selected in direction toward the houses and outside the exploitation field is carried out the noise monitoring to determine whether the permissible noise level exceeds in the environment.

According the time flow the noise id variable, and according the frequency content the noise is broad belt. Measurement point MM-1 is located at the south side of the surface mine toward the settlement Beočin about 200 m far away from the first house and about 70 m form predicted works in the surface mine. MM-2 is located at the north-east side and first inhabited objects are 150 m away from the measurement point.

Table 1: Noise level at measurement point B-1 in the period (2012-2016)

Year	2012	2013	2014	2015	2016
Noise level dB (A)	43	36	36	38	41

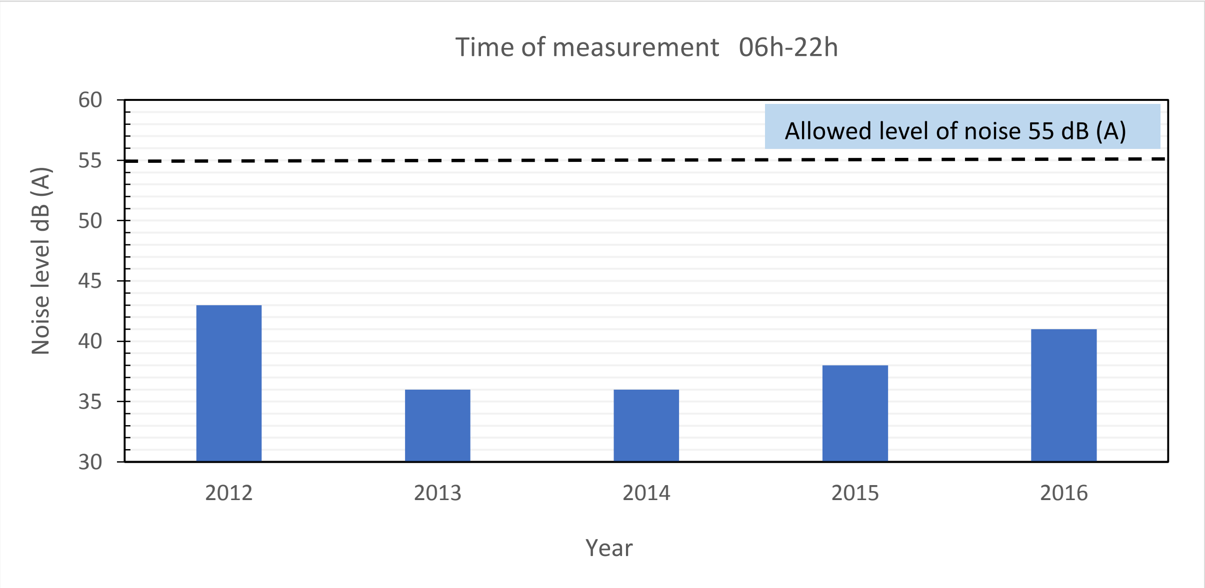

Figure 1: Noise level at measurement point B-1 in the period (2012-2016)

Table 2: Noise level at measurement point B-2 in the period (2012-2016)

Year	2012	2013	2014	2015	2016
Noise level dB (A)	43	-	38	37	41

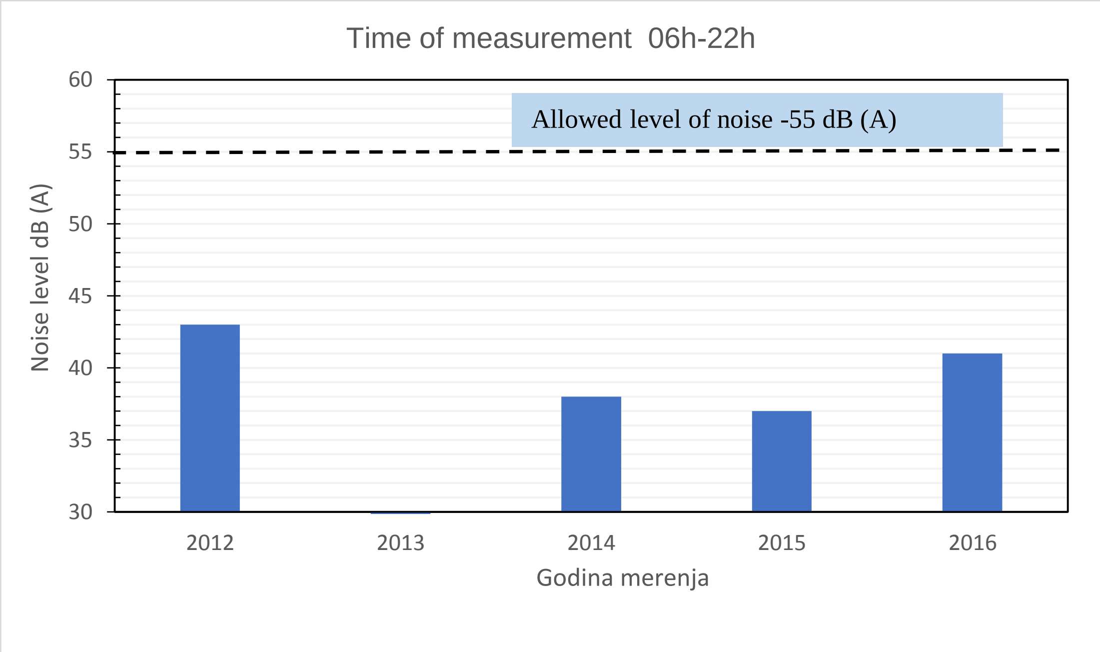

Figure 2: Noise level at measurement point B-2 in the period (2012-2016)

5. CONCLUSION

Noise level measurements in the environment in the vicinity of the surface mine Filijala showed increase of the noise level but in comparison with noise indicators, extreme values, by methods of noise indicators assessment, of disturbing and hazardous effects in the environment (Official Gazette of RS no. 75/10) and values taken as limit values of 55 dB (a) and for zone 3 (which are not officially confirmed by the competent local government thus taken conditionally) there is no overrun. Relevant noise level for B-1 is 36-41 dB (A) and B-2 38-43 dB (A), which satisfy prescribed criteria provided that measurement points are at the border line of the exploiting field and inhabited object more distant.

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ROCK BURST PREVENTION MEASURES IN THE COAL MINE VELENJE

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ABSTRACT

The history of rock bursts in the Velenje Coal Mine has a long tradition. Rock burst is defined as a dynamic phenomenon where a large amount of energy is released from surrounding rock, affecting both surface and mine infrastructure. Rock bursts can be felt on the surface as ground vibrations, while in the mine they result as sudden closure of roadways, interruption of mine ventilation and injuries of miners due to bumps. The reason for the emergence of rock bursts is increased stress around mine roadways. Preventive measures are a result of systematic monitoring in the past and contain both measures for stress indication and controlled stress release.

Key words: rock burst, seismicity, coal mine, preventive measures

1. INTRODUCTION

A rock burst occurs when the pressure accumulated in a certain rock mass area is suddenly released. The initiator of stress release is a change in the secondary pressure that changes around mine roadways and brings to the point of releasing the energy accumulated in the rock mass. Even until today, the occurrence of a rock burst has unfortunately not been researched to such an extent that it would provide uniform and effective measures to eliminate the phenomenon entirely. Execution of preventive measures is limited to the area where it is estimated that there is at least a certain degree of probability of occurrence of a rock burst, as determined based on the frequency of occurrence of rock bursts, on measurement results and knowledge of geomechanical conditions in the coal seam.

2. REVIEW OF MEASURES TAKEN ABROAD

Rock bursts accompany mining works – not only in the coal mining industry but also in tunnel construction – and they are present to the greatest extent in extensive excavation using the room-and-pillar methods in deposits of precious metals, copper and iron ore from Sweden to the South African Republic. Causes for their occurrence are quite specific in each case; in review of the situation, we limited our focus to coal mining. We visited DMT in Germany, where preventive measures for German coal mines have been developed; OKD coal mines in the Czech Republic, and the DPB Institute and the Geomechanics Institute operating within the Czech Science Academy. In Poland, we visited the Central Mining Institute - GIG, the Jazstrebie Coal Mine and the Faculty of Mining - Department of Geomechanics in Krakow. The overall conclusion from all our visits is that the established measures must be adapted to the situation in the Velenje Coal Mine and that a direct implementation of measures used abroad is not possible. It is reasonable to selectively use some of the measures, e.g. indicator drilling, stress-relief drilling, and installation of alkathene stress indicators. Blasting in the form performed in the above mentioned coal mines would not achieve the purpose in the pits of Velenje Coal Mine; therefore, we have developed our own blasting scheme and dynamics. It is our unified opinion that correct scheduling and exclusion of mutual impacts of mining works is the most important measure for preventing the occurrence of rock bursts.

3. ROCK BURSTS AND MEASURES TAKEN IN THE VELENJE COAL MINE

In the pits of the Velenje Coal Mine, rock bursts have been occurring to a greater extent since the introduction of the highly productive Velenje mining method. Based on the data obtained from the books of rock and rock mass bursts, we elaborated a chronological overview of the number of rock bursts. We could see that the number of rock bursts has varied through the years. The actual number does not have a linear connection with the production; however, it is connected to the location of excavation in a certain time period. The chart shows the number of recorded rock bursts per pit and production between the years 1961 and 2015.

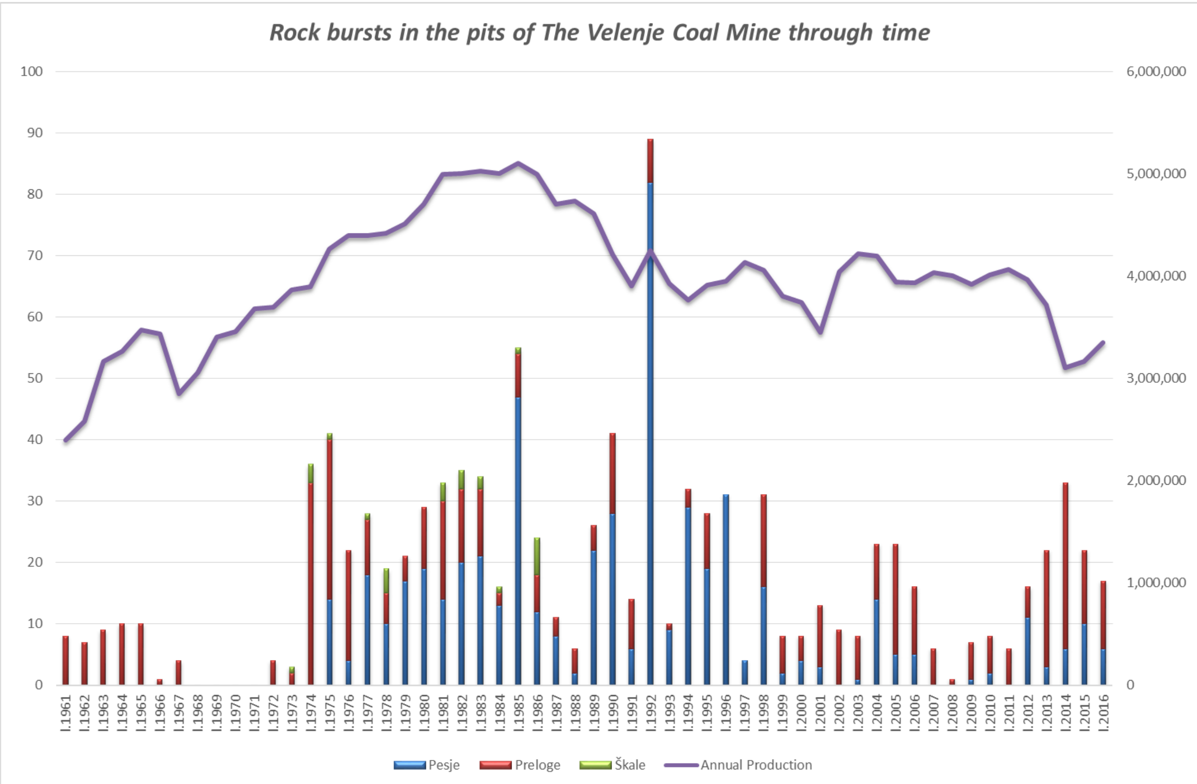

Figure 1: Chart: Rock bursts in the pits of The Velenje Coal Mine through time. The left axis illustrates the number of rock bursts per year, and the right axis illustrates production in [t].

A rock burst is a dynamic and sudden phenomenon, whereby a large amount of accumulated energy is released. In the mine, it results in a sudden closure of roadways, interruption of mine ventilation and injuries of miners due to bumps [1].

Figure 2: Consequences of the rock burst of 29 July 2014 in the former transverse conveyance line from G-panels at the height point k. -115.

Measures against rock bursts are divided in two groups, i.e. projective and operative measures.

Projective measures:

- measures from the aspect of placement of exploitation panels,
- measures from the aspect of time scheduling of excavation,
- adapting the dynamics of preparatory sites,
- numerical modelling,
- seismic monitoring of rock bursts,
- a data base and statistical analysis of rock bursts,
- a data base and statistical analysis of monitoring of stress-relief drilling,
- limiting the area of performance of preventive measures,
- selection of supports with better resistance to rock bursts,
- increasing the size of the safety pillar while finishing the excavation,
- installation and monitoring of alkathene stress indicators.

Operative measures:

- high quality of construction of roadways,
- simultaneous construction of the casing,
- timely liquidation of roadways,
- strict observance of post-blast relaxation time,
- stress-relief drilling,

- stress-relief-blasting,
- limiting the presence of employees to the minimum necessary number,
- appropriate dynamics of site operation,
- additional measures.

4. STRESS indication

An increased pressure can be detected before the occurrence of the release point, as follows:

- by drilling indication/stress-relief boreholes and monitoring the amount of excavated material,
- by installing the alkathene stress indicators,
- by installing the measurement cells.

Drilling of indication boreholes is intended exclusively for indicating pressure at the moment of drilling. Drilling of stress-relief boreholes with the diameter of 115 mm is intended for indicating pressure and for stress relief. In both types of boreholes, the amount of excavated material is monitored. Our experience has shown that when drilling into an area under stress, the amount of extracted material can be up to 40 times larger than the volume of the borehole.

For monitoring purposes, we created a stress-relief drilling database which contains all the parameters obtained from the reports on drilling of stress-relief boreholes.

Until now, more than 100 stress-relief boreholes have been drilled. A summary of reports shows that the average amount of extracted material from a stress-relief borehole with the diameter of 115 mm per 1 metre of borehole is approx. 40 litres while the volume of the borehole is only 10 litres. There occur areas of increased amounts of extracted material - up to 200 litres of material per 1 metre of borehole. This is primarily the case in the areas where the coal had been subject to certain impacts of previous excavations and has been crumbled. We have also recorded a case of drilling a stress-relief borehole in an area where the material extracted from a 10 m borehole in the compact coal amounted to 450 l.

Drilling of stress-relief boreholes and a parallel analysis of the stress-relief drilling database have shown that drilling and monitoring of the amount of extracted material is an effective measure for preventive detection of areas in the coal that are under stress. It is one of the measures that should be performed and monitored on a daily basis, as in the case of detecting increased pressures, immediate action is required.

Another method of indicating increased stress is the use of alkathene stress indicators as it is the case in German coal mines [2]. We have decided for trial use because rock mass pressure is subject to time-related change; an indication borehole provides us with the data only for the time of drilling, and an alkathene indicator provides the data for the time from the installation until the end of use. An alkathene stress indicator is a measurement cell used for measuring the increase of pressure in a pillar. It operates on the mechanical principle of loading the alkathene pipes. It consists of two alkathenes of two different diameters. The pipe that is smaller in diameter is inserted in the larger one, and the latter is inserted into the borehole, serving as an indicator of pressure increase. After inserting into the borehole, movement (rotation, moving) of each individual element is possible. In case of increased pressure in the pillar, the pressure on the walls of the outer alkathene pipe increases. Rotation of the outer pipe is no longer possible, while the inner pipe can still move. If the pressure increases further, the movement of the inner pipe is prevented as well.

5. MODELLING OF THE EFFECT OF STRESS-RELIEF DRILLING

For the purpose of predicting and verifying the expected effect of preventive measures for stress relief, we have conducted numerical simulations of individual stress-relief measures. In the presented numerical simulation, a 3D analysis of mine roadway construction and a stress-relief borehole into the face of the roadway are made by using the Itasca FLAC 3D software [3]. An area of construction of a mine roadway without any other facilities in the vicinity has been taken as the basis. To a certain extent, the calculation simulation is a presentation of a geomechanical process during actual construction of a mine roadway in the mine's pits. First, the clearance gauge of the mine roadway is excavated, then the roadway support elements are installed, followed by drilling of a borehole in the roadway face.

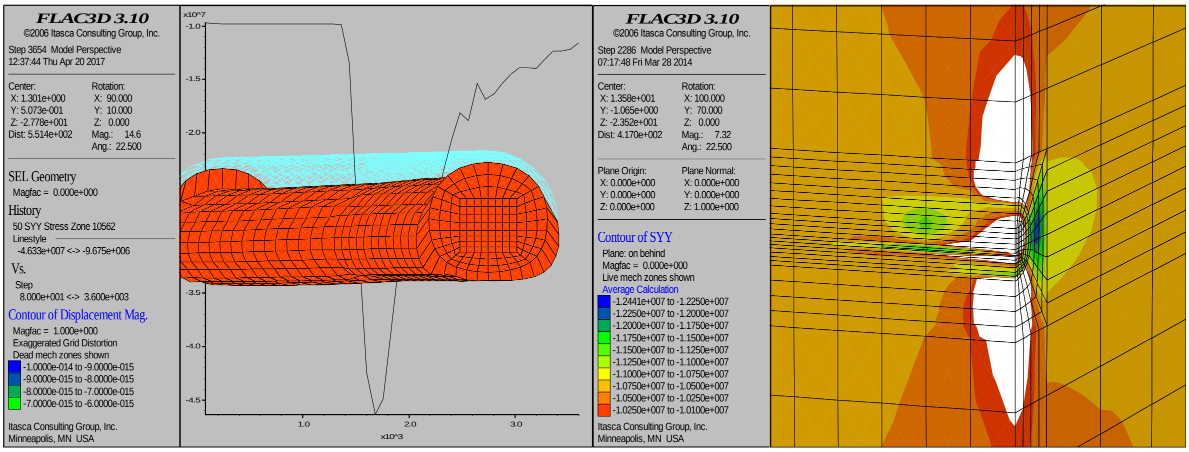

Figure 3: Illustration of a stress-relieved area before (left) and after stress-relief drilling of a borehole (right)

As it is evident from the picture, the areas of maximum stress before the face shift forward in the direction of the progression of the preparatory site. In the immediate vicinity of the face wall, the stress-relief area increases in size, and the pressures decrease (the area marked in white). According to the simulation, we can conclude that stress-relief drilling of large diameter boreholes has a significant positive effect of stress relief in the immediate vicinity of the mine roadway face wall. The presented method of numerical simulation also allows the implementation of back analyses in researching the mechanism of occurrence of rock bursts in other situations leading up to this event [4].

6. TECHNICAL SOLUTIONS

In the context of technical solutions, the mining technical documentation S-1/2015 - "GUIDELINES FOR CARRYING OUT MEASURES AGAINST ROCK BURSTS AND FOR REDUCING THEIR EFFECTS IN THE EVENT OF THEIR OCCURRENCE" has been elaborated. It contains guidelines for carrying out measures against rock bursts and for reducing their effects in the event of their occurrence. The prescribed guidelines for carrying out the measures are based on the research work, review of solutions to this type of problems, and numerous experiments conducted. The measures are carried out in the area of the pit that is, based on the past events, recognised as an area with an increased frequency of occurrence of rock bursts.

The following measures are discussed:

- indicative stress-relief drilling,
- stress-relief blasting,
    - PREPARATORY SITE PROGRESSION
    - MINE ROADWAYS RECONSTRUCTION
    - MINE ROADWAYS LIQUIDATION
- monitoring-based measures and
- additional measures.

7. PRESSURE RELIEF BY MEANS OF BLASTING

Pressure relief procedures are regularly performed in the area where carrying out of preventive measures is obligatory and, additionally, on those sites where we estimate that introduction of measures would be reasonable. A different method of stress relief of the rock mass is prescribed for each site type - construction of a new mine roadway, reconstruction or liquidation.

When blasting the boreholes during stress-relief blasting, we occasionally released a minor rock mass burst which was recorded in the book of rock bursts. This indicates that the planned measure of stress-relief blasting is a good one as it allows, in certain cases, controlled initiated release of pressure in the rock mass without any employees present.

Within the planned stress-relief blasting of larger amounts of explosives, 29 blasts were performed in the year 2016. Locations are shown in the figure below:

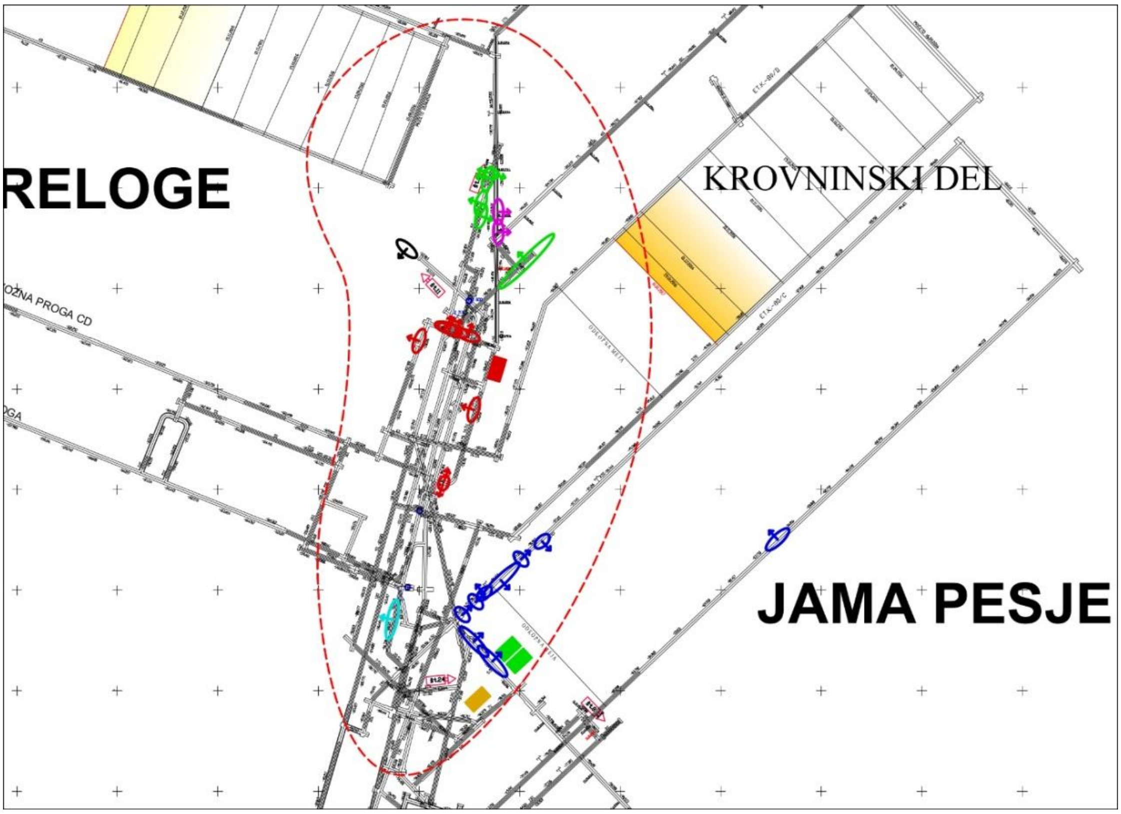

Figure 4: Map of blasts of larger amounts of explosives performed in the year 2016

8. SELECTION OF ARCHED SUPPORTS

In the market, there are several types of yielding arched supports made of different types of steel. Laboratory analysis of supports yielding under increasing load has shown that the K24 supports yield in significantly larger jumps than the TH supports. Smaller deformations in arched supports yielding also allows smaller releases of rock mass pressure and lower intensity of seismic events. The areas where the occurrence of rock bursts is expected are reconstructed, if necessary, with the TH29 supports.

The TH29 supports have at least three advantages if compared to the K24 supports:

- the joint design allows for smoother (less jerky) yielding, which is more favourable from the aspect of stress relief;
- the arch is not made of tempered material and does not have spring properties as the K24 arch;
- the load-bearing capacity of the frame of the TH29 arched supports is higher than with K24, which allows construction of support with greater distance (50 cm) between the frames of the steel arched support.

In the locations where the TH supports have been installed until now, we have had good experience. When rock bursts occurred in the proximity of these locations, the TH supports proved much better in withstanding the increase in rock mass pressure and roadway deformations were significantly smaller.

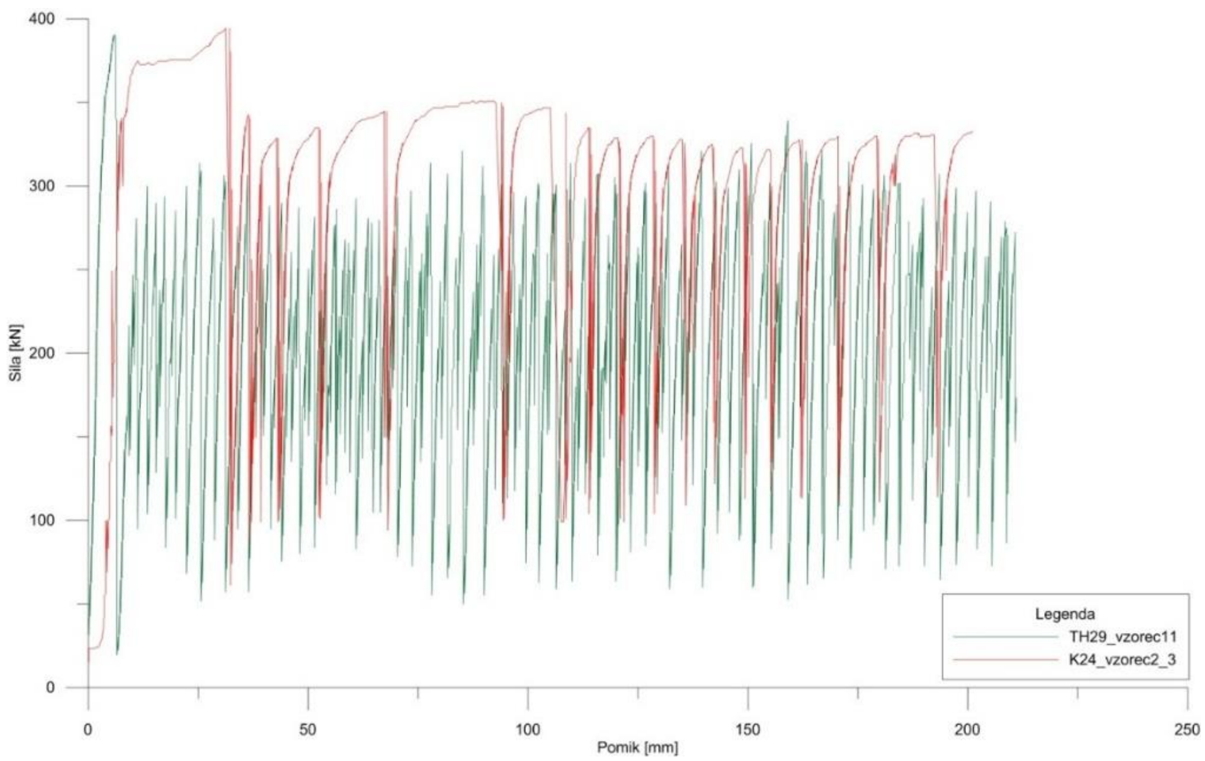

Figure 5: Comparison of yielding in the K24 and TH29 supports

It has been proven that the TH29 supports allow release of smaller instantaneous deformations during yielding and, therefore, also lower level of stress relief in the rock mass.

9. MONITORING OF ROCK BURSTS

Monitoring of rock bursts is performed by entering them in the book of rock bursts and by seismographs both on the surface and in the mine [5]. In most cases, the events are also detected by the seismic system; however, a large number of events occurs for which there are no records in the book of rock bursts. The events normally appear on working days, there are less of them on non-working days. A part of these events is also recorded by the national seismological network of the Environmental Agency of the Republic of Slovenia. The recording of the event has a typical shape which differs from an earthquake [6]. In an earthquake, oscillations are longer lasting and with lower frequency and higher intensity of tremor [7].

Records in the book of rock bursts are entered in the database of events which allows statistical processing of the events' characteristics, such as type of work, the length of the affected area, location, etc. Findings of statistical processing help us in planning the preventive measures. The most common length of a rock burst is 20 m, which required the compliance of the measures - the distance between the indication and/or stress-relief boreholes must be of at least that length.

In October 2016, seismic monitoring of rock bursts was modernised by the installation of a new system manufactured by Kutec. With the installation of the new system, the focus of seismic monitoring of stress-relief at the coal faces is now shifting to monitoring of rock bursts in stable facilities between the pits Preloge and Pesje.

The former system was installed in 1999, and during its 16-year operation, it has shown that the majority of stress reliefs in the vicinity of coal faces occurs up to 50 m before and up to 30 m above the coal face [8].

In the future, we would not want to completely abandon the monitoring of stress reliefs at the coal faces, and we wish to extend the new system with additional seismometers which would also cover the coal faces. The new system is already prepared for such upgrade and can be extended by eight sensors to cover two coal faces.

The procedure of determining the location of events is very demanding and is fully covered by the manufacturer of the system (Kutec) within their monthly monitoring; the company has adequately trained professionals and equipment. At the end of each month, we receive coordinates of events; for special cases, even on the next day upon request.

In the first month of operation, the system has shown that:

1) we can determine the location of blast or rock burst with 20-meter precision,
2) already a blast of 8 kg of explosive can be recorded,
3) by monitoring additional stress reliefs immediately after the blast, we can determine as to whether the stress-relief blast was successful or not,
4) the majority of rock bursts occurred in the vicinity of former connections to the chamber of coal face CD2.

Currently, it is still too early for any conclusions, as the system has been only operating for one month. However, it is evident that the decision on the introduction of preventive measures against rock bursts was a correct one (TH supports, limiting of area, stress-relief blasting, stress-relief drilling, stress indicators) and that we will be able to upgrade them with the results of seismic monitoring while monitoring their effectiveness.

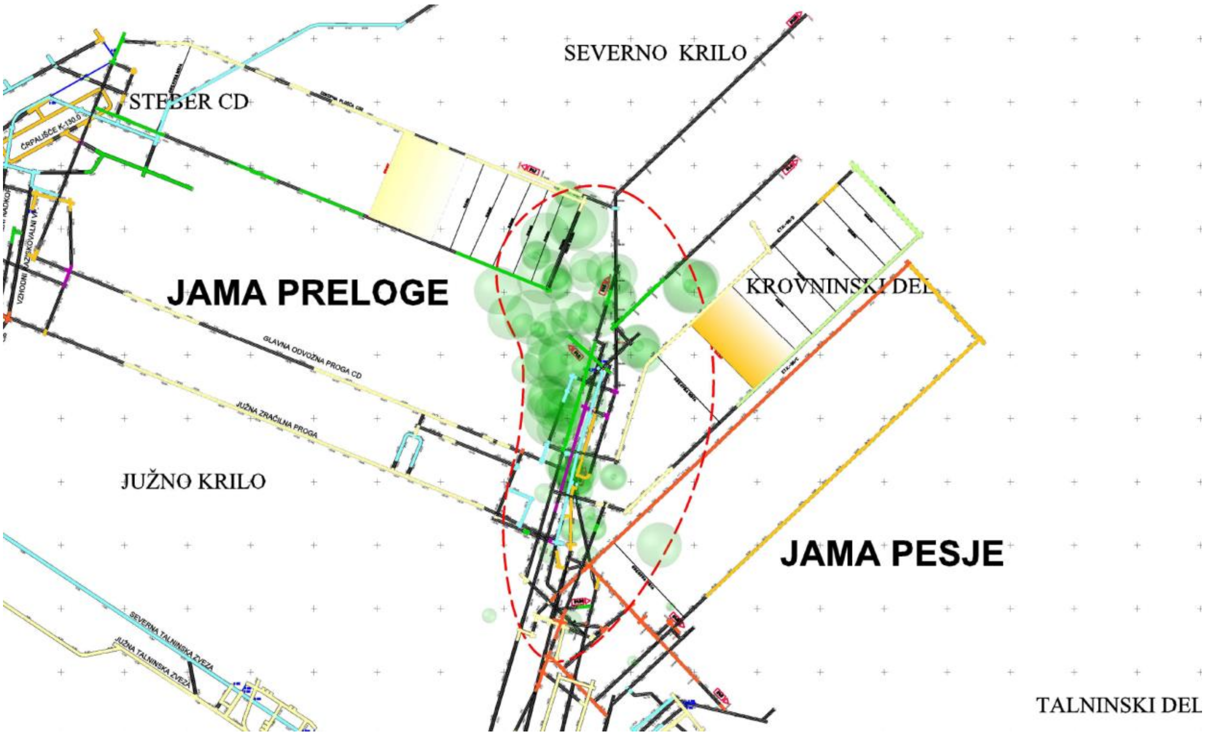

Figure 6: Seismic activity monitoring map - Kutec system

10. CONCLUSION

The selection of preventive measures against rock bursts is based on the review of methods used in coal mines in Germany, the Czech Republic and in Poland. We visited the coal mines and institutions where these methods had been developed, and we made a reasonable selection and application of these methods to our geomechanical conditions. It is our estimate that with strict introduction of measures, monitoring and development activity, we will be able to reduce the number of events to the minimum. We are aware that complete elimination of these events is an idealistic goal, but if we can avoid at least one event which might result in the employees' injuries or larger material damage, our purpose will be achieved.

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THE PREVIEW OF THE CROSS-BORDER DISASTER IN BAIA MARE CAUSED BY THE MINING INDUSTRY, AFTER 17 YEARS

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ABSTRACT

The current paper presents a review of last twenty years of main mining activities, carried out in the Baia Mare area. Details of the mining activity carried out by the former Romanian state company in partnership with the Australian company Esmeralda are also included, extensively dealing with the circumstances of the cyanide spill in 2000.

The disaster of the Baia Mare mining project led to a review of European environmental legislation, in the coming years. Romaltyn's current proposal announces, as Esmeralda's did 18 years ago, the use of the latest technology that complies with European standards. The present reality is, however, considerably different from that of the 1990s, when civil society not yet consolidated, when there was no precedent known as dangerous, when local authorities were entirely serviced to mining operators.

Key words: poluant, tailings processing, cyanide, major accident, cross-border pollution

1. BRIEF HISTORY AND LOCATION

According to studies on the history of mining in Maramures, Baia Mare, as well as surrounding localities, first of all Baia Sprie, was founded because of the presence of ferrous and non-ferrous ore resources in the area [1].

The mines at the foot of the Gutâi Mountains were, in the second half of the 14th century, the main sources of gold in the Angevin kingdom. The mining activity continued in the areas of Ilba and Botiza, in a 60 km long and about 12 km wide area until nowadays.

The area, also known as the 'Baia Mare Golden Zone', brings together, alongside the golden polygon of the Apuseni Mountains, the most important gold deposits in Romania.

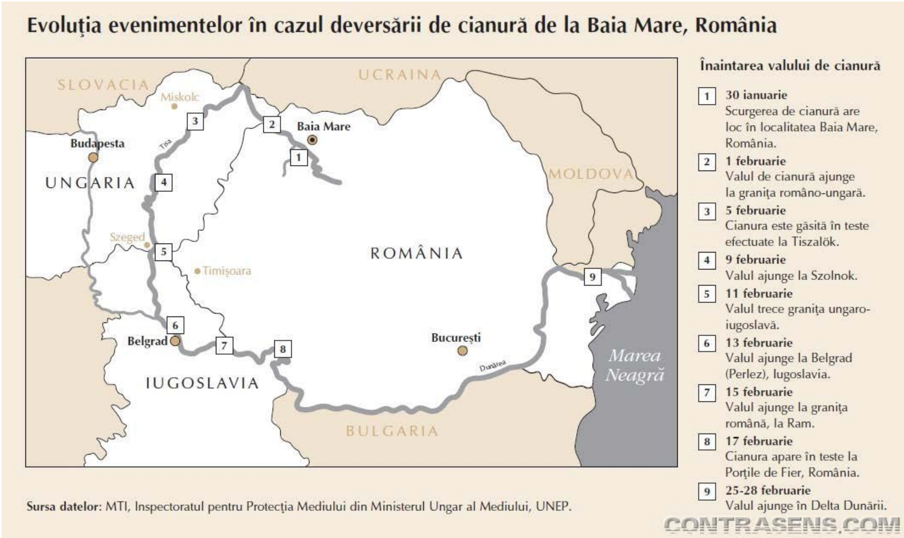
For the most part, they have been exploited, being estimated that in the course of history, from the over 20 mineralized structures in the Baia Mare district, about 125 tons of gold have been extracted [2]. At present, all mines in the Baia Mare area are closed.

Only 9% of the approximately 2000 tons of gold considered to have been over time extracted from the current territory of Romania, were exploited during communism (1945-1989). In the years to come, until 2006 when gold mines ceased operations in Romania, 2% of this quantity was extracted.

2. THE FAILURE OF FOREIGN INVESTMENTS IN MINING, THE BAIA MARE ACCIDENT

Only a few months after the tailings processing began in Baia Mare, the cyanide accident occurred on January 30th 2000, known as 'second Chernobyl', because of the devastating impact it had on the environment. The report, entitled "The Cyanide Leakage from Baia Mare, Romania", conducted by the United Nations Environment Program (UNEP) and the Office for the Coordination of Humanitarian Affairs, concluded that following the cracking of the Aurul S.A. tailings dam, about 100,000 cubic meters of liquids and wastes containing between 50 and 100 tons of cyanide, as well as heavy metals reached Săsar river, then Tisa and Danube. The Tisa Pond was considered as one of the cleanest in Europe, sheltering at least 20 protected species of fish. The crack was probably caused by a combination of mistakes in designing the installations used by Aurul S.A., unexpected operating conditions and abundant rains [3]. Romanian sources stated that in Romania the leakage caused interruptions in the supply of drinking water in 24 cities and costs for purification plants and ot her industries caused by the interruption of production processes [4].

Four weeks after the accident, cyanide traces were also found in the Danube Delta. According to official estimates, it took five years for fish to repopulate the affected rivers and ten years for the complete restoration of flora and fauna. Damage to aquatic life has been aggravated by the fact that leakage occurred in winter, when because of low temperature and ice, cyanide degrades much slower. In addition, cyanide toxicity for fish increases three times for every 13 degrees Celsius of temperature drop .



Hungary has claimed compensations of \$ 100 million for the environmental damage caused by the Aurul S.A. Baia Mare mining company. After the accident, Aurul S.A. received a single fine of about \$ 150 for delays in reporting the accident to the authorities [5]. However, the UNEP mission report found that in fact the delayed cross-border warning was caused by Maramureş Environmental Protection Agency, probably due to the fact that the accident occurred on the weekend. Ten hours have been lost since the Environmental Protection Agency received the accident notification up to the moment the Romanian Waters were notified. Therefore, the inhabitants of the area were not informed as early as possible about the accident.

3. Baia Mare accident - effects on neighboring communities

Testimonies of the area's residents show that the Baia Mare accident had complex repercussions on their lives. Ana Ghişa from Săsar has given up selling eggs, milk and vegetables to the market because people refuse to buy them when they find out that they come from Săsar: "These are polluted by Aurul", they say. In the medical office in Săsar, the journalist reports that the waiting room was full of adults and children, and their most frequent complaints were related to nausea and vomiting.

Dr. Anca Strempel indicates as problems respiratory affections and diseases of the digestive system. Although the doctor does not blame cyanide directly, she says that pollution weakens the immune system, especially in children, making them vulnerable to various diseases. Fourteen years after the accident, although the processing of Baia Mare's gold has left a significant footprint on neighboring communities, press reports describing fear and drama of inhabitants are few and documented particularly by foreign press.

4. CYANIDE MINING POLLUTION FROM BAIA MARE - SANCTIONED BY AN ECHR SENTENCE

The European Court decided unanimously in Tătar and Tătar against Romania that the rights of the two applicants, to a healthy and protected environment was violated by Romania. The case is an unprecedented one for our country. It is the first sentence that criminalizes Romania for not respecting citizens' right to an unpolluted environment. Initially, the spill-over has reinvigorated the efforts of the European Union agencies to establish and apply uniform standards on the handling of toxic waste. In the long run, however, few have changed regarding the use of cyanide in mining.

5. POLICY CHANGES FOLLOWING THE BAIA MARE ACCIDENT

In December 2003, the European Union changed part of the environmental legislation. The Seveso Directive [6]. which regulates major industrial accidents involving hazardous chemicals, has been adopted. Seveso II replaced the original Seveso Directive, bringing provisions that regulate the storage of hazardous substances at processing plants and mining operations. However, Seveso II does not cover tailings ponds containing hazardous substances, other than heavy metals.

On 15th March 2006, the European Parliament and the Council adopted Directive 2006/21/EC on the management of waste from extractive industries, regarding the use of cyanide in mining activities and, at the same time, sets the maximum permitted levels of cyanide concentration [7].

In the explanatory statement, the Baia Mare accident plays an important part: "Over the last 25 years, worldwide, there have been over 30 major cyanide spill accidents, the worst being 10 years ago, when more than 100,000 cubic meters of cyanide contaminated water were discharged from a basin of the gold mine in Baia Mare (Romania) into the Tisa- Danube river system, leading to the worst ecological disaster in Central Europe at the time, and whereas there is no real guarantee that such accidents will no longer occur, especially in view of the increasing number of extreme atmospheric phenomena, including abundant and frequent rainfall, as estimated in the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, the resolution calls on the Commission to ban cyanide in mining activities by 2011".

6. LESSONS LEARNED

European Commissioner Margot Wallstrom, who held the environmental portfolio in 2000, visiting the Tisa banks immediately after the accident, said: "We have a lesson to learn from all of this and we have to act." However, the lessons learned are not so much reflected in the public policy changes at European or national level but rather in the drawing up of a picture of mining industry behavior, practices used, propagated discourse and the reaction of the authorities when faced with accidents environmental [8].

According to the law, local and county environmental authorities have the obligation to monitor mining operations explicitly carried out to prevent the occurrence of accidents that affect human health and the environment. However, regulatory agencies are unable to effectively supervise mining activities because of lack of qualified staff and necessary funds, but also because of possible political pressures. In the case of Aurul S.A., the Romanian state was in conflict of interest when enforcing regulations and environmental sanctions, Remin Company holding 42% of the shares [9,10, 11]. After the disaster, the Aurul S.A. factory, later renamed Transgold, has been operating for years, causing minor accidents all the time, until in 2005 it went bankrupt [12].

7. CONCLUSIONS

The market value of the 5.5 tons of gold extracted from Baia Mare would have been about $ 50 million, considering the average value of $ 279 per troy ounce in 2000. The initial investment of the Romanian state, of 6 million dollars, a lot of direct expenses have been added, including the hundred million dollars in compensations demanded by Hungary. Multiple indirect costs, such as the long-term health damage of population in the area, or the lack of other investors who are rightly afraid to open their businesses in polluted areas, lead to a minimum opportunity to sell cyanide-extracted gold.

A simple analysis of the distribution of the invariable risks associated with the use of cyanide shows that the most affected entity is the state on whose territory the mining project is developed.

The communities in the area are the worst affected, and the nature of the damages makes the locals living in the area the ones who have pay, at the cost of their health, the very bad business developed by the authorities. In the case of Baia Mare, the guilty company went into bankruptcy proceedings and was consequently absolved of any sanctions that should have been enforced. There are no references to any sanctions imposed on the persons who have been managing the guilty company.

Even if the locals were able to prove the causation of pollution-induced illnesses, they would still have no one to call to court for damages. Therefore, the outstanding amounts of money following cyanide exploitation and accidents caused by the use of this technology are paid by all taxpayers, including those whose health has suffered. These amounts are well above the value of a company's profits, even if it is willing to internalize some of the costs. In this case, these costs were outsourced primarily to the Romanian state and its citizens.\

The analysis of the Baia Mare case and the accidental cyanide spill reveals the attitude of the control authorities, at the border between incapacity and complicity. They are unable to predict or react promptly before or during a major accident. Control activity should provide ceasing of company operations, in the event of non-compliance with the permit conditions.

Tailings overfilling and the breakage or cracking of dams is one of the most common causes of accidental spills of toxic substances. A simple periodic inspection of the tailing pond could have shown that the tailings level is too high to keep the water from possible heavy rainfall. There is no information on sanctions imposed on inspectors who did not foresee this catastrophe, there are no documents showing that local authorities had presented at least a collection of lessons learned from the accident or a set of proposals to be taken into account when approving similar projects.

The 2000 accident remains an unfortunate reference for the shortcomings of cyanide mining projects. The fact that some authorities consider it appropriate to restart gold mining operations through cyanide, is just an effect of lack of vision and unjustifiable desire to attract this type of financial investment to heavily occupied areas. The mere mention of the 2000 accident should have been sufficient to block any support for the same type of mining project, taking into account that the first was completed with a tremendous environmental and financial disaster.

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ANFIS MODEL FOR PREDICTING THE RECOVERY OF COPPER FLOTATION CONCENTRATE

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ABSTRACT

This paper presents the results of the development and validation of predictive model, based on ANFIS hybrid system. The model predicts values of copper recovery in flotation concentrate from the flotation plant "VelikiKrivelj". The copper content in the feed ore, collector consumption in the rough flotation stage and consumption of frother, were selected as independent variables. Other technical and technological parameters, relevant for the process of flotation concentration were considered constant. The results of the model validation showed that the model provides moderate predictions of changes in the copper recovery.

Key words: model, flotation, copper, recovery, ANFIS

1. INTRODUCTION

Modeling of flotation processes is not a simple task, mainly thanks to the complexity of the process.Namely, a large number of variablesthat exist in flotation system affect the final outcome of mineral grains separation according to differences in theirsurfaceproperties.

In general, flotation models can be divided into two large groups. These are: (1) models based on standard mathematical equations and (2) models based on soft computing methods [1].

Although attempts to model flotation processes with classical mathematical equations are numerous – with significant variations in approaches – previous research in this field has not given satisfactory results. The nature of the process, based on the interaction of solid, liquid and gaseous phases, makes the application of classical equations very difficult. According to some researchers, each individual model is limited to precisely defined process conditions. Furthermore, the different degree of complexity of existing models affects that the accuracy and precision of modeling results differ from one another, even when the models are formed on the basis of the same experimental data.By introducing more parameters into the model, the accuracy of the results increases, but the significance of each parameter decreases [2].

Bearing in mind the current situation regarding the classic modeling of the flotation processes, it is necessary to consider the possibilities of innovative approaches in this field, which are offered by the methods of soft computing.

One of soft computing methods, used in the modeling of various flotation phenomena is hybrid adaptive neuro fuzzy inference system (ANFIS). The architecture of this system integrate the principles of fuzzy logic and artificial neural networks [3].The elementary idea of the ANFIS algorithm is to construct fuzzy inference system on the basis of known input/output data sets, where the parameters of membership functions are adjusted using the backpropagation algorithm only, or in combination with the least squares method (hybrid algorithm).Adjustmentsenablethe fuzzy system to learn on the basis of input/output data sets.Possibilities of ANFIS application in modeling and control of different flotation subsystems are described by several researchers [4-7].

2. EXPERIMENTAL

Experimental studies were carried out in virtual conditions, using MATLAB programming language. The validation of the proposed model was performed in Microsoft Excel. The independent variables were: the copper content in the feed ore (FCU), collector consumption in the rough flotation stage (PXR)and consumption of frother (FRT), while the dependent variable was the recovery of copper in final concentrate (RCU). Model development and testing wasbased on the real process data, collected from the flotation plant "VelikiKrivelj" during the multi-annual monitoring.

The development of a given hybrid model is performed using the ANFIS Editor GUI,within the framework of Fuzzy Logic Toolbox software module, which applies the methodology of neural networks in order to generate, train and test Takagi-Sugenofuzzy inference system.
During the optimization of elementary conditions of process modeling, the following two criteria were taken into consideration:(1) resulting surfacesshould describe the real process in the best manner, and (2) the root mean square error of training should be minimal. In this regard, expert analysis showed that the best results were achieved in the following conditions:

- Bell membership functions were proven to be optimal for fuzzificationof input variables (other membership functions gave recoveries higher then 1, as, in this case, recovery is expressed in parts of 1), while the linear functionsdescribedthe output better thenthe constants.
- Backpropagation algorithm was chosen as learning algorithm. Number of epochs was 400.

For neural network training, every second series of values of variables FCU, PXR, FRT and RCU (corresponds to the data of one shift) is chosen from the data base – "even cases".Figure 1 shows the training data entered in the ANFIS Editor and training error trend, while Figure 2 shows the basic structure of the generated fuzzy inference system, as well as the membership function for FCU variable.

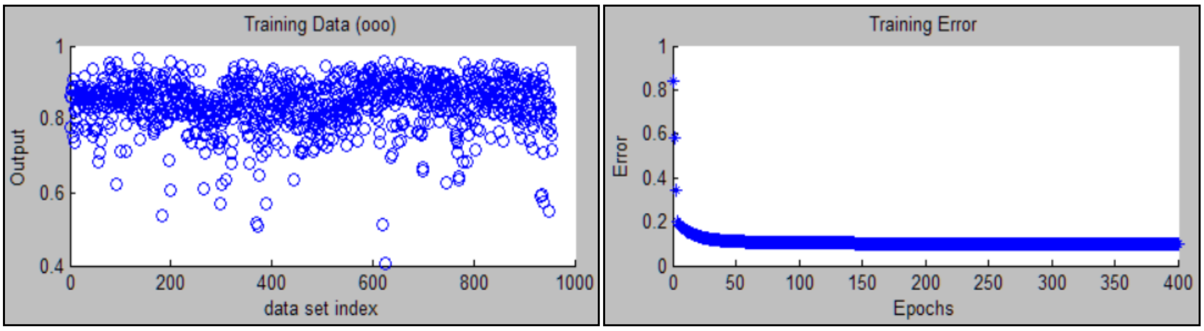

Figure 1. Entering of training data and training error.

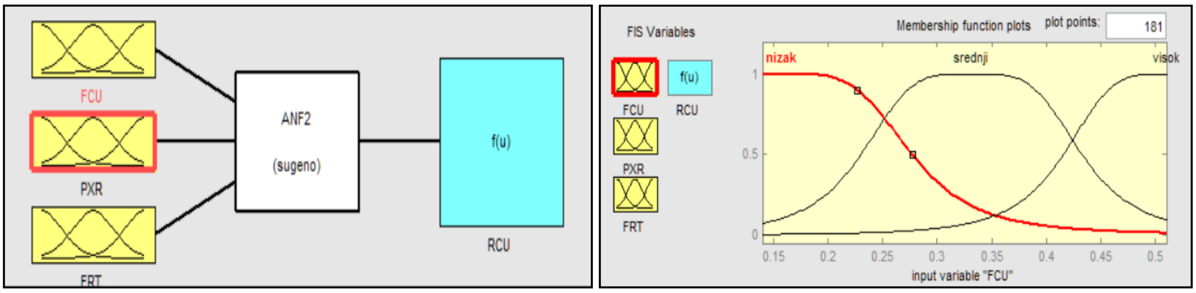

Figure 2. Structure of generated fuzzy inference system and membership function for FCU variable.

Structure ofgenerated neural network is [3-9-27-1] (see Figure 3(left)). Number of nodes in the first hidden layer corresponds to the number of membership functions belonging to each input variable (total of 9), while the number of nodes in the second hidden layer corresponds to the number of fuzzy rules (total of 27), where the consequence of each rule is a linear function with different coefficients.

Figure 3 (right) shows one of the resulting surfaces generated by ANFIS.

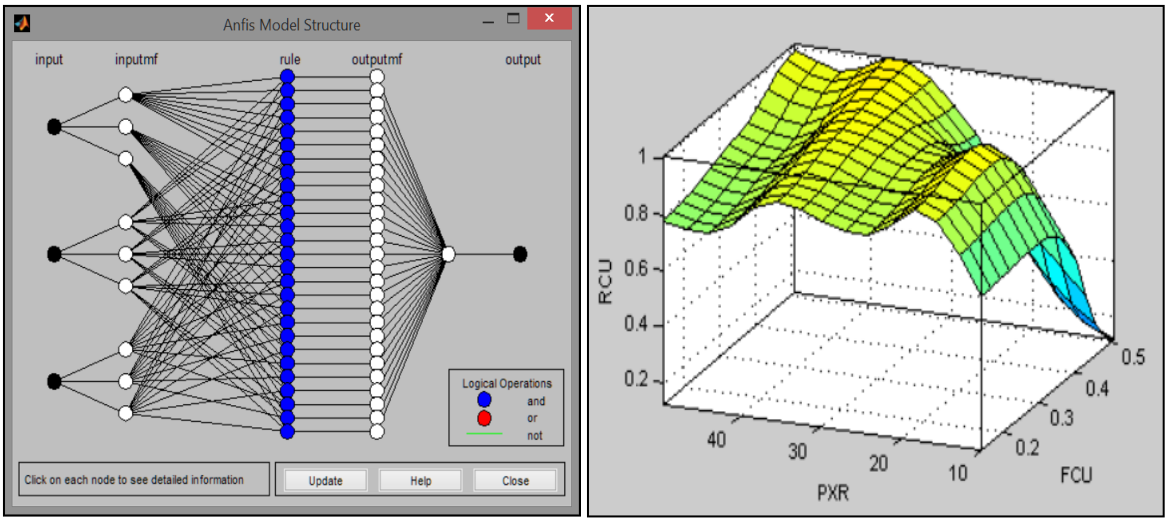

Figure 3. Structure of neural network and dependence of the copper recovery in final concentrate on the collector consumption and copper content in feed ore

As it can be seen from the Figure 3, presented surface does not describe real dependences in flotation process in the best way. In the observed range of values, with an increase of the amount of collector, copper recovery in concentrate should be constantly increased. In this case, resulting surface has a "wavy" shape.

3. RESULTS AND DISCUSSION

Evaluation of the model was performed in the software package MATLAB– by entering the real values of the process input variables from industrial flotation plant "VelikiKrivelj" and generating corresponding outputs predicted by model. The evaluation of model was made by forming a matrix of three independent variables and generating the column matrix for output variable, using the module Fuzzy Logic Toolbox.

With the aim of determining the possibility of the model to reliably predict the recovery of copper in final concentrate on the basis of the given input parameters, regression analysis is performed in Microsoft Excel. By the regression analysis, the correlation between the actual process values of copper recoveryand the values predictedby model is established.

Table 1, 2 and 3 show the results of the regression analysis for the formedmodel, while the Figure 4 shows the error of predicting the copper recovery in final concentrate. Prediction error (ε), which served as one of the criteria for assessment the predictive properties of the model, is calculated according to formula (1):

$$\varepsilon = y_{pr} - y_{re} \quad (1)$$

Where:
y_{pr},y_{re}– predicted and real value of copper recovery, respectively

Table 1.Regression statistics

Correlation coefficient R	0,99608
Coefficient of determination R^2	0,99217
Adjusted R^2	0,99164
Root mean square error	0,079921
Observations	1910

Table 2. Analysis of variance

	df	SS	MS	F	SF
Regression	1	1544,76	1544,76	241848,19	0
Residual	1909	12,19	0,00639		
Total	1910	1556,95			

Table 3. Statistical analysis of regression linear equation

C	SE	t	p	L95	U95
1,06415	0,00216	491,78	0	1,05991	1,06840

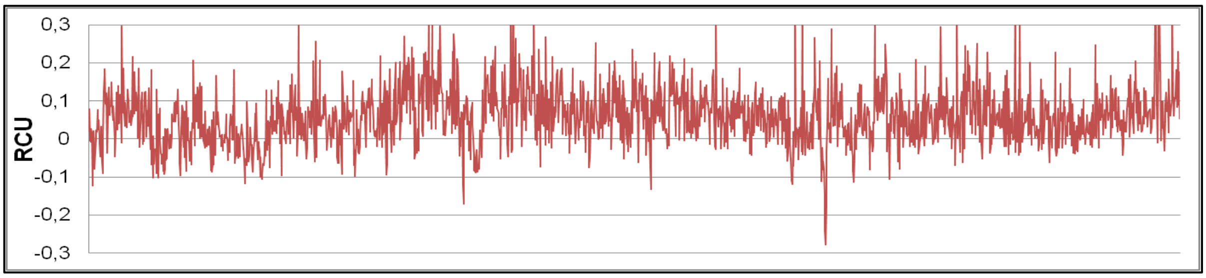

Figure 4. Prediction error of copper recovery in final concentrate

After considering the results of the regression analysis shown in Table 1, it can be concluded that the valuesof coefficients are high, which refers to the strong link between the actual and predicted values of the copper recovery in the final concentrate. In other words, model wellfollows changes in real values of the observed parameter related to their rise or fall over time.

However, by visual analysis (see Figure 5), it can be concluded that the recovery values obtained by the model are generally higher than the real ones.This is also confirmed by the prediction error, which is mainly positive (Figure 4).

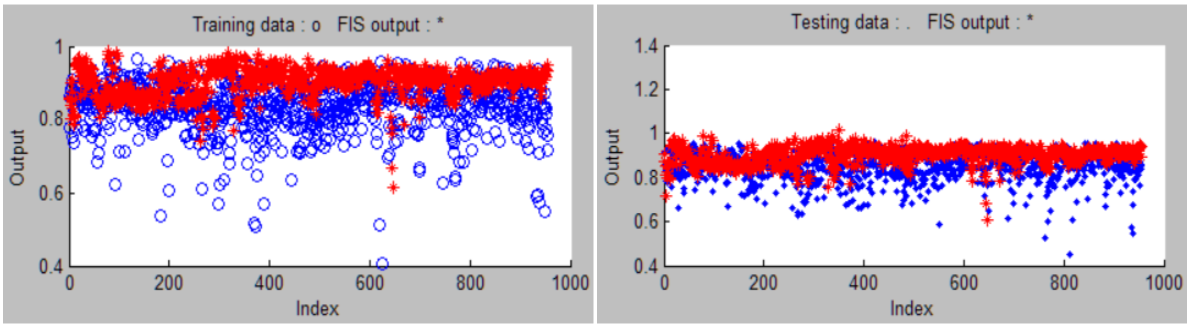

Figure 5. Prediction of the copper recovery in comparison to the training and test data

4. CONCLUSION

The results of modeling the process of flotation concentration using the hybrid system ANFIS indicate that given model has a medium to goodpossibilities to predict the copper recovery in the final concentrate from the plant "VelikiKrivelj". Namely, high correlation coefficient means that the model well follows changes in the actual values of the observed parameters, but, in the same time, predicted values do not always meet the required criteria in terms of precision.

5. ACKNOWLEDGMENTS

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EXPANSIVE MORTAR TO DEMOLISH AND CUT ROCKS AND CONCRETES

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APSTRACT

In this paper are describe the material - expansive mortar for demolish and cutting rocks and all tipe of concretes. Also are given some results of use in the queries in Macedonia for extracting commercial blocks of pure white marble.

Key words: mortar, no explosion, cutting, demolish, marble

1. INTRODUCTION

This materialishighly expansive mortar to demolish and cut rocks and concretes. When is purred into a hole after some time develops a pressure higher then 8000 t/m^2 on the hole walls.

It is non explosive material, and for storage requires no special conditions, provided the containers are not tampered with and are kept in a dry place.

FRACT.AG can be used in an unlimited range of applications and particularly to break, cut, or demolish rocks, concrete and reinforced concrete when explosives cannot be used for safety reasons.

We can used on any type of rocks formation, concrete or tiled structure in: excavating foundations, leveling rocks for road works removing boulders, different demolitions for buildings , poles, towers, walls etc .Also this is very important: can be use for cutting blocks of marble , granite and travertine more economically than with the traditional helicoidal wire-cutting method and excavation and demolition of rocks formation or cement/concrete structures where the use of explosives would be expensive due to long operating times, special transport, more secure and safety ways, storage and handling precautions and the need to comply with public safety regulations.

This material are produce with diferent commercial names. Most popular is this tip FRACT.AG, from the firm CHIMICA EDILE, srl, Italy. Six tipes of Fract,AG are available on the market. This all types are in use depends of temperature in the air when we use.

2. WHO CAN USE AND HOW FRACKT.AG?

In general anyone can use it in any situations, because it is perfectly safe, soundless and nonhazardous. It does not debris or dust, not does it form gas or cause any shock waves. Unskilled labour can be very easily trained to use in a short time. FRACKT.AG is a powder that must be thoroughly mixed with clean cool water in a ratio of 30% of the overall weight. Put the required amount of water into a large container (1,5 liters for each 5 kg package), gradually add the powder to water stirring all the time to obtain a smooth, lump free mortar . Pour the mortar into the prepared holes within 5 to 10 minutes.

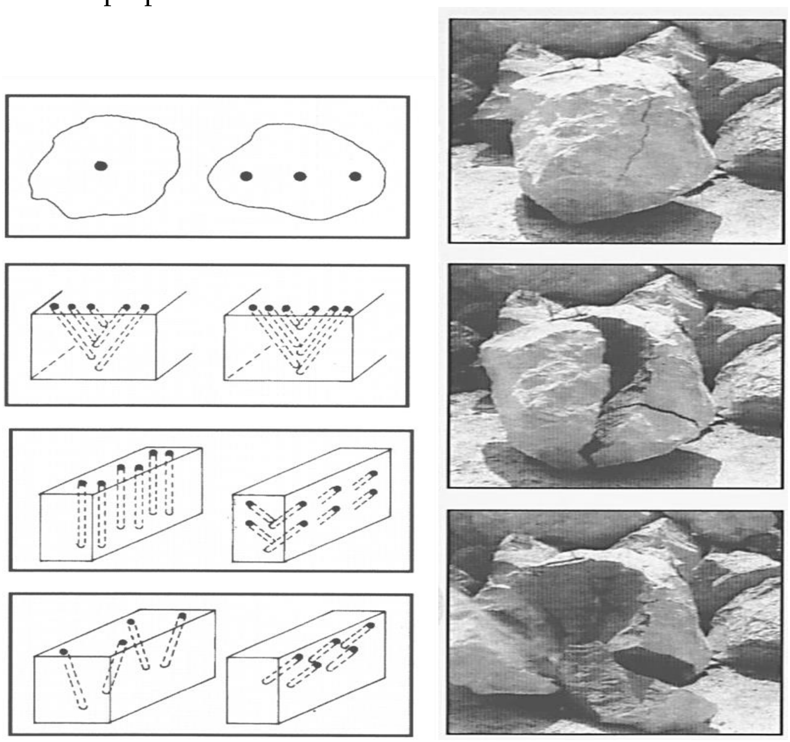

Figure1. Ways of use fract.ag (for demolition, cuts, splitting, breaking rocks)

TIPES OF FRACT. AG AVAILABLE

On the market are any types of this material or agent. There are six types of fract.ag like powder and plus type with cartridge for horizontal holes.

Depends of temperature in the air this types can be used.

RED – for near 5 ^{0}C, GREEN – for temperatures from 5 to 25 ^{0}C, YELLOW – from 20 to 35 ^{0}C, BLUE – 50 to 60 ^{0}C – universal.

The product in cartridges is conveniently supplied ready – mixed in plastic wrapped cartridges and as such there are no limitation to its use in any working environment. Mixing is not necessary thereby eliminating the possibility of using the wrong amount of water, since it will only absorb the required amount. It can be used anywhere without taking special measures (roofs or wall holes). reaction time is quicker, therefore it demolishes or cuts faster. Cartridges are available in 100 cartridge – boxes. each cartridge is f 28 mm, 22 cm long and contains 200 g of agent. They must be used in 32-34 mm diameter holes.

Figure 2. Types of frack.ag available

TIPS ON HOW TO USE AND WARNING TO USER

When we use FRACT.AG must to know tips for best useful. The distance between the centres of the holes in the rock (marble or granite) or non-reinforced concrete should be 30 to 60 cm, depending on the diameter of the holes. (for example: d= 32 mm dist = 30 cm, 35=40 cm, 40 mm=50 cm).

Estimated consumption of FRACT.AG powder for 1meter of hole is:

Diameter	**30**	**32**	**34**	**38**	**40**	**45**	**50**
Consumption (kg/m')	**1,1**	**1,3**	**1,5**	**1,8**	**2,0**	**2,6**	**3,0**

When we use this agent must keep our face from the hole during the first 2-4 hours as the product might (thigh highly unlikely) eject from the hole violently (blow-out) if instruction have not been followed correctly. Goggles and rubber gloves should be worm as a safety precaution. This is an alkaline product with a PH = 13 and could cause severe irritation to mucous membranes, especially eyes.

3. SOME RESULTS OD USE FRACT.AG IN QUERIES

We make some test in quarries in Macedonia for marble and granite. We will present as bellow.

1 st test in marble quarry:

Diameter of holes: 32 mm, Distance between holes: 30cm,Consumption: 1,2 kg/m',Type of rock: white marble, Use for make cut between two blocks and breaking the blocks.

		
	 Breaking the blocks	

.

2st test in marble quarry:

Diameter of holes: 32 mm,Distance between holes: 30cm,Consumption: 1,2 kg/m'.Type of rock: white marble,Use is for make new CUT between holes.

 Before	 After	 After
 Before in the right site	 After crack left	 Crack right After 5-6 hours

4. CONCLUSION

This material (base is $CaCo_3$) can use in any situation for more methods for cutting and splitting blocks in the quarry mine. Also this agent we can use for demolition concrete/cement structures.

This method is more economically than standard methods to cutting blocks of marble or granite. The time for action effects depend of weather and temperature on the blocks. This time was between 5 and 12 hours for our tests which we make in this quarries.

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NOISE SOURCES IN MINING, THE IMPACT OF NOISE IN THE WORKING ENVIRONMENT AND MEASURES FOR ITS CONTROL

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ABSTRACT

Application of modern technologies in the mining industry through energy efficiency, higher labour productivity, adopting continuous production methods, operational flexibility, resulted the use of machinery and equipment of high capacity. Parallel to this, the result was a significant increase in the number of noise sources and noise levels in open pit and underground mining. The paper presents noise sources, the impact of noise on labour and suggestions to reduce noise impact in the workplace.

Key words: noise, impact, mining.

1. INTRODUCTION

Noise pollutionornoise disturbanceis the disturbing or excessive noise that may harm the activity or balance of human or animal life. The source of most outdoor noise worldwide is mainly caused bymachinesand transportation systems, motor vehicles, aircraft, andtrains. Outdoor noise is summarized by the wordenvironmental noise. Poorurban planningmay give rise to noise pollution, since side-by-side industrial and residential buildings can result in noise pollution in the residential areas. Documented problems associated with urban noise go back as far as Ancient Rome.

Outdoor noise can be caused by machines, construction activities, and music performances, especially in some workplaces.Noise-induced hearing losscan be caused by outside (e.g. trains) or inside (e.g. music) noise.

High noise levels can contribute to cardiovascular effects in humans and an increased incidence ofcoronary artery disease [1]. In animals, noise can increase the risk of death by altering predator or prey detection and avoidance, interfere with reproduction and navigation, and contribute to permanent hearing loss [2].

2. NOISE IN MINES

Works carried out in order to expand productivity in themining industry have pointed out the necessity to utilizelarger machinery in parallel with improvements in technology.An increase in mechanisation also has resulted in anincrease in noise levels, leading underground and open pitmines and mineral processing plants to generate enormouslevels of noise. Occupational noise in underground mineshas reached unbearable levels due to the reverberant natureof the narrower spaces. Therefore, it is hard to find a relativelylow-noise environment for workers. Although theequipment employed in open pits are comparatively largerin size than the ones encountered underground, they maybe said to be less significant as the noise emitted from themeasily spreads hemi-spherically in the free sound field.

In reality, the noise occurring during extraction works(i.e. drilling-blasting, excavation, loading and transporting)that take place in both open and underground pits is noteworthywhen considering labour health and job performanceas the highest disease and illness rates in mining continue tobe mine worker’s permanent or temporary hearing loss [3].

Each machine, device or means of transportation has many elementary vibroacousticenergy sources. The vibroacoustic energy source is understood as a mechanical oracoustic system generating acoustic vibrations. Properties of such source can be assessedin two ways:

- considering the properties of an acoustic field generated by the source, whichprovide the so-called external or field characteristics of the source,
- considering the properties of the source itself as the vibroacoustic energy emitter.

The collection of such properties constitutes the socalled internal characteristics ofthe source.

External characteristics of the source are used for assessment of an acoustic effectgenerated by the source, while internal characteristics - for assessment of the sourceitself [4].

Noise sources can be classified from many points of view. The basic division consistsof: theoretical models of radiation, physical reasons of noise generation and the noiseorigin. The detailed description of vibroacoustic energy sources can be found in reference [5].

Classification of vibroacoustic energy sources occuring in open pit mines, performed when taking into account two criteria: physical causesof noise generation and the noise origin, represetedon Figure 1. The most representativesources were selected for the presentation on Figure 1. The machines which emit most vibroacousticenergy: are mining machines, especially: crushers, pneumatic hammers, drilling rigs,excavators, dumping conveyers and belt conveyers. The most annoying sources of vibroacousticenergy are explosions at blasting works, which are also the sources of shortlivednoises.

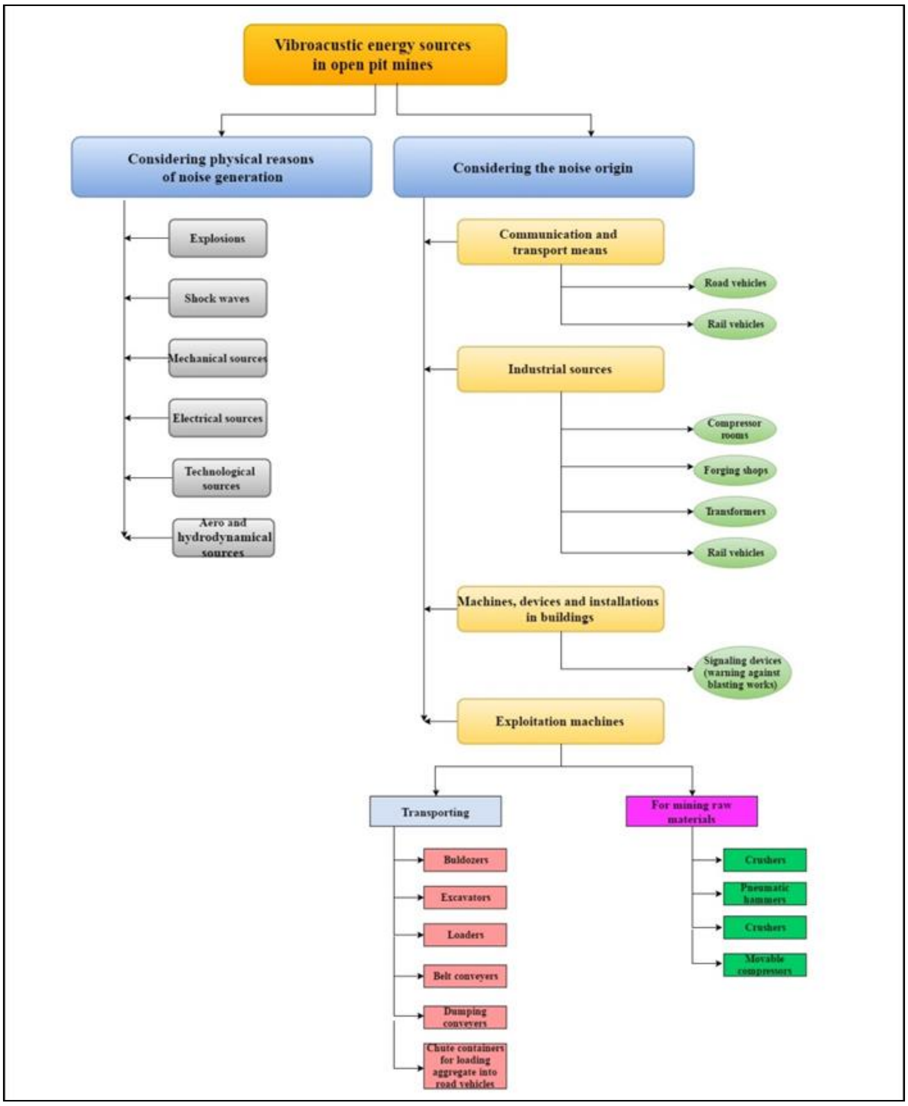

Figure 1. Classification of vibroacustic energy sources

3. EFFECT OF NOISE ON HEARING MECHANISM

Upon the receival of an acoustic signal, pressure changes occurring in the auditory canal move the drum membrane (Figure 2). The bones called hammer, anvil and stirrup, which are located behind the eardrum are connected in a chain between the tympanic membrane and the round window of the cochlea. In the case of these bones being exposed to noise, they start to vibrate.

Therefore, the sound energy caused by this vibration is converted into mechanical energy and then into hydraulic energy in the cochlea. The motion in the cochlea will affect the small hair-like cells in the cochlea depending on the electrical signal frequency. When a cell is stimulated it sends an electrical signal to the brain. The loss of hearing in the inner ear, apart from natural diseases, may be faced in the case of small hair-like cells becoming damaged or weakened due to excessive noise levels for a long period[6]. Noise-induced hearing loss is 100% preventable but once acquired, hearing loss is permanent and unfortunately irreversible.

Miners have to put up with a variety of noise sources during their daily working environment. Contrary to popular thought, hearing loss arising from instant high levels of noise rarely happen; however, the main cause is prolonged levls of sound. The length of period during which workers are exposed to excessive noise is rather important as it takes a foremost role in distinguishing the type of hearing loss being either temporary or permanent. In Fig. 2, the hearing loss percentage of underground colliery workers can be seen [10].

The parameters which are effective for hearing loss due to noise are exposure period, noise level, age of workers and physical condition of workers (existence of other illness etc.). For most effects of noise, there is no cure. However, prevention of excessive noise exposure is the only way to avoid health damage.

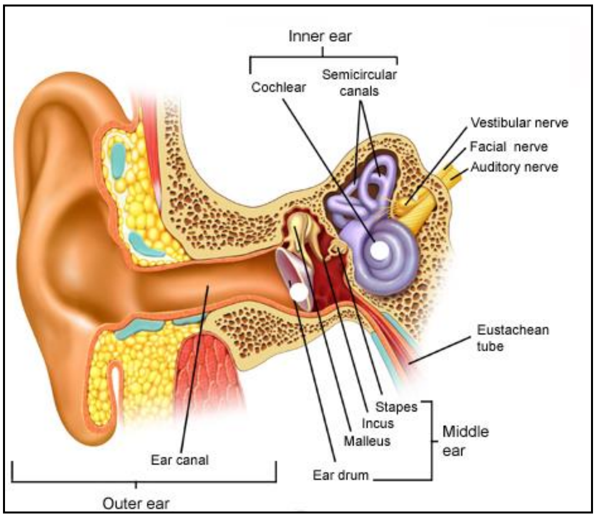

Figure 2. Anatomical layout of ear [7].

The noise adversely acts on the central nervous system, and from there to other parts of the body, organs and systems, in particular, in the sense of hearing, and the endocrine glands. According to the harmfulness the noise is divided into three stages:

1. The first level of noise harmfulnes is intensity of 30-60 dB. It disturb intellectual work and concentration. The occurrence of these noise levels at night, when a man needs to rest, then its harmful effects is stronger, because it leads to insomnia, neurosis, nervous exhaustion and a general weakening of the body.
2. The second level of noise harmfulnesis intensity of 60-85 dB. It occurs in the working environment and industrial facilities. It acts adversely on the nervous system, and as a result causes a disturbance of other organ systems, such as the heart, blood vessels, endocrine and heard. The noise level of 85 dB at some people causes hypoxia of small hair-like cells in the ear, leading to hearing loss. Other consequences are loss of balance, dizziness, stomach ulcers and others.
3. The third level of noise harmfulnesexceed intensity limit of 85 dB. Upon the sudden and unexpectedly occurrence, it leads to spasms of blood court proceedings increased blood pressure. The noise of this level damages the central nervous system, heart, blood vessels, sense of hearing, and other organs and systems, which has not yet been established correlation between exposure and damage.

4. CONCLUSIONS AND PROPOSED MEASURES OF MINIMIZING ANDREDUCTION OF THE NOISEIMPACT IN THE MINE

Noise survey sampling is necessary to determine anyoverexposure in order to effectively eliminate or reducethem. Additionally, reduction of occupational noise inmines is an effective factor to ensure adequate and productiveworking conditions. Thus, the measures categorizedas administrative and engineering noise controls toremedy noisy environment in mines are given below:

Administrative

- supplying the workers being exposed to occupationalnoise exceeding 87 dBA with earplugs, semi-insertplugs, muffs and helmets,
- reducing hours of work where excessive sound pressurelevels are experienced,
- task rotation of workers,
- training the workers about the use of personal protectorsand explaining their advantages,
- having the mine workers undergo periodic medical inspectionsto check hearing.

Engineering noise controls

- selecting the processes with lower sound pressure levels,
- locating the mine-related plants in noiseless places,
- enclosing the source of noise and preventing the noisefrom being transmitted,
- isolating the operators’ cab,
- moving the noisy machine to a little-used section of amine.

The effectiveness of hearing protection programsmay be hindered sometimes by poor compliancein the use of hearing protection devices due to communicationdifficulties, comfort issues, individuals’ attitudesabout protecting themselves from noise-induced hearingloss, and individuals’ perceptions about how otherswho do not use hearing protection will view them if theychoose to use hearing protection [18].Comprehensive programme of hearing conservationin Serbian mines should be initiated toidentify those activities that carry most risk and to minimizenoise exposure.

ACKNOWLEDGEMENTS

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IMPROVING THE PROTECTION OF MINING EQUIPMENT BY DEVELOPING NEW GENERATION OF METAL DETECTORS AND MAGNETIC SEPARATORS

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ABSTRACT

Different kinds of metal parts fall into the conveyor belts very frequently in the open pit coal mines. Sometimes that causes damage to conveyor belts and other equipment, such as crashers. Newly constructed metal detectors are capable to recognize different kinds of metal and their dimensions, as well.

Key words:Open pit mines, conveyor belts, metal parts, crashers, metal detectors

Conveyor belts are one of the most commonly used transport systems in industry. In open pit mines, especially in Europe, conveyor belts are used for the transportation of coal and excavated dirt. They operate as an integral element of the BTO or BTD systems. The excavated dirt in coal mines is also being excavated with rotor excavators or bucket excavators, transported with conveyor belts to the landfill, and then to the depositors. The coal is also dug up with rotor excavators and bucket excavators, and then transported with conveyor belts to the accepting point for the dug up coal. The conveyor belts are the most expensive element of the BTO system, so it is necessary to protect them from damage, which is very difficult in working conditions at open pit mines.

One of the most common types of damage is the intake of metal objects. Metal objects can be dug up together with the material excavated with the excavator, and they can be part of the construction of the mining equipment which, for some reason, falls off and finds itself on the conveyor belt. Most commonly these are metal parts that have not been picked up after the system haul and servicing, which then find themselves in the excavator's bucket together with the excavated material. These are often the excavator cogs, pedals, wearing dredges and belts. When it comes to coal systems, the transport of coal material ends up in the bunker of a crushing plant or a similar plant.

Prior to being loaded into wagons, the coal is crushed in order to be prepared for combustion in the Thermal Power Plant. The crushers are particularly sensitive to the intake of metal objects, so that an integral part of this facility is the delivery of coal to the crusher and the system of crusher protection. Besides the crusher in a crushing plant at the Thermal Power

Plants, prior to its introduction into the boiler, the coal is also being crushed in mills. These mills are very sensitive to the intake of metal objects and they also must be protected. The practice of installing protective systems on open mines is such that the BTO systems are generally not protected while the BTD systems as well as the crushers are protected against metal objects falling onto the conveyor belt.

Protection against damage to equipment incurred by metal objects is done with magnetic separators and with the help of metal detectors. Metal detectors are mainly used in two ways, or as a stand-alone device which stops the conveyor belt when detects any metal parts, or acts as an initiator of magnetic operation and magnet operation control. The principle of operation of metal detectors is to register the deformation (strength) of the electromagnetic field.

Therefore, the metal detector has two basic elements: the transmitter of electromagnetic field which emits a homogeneous field on one side of the conveyor belt and the electromagnetic field receiver on the other side of the conveyor belt. The electromagnetic field extends through the conveyor belt and the material which the conveyor belt transports. The metal detector is adjusted so that the reference value of the received field is its normal value. If a metal is found between the transmitter and the receiver of the electromagnetic field, there occurs a deformation of the homogeneous field, which the detector "recognizes". That information is then used either to stop the conveyor belt, or to turn on the full power of the electromagnetic separator.

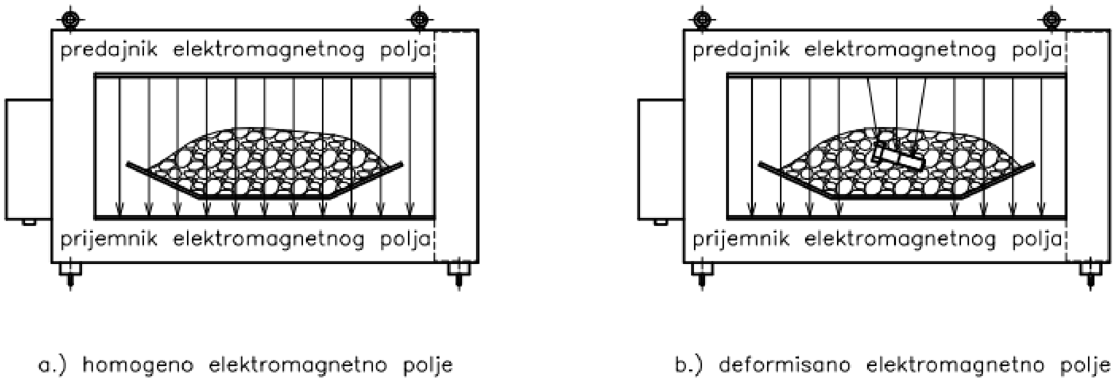

Figure 1. Metal Detectors Basic Scheme:

a) homogenous electromagnetic field
b) deformed electromagnetic field

The basic conditions for the operation of metal detectors are that the conveyor belt is made of textile and that the influence of metal rollers and metal construction of the conveyor belt are eliminated. The detector has the ability to adjust its sensitivity so that the size of the metal object which stops the conveyor belt may be selected. Problems in the operation of the detectors are such that that the light opening of the frame must be large enough to allow for the passage of the largest pieces of coal dug by excavators. It is known that different excavators deliver different sizes of the excavated coal. Those excavators are primarily bucket excavators and dredge excavators. The pieces of coal dug with these excavators size up to 1 m. With rotary excavators, the size of coal pieces is considerably smaller and it is inversely proportional to the cutting speed of the bucket wheel.

However, large chunks of coal sometimes occur with these excavators, as well, and that is when the first cut is being dug. Because of this, the light opening of the frame is often very large, which weakens the magnetic field, i.e. the sensitivity of the device. One of the alternative solutions is the installation of a device in the form of a trough of a conveyor belt, and such a form of device allows the passage of pieces of any size. However, such configurations do not have a homogeneous magnetic field, so their sensitivity is variable along the depth of the trough of the conveyor belt.

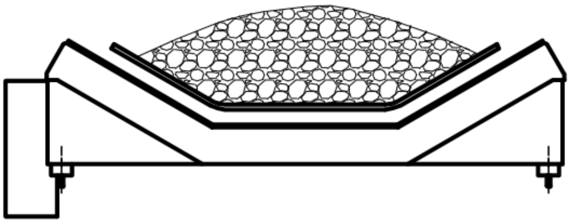

Figure 2. Metal Detector Open Configuration – Open System

The disadvantages of the devices that were used earlier were that they could not detect long thin metal objects. They also could not distinguish the types of metal that the metal objects were made of. Today, with the advancement of technological solutions, these two problems have been solved. The problem of distinguishing the type of metal from which the metal objects are made was solved by analyzing the response of metal to the emission of the electromagnetic field. Each type of metal has its own phase response, so the type of metal can be determine by knowing its phase characteristics. The amplitude depends on the type and size of the metal.

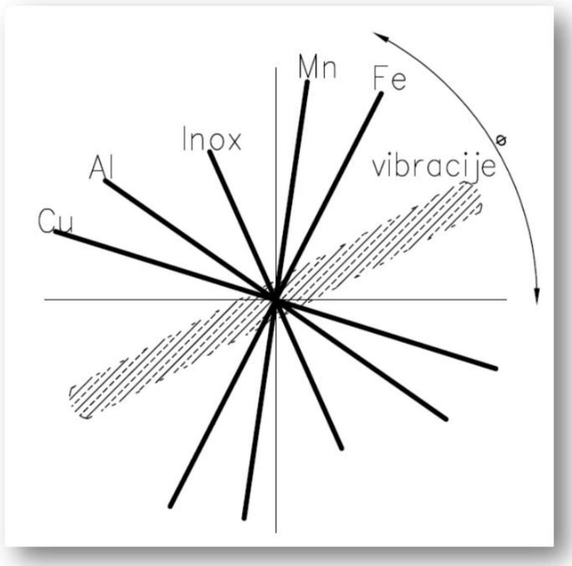

Figure 3. Phase Diagram of Various Metals

Nowadays, it is also possible to detect long and thin metal objects, and while at it, their length can also be measured. When working independently, metal detectors have the role to stop the conveyor belt in the event that a metal object is being dropped onto the conveyor belt, and to mark the place where such object is located, and such a method of operation requires the delay and engagement of the operator in finding and taking out the metal object.

There is a technical solution where the metal detector is used to activate the full power of the magnetic separator. In this solution, the installation of two metal detectors is applied: one to turn on the magnetic separator which stands in front of the magnet and the other behind the magnet which controls the performance of the magnetic separator.

The second detector stops the conveyor belt if for some reason the magnetic separator has not extracted and separated the metal object (non-ferromagnetic metals - stainless steel, manganese,...). Magnetic separators are essentially very strong electromagnets which in addition to separating a metal object from the conveyor belt, extract and eject the object in the trash bin using the conveyor belt. Since electromagnets are very powerful devices that consume a lot of electricity when in full operation mode, when idle, they are usually held in a "standby mode" regime. Switching the magnet on and off, as well as its very operation, leads to its heating, which is why it often involves the introduction of the forced cooling, which further complicates the construction.

Nowadays, there are electronic devices for easy commands, by turning the magnet on and off. In addition, the isolation of the conductors with glass insulators enabled significantly higher operating temperatures of the device. The new solutions allow for easier operation, and the possibility of much more frequent switching on and off.

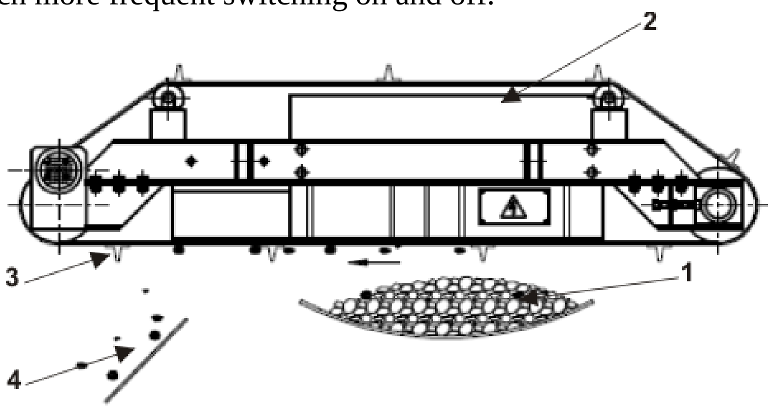

Figure 4. Basic Scheme of Electromagnetic Separator Operation:

1. Conveyor belt with the material
2. Electromagnet
3. Conveyor belt for transport of the removed metal
4. Removed metal

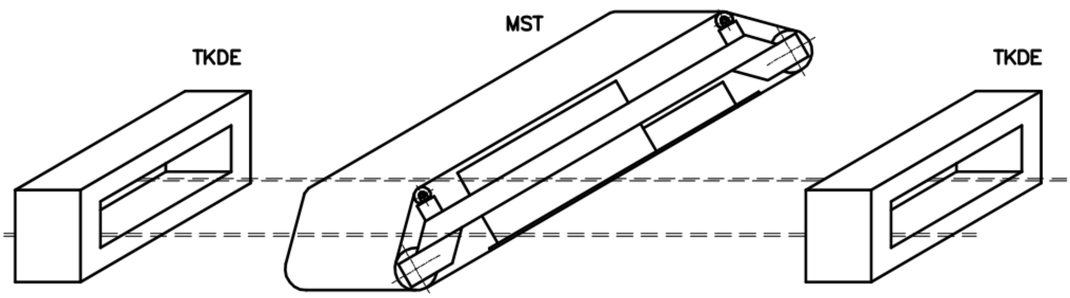

Figure 5. Basic Scheme of Electromagnetic Separator and Metal Detectors Operation:

1. Metal detector for turning on the electromagnetic separator
2. Electromagnetic separator
3. Metal detector for turning off the conveyor belt
4. Conveyor belt

When it comes to fast conveyor belts, the magnetic separator is placed above the unloading drum in the direction of the conveyor belt movement. Then the magnetic separator is above the material that floats, and in this state it is much easier to extract metal objects than when they are in the trough of the conveyor belt and trapped and enclosed with pieces of coal. The disadvantage of this position is that when two conveyor belts are in the axis or approximately to it, the unloading of metal objects from the magnet must be performed over some steep plane. If the conveyor belts are at an angle of approximately 90° there are no problems in the unloading of the separated metal objects. Such a configuration has the best effects. If a control magnetic detector is placed in this configuration, it will be on the next conveyor belt and it will stop it.

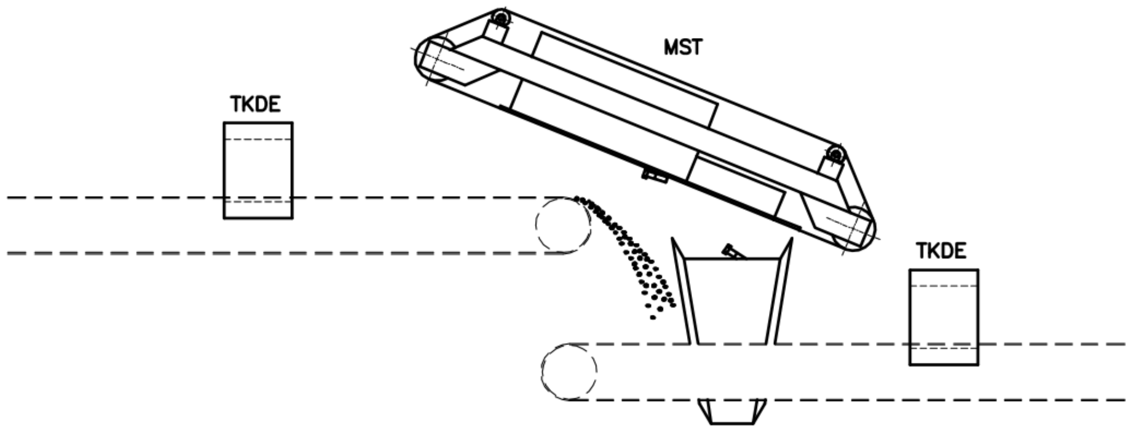

Figure 6. Magnetic separator placed above the unloading conveyor belt that is in axis

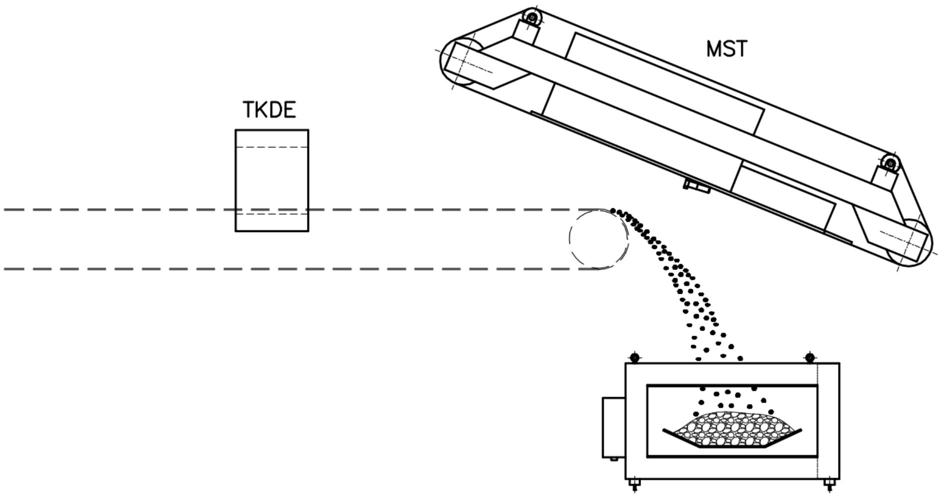

Figure 7. Magnetic separator placed above two unloading conveyor belts at 90° angle

CONCLUSION

Although metal detectors and electromagnetic separators represent a relatively high investment, they can be reimbursed even at the first detection or elimination of the ferromagnetic foreign object. Metal foreign object can namely damage the conveyor belt or the technological equipment, and any such damage is associated with high costs, both due to production cessation and the cost of repair itself. Correct choice and installation of separators and detectors is essential for smooth and optimal operation and protection of production.

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MEASURING THE SEISMIC EFFECTS OF A QUERRY FOR MARBLE

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ABSTRACT

Abstract: In the querry for white marble "Sivec", where the research was carried out during normal exploitation, in the zones where digging is done, marble masses appear, which are broken down, not quality, and they need to be quickly removed. Drilling and mining operations are applied using certain quantities of explosives. In this application there is a danger of damaging the quality marble masses that are located around the blasting zone.

This paper is actually a continuation of the paper from the same authors regarding the seismic effects from blasting in surface mines.

1. INTRODUCTION

To get a marble blocks and larger lamellas it is necessary to perform controlled blasting for the removal of the cracked masses. During these blasting, there is the greatest danger of the effect of seismic action, whereby existing invisible cracks can be activated or new ones created. Also, this seismic effect has influenced to the surrounding benches and workshops by creating oscillations that can cause certain vibrations and damage to the marble massif.

When mine holes are located it is important to correctly define the existing cracks, discontinuities and the general direction of fall and stretching of the rock mass.

This paper presents some of the results which were obtained by measuring and will be clearly explained with a special commentary, which will provide a clearer picture of the impact of the mine work on the surrounding benches.

2. DESCRIPTIONOF BLASTING SERIES WITH THE BASIC DRILLING-BLASTING PARAMETERS

These blastings are performed at the surface mine Sivec, which works within the frames of Marble Company AD Prilep. The mining was organized and carried out by the company Dam-explo, Radovis in cooperation with the experts and the mining group from the Sivec mine. All series are performed in marble mass with pronounced geological deformities, lasses and cracks of different character. The measuring points, ie the instruments detecting and registering the seismic oscillations were set at the same level as the location of the marble mass at different distances in a relatively straight line depending on the distance of the mine series, the measurement site and the working conditions. All blasting of the series were successful according to the foreseen schedule and schedule of activation.

The mine series are shown in the order of ignition and the effects of the obtained results from the seismic oscillations are presented below.

2.1. Blasting series No.1

This blasting series have a volume of 392 m^3. The blasting series is characterized by present cracks and loose masses in the upper part of the bench. In all the holes there is a visible presence of water and dirt that makes the ignition itself and the effects of the mining difficult.For this blasting, six horizontal holes were made at a height of 1.5 meters from the floor of the bench, the depth of which is different and ranges from 1.0 to 4.0 meters, arranged in one row with a distance of 2.0 to 2.4 meters.

The drilling diameter is 90 mm. Explosive Amonex-4, marked 60/1000, was used for chargingThe activation of the explosive in the hollows was carried out with the Nonel detonators U_{500}. The initiation of nonel tubes is with a capsule 8 and a slow-fitting wick.

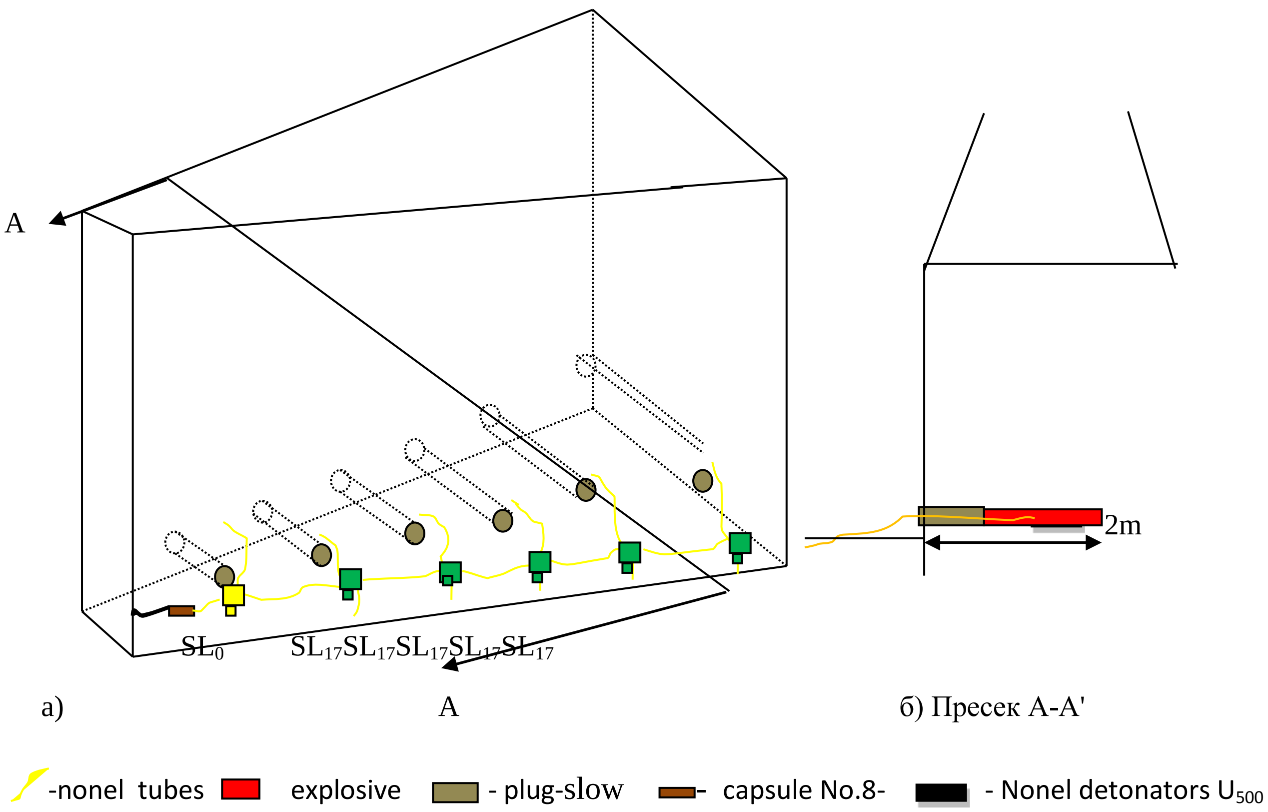

Figure. 1:Schematic of the blasting series No.1 and the way of connection

Table 1. Arrangement of the explosive in holes and their length

Ordinary number of drilling hole	Depth of the hole, L_b (m)	Quantity of explosives, Q_b (kg)
1	1,0	1,0
2	1,5	3,0
3	2,0	4,0
4	2,5	3,0
5	3,0	4,0
6	4,0	7,0
Total	**14**	**22**

Instrumental measurements

Registration of seismic vibrations was performed on 7 measuring instruments of type VIBRALOK.

The seismograph is constructed so that it can record the oscillation speed (v), calculating the acceleration (a) and the displacement of the ground (x), as well as the values for the frequency.

The Vibralok instrument is equipped with 8 megabytes of memory for measurement and can store 1000 individual measurements stored in this memory in accordance with the time sequence.The oldest measurements are deleted and replaced with new ones. The recording length can be set to 1,2,3 .... 5,10,20,30 ... 50, ... 100 seconds.

The measuring points are determined in cooperation with the responsible persons in the surface mine Sivec.

The corresponding influential parameters are given:

- Distance rom the center of the blasting series (MS) to the measuring points (MM),
- Maximum quantity of explosives per one interval, Q_i ,
- Total quantity of mine explosive, Q_{vk} ,
- Maximum oscillation speed per component, V_V ; V_T ; V_L ,
- The maximum resultant oscillation speed, V_{max} ,
- The real maximum resultant oscillation speed, V_{st} ,
- Calculated reduced distance, R.

Table 2. Results of seismic measurements for blasting series No. 1

Measuring place, MM	Distance of the minefield to MM, (m)	Maximum quantity of explosives per one interval ,Q_i, (kg)	Total quantity of mine explosive Q_{vk}, (kg)	Maximum oscillation speed per component, (mm/s)			The maximum resultant oscillation speed,V_{max} (mm/s)	The real maximum resultant oscillation speed V_{st}, (mm/s)	Calculated reduced distance, R, (m)
				V_V	V_T	V_L			
MM-1	195,5	I int- 1,0	22,0	-	-	-	-	-	
MM-2	152,0	II int- 3,0		-	-	-	-	-	
MM-3	117,8	III int- 4,0		-	-	-	-	-	
MM-4	91,2	IV int- - 3,0		1,14	1,35	1,87	2,573	2,100	32,5
MM-5	66,0	V int- -4,0		2,82	2,08	3,20	4,739	3,460	23,6
MM-6	72,0	VI int- -7,0		-	-	-	-	-	
MM-7	126,0			-	-	-	-	-	

According to the obtained results, the impact is insignificant, and only two instruments have recorded minor oscillations on the ground at the nearest measuring points MM-4 and MM-5. These oscillations according to the Criteria for vibrations do not affect to the surrounding marble masses.

Explosive consumption is:

$q = Q/V = 22/392 = 0{,}056\ kg/m^3$ or 0,019 kg/t or 19 g/t.

The following formula will be used to determine the safety distance from the blasting series of the surrounding marble massif:

$r_s = K_s\ \alpha\ \sqrt[3]{Q}$, (m)

where are:

- r_s - radius of the seismically dangerous zone, m;
- α - coefficient that depends on the action indicator of the explosion (we adopted n=1,1);
- K_s- a coefficient that depends on the physical and mechanical characteristics of the rock massif and ranges from 3-30;
- Q - total amount of explosive charge, kg;

For a quantity of 22 kg explosives that is initiated simultaneously for a dangerous zone of vibrations we get:

$r_s = K_s\ \alpha\ \sqrt[3]{Q} = 5 * 0{,}98 * \sqrt[3]{22} = 11{,}0$ metres

This practically means that within a radius of 11 meters this 22 kg in the blasting series, will have an impact on the surrounding massif in the form of tremors, minor deformations and significant values of the oscillation speed.

2.2. Blasting series No.2

This blasting series have a volume of 300 m^3. For this blasting, seven horizontal holes were made at a height of 1.5 meters from the floor of the bench, the depth is 3.0 meters, arranged in one row with a distance of 2.0 to 2.4 meters.

The drilling diameter is 90 mm. Explosive Amonex-4, marked 60/1000, was used for charging. The activation of the explosive in the hollows was carried out with the Nonel detonators U_{500}. The initiation of nonel tubes is with a capsule 8 and a slow-fitting wick.

Table 3: Arrangement of the explosive in holes and their length

Ordinary number of drilling hole	Depth of the hole, L_b (m)	Quantity of explosives, Q_b (kg)
1	3,0	4,0
2	3,0	4,0
3	3,0	4,0
4	3,0	4,0
5	3,0	4,0
6	3,0	4,0
7	3,0	4,0
Total	**21**	**28**

- **Instrumental measurements**

Registration of seismic shocks was performed on 7 measuring instruments at the same locations as the previous mine series.

Table 4: Results of seismic measurements for blasting series No. 2

<table>
<tr><th rowspan="2">Measuring place, MM</th><th rowspan="2">Distance of the minefield to MM, (m)</th><th rowspan="2">Maximum quantity of explosives per one interval ,Q_i, (kg)</th><th rowspan="2">Total quantity of mine explosive Q_{vk}, (kg)</th><th colspan="3">Maximum oscillation speed per component,(mm/s)</th><th rowspan="2">The maximum resultant oscillation speed,V_{max}, (mm/s)</th><th rowspan="2">The real maximum resultant oscillation speedV_{st}, (mm/s)</th><th rowspan="2">Calculated reduced distance, R, (m)</th></tr>
<tr><th>V_V</th><th>V_T</th><th>V_L</th></tr>
<tr><td>MM-1</td><td>232,6</td><td>I int- 4,0</td><td rowspan="7">28,0</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td></td></tr>
<tr><td>MM-2</td><td>189,7</td><td>II int- 8,0</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td></td></tr>
<tr><td>MM-3</td><td>154,0</td><td>III int- 8,0</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td></td></tr>
<tr><td>MM-4</td><td>124,5</td><td>IV int- - 8,0</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td></td></tr>
<tr><td>MM-5</td><td>87,0</td><td></td><td>0,68</td><td>1,422</td><td>0,938</td><td>1,835</td><td>1,460</td><td>29,8</td></tr>
<tr><td>MM-6</td><td>34,3</td><td></td><td>4,45</td><td>10,108</td><td>9,183</td><td>14,363</td><td>13,220</td><td>76,0</td></tr>
<tr><td>MM-7</td><td>85,7</td><td></td><td>1,29</td><td>2,683</td><td>2,047</td><td>3,614</td><td>3,350</td><td>34,0</td></tr>
</table>

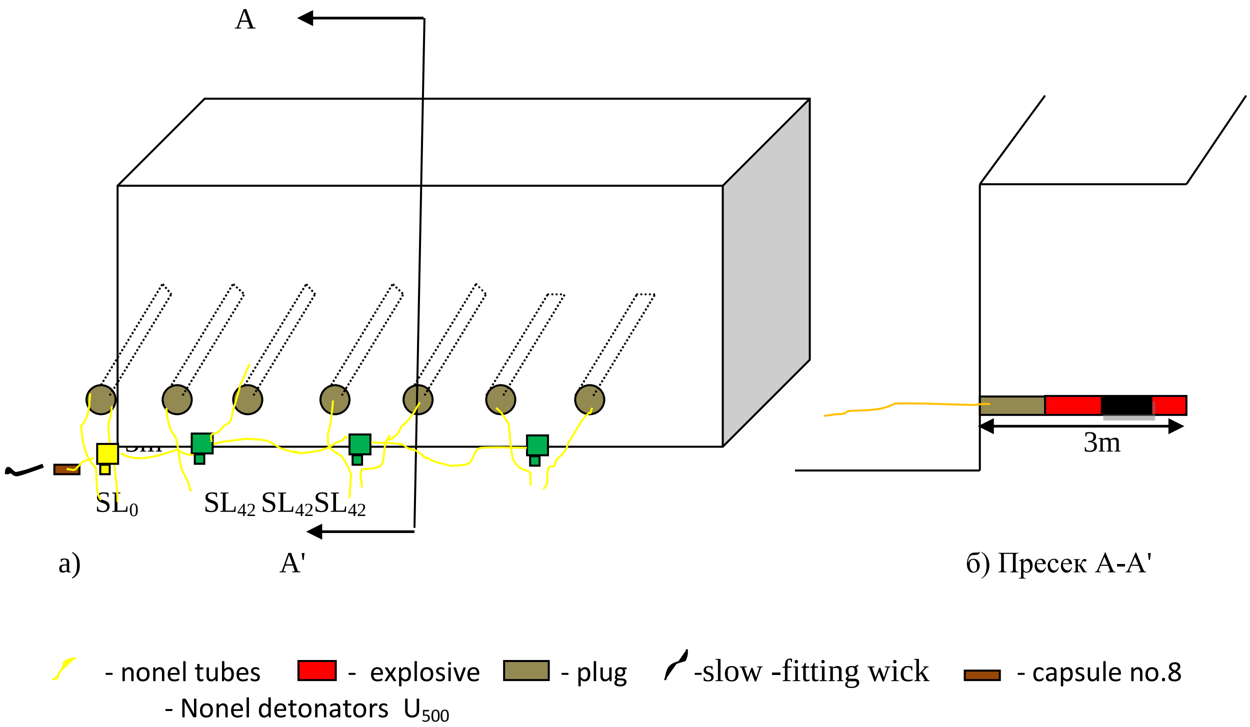

Figure 2. Schematic of the blasting series No.2 and the way of connection

According to the obtained results, the impact is insignificant, and only three instruments have registered minor oscillations on the ground, at the nearest measuring points MM-5, MM-6 and MM-7. These measuring points are from 140 to 330 meters from the site of the active excavations.

Explosive consumption is:

$q= Q/V = 28/300 = 0{,}09\ kg/m^3\quad 0{,}032\ kg/t$ or 32 g/t

The maximum oscillation speeds registered according to the above criteria are below the permissible values for oscillations (<2 cm/s) and therefore these oscillations - vibrations according to the Criteria for vibrations do not affect to the surrounding marble masses.The safety distance in relation to the vibrations of the blasting series on the surrounding marble mass is determined according to formula:

$r_s= K_s\ \alpha\ \sqrt[3]{Q}$, (m)

where are:

- r_s - radius of the seismically dangerous zone, м;
- α - coefficient that depends on the action indicator of the explosion (we adoptedn=1,1);
- K_s- a coefficient that depends on the physical and mechanical characteristics of the rock massif and ranges from 3-30;
- Q - total amount of explosive charge, кg;

For a quantity of 28 kg explosives that is initiated simultaneously for a dangerous zone of vibrations we get:

$r_s = K_s\ \alpha\ \sqrt[3]{Q} = 5 * 0{,}98 * \sqrt[3]{28} = 14{,}8$ metres

This practically means that within a radius of 15 meters this 28 kg in the blasting series, will have an impact on the surrounding massif in the form of tremors, minor deformations and significant values of the oscillation speed.

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Figure 3. Blasting effects relative to granulometric composition

CONCLUSION

As can be seen in the enclosed analyzes of the blasting series, the registered seismic waves with these blastings are within the permissible limits, so the impact is only on the near marble masses where it is possible to expand the already existing cracks and the appearance of new micro cracks.

The NONEL initiation system allows blasting at intervals, with the entire amount of explosives sequentially dividing and initiating, which ape directly reduces the formed oscillations.

To reduce the impact of blasting on nearby benches is recommended:

- Apply vertical holes in combination with horizontal holes in places where there is such a possibility,
- The blasting series should be placed more vertically in relation to the site that is protected and the smallest oscillations appear,
- The drilling geometry is in accordance with the other parameters,
- filling the mine holes is with a pre-defined and adopted type of explosive in accordance with the rocky massif,
- clamping of mine holes with clay plugs is required,
- The initiation is by applying a Nonel initiation system,
- Continuous monitoring of changes in the marble mass through periodic seismic measurements.

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A COMPARISON OF SLAKE DURABILITY INDEX (SDI) BETWEEN SPHERE AND ROUNDED MARL TEST SAMPLES

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ABSTRACT

There are a lot of factors affecting the results of Slake Durability Index (SDI) test which is used to be determined abrasiveness and degradability of weak rocks. One of these factors is also the geometrical shapes of test samples used in SDI test. Although it is suggested that test samples should be equivalent sized spherical sample recommended by ASTM and ISRM, the formation of this geometrical shape is quite hard with the applied technique of sample preparation according to standards.

In this study, SDI values have been determined on sphere and rounded test samples preparing to massive marl. A new sample method called Pasha Method was used to prepare sphere samples from the massive marl blocks collected from Tuncbilek lignite mine in Kutahya-Turkey. The SDI tests were performed on equal weight sphere test samples and rounded test samples with balanced charge. The SDI values were determined for the three different groups subjected to the SDI test for 12 cycles. The index values of the massive sphere test sample group were found to be higher than the index values of rounded test sample groups having balanced charge. As a result, such a study can be complement and development for slake durability index test and.

Keyword: SDI; massive marl; sphere test sample; rounded test sample; balance charge

1. INTRODUCTION

The SDI test was improved by Chandra [1] and Franklin and Chandra [2]. The test was proposed as an important test for rock mechanics by ISRM [3] and ASTM [4] standard. The goal of SDI test is to ensure an index that is concerned to durability of rock against alteration when subject to two cycles [2,5-6].

The SDI test is significant test for shales, clay-bearing rocks etc. [2]. The tests is offered in the standards that the samples should be nearly to spherical. But, preparation of close spherical samples is difficult [5,7]. For this reason, some papers were examine to the effects of rock samples profile and disorders on the SDI test [8].

The aim of this study is to suggest a method of preparation of spherical samples used in SDI test and apply this new method on massive marl samples collected at the coal quarry located at Kutahya in Turkey. It also aims to carry out slake durability test on these prepared samples and also to compare the results.

2. MATERIALS AND METHODS

2.1. Massive Marl Samples

Massive marl rock blocks used in this study were collected from Tuncbilek Lignite Open Pit Mine operated by Garp Lignite Enterprise (GLI) located at western part of Turkey.. Mineralogical structure of marls consists of quartz, calcite and dolomite [10]. The chemical composition of massive marl samples is SiO_2 53.26 %, Al2O3 7.11%, Fe2O3 4.20 %, MgO 4.58 %, CaO 10.34 %, LOI 18.3 %.

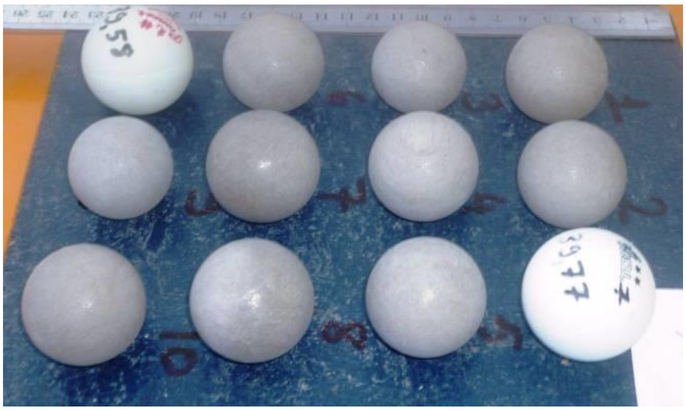
2.1. Sphere Sample Preparation Method

The preparation of close sphere samples occurs of three process. First process is to cut cubes from obtained rocks. Second process is to cut cubes to form a pre-sphere shape which is called as Pasha Cut method. The third process is to obtain close sphere samples by means of an instrument modified for this aim [11-16].

2.2. Slake Durability Test

In this study, the SDI test was conducted the marl rock samples in suitable with ISRM standards using a Standard slake durability test apparatus. Three different representative test samples were prepared; equal sized spherical representative samples according to pasha method (Grup#1), rounded representative samples (Grup#2 and Grup#3) having balanced charge according to standard. Samples were placed in drums mounted in the respective troughs filled with water. The drums were rotated in the samples. All samples retained in the drums were carefully removed and put in the oven according to ISRM standard [3]. The samples were again put in the drums and the whole process repeated. The final oven-dried weight of the retained samples after the twelve cycles was recorded. The data were used to calculate the Slake Durability Index after from the first to twelfth cycles.

The equal sized sphere and rounded samples shown in Figure 1 were subjected to the SDI test according to standard. The condition of samples after the test for sphere and rounded samples also shown in Figure 1, respectively. Grup#2 contains 5 samples of 50 grams, 3 samples of 55 grams and 2 samples of 45 grams. Grup#3 contains 4 samples of 50 grams, 3 samples of 55 grams and 3 samples of 45 grams.



Sphere test samples before the test

Sphere test samples after the test

Rounded test samples before the test (Grup#2) Rounded test samples after the test

Rounded test samples before the test (Grup#3) Rounded test samples after the test

Figure 1. Sphere and rounded samples and the condition of the samples at the end of 12th cycle.

3. RESULTS AND DISCUSSION

In this paper, slake durability tests were applied comparison of the SDI values on the equal sized sphere and rounded samples prepared Marl block samples taken from Tuncbilek lignite mine. Index values after twelfth cycle for equal sized sphere and rounded samples were found to be 97.47 %, 93.47 % and 93.48 % for Id_{12} index values, respectively. In addition, index values of sphere sample after second cycle were determined as between 99.33 % for Id_2 index values and after fourth cycle were found 98.93 % for Id_4 index values. On the other hand, index values of rounded sample after second cycle were determined as between 98.61 % and 98.42 % for Id_2 index values and after fourth cycle were ranged from 97.35 % to 97.21 % for Id_4 index values Table 1.

High index values taken after two cycles of SDI test cannot be useful for the evaluation of the durability. Therefore, Gökçeoğlu [7] suggested that durability of compact rocks could be evaluated with index values after fourth cycle, Id_4. In this study, the average index values after four cycles were found to be 98.93 % for sphere samples and 97.35-97.21 % for rounded samples. Durability classifications of sphere and rounded samples are assessed as very high durability and high durability by Id_4, respectively. In addition to, after twelve cycles, higher index value, 97.47 % for Id_{12}, was obtained from the spherical samples when compared to rounded samples, 93.47-93.48 % for Id_{12}. Similarly, this situation was observed for all cycles, Figure 2.

Table 1. Comparision of the results of the slake durability index tests

Cycles	Sphere Samples	Rounded Samples	
	GRUP#1	GRUP#2	GRUP#3
C-1	99.60	99.30	99.02
C-2	99.33	98.61	98.42
C-3	99.12	97.81	97.89
C-4	98.93	97.35	97.21
C-5	98.80	96.79	96.71
C-6	98.57	96.26	96.21
C-7	98.40	95.78	95.73
C-8	98.17	95.32	95.27
C-9	98.00	94.84	94.77
C-10	97.81	94.30	94.31
C-11	97.64	93.89	93.90
C-12	97.47	93.47	93.48

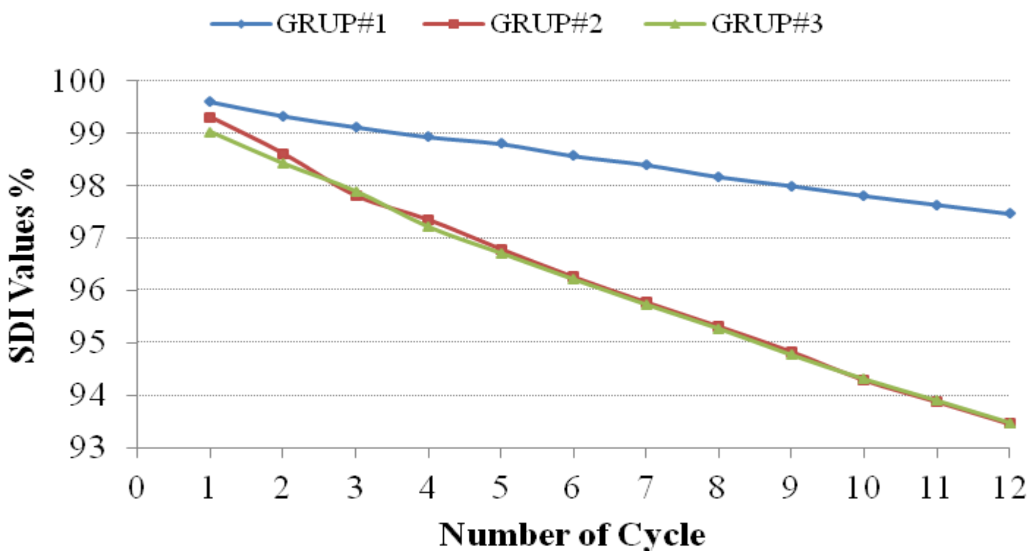


Figure 2. Comprasion of the SDI values of sphere and rounded marl samples

4. CONCLUSIONS

In this paper, slake durability tests were applied on the sphere and rounded massive marl samples taken from Tuncbilek Lignite Open Pit Mine. Index values of sphere samples after Second, fourth and twelfth cycles for sphere samples were found to be 99.33, 98.93 and 97.47 %, respectively. On the other hand, index values after second, fourth and twelfth cycles for rounded samples were found to be 98.61-98.41, 97.35-97.21 and 93.47-93.48 %, respectively. Higher index values were obtained from the sphere samples when compared to rounded sample results. In addition, durability classifications of sphere and rounded samples are assessed as very high durability and high durability by Id_4, respectively.

It could be claimed that rounded or irregular samples tended to represent more disintegration due to surface roughness and properties when compared to the sphere samples. It can be said that sphere samples can give more accurate results in terms of SDI test.

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SAMPLING AND MESUREMENTS ON THE SYSTEM FOR PREPARATION AND TRANSPORT OF ASH AND SLAG AT THERMO POWER PLANT KOSTOLAC B

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ABSTRACT

Warranty measurements have been performed for work of the plant according to the designed parameters at the new system for collecting, preparation and transport of ash and slag hydro-mixture in TEKO B. The basic designed parameters, which need to be maintained, are in the process of achieving assigned flow of ash and slag hydro-mixture with designed mass participation of solid phase in the hydro-mixture, and upon the protocol prepared prior to the warranty measurements. In the process of warranty measurements was necessary to prove the plant capacity in permanent work and given parameters. Samples of dry ash and slag have been taken as well as hydro-mixture at the end of transportation lines to process it partially in the mobile field laboratory and in laboratories of the Mining Institute.

Key words: ash, slag, transport, sampling, control measurements

1. INTRODUCTION

In the new system for preparation and hydro-transport of ash and slag in the form of dense hydro-mixture in TEKO B have been done warranty measurements of the plant work in the designed parameters. The basic project parameters, which ought to be maintained in the process of implementation of the ash and slag hydro-mixture flow with designed mass participation of solid phase in hydro-mixture and according the protocol prepared before warranty measurements.

In addition to electronic record of measured parameters from the automatic process management system for preparation and transport of hydro mixture of ash and slag, during the work of the plant has been done the permanent sampling of dry ash and slag in silo at input point in the process of the hydro-mixture preparation, while at the end of transportation lines sampling of ash and slag hydro-mixture. Specific mass has been determined on the ash samples and total humidity and specific weight on the slag samples. Determination of these data was done in adequate laboratory for solid fuels in the Mining Institute in Belgrade.

Density of ash and slag hydro-mixture was determined during warranty measurements in field laboratory behind valve station at the end of the transportation line for hydro-mixture by the steel pipeline.

2. SAMPLING AND PROCESSING METHODOLOGY FOR DRY ASH, SLAG AND HYDRO-MIXTURE

Before the start of warranty measures there has been conducted testing for the process water flow. Measurements of the process water flow were gravimetric by two electric devices for measuring of piezometers connected and placed in cylindrical section of hydro-mixture tank with altitude difference of 1 m precisely.

Measurements were conducted in a way that hydro-mixture tanks, one by one, were filled and emptied with process water with different, selected flows. It was measured the time for which water fills 1 m of cylindrical part of the tank. Per each selected flow of 150, 200 and 250 (155) m^3/h three measures was conducted at each line.

Measured flows of process water comply with calibrated curve of flow gauge; and designed flow of 170 m^3/h is possible to conclude that gauges display accuracy declared by that device manufacturer ,,ENDRESSHAUSER".

3. SAMPLING EQUIPMENT

Sampling equipment was adjusted to the mode and place of sampling and it was compiled of:

- Sampler for dry ash, of cylindrical shape with diameter of 40 mm, height 70 mm (Figure 1),
- Sampler for slag, of spoon shape, i.e. spatula (Figure 2),
- Sampler for hydro-mixture, of cone shape (dimensions 350x30 mm) which widens toward collecting pipe of lean position in relation to the cone with diameter of 60 mm, (Figure 3).

4. ASH

Ash doze for preparation of hydro-mixture at start of warranty measures was selected from the ash silo. With noted regime of sampling it was conducted at the last revision outlet of pneumatic hull directly in front of mixer for dense hydro-mixture preparation.

Figure 1: Sampler for dry ash

During the plant work in the period of warranty measures in precise time intervals of 15 and later 30 minutes it was conducted single sampling of dry ash. Sampling was manual by sampler with longitudinal braking of the dry ash jet in air stream if transporter directly before measurements of mass flow (console scales).

Samples at the spot were packed in prescribed double paper bags and labeled. It was taken total of 130 samples. Laboratory testing was done on 72 samples for determination of specific mass of samples. Other samples of dry ash as well as control samples were collected at each one hour.

5. SLAG

Slag dozes for preparation of hydro-mixture at the start of warranty measures was selected from slag silo, and slag sampling was at revision outlet of the bar with cover directly in the front of mixer for dense hydro-mixture preparation.

During the plant work in the period of warranty measures in precise time intervals of 15 and later 30 minutes it was conducted single sampling of slag. Sampling was manual by sampler with longitudinal braking of the flow, falling slag jet directly in front of the hydro-mixer.

Figure 2: Sampler for slag

6. HYDRO-MIXTURE OF ASH AND SLAG

During warranty measurements and the work of the plant for preparation and transport of ash and slag from EKO B in the form of dense hydro-mixture it was necessary to prove the plant capacity and to secure free flow out of the hydro-mixture of ash and slag. At the end of the transport line with steel pipeline it was placed break chamber produced of steel tin plate with dimensions of 2x2x2.5 m. At the bottom of the break chamber it was installed pipeline DN 350 for gravitational transport of hydro-mixture to landfill.

On the transport line toward ash landfill, near valve station, there have been formed temporary field laboratory for measurement of hydro –mixture density samples. Laboratory was formed in the container for workers lodging near the valve station due to necessary space conditions and necessary power supply.

In laboratory has been placed calibrated electric scale. Sampling was executed by special dish by breaking the hydro-mixture jet in one flow. The sampler had one rectangular slit 350x30 mm which secured the condition that $B=2.5\text{-}3d_{max}$.Collected samples were transported by field vehicle to the field laboratory.

Figure 3: Sampler for hydro-mixture

Sample from sampler was transported to the dish by steel pipe. Dish for samples with volume of 5 l with hermetic cover. Collected samples were with volume of 1.5-2 l. samples were taken every 15-30 min and every hour control samples. There have been taken samples for each transport line separately and during their work.

7. METHOD FOR SPECIFIC MASS DETERMINATION

Ash specific mass was determined by the standard method (SRPS B B8 032) in glass picnometer with volume of 50 ml in distilled water. Determination is done with dry sample (dried to analytical humidity) reduced to the 90% size – 0.09 mm. Examinations was conducted in accredited laboratory for solid fuels in the Mining Institute.

8. METHOD FOR HUMIDITY AND SPECIFIC MASS DETERMINATION

On the slag samples were conducted determination of humidity value and specific mass. Determination of the specific mass was conducted by the same method as for the specific mass of ash. Specific mass was determined after humidity and on the same samples.

Gained value of average specific mass for ash is 2.2813 g/cm^3, for slag 2.0058 g/cm^3. For mass relation ash/slag = 90:10; specific mass of solid phase is 2.2513 g/cm^3. Average content of total humidity in slag samples is 44.8%.

9. METHOD FOR DENSITY DETERMINATION

Slag specific mass was determined in glass picnometer with volume of 50 ml in distilled water or xylol on samples prepared in accordance with standard SRPS B.H9.003. Determination is done with dry sample (dried to analytical humidity) with mass of 1-2 g, reduced to the size – 0.2 mm. Examinations was conducted in accredited laboratory for solid fuels in the Mining Institute.

Average values of hydro-mixture density on the thrust pumps, with permanent work or without break, are between 1268.93 over 1309.90 do 1315.09 kg/m^3. Minimal recorded value is 1059.00 kg/m^3 and maximum 1352.00 kg/m^3.

10. PROCESSING SAMPLES OF ASH AND SLAG HYDRO-MIXTURE

Each sample dish for hydro-mixture was formerly measured and its mass was marked on the dish and cover. After transportation the dish was inspected and cleaned when needed by paper towel outside then was measured with the samples so the mass of samples was determined by subtracting the mass of dish. After determination of the sample mass, the volume was determined in graded test tubes with volume of 1 or 2 l; previously checked by filling with water and measuring on the scale. Sample was carefully poured into the test pipe. During pouring from sample dish to test pipe, deposit on walls and bottom of the dish was washed by the known quantity of water from the injection bottle. As control it was measures and emptied the sample dish. All data were recorded electronically in the form in the lap-top computer so data of measured density were instantly known.

Determination of the mass participation of solid phase was done after determination of density of solid phase in the laboratory of the Mining Institute.

During warranty measures it was continually monitored and recorded the work regime of the plant for preparation of dense hydro-mixture and average values were accomplished (Table 1).

Table 1.The mean value of the parameters reached during the entire warranty measurement

Parameter	Measure unit	Value
1. Hydro-mixture density on thrust pump	kg/m^3	1277.25
2. Ash quantity	t/h	172.08
3. Water quantity	m^3/h	218.15
4. Ash and slag hydro-mixture quantity	m^3/h	326.61
5. Pressure on thrust pump	bar	25.79
6. Speed of slag breaker	%	18.84
7. Speed of slag breaker	%	23.28

11. CONCLUSION

Using estimation based on gained values for specific mass of solid, water, quantity of ash and slag we can calculate the quantity of hydro-mixture. Based on gained results it is possible to conclude that values of given technological parameters of the quantity of ash, slag and density of hydro-mixture during warranty measurements mainly were fully respected. The water quantities added during this procedure for preparation of dense hydro-mixture were mostly below given values.

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MONITORING OF SEISMIC ACTIVITY OF THE EARTH DAM TOPOLNICA – MINE BUCHIM, REPUBLIC OF MACEDONIA

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ABSTRACT

Blasting, whether pointwise, linear, individual or massive, are treated as small earthquakes. So, it is known in advance the place and time of the earthquake, and the energy of the blasting, we know, is much less than the energy in the earthquake.When blasting, in the first phase, the solid matter of the explosive is transformed in the compressed gaseous state, and then the gas is spreading, whereby the potential energy turns into mechanical work. This energy at the site of blasting, ruining, crushing rock masses, creates permanent deformations in the rock. Seismic waves, which are spread by the transfer of the deformation, cause oscillation of the ground and the objects.Seismic waves that occur during blasting are similar on the waves that occur in earthquakes, so many seismic blasting uses many laws that are defined in seismology. Modern instruments transform these movements, i.e. oscillations into electrical motions, and as such they register them on photo-paper or digitize them and record them on a magnetic tape. In this paper is present monitoring of the seismic activity of the earth dam Topolnica near the mine Buchim.

Key words: monitoring, seismic activity, equipment, registration

1. INTRODUCTION

Every object with appropriate structural features, acts as an oscillatory system and is subject to the action of earthquakes. But at the same time, it is (can be) influenced by changes in the geodynamic conditions of the environment where such an object is built. If they are monitored within a certain periodof time, the changes in certain ambient parameters of the object's vibration can provide very important data that can be in appropriate relation with its structural parameters. The monitoring of the seismic activity of the dam and its surroundings, as well as the dynamic response of the dam as an oscillatory system, will largely depend on the installed seismological equipment and its operation.

Installing seismological equipment at certain locations is due to:

- Monitoring the local or regional seismicity of the area where the seismological station is located.

- Monitoring the action of strong earthquakes that are expected to occur on, or around the selected site, dam, bridge or other capital facility.
- Measuring ambient vibrations of the object being monitored.

2. SEISMICITY OF THE AREA OF MINE BUCHIM

Location of the dam Topolnica is in area of mine Buchim, in Radovish epicentral area, that belongs to Eastern Macedonian zone on the territory of the Republic of Macedonia (fig. 1).
From the previous investigations of the regional seismicity on the territory of the Republic of Macedonia. Macedonia and the border areas, it has been shown that strong earthquakes have not been recorded in this area so far. But due to the high seismic activity of the neighboring epicenter are as where very strong earthquakes have occurred in the last 100 years (theValandovo epicentral area and the area of Pehchevo-Kresna), the Topolnica dam will be exposed to the effects of future earthquake sinthese areas. [1]

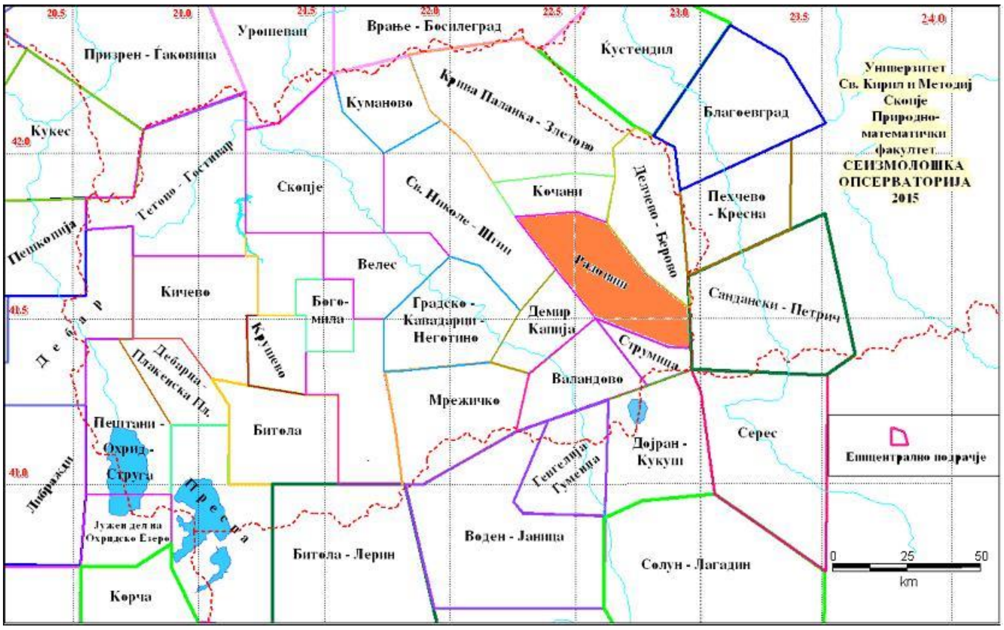


Figure 1. Map of the boundaries of the epicentral areas on the territory of the Republic of Macedonia and the surrounding areas. Radovish epicentral area is marked separately

On Fig. 2, is given the epicentral map of earthquakes from the territory of the Republic of Macedonia, which happened in 2015. The clustering of epicenters of earthquakes is clearly seen (which are relatively stronger than those in the Radovish epicenter area) [2].

By installing highly sensitive seismological equipment in these ismological stations on the territory of the Republic of Macedonia and the neighboring countries, and especially after the installation of these ismological stationon Plachkovica in 2012, it has also been shown that Radovish epicenter area is characterized by high seismicity, followed by a number of weak earthquakes.

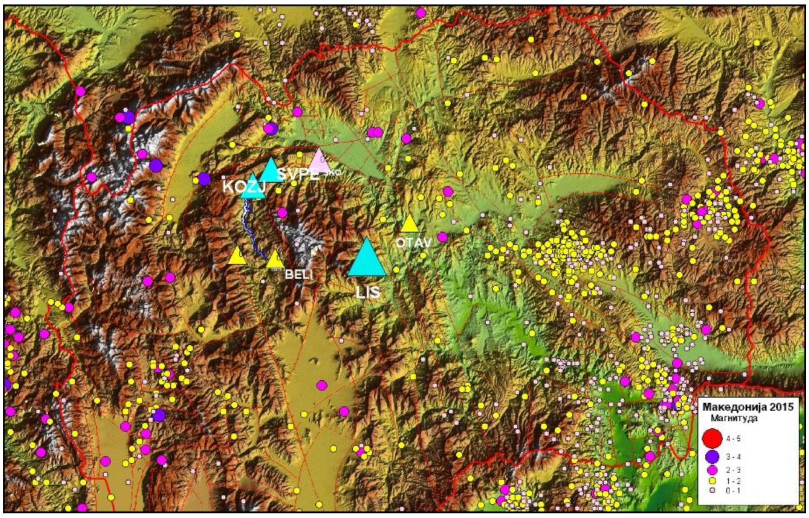


Figure 2. Epicentral map of Macedonia for 2015

This is clearly seen in Fig. 3, which shows the epicenter of earthquakes from the Radovish epicenter region, in the period from 2013 to 2015. The location of these ismic station of Plachkovitsa (STIP), as well as the location of these ismic monitoring system of the Topolnica dam (TOPL) are shown.

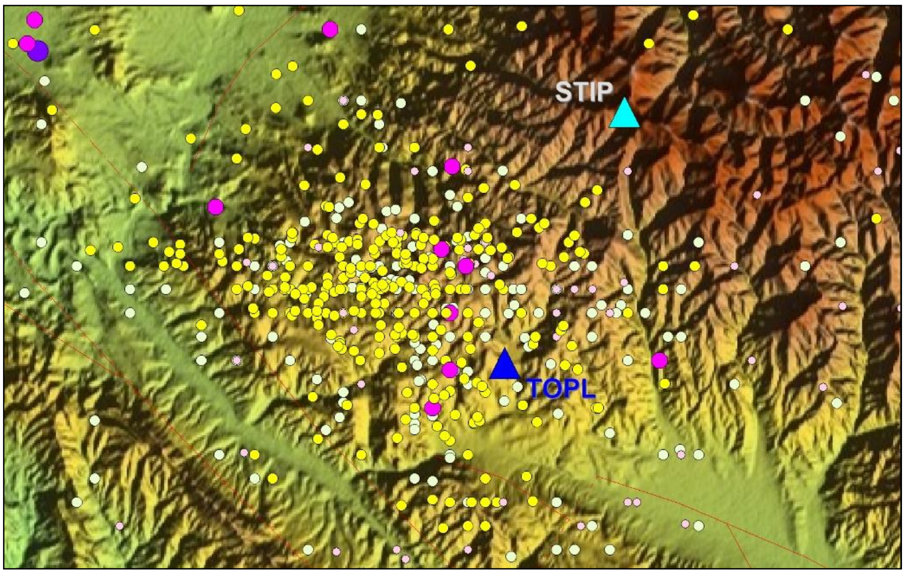


Figure. 3.Epicentral map for registered earthquakes in the period 2013-2015 in the area between the locations of these ismological stations in Stip (STIP) and damTopolnica (TOPL).

2. INSTALLED SEISMOLOGICAL EQUIPMENT AND REGISTRATIONS

Digitexx's installed seismological equipment is mainly designed to monitor the effects of strong earthquakes. These are three accelerometers with the accompanying analogue / digital equipment and serve to register the shift to the ground. They are placed in three measuring points: S1, S2 on the dam crown and S3 at 100 m from the dam crown (Fig. 4).

Figure 4. The locations of the three measuring points on damTopolnica (S1, S2 and S3)

The whole system is in a state of waiting for an earthquake or other waves that would satisfy the activation parameters of the built-intrigger, which would make such an event possible.

In order to demonstrate the capabilities of these ismological stations, the received registrations have separated the registrations of locale earthquakes, but also the registration of very close events to the very locations; S1, S2 and S3.

Presented registrations are represented on figures 5 and 6. They clearly pointed on different geomechanical characteristics of the ground in the three measuring points. Sufficient strong waves are registered in all three places (Fig. 5), but with very poor motions / earthquakes, registrationin S3 is absent (Fig. 6). This requires adjusting the dynamic characteristics of the instrument at the measuring point S3. [3]

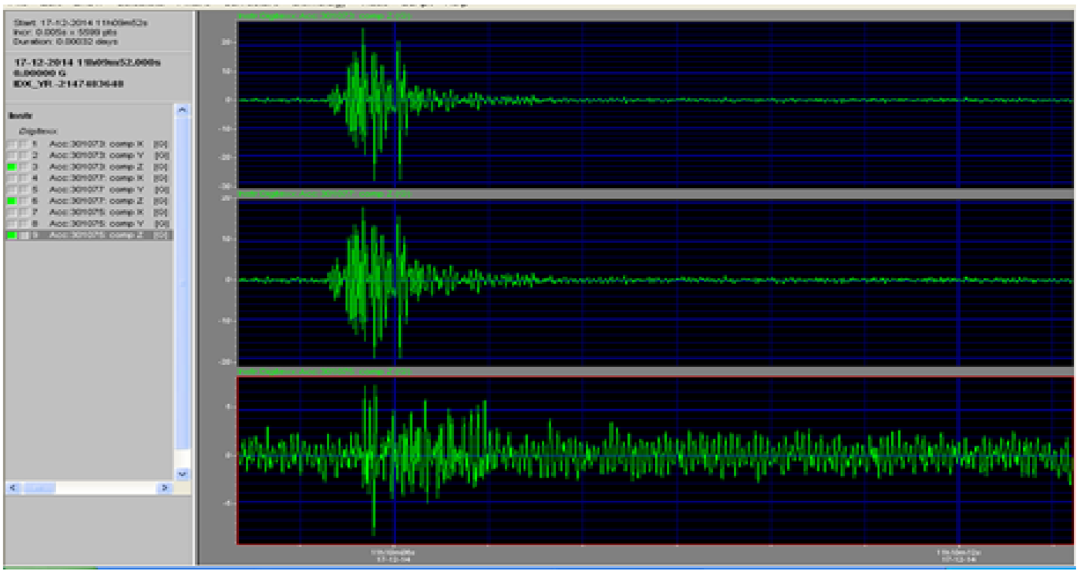


Figure 5.Local earthquake. Registrations of horizontal Z components in the measuring points S1, S2 and S3 on damTopolnica(17.12.2014, 11:09).

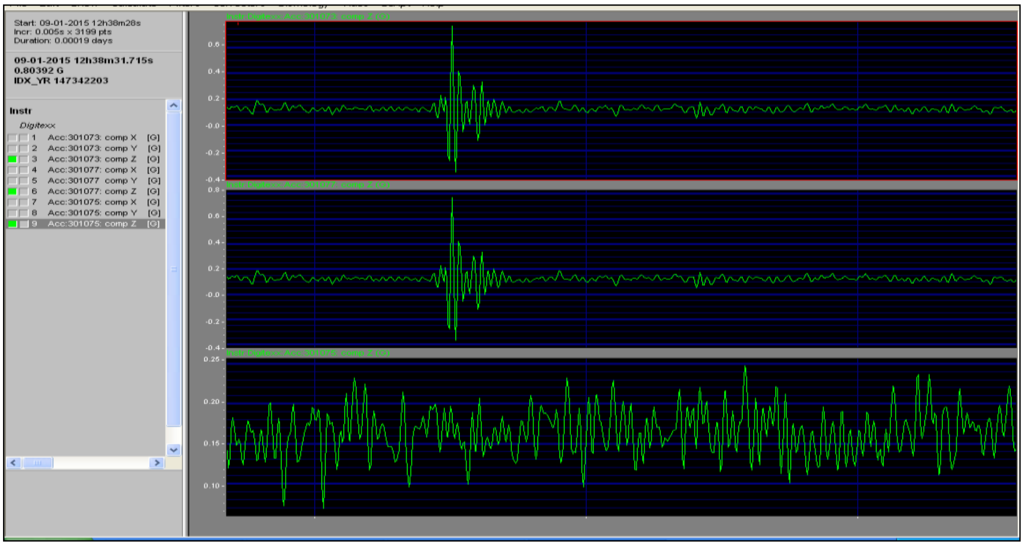
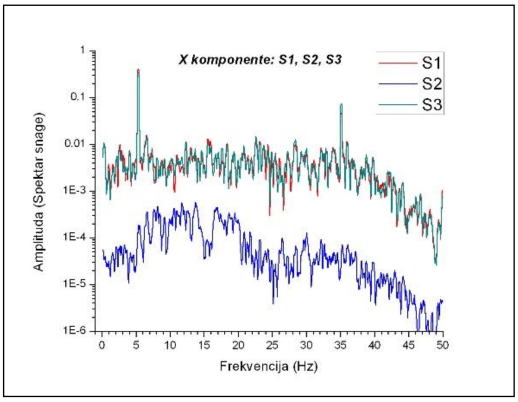
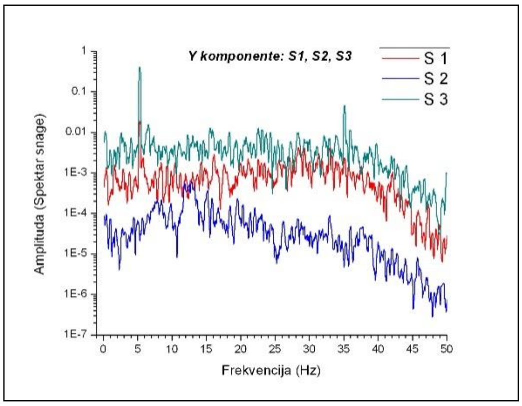


Figure 6.Very close earthquake. Registrations of horizontal Z components in the measuring points S1, S2 and S3 ondamTopolnica (09.01.2015, 12:38)

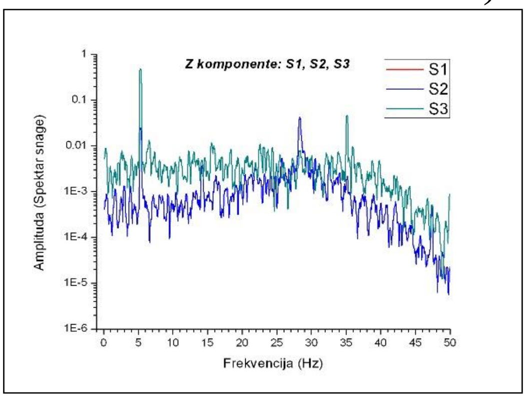
In order to monitor the changes in the dynamic characteristics of the dam Topolnica, the spectra of ambient vibration of the dam are of great importance. Registration of ambient vibration is selected from 22.01.2015 (fig. 7). From this registration, the spectra of power are made and immediately the characteristics are detected in the individual measuring points. [4]



a) X components



b) Ycomponents



c) Zcomponents

Figure 7. Spectra of power on the ambient vibration at the dam Topolnica

3. CONCLUSION

The installed seismic instruments satisfy all standards for monitoring the effect of strong earthquakeson the dam Topolnica, as well as, if necessary, monitoring the changes in health, from a dynamic and static aspect, to the whole building itself.

Clear clustering of the epicenters of weake earthquakes in the immediate environment of the Topolnica dam (Fig. 3) indicates the need to monitor the registrations of this system, in the process of determining the locations of local and very nearby earthquakes. This also requires continuous registration of the seismic activity of the dam, archiving and processing of data.

By obtaining seismic data from these ismological station installed precisely in this epicenter area, it will be possible to determine more precisely the spatial distribution of the hypocentres of locale arthquakes.

This will enable the determination of local seismogenic sources, an important data in the micro-resettlement of the location of the Topolnica dam, as well as in the wider area, an important factor for the present and future work of the Bucim mine.

Regular monitoring of the changes in the spectral characteristics of ambient vibrations at the Topolnica Dam is of great importance for monitoring the current state of the object (its structural health), but also to anticipate some future problems that may arise after the action of earthquakes or as the re sult of changes in the local conditions of the location where the facility was built (due to exploitation, weather disasters, etc.).

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MAINTENANCE OF MINING EQUIPMENT BY APPLYING THE SYSTEM OF AGGREGATE REPLACEMENT OF LARGE ASSEMBLIES

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ABSTRACT

Restructuring of "Electric Power Industry of Serbia" requires significant changes in operationsof all organizational units. The Coal Production Sector does not have a balanced development in relation to the Electricity Production Sector. Further efforts are needed toward a change inthe organization of coal production system,along withthe more efficient implementation of investments that are currently seriously lagging behind the plans.

Electro-mechanical maintenance of mining equipment in very complex conditions of mining production requires the application of modern principles of rationalization and optimization, provenin the numerous open-cast mines of Western Europe. This paper presents only one example of possible rationalization in the maintenance system of mining equipment, which refers to the system of aggregate replacement of large assemblies.

Key words: Electric Power Industry of Serbia, surface mining, mechanical maintenance, aggregate replacement

1. INTRODUCTION: MAINTENANCE IN OPEN-CAST MINES OF MB KOLUBARA AND MB KOSTOLAC

Electro-mechanical maintenance in EPS open-pit mines mainly relates to continuous systems:
ECS (excavator, belt conveyor, spreader - Figure 1)
ECC (excavator, belt conveyor, crushingplant - Figure 2) and
ECL (excavator, belt conveyor, loading point - Figure 3).
All of these systems are "lifelines"to surface mines and the excavation of overburden and coal depends on their operation.

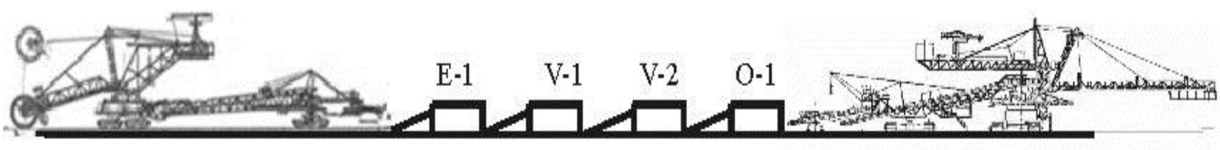

Figure 1: Discrete scheme of ECS system

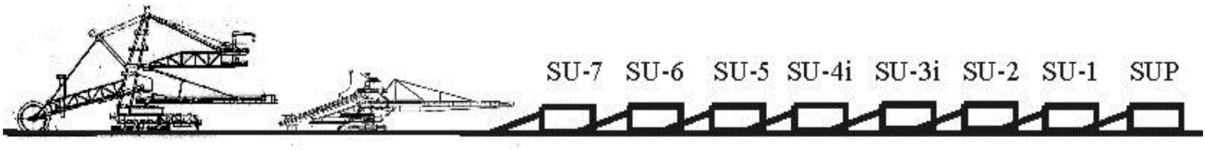

Figure 2: Discrete scheme of ECC system

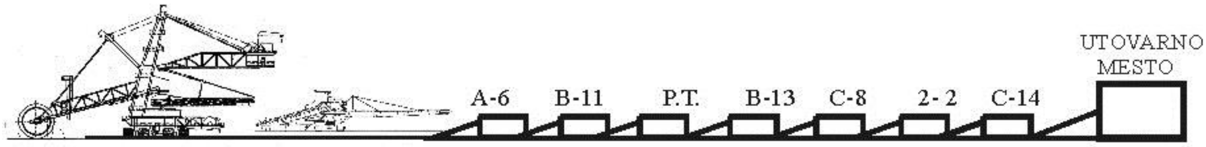

Figure 3: Discrete scheme of ECL system

The maintenance facilities in the open-cast mines of MB Kolubara and MB Kostolac include 32 bucket wheel excavators (total weight 47,000 tonnes, average age 29 years), 24 spreaders and self-propelled conveyors (total weight 19,000 tonnes, average age 29 years), 3 bucket dredgers (3580 tonnes, average age 33 years), 32 draglines (weight 9,600 tonnes, average age over 35 years), conveyor belts - (144 conveyor drive stations, 115 km of routes) + coal processing facilities (crushing plantin Drmno, Tamnava, Kolubara Coal Processing Plant). The total weight of maintenance equipment is about 200,000 tonnes. It is worth mentioning that over the last 10 years, very modern equipment, including five ECS systems with a capacity of 6600 m^3/h and one bucket wheel excavator with a capacity of 4800 m^3/h, as well as new equipment for Tamnava dumping site,were purchased and that, at the same time, revitalization and modernization of apart of the equipment were carried out.

There have been constant concerns and permanent challenges for EPS management and branches management as to how to organize good and efficient maintenance with machines older than 30 years on average and achieve ambitiousplanned production balances, all within the scope and function of planned funds, i.e. budget.

Various types of equipment, purchased over a longer period of time from different manufacturers, were installed in the open-cast mines, which has resulted in a great variety of equipment and a low degree of unification.

About 6300 workers are currently engaged in the maintenance work, of which about 2100 workers in Kolubara Metal. Besides, the age structure is very unfavorable.

The excavator- belt conveyor- spreader system (ECS) is very complex for maintenance. This can be seen consideringsome of its characteristics from the perspective of maintenance. The system consists of a large number of assemblies and elements with different needs for maintenance.

A regular connection between the elements of this system createsa need for high reliability of elements.In this regard, the maintenance of all elements essential for the functioning of the system must be intensive enough to keep the reliability of the excavator-conveyor-spreader or loading point system at a required level.

Operating conditions of systems are very difficult. The purchase value of a system is around € 80,000,000 and therefore it is very important to maximize the system's longevity.

The way of maintenance of excavators, spreaders, conveyors and other equipment in the open-cast mines “Kolubara” and “Kostolac” has its origins in the organization of maintenance that was typical of the former East Germany, from which the first excavators for our open-cast mines had been purchased. From them we acquired key knowledge and experience relating tomaintenance management of these machines, especially in terms of the maintenance scope, time-schedule of particular works,provision of spare parts and maintenancematerials, erection yards, and so on.

Such a maintenance system has been applied for many years inthe open-cast mines in Kostolac and Kolubara, occasionally introducing some changes arising from our own experiences and depending on the country’seconomic circumstances, etc. It should be noted that the system implemented in the former GDR was modified immediately after the reunification of Germany, with special focus on cost rationalization.

2. MAINTENANCE COSTS

The main goal of the mining sector in EPS is to achieve maximum productivity at minimum costs. Regardless of the applied maintenance methods (or their combinations), it is necessary to monitor the production process, collect data and calculate the cost structure elements. Based on the obtained results, the policy and strategy of maintenance can be influenced (feedback).

If the total maintenance costs are analyzed, they can be classified into two groups: 1) direct costs, and 2) indirect costs.

Direct costs (depending on the maintenance method) refer to:

- Implementation of system servicing activities,
- Detection ofdefective parts in the technical system,
- Replacement of defective parts,
- Carrying outof preventive periodical repairs, and
- Repairing of defective parts in the system.

When analyzing direct costs, it should be also noted that they always include all those costs related to consumables (oil, grease, etc.).

Indirect costs are associated with:

- Unplanned time lags in production (downtime),
- Damageonthe parts of technical systems and decline in the quality of products, i.e. rejects, etc.

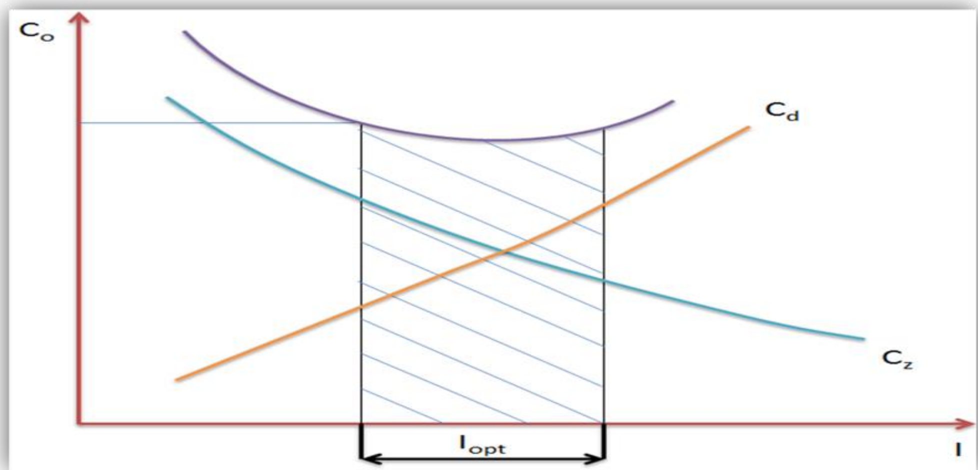

Figure 4: Ratio of maintenance and cost intensity Co-maintenance costs; I - maintenance intensity; Cd - direct maintenance costs; C_z- downtime costs; Iopt - an area of optimal maintenance intensity

Given the importance of ensuring the continuity of systems for the excavation of overburden and coal, it is necessary to define the maintenance intensity, since it has a dominant impact on costs (Figure 4).

The required availability of equipment determines the importance of continuous systems for the excavation of overburden and coalas well as the selection of maintenance method, which together affect the costs.

3. MAINTENANCE OF MINING EQUIPMENT IN "ELECTRIC POWER INDUSTRY OF SERBIA"

The main objective of the mining equipmentmaintenance, as an integral part of the overall production process, is to implement the activities aimed at preventing the occurrence of damage to the equipment and fixingthe existingmalfunctions as soon as possible.

The types of maintenance that are applied in the mining sector of "Electric Power Industry of Serbia" are as follows:

Preventive maintenance planning

Preventive maintenance implies all procedures that are carried out before the occurrence of a malfunction.

It is needless to emphasize the advantage of preventive maintenance, especially when it comes to the equipment which may lead to extremely high material loss in case ofoperation interruption, with high investment value, etc. The occurrence of sudden defects, which are always, more or less, associated with the exploitation of these machines, will always be present so the one of the most important criteria for the success of preventive maintenance is also the reduction of sudden equipment malfunctions.

The orientation toward the preventive maintenance of equipment of this type, which is applied in EPS, is quite justified. The concept of preventive maintenance, starting from identified condition of a machine and its elements, is most appropriateone, since the understanding of the actual state of elements allows timely planning and implementation of maintenance procedures that can extend the lifetime of elements.Moreover, it enables tomake full use of the elements throughout their lifetime, since a replacement is done only when it is really needed, i.e. when an element has reached the extreme limit of usability or the limit of wear that allows its cost-effective repair.

Basic (ongoing) maintenance

From an aspect of organization, basic (ongoing) maintenance is divided into mechanical and electrical maintenance. However, from a functional point of view, they are closely interconnected and interdependent, since many jobs and tasks are carried out simultaneously.

Ongoing maintenance is organized as a shift work and includes visual, tactile and auditory activities, as well as performingof simple measurements on gearboxes (oil level, noise, etc.), drums and other devices.

It is well known that in some mines in Europe the ongoing maintenance is carried out by mobile specialized groups intervening on call when the equipment operators notice a malfunction. The advantage of this type of organization is that it requires a smaller number of staff members in comparison to the organizational model of EPS. On the other hand, the disadvantage is that the functions of equipment control during operation cease to exist as well as the participation of ongoing maintenance staff in defining the service lists.

Service maintenance

The content of service maintenance works consists of two groups:

a) Works that are carried out according to previously established time schedule;

b) Works that are performed as the need arises based on identified condition of the equipment.

This means that the service has a dual nature: on the one hand, it is aimed at detecting the state of certain elements and, on the other, at removing the defects based on the condition which is previously identified. Some repairs are made based on the conditiondetectedduring the service itself.

Mechanical and electrical maintenance services are performed simultaneously, with complete synchronization of works, and in full compliance with all necessary safety and protection measures.

Interventional maintenance

Interventional maintenance retains its role due to the occurrence of sudden failures that will always follow the exploitation of mining machines, especially those which are strongly influenced by work environment and the events related to it.

One of the most important criteria for measuring the success of preventive works is the reduction in the number of sudden failures, i.e. a share of interventional maintenance. Due to their sudden character, it is impossible to prevent them, so the elimination of these malfunctions is the main task of the interventional maintenance.

Overhaul (investment) maintenance

Overhaul is considered asthe highest level of preventive maintenance and, considering its character and duration, it provides the opportunity to implement the largest number of reconstructions and innovations in order to improve the state of certain assemblies and parts of machines that have been identified as weak spots.

Bearing in mind the complexity and long durationof performed worksanda need for long preparations, an overhaul is planned in advance, with the possibility of a slight shift of the starting day in order to adapt to the production possibilities.

The scope of overhaul works is defined based on the identified condition of assemblies and parts during the performed services. Exceptionally, the fault diagnosis of certain elements is doneduring the repair itself. Overhauls ofmining equipmentinthe open-cast mines of EPS are usually performed once a year and planned well in advance. They are performed on the basis of a network diagram, with the use of network planning techniques thatserve to determine the duration of repair.

All investment repairs and overhauls in "Electric Power Industry of Serbia" are performed by "Kolubara Metal – Vreoci" and "PRIM – Kostolac", which are fully qualified to carry out complete works.

4. SYSTEM OF AGGREGATE REPLACEMENT OF LARGE ASSEMBLIESDURING THE OVERHAUL SERVICES

In order to implement the system of aggregate replacement of large assemblies during service and overhaul works, it is necessary to do the following:

a) Project of the unification of individual machineries, aggregates, assemblies of parts and elements in ECS systems –to examine the possibility of unifying individual machineries, aggregates, assemblies of parts and elements, and to undertake projects where it is feasible to facilitate system maintenance by aggregate replacement.
b) Analysis of currently used maintenance practices by applying some of the methodologies, including a detailed analysis of spare parts management for all organizational units within the Coal Production Sector. Such an analysis is the starting point for further improvements. The comparison is done relative to the companies from the same industrial segment (coal production), as well as among organizational units.
   The results of the analysis can be used later to monitor the results of the applied improvements.
c) Optimization of spare parts inventory by using modern optimization methodologies. After defining the criticality of equipment within the maintenance strategy project, it is possible to begin with the optimization of spare parts inventory. The methodology covers all stages of spare parts inventory management: identification of needs, forecasting consumption, defining the required stock levels based on equipment criticality, and inventory optimization.

The implementation of aggregate replacement system in the maintenance of mining equipment would lead to a change in the existing maintenance method, which would be manifested in the following:

1. The role and goal of services would drastically change. The application of aggregate replacement system of large assemblies of mining equipment would mostly affect services. This implies that a service would take 4 to 7 shifts, depending on which aggregate is changed, and would be performed every 5 to 7 weeks. This is the experience of RWE (the largest German mining area in the vicinityof Cologne).
2. The preparation of the service implementation would be more complex and demanding, and it would be mainly related to access roads, machinery engagement and ensuring the safety and security ofwork environment, especially duringthe night shifts.
3. It is estimated that in the next 5 to 7 years the required investmentin necessary aggregates would amount to more than 20 million euros. The overhaul activities would be reduced to a minimum. The overhaul would be carried out every 4 to 5 years, i.e. only when the replacement of large aggregates should be done (superstructure slewing bearing, working wheel, etc.),which requires a technological time of about 60 days.
4. After the application of aggregate replacement system,alldismantled aggregates and parts should be immediately revitalized and then stored until the next installation on another device belonging to the same group.

5. ADVANTAGES OF THE SYSTEM OF AGGREGATE REPLACEMENT

The several advantages ofbasic systems of aggregate replacement are listedbelow:

- Planned system downtime is reduced.
- The reliability of the system is higher, which means that unplanned interruptions are reduced andtend to be 0.
- It is technologically possible to perform any aggregate replacement in the downtime during the service.
- A need forengagement of workforce on site is significantly reduced;a ratio on annual basis is 1:3, which means that it takes up to 3 times less engagedworkforce.
- Works on site would mostly involvedismantling and assembling, without the works on dismantled aggregates, which would increase the quality of works.
- The necessary auxiliary machinery can be significantly reduced.
- Workshops tasks would be performedaccording to planned schedule, with excellent preparation process, timely procurement of parts and elements, without tension and introduction of overtime work, which would lead to lower costs and higher quality of revitalization of aggregates.
- Initial investment is substantial, but costs could be drastically cut down through the later stages of system operation, engagement of personnel and necessary machinery, and be minimum 3 times smaller than the existing ones.
- This system will contribute to the optimization and rationalization of workshops and warehouse space.
- This system contributes to the introduction of the information system for the planning and monitoring of maintenance process (SAP).

6. CONCLUSION

One of the priorities of EPS is "Improvement in the maintenance process of mining equipment by introducing a system of aggregate replacement of large aggregates during servicing and overhaul works with inventory rationalization in warehouses", because the current maintenance costs, with outlabor costs, amount toabout € 2 per tonne of produced coal.

This system is to be introduced in stages, i.e. with the increase in the volume of purchased aggregates, the overhaul activities aregradually reduced to the point when they are carried outevery 4 to 5 years.

After a detailed techno-economic analysis, taking into account the above-mentioned facts, it can be seen that after introducing a system of aggregate replacement of large assemblies during servicing and overhaul works,the costs of future maintenance can bemuch smaller than today, while the effects are far greater.

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LOGISTIC PROCESSES AND ECOLOGICAL EFFECTS

- ECOLOGICAL EFFECTS -

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SOLUTION FOR PROTECTION AGAINST WATER IN SURFACE MINE KAZANDOL, VALANDOVO IN REPUBLIC MACEDONIA

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ABSTRACT

The analysis of hydrological and hydrogeological characteristics of the wider area, specifies the methods and objects that will be used to protect the mine from surface water and groundwater. The most important mining and objects of drenage are drainage canals and artificial reservoirs. These facilities will be used at all stages of exploitation, but also for reclamation.

Key words: Open pit mine, Surface and underground water, object for dewatering, Macedonija

1. INTRODUCTION

When we talk about protection against water in surface mine, we can say that ground water inflow is minimal and will not endanger mining operations during or after the end of surface mine exploitation.

The current area is characterised with small quantities of rainfall, big evapotranspiration, waterproof rocks, it is not expected significant rainfall inflow. To protect against rainfall for the period of hundred years it will be applied floor channels accepting water i drain it out of the surface mine.

In next chapters is given summarized description of hydrological, hydrographical and hydro-geological characteristics of terrain to grasp hydrogeological factors ruling at current research area and affecting drainage of the working area in the surface mine.

2. HYDROLOGICAL CHARACTERISTICS

The hydrographical network is middle developed. All water flows in the research area and wider environment belongs to the Aegean basin and the biggest river is Gabroška River representing the main water flow in the research area.

Hydrographical density is conditioned by type of rock masses which build this terrain where are permeable rock providing the most of rainfall deposit fast infiltration into underground where it forms ground water flows.

Drainage of this water is done through springs which appear at the contact of waterproof parts of terrain so these environments are characterised by small coefficient of the surface drainage.

3. HYDRO-METEOROLOGICAL CHARACTERISTICS

Hydro-meteorological data tells that this is the warmest territory in Republic Macedonia. Average annual air temperature is 14,5^{o}C and absolute maximum 43, 5- 44,3^{o}C. The number of days with air temperature of 5-10^{o}C is more than 230 days with air temperature over 15^{o}C is more than 170 days. Annual sum of rainfall for this region is between 586 – 675 mm.

4. HYDRO-GEOLOGICAL CHARACTERISTICS

We divide lithological factors according to porosity as follows:

- Wall masses of inter-granular porosity
- Wall masses of karst-cracking porosity
- Wall masses of cracking porosity
- Conditionally anhydrous parts of terrain.

The intergranular porosity occurs mainly in the walls of quaternary age such as alluvial-proluvial and diluvial sediments. Alluvial sediments spread over major rivers and their tributaries, and were built of sand and gravel. Thickness of these layers is of several metres and aquifer formed in it is in direct hydraulic connection with surface water flows.

Permeability measured at wells is 15-30 m^2/day and abundance 0, 5-1 l/s.

Supply is through infiltration of atmospheric sediments and hydraulic connections with pits and it drains through wells which are used by the local inhabitants.

Proluvial and diluvial sediments are present in the wide research area. Monitoring the work of existing wells it was concluded that abundance of the same is within the limits between 0, 5 – 2 l/s and transmissibility of 15-50 m^2 /day.

Karst-cracking porosity occurs in marble and gneisses and it is of limited spreading in depth and plan. This abundance is conditioned by the grade of cracking of the wall mass.

Supply is done through infiltration of rainfalls and it is drained through contact springs which measured abundance is over 1 l/s.

Cracking porosity occurs in andesites and granites and together with fragile and cracked shales makes composite cracking aquifer. Exploration drilling through these sediments provided conclusion on presence of ground water.

Supply of aquifer is directly from rainfall infiltration through cracking wall masses. Aquifer is drained through spring which abundance is about 0, 5 l/s.

Conditionally anhydrous parts of the terrain belong to lower Palaeozoic complex of shales and compact gneiss which makes them waterproof.

Interrelations of hydrogeological insulators and collectors are illustrated in the figure 1:

G-gneiss complex; S sceo – shales; γ-Granit.

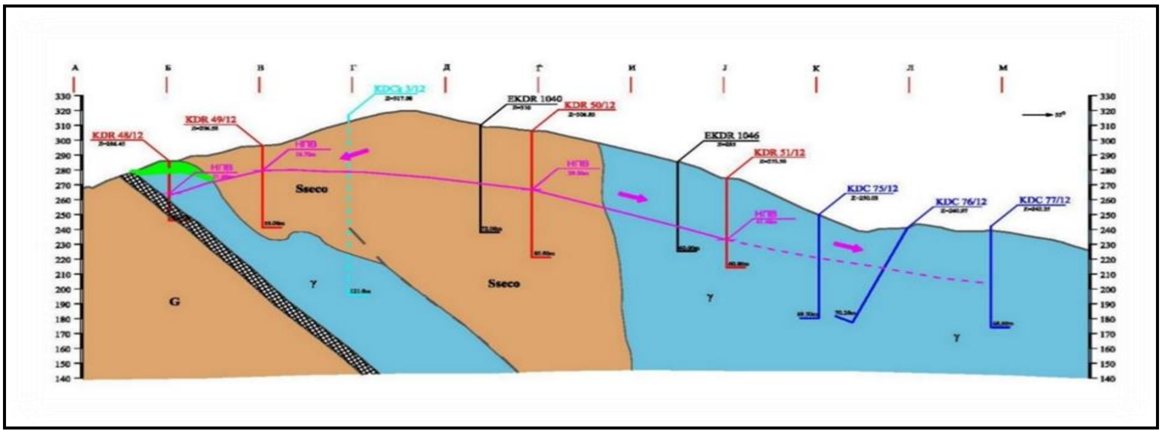

Figure 1, Hydrogeological profile

Based on the level of ground water (NPV) it was concluded that depth to ground water level is 15.30 m, and depth changes are over 50 m.

When we talk of ground water, knowing that are dominant compact waterproof walls it will not occur disturbance of natural conditions of ground water flow. Rainfalls that drop to the working area will fall gravitationally over floors to the lowest level where it will be through floor channels directed out of the working area. Considering above mentioned conditions it can be concluded that here we have low grade of water and such conditions do not request construction of facilities for protection against ground water.

5. PROTECTION AGAINST SURFACE WATER

As it is already mentioned, current territory is characterised by small quantity of rainfall, high air temperature, big evapotranspiration, small surface drainage, due to which reasons is not expected significant supply of surface water that could endangered mining operations.

Facilities in the area of surface mine Kazandol are: Damage lake – 1, working lake – 2, accumulation lake – 3, external landfill, surface mine – A, surface mine – B, ore landfill for soak in lye.

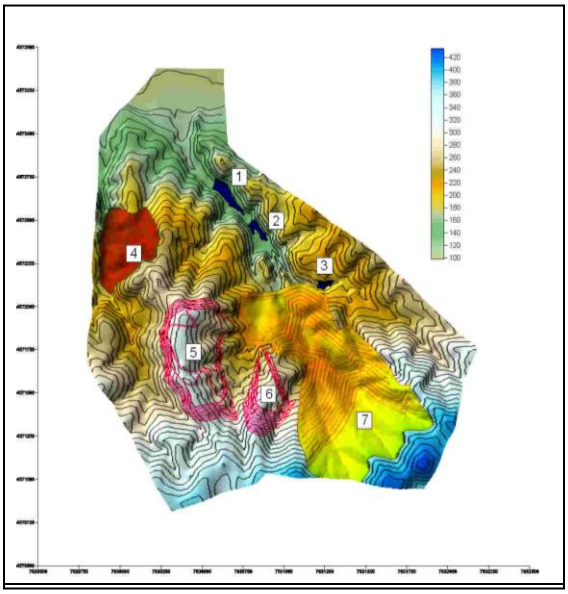

Figure 2: Surface mine with facilities

Surface mines (A and B) do not request special objects for protection against surface water due to lack of formation of any deep floor in the surface mine, and the lowest floor altitude is at the terrain altitude. Working floors are compatible, follows up with terrain topography so water flows from the floor gravitationally toward the lowest floor and then out of the surface mine.

Landfill of the material for lye – rainfall that directly drop or flow to the area of the landfill for ore where soak in lye is done should not be removed, on the contrary, the water will provide the process of natural flushing of the residual material after the end of the exploitation of the surface mine.

External landfill – tailings masses are of compacts parts of walls which during the unload make external landfill taking natural fall. In such way are formed stable slopes of landfill which cannot be disturbed due to rainfall.

The landfill formed as such does not request facilities construction for protection against water.

6. CONCEPTUAL SOLUTION FOR PROTECTION AGAINST WATER

Damage lake (1) – embankment of the lake is constructed of homogenous alluvial sandy material. Upstream surface of the dam and whole accumulation surface is covered with geo-membrane resistant to chemical processes which will occur in the lake.

The dam has overflow, intake part and foundation outlet through which is enabled to empty accumulation in 12 hours. Accumulation space is of 35 000 m^3 with normal level. Between the altitudes 134 and 132 mnm is predicted retention space of 13 000 m^3 in volume for acceptance of flood wave for 100 years water.

Working lake (2) has function to collect water used for spraying the ore at landfill. Embankment is built of filled material with overflow defined for 100 years water (5,61 m^3/s).

Foundation outlet of the dam has dividing shaft where pipeline take water to the recipient.

Accumulation lake (3) has function to collect water of local water flow which is used to supply missing quantities of water during dry season.

The dam of the accumulation lake is built of the ground material. Upstream surface of the dam and entire accumulation surface are covered with geo-membrane in order to protect against permeability and infiltration.

The dam has overflow, intake part and foundation outlet, and for evacuation of high water (2.27 m^3/s) is predicted side overflow.

Foundation outlet of the dam has dividing shaft where pipeline take water to the recipient.

Basic concept for protection of working and after re/cultivated surface mines A and B against intake of surface and ground water is planned on the construction of floor channels to collect water in the lower altitude and lead it in controlled way to the working lake.

7. OBJECT DIMENSIONS

Floor channels are of trapezoid cross section and will be built in the basic material with no delay. They are dimensioned for maximal summer rainfall intensities = 30 mm/6h and value of the ground water supply at the lowest altitude of the surface mine of 0.32 m^3/min.

Hydraulic calculation of permeability of floor channels is done by Darcy law with application of Damjanović methodology.

For the trapezoid cross-section:

$$Q_k = F \cdot v \Rightarrow F\ c\sqrt{R \cdot J}; c = \frac{87\sqrt{R}}{\gamma_1 + \sqrt{R}}; R = \frac{F}{U} = \frac{(b + mh_o)h_o}{b + 2h_o\sqrt{1 + m^2}}$$

Where are:

F – Surface of channel cross-section (m^2)
v – Water speed in channel (m/s)
c – Coefficient by Bazin
J – Channel bottom slope
R – Hydraulic radius (m)
γ_1 – Coefficient of harshness by Bazin (for uncovered bed 1.75)
U – Wet volume (m)
b – Channel bottom width (m)
h_o – Channel depth (m)
m – Slope of the side edge of channel

Should be satisfied the condition $Q_k \geq 1.2 \times Q_u$.

Table 1. Object dimensions

Object	J	h_o	b	R	U	C	V	F
	(%)	(m)	(m)	(m)	(m)	(-)	(m/s)	(m^2)
EK-1	0.2	0.61	0.44	0.3	2.33	20.83	0.51	0.71
EK-2	0.2	0.49	0.36	0.25	1.88	19.18	0.42	0.46
EK-3	6.0	0.39	0.29	0.20	1.51	17.57	1.90	0.29

8. MONITORING

Regarding the fact that here is in question specific chemical method of copper extraction and in order to monitor environmental effects of the work of surface mine, it is crucial to establish the environment monitoring system. This will provide possibility in the early phase to discover possible unfavourable environmental effects with conditions for successful remediation.

In the framework of the environmental monitoring system is predicted to build piezometers for water sampling for chemical analyses in order to monitor possible change of the water quality in comparison with starting *zero* condition.

Water sampling piezometers are positioned in the landfill, in the damage lake (1), in the working lake (2), in the lake for raffinate. There would also be used two shafts positioned in the landfill of grinder ore to monitor effects of water-hold of waterproof foil at the bottom of the landfill.

In the first year after completed re-cultivation sampling would be done four times per year, and further dynamics of sampling depends on the results of the chemical analyses of the water samples.

9. CONCLUSION

When we talk of the facilities for protection of the working space against surface and ground water, we can say that it is the level of water in soil that requests minimal number of facilities and only for controlled drainage of surface water. Wall masses building the observed area, regarding hydrological aspect, are hydrogeological insulators in the frame of which aquifer is formed inly in the cracks or surface smashed layer. Such aquifers are of small abundance (up to 1 l/s). The facilities for protection against ground water are not necessary and entire concept of protection of working area against water is embedded in the facilities for collecting and drainage of surface water or to construction of floor channels. It is crucial to form piezometers network for sampling the water in order to monitor possible bad environmental effects of the copper exploitation.

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SOME OBSERVATIONS REGARDING PROJECT SOLUTION APPLICATION EFFECTS IN SURFACE EXPLOITATION

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ABSTRACT

A large number of design solutions that were conceived at the request of the customer, their available capacity, relevant experience from the field, agreed and applied expertise, defined within the legal framework and in accordance with the business plan and program in specific areas realized in the form of projects are often significantly changed with of without a reason or unapplied at all.

Mine closures and termination of exploitation works, residual mining operations left to the influence of a natural processes and completely abandoned fields are very common in our mining practice.

Designing in mining requires a multidisciplinary approach, as in the wider scientific sense it comprises the area of technical, natural and social spheres, such as geology, geodesy, construction, industry, information technology, economics, ecology and other areas, which basically have project content. Finding the original design solution essentially has to be connected with the use of the latest scientific achievements, current development of techniques and technology as well as the possession of the practical experience of the design team. Reliability of numerous starting parameters is the basis in designing and this is the main requirement needed for developing a quality project solutions.

Key words**:** d esign solution, starting parameters, surface mining

1. INTRODUCTION

Specificity of mining energy complex is usually characterised by changes in natural eco-system as inevitability for processes of exploitation which are not always complying with project solutions. Frequent changes occur due to inactivity of local communities, preferred planning activities, economic or political interests, which are some of local level causes binding professionally implemented project solutions for regional development. This is particularly recognisable with large mining energy complexes or industrial systems with developmental goals embedded in surface exploitation of lignite for electric energy production.

Growing needs for energy condition increase of production system capacities in surface exploitation. The result of such requests is followed with whirling and wide degradation of territories in shorter time terms. The purpose and planning of the space establish in a long term spatial and urban plan. This primarily includes coordination of spatial plans with occurred changes which must be founded in results of many research works upon different research topics. The plan has to include physical volume, conceptual solutions, and economic, social, technical -technological, and ecological aspects.

The lignite exploitation, as a section of the energy system with accompanying contents such as tailings and ash landfills, is characterised with long-term influence on air and water resulting in requests for the spatial plans work out in such regions with high level of insights in possible technological processes and innovations.

In the impact zones of large systems the project activities in the field of planning and landscaping includes demanding application of the law, by-law acts and regulations in the field of mining, energy, industry, agriculture, water management, environment, nature protection, heritage protection, and other.

Within these circumstances, the project activities in planning and landscaping bear special importance due tothe mining energy complex development and its impact zone should be an integral part of long – term progress of the region. Work out of quality project solutions means well developed information level, planning technique and high level of team coordination.

2. THE ROLE OF PROJECT SOLUTIONS

The main purpose of the project solutions is to present to decision making subjects all analysed possibilities with accompanying effects. These solutions, in addition to input parameters, should include published synthesized research providing guidelines toward the most advantageous direction in the sphere of technological and economic growth in the community with the best landscaping solutions. Further role of the guidelines relates to the coordination of ruined spaces with natural conditions, demands for upgrading and maintenance of the environment quality and approach to reduction of risks and damages.

Focus in the planning project activities must be oriented to the territory of mining basin spreading. However, the project solutions based on the longer time projection that relates to the state of operations at the end of exploitation period with predicted concepts and agreed solutions should be deemed orientational.

More reliable solutions of landscaping in the impact zones of the large mining energy systems may be expected through bringing stage plans as well as spatial plans for more narrow continents such as zone of surface mine or energy complex as whole.

The project solutions should conceptually match with development plans of mining energy systems, with local community plans and plans of other economic organizations in the impact zone of production systems with surface exploitation.

Importance of the project solutions is the need to synthetize a whole set of phenomena and relations in the impact zone of mining production systems in order to optimize consequences of structural changes which surface exploitation of coal has left in the subject territory.

3. POTENTIAL OF COAL BASIN IN KOSTOLAC

Economic potential in the territory of Požarevac is primarily embedded in the thermo energy and mining complex in Kostolac. With its industrial potential, this territory also has significant heritage and touristic contents.

One of the most important archaeological sites is Viminacium with excavation site, necropolis and permanent exhibition in the museum in the vicinity of the surface mine Drmno and thermo power plant Kostolac B. Remains of the Roman city Viminacium and the legion camp are in the middle of the lignite deposit at the distance of around 12 km from Požarevac and close to Old Kostolac. The archaeological site Viminacium is categorised as immovable heritage and cultural good of exceptional meaning in the Republic Srbija and it is in progress the work out of the proposal for enrolment in the preliminary list of the world cultural and natural heritage –the UNESCO list.

In the landscaping plan of Požarevac municipality are defined the progress goals of the municipality regarding development and protection of the environment. This primarily relates to the conclusion of the process of further destructive impact to the environment with reasonable exploitation of the natural resources and making potential in regard to preservation, advancement and protection of the environment.

The plan predicts progression of the conditions for living and work with building of recreational objects and trees planting with maximum preservation of natural characteristics of the landscape The spatial and urban plan defines surfaces in the cadastre municipality (KO) Kostolac. The future purpose of the subject space, after completion of the surface coal exploitation of surface mine Kostolac, is matched with spatial and urban plan by the current project documentation. Thus, defined said parameters and terrain conditions by technical and biological re-cultivation of the space of surface mine Klenovnik represent the basis for the successful permanent suspension of works in the subject space with initial solutions directed to further touristic orientation.

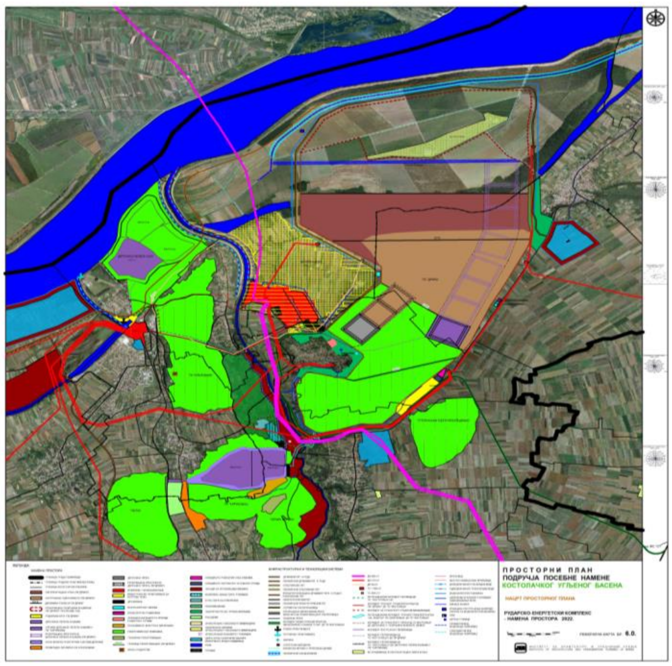

Figure 1: Spatial plan of the special purpose areas
in the coal basin Kostolac

Figure 2: Sport and recreation development concept in Kostolac

It is necessary to remind that the end of exploitation in the surface mine Klenovnik obliges the subsidiary TE-KO Kostolac to realize the project solutions complying with existing project documentation and measures of the technical and biological re-cultivationand to execute spatial ambient fitting of ruined surfaces by mining operations and their fitting and possible change of purpose, or to bring it back to the initial determination.

The current project documentation outlines at devastated area of PK Klenovnik all accompanying goals of the subject landscaping. There are four functional continents, like complex of the museum, education andlodging complex, art colony, and complex for sports and recreation, representing centres of future leisure and touristic activities at the space of the subject surface mine.

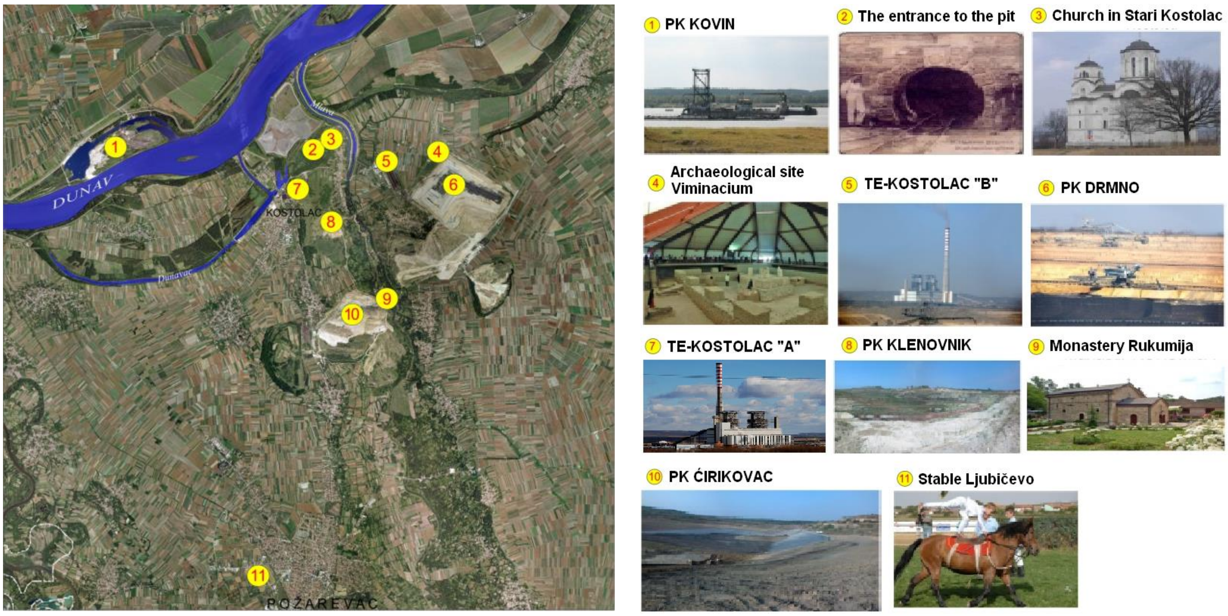

Figure 3: Characteristics of the territory of Kostolac

Predicted mining museum as exhibiting space should illustrate history of mining offering retrospection of mining activities from the beginning until present. That is just one of the existing projects which should be completed aiming to use current capacities. There should be exhibited all artefacts and mining machines to show excavating periods at the territory of all mines in Kostolac.

Landscaping plan of the surface mine Klenovnik means levelling works with formation of floor plateaus. In the north section of the surface mine is planned an art colony construction while the western section is predicted for the construction of the mining museum and education and lodging complex. The central part of the surface mine is aimed for construction of centre for various sports and recreation activities. Internal landfill space is for re-cultivation and returning the land to its initial determination.

All space between museum and education and lodging complexes is organized as green area with railroad crossing it and aiming to renew past transportation track in the new function, or for transportation of tourists from the Danube quay and the archaeological site - Viminacium to the mining museum.

The education and lodging complex represents great potential for education of young people just at the place where the ore is exploited for decades. In addition to the insight in the history of development and presented machines in the mining museum and its open space exhibition, students would be accommodated in the education and lodging centre with classrooms and laboratories at their disposal. Big green surfaces in this centre, gym, and playground for children represent the content for sports and relaxation of visitors.

Unique history of Kostolac territory with intended space of the surface mine Klenovnik need to be functionally merged with touristic potentials and preservation of the environment quality. In this sense, it is necessary to initiate operations for preservation of all ruined areas that are left unemployed to their natural existence after industrial exploitation. Permanent stabilisation, set up and integration in the features of surrounding landscape precede establishment of ecological synchronisation as the part of the wider territory complex with touristic potential.

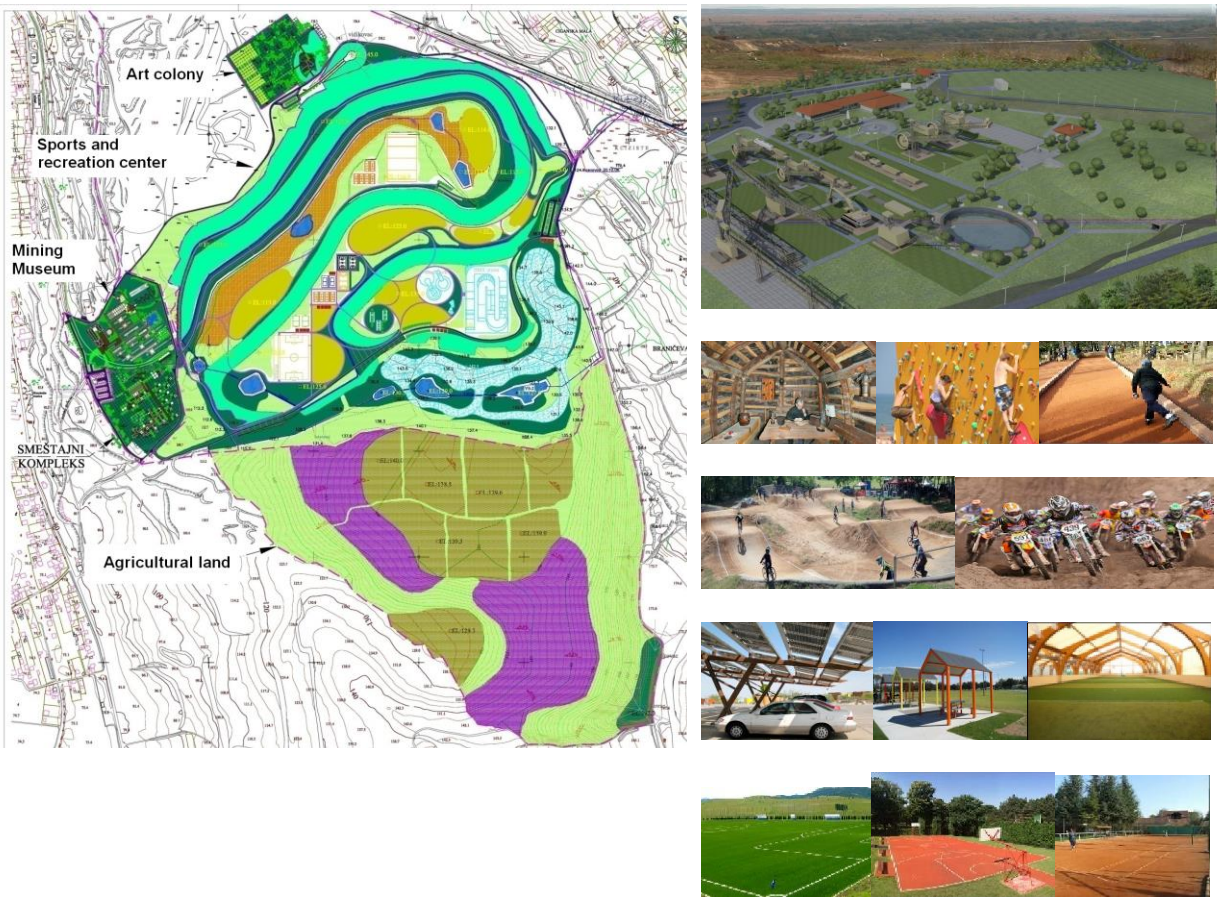

Figure 4: Landscaping plan of the surface mine Klenovnik

4. PROJECT SOLUTIONS IMPLEMENTATION EFFECTS IN THE COAL BASIN KOSTOLAC

The project solutions in the surface exploitation are defined by the program content within the legal framework. Implementation results of the quality solutions mirror in reliable work of the entire system influencing economic growth of the region.

Implementation of the valid regulations in function of landscaping needed to be coordinated with all factors dominating in the subject territory. Starting basis in the sense of landscaping is the Spatial Plan of special purpose area, or the coal basin Kostolac.

For this work creation was used basics of the planning documents and actual projects that are grounded in landscaping of all spaces of industrial complex where is rehabilitation needed, after exploitation, or redefining unused and abandoned areas.

The spatial plan and solutions in coal basin Kostolac are conceived to prevent further devastation of affected spaces by surface exploitation in Klenovnik, Ćirikovac and Drmno. Landscaping by itself is one of the measures preserving environment. In this sense, it is necessary to initiate activities in order to complete existing projects.

Described planned subjects targeting production of more complete touristic offer needed to be linked with cultural content in this area, or archaeological site Viminacium, monastery Rukumija, art gallery Milena Pavlović – Barili and existing touristic potential in wider territory of Kostolac. This would create conditions for new investments, new employments, more content and quality as the base for this area progress.

Having in mind economic effects of tourism it should be demanding to create adequate conditions for its development with detailed regional plans. In that sense it matters to note that archaeological site Viminacium had 300.000 visitors during the last year. Accelerated economic development of the territory would influence reduction of migrations and increase the life quality of the population. Tourism may be significant regarding the aspect of direct foreign investments in all territories with potential, applicable and attractive spatial plan, harmonised current project documentation. With cooperation of local government and application of simple procedures, the realization of quoted factors should be secured in the interests of wider social community.

At the same time with construction of planned objects of infrastructure and landscaping ruined spaces, touristic offer would be completed including cultural topics and would represent unique whole in the territory of Kostolac. This primarily includes arranging the costal belt of Danube, construction of quay and marina and arranging of existing sports airport on the middle island of Kostolac.

Mining museum together with education and lodging contents, art colony and particularly sports and recreation center has economic basis and may represent very attractive *business plan*. It is for sure that described project solutions in the form of sports, recreation and the rest of quoted content would contribute significant touristic offer of this region. Consequently, it would be comprehended the importance and effects of the project solutions implication that are still not realized and would affect the quality of life improvement in this area.

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COAL'S MODERN CHALLENGE. ECO-DEVELOPMENT OR ECOLOGY

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ABSTRACT:

Coal is an affordable, abundant, safe to store and reliable resource, relatively straightforward to convert to electrical power. Coal makes an important contribution to the economic and social development and it can also meet the growing energy needs of many developing countries. But coal remains essential in achieving a balanced and secure energy grid for many developed countries too. Therefore, coal will play an important role in energy sistems as part of the future energy mix, because it offers accessible distribution, attractive costs and reliable availability.

In the same time, new concerns about climate change add the most important challenge to the long-term use of coal in a sustainable development context. The environmental impact of the coal industry includes air and water pollution and waste management. It is well known that direct coal burning produce greenhouse gases and solid waste products, including fly ash, flue-gas and sludge that contain various toxins and/or heavy metals. But, even the most modern and advanced conventional coal-fired power plants emit over 15 times more CO_2 per unit of electricity than renewable energy systems, and more than twice the amount of efficient gas-fired power stations.

In this regard, Governments must accept that coal will necessarily play a major role in world energy supply for many decades, and to put in place policies that will accelerate innovation, investment in and rapid deployment of cleaner coal technologies. This position contrasts with the more commonly adopted policy of encouraging a shift away from coal to less reliable energy sources (wind, water or solar).

In addition to direct coal burning, coal can be used as a feedstock for the production of liquid and gaseous fuels. In the last years, bio-fuels produced from raw materials of organic nature such as coal, wood and biomass and biological, industrial and minerals waste, represent a viable alternative to petroleum products. Because of new technologies, in the future, bio-fuels can replace gradually the volumes of crude oil from depleted deposits. In the same time, a large quantity of existing waste is adequate to produce synthetic oil, but is not enough to produce a sufficient amount, so the difference can be covered with solid energy raw materials, currently responsible for the appearance greenhouse gas emissions.

Therefore, authors consider that transfer of clean coal technologies from developed to developing countries represents the modern challenge of coal and related industries and, in the same time, the answer to main question: eco-development (sustainable development) or ecology (mines closure)?

Key words: coal, challenge, eco-development, ecology

1. REDUCING EMISSIONS

In 2013, the Intergovernmental Panel on Climate Change (IPCC), the world's foremost collection of climate scientists, representing all major continents, concludes that we are quickly using up our "Carbon Budget", the amount of carbon the world can emit while still having a likely chance of limiting global temperature rise to 2ºC (burning all known fossil-fuel reserves now would produce about 3,800 gigatonnes of CO_2). According to the IPCC, keeping the global temperature increase from pre-industrial levels below this threshold – the recognized tipping point beyond which climate change is likely to get seriously out of control – requires that the world emit only about 1 trillion tonnes of carbon (1,000 GtC). IPCC consider that more than half of this amount was already emitted by 2011; the remaining budget will run out in next 30 years (three decades).

Immediatly, many governments and financial institutions recognize this problem, and to the Paris climate conference (COP21) in December 2015, 195 countries adopted the first-ever universal, legally binding global climate deal. The agreement sets out a global action plan to put the world on track to avoid dangerous climate change by limiting global warming to well below 2°C.

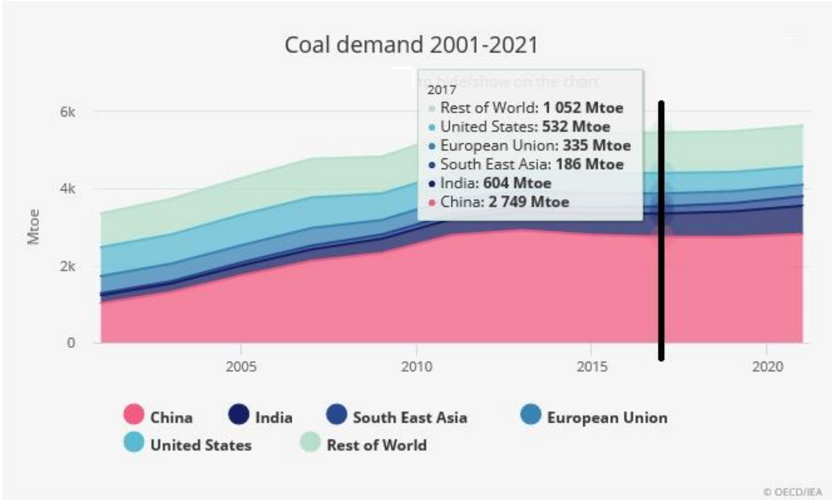
In the same time, The World Bank, the European Investment Bank, and the United States Export-Import Bank have introduced policies that restrict financing of new coal-fired power plants unless they can capture and store their CO_2 emissions, and five Nordic countries have joined the US Treasury in ending public financing of new coal-fired power plants overseas, and others may soon follow suit.

The European Union decide to continue to support climate action to reduce emissions and build resilience to climate change impacts in developing countries, and eveloped countries intend to continue their existing collective goal to mobilise USD 100 billion per year by 2020 and extend this until 2025.[1]

China, concerned about the serious health costs linked to burning coal, is prohibiting new coal capacity in three coastal provinces under its newly adopted action plan on air pollution and have also introduced policies to reduce the proportion of coal in the country's overall energy mix. [7]

The number of coal-fired power plants under development worldwide saw a dramatic drop in 2016, mainly due to shifting policies, from up to 1,200 proposed coal-fired power projects around the world, with a total installed capacity of more than 1,400 GW in 2013, 1,090 GW in 2016 to 570 GW in 2017. [2] In the European Union and the U.S. a record-breaking 64 gigawatts of coal plant retirements was estimated in the past two years (the equivalent of nearly 120 large coal-fired units) and, in the same time, 48 percent decline in overall pre-construction activity, a 62 percent drop in new construction starts, and an 85 percent decline in new Chinese coal plant permits. Reasons for the rapid fall-off include a dramatic clampdown on new coal plant projects by Chinese central authorities and financial retrenchment in India, where construction is now frozen at over 100 project sites.

[1] https://ec.europa.eu/clima/policies/international/negotiations/paris_en
[2] World Resources Institute



New improvements in technology continue to modify the outlook for the energy sector, the business models, energy demand and supply patterns as well as regulatory approaches. Climate changes, energy security and economic competitiveness are increasingly being factored in by decision makers. Governments have far more cost-effective electricity-generation technologies at their disposal.

2. COAL

- So, are we ready to abandon immediately coal mining?
- Of course not!

Coal continues to offer millions of people a reliable source of electricity[3]. Transition to low-carbon technologies will not happen overnight. We need to expand access to these technologies rapidly, while helping people whose livelihoods depend on the coal industry. In addition to direct coal burning, coal can be used as a feedstock for the production of liquid and gaseous fuels. [1][2]

Because of new technologies, in the future, bio-fuels can replace gradually the volumes of crude oil from depleted deposits. In the same time, a large quantity of existing waste is adequate to produce synthetic oil, but is not enough to produce a sufficient amount, so the difference can be covered with solid energy raw materials, currently responsible for the appearance greenhouse gas emissions.

In this regard, Governments must accept that coal will necessarily play a major role in world energy supply for many decades, and to put in place policies that will accelerate innovation, investment in and rapid deployment of cleaner coal technologies. This position contrasts with the more commonly adopted policy of encouraging a shift away from coal to less reliable energy sources (wind, water or solar).

[3] http://www.iea.org/topics/coal/

3. ECO APPROACH

a) Open pit coal mine's Greening

European major policy for coal is to initiate large programs of mine closure and greening. In the past, the declared objective of environmental mining works was to restore the mined landscape to its original shape and use after the completion of mining. But companies, regulatory authorities and social groups have realised that no matter what the technical and financial resources invested, the amount of coal removed make it virtually impossible to return a mined area to its original state. Instead, companies now are leveraging the economic and technical capacity of the mining operation to upgrade the affected land and surroundings at very low additional costs, creating new and possibly more useful space for nearby communities even if the landscape is not returned to the previous state.[4]

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b) Coal liquefaction and modern technologies options [10][11][12][13]

Due to the high efficiency, interest in coal liquefaction technologies (CTL) and coal gasification has now grown in many countries rich in this resource, a good example being China. The Chinese government aims coal liquefaction projects (CTL) as part of a national energy policy with a cost exceeding $ 10 billion. Beijing plans to have a capacity of CTL to approach 50 million tonnes by 2020 and the province of Inner Mongolia plans to turn half of coal production (about 135 mil. Tons - the equivalent of 40% of the annual production of coal in Australia) in the liquid fuel or chemicals. [7][17]

To this was added catalytic depolymerization technology without pressure - DCP. After decades of intensive research and development reactor DCP and successful application of this technology in a proven system in Germany it is now opened for its widespread use. This innovative technology allows substantially complete conversion (80 to 90%) of the raw materials of organic nature such as charcoal, wood and biomass and bio-waste, mineral and industrial, in a biofuel as a source of energy friendly the storable. Biofuel result has low contamination, high calorific value, and can be used without restriction, so in all types of diesel engines and especially energy. Given the geopolitics of oil, alternative recycling methods will take a leading position. With this technology it is possible to transform not only coal but also residues of organic material such as waste plastics, waste oils and residues of paraffin and initial sources such as rape, wood, plant residues, biomass and deşeuril organic pollutants in food and meat processing in an economical way in biofuel (diesel). The final product resulting from the application of technology DCP has outstanding quality and can be used without restrictions as a fuel for vehicles and for diesel engines. [9]

[4] https://www.iea.org/newsroom/news/2012/december/the-greening-of-open-pit-coal-mines.html
[5] https://www.iea.org/newsroom/news/2012/december/the-greening-of-open-pit-coal-mines.html

c) Organomineral fertilizers [26][27][28][29][30][31][32][33]

Organomineral fertilizers, having in their composition natural organic polymers and/or synthesis associated with various minerals, which in addition to providing elements deficient in plant nutrition have qualities for improvement of soil properties, are produced relatively new used in agricultural practice. They were created and developed, in particular due to the need of improving sandy soils, those luvic degraded and other soils with low humus, with the development of intensive agriculture and for improving soil contaminated products organic or heavy metal. Scientific research conducted in Romania, showed beneficial effects of these substances in various fields (medicine, engineering, water treatment, remediation of the environment or agriculture), due to their chemical and biochemical outstanding (nitrogen heterocyclic chemical structures complex functions hydrophobic and hydrophilic qualities and chelating cation exchange, etc.). Among these effects may include: increasing the accessibility of nutrients in the soil and stimulate microbiological activity, resulting in an improvement in the humus soil, stimulating the physiological processes of the plants, an improvement in the aerohidric and physical properties, restoration of fertility of soil degradation, reduction in the need of fertilization with macro and micro elements, increasing the resistance of plants to drought, and as a consequence, significant increases in production for many crops plant diversification of the fertilizer organo-mineral application radicular extraradicular and new technologies introduced to achieve a modern agriculture, intensive and environmentally led to the increase of this type of fertilizer balance substances used for fertilization approx. 10 to 15%. The research activities carried out in Romania [26,27,28] focused on the extraction of the humic substances (humic and fulvic acids) of native carbonaceous material (lignite) and their exploitation in the form of organo-mineral fertilizers together or without other carriers nutrient substances and experimental testing of their agronomic efficiency. Due to the dark colour and special properties, humic acids are known as "black gold".

4. CONCLUSION

Open-pit mines will not disappear soon, any more than coal usage will. All over the world, companies are using open-pit mining as a low-cost way to recover the world’s fastest-growing energy source. At 28% of total primary energy consumption, coal is second only to oil as a fuel. But while other policies can address impacts such as noise and dust produced during the mining, *Medium-Term Coal Market Report 2012* highlights how the right environmental, operational and management approach exists to leave behind a useful and scenic, if not original, landscape after the mining, at limited cost to the operator. [3]

This scenario would mainten coal market and ensure that the mining activities will continue until all resources will be exploaited, in a modern and sustainable European economy.

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PROPERTIES OF TECHNOGENIC SOILS AS THE BASIC INDICATORS IN METHOD AND SUCCESS OF RECLAMATION

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ABSTRACT

The surface mining, as a method of intensive exploitation of the mineral raw material deposit, coal in particular, is getting more and more applications in the world. Consequently, it appears to cause destruction of soil. "Soils at the open pits" (mine soil, mine land sites, mine degraded land, antropogeomorfic soil material, technosols) have been created by anthropogenic effect, but seem to be different from the class of anthropogenic soils in many properties. These soils have been created on various substrates that occur to be moved by mining activities in the course of technological process. These soils are called technogenic soils. Deposols within the major open pits in RS/BiH have been created from various geological-lithological sediments from the overburden of several basic types of mineral raw material. The reclamation of degraded land has the goal to reclaim its basic productive-ecological function.

Key words**:** Deposol, productivity, Rekultisol, nutrients, substrates

1. INTRODUCTION

The technogenic soils of the mining basins with the surface layer (Deposol) are the most often limiting factor in the realization of measures of technical and especially agrotechnical, and biological reclamation. In particular, they emphasize mainly the unfavorable chemical characteristics of the subtypes of the Deposols, which are very heterogeneous. The pedological properties of the Deposola (parent material for reclamation) are of great importance for the successful establishment and maintenance of terrestrial ecosystems.

The fertility of the Deposol, and most other types of technogenic soils (mine soils), is usually low. The density of the Deposol with the basic biogenic elements (N, P and K) is within or below the minimum concentrations. This is confirmed by many published domestic and foreign papers in this field: Malić *and* Marković, 2012; Pivić *et al*., 2011; Marković, 1996; Veselinović, 1995; Dvurechensiy *and* Seredina, 2015; Sheoran *et al*., 2010; Coppin *and* Bradshaw, 1982).

In addition to the deficit of nutrients, technogenic soils are poor at all with pedobios, organic matter, and poorly developed adsorptive complex (Rasulić *et al*., 2005). The adsorptive soil complex is an important parameter and a big obstacle to raising the fertility of most soil types (Malić *et al*., 2016; Živković, 1991; Ćirić, 1991). Shukla *et al*. (2004) states the following disorders in technogenic soil: loss of aggregate and soil structure, decrease in soil C concentration, an increase in volume, and decrease in porosity.

2. CLASSIFICATION OF MINING DUMPSITES, BY A SOME PEDOLOGICAL PROPERTIES

Limstrom (1948) carried out the first research on the potential productivity of Deposols at dumpsites, which showed a direct dependence on the acidity of soil and texture. The soil classification method, degraded by surface exploitation of coal (according to the possibilities for reclamation), was carried out at the Central Forest Research Station in 1946 in the United States. Acidity and texture together, determine the type (degree, size) of damage or degradation. The first system of classification of mining areas and soils (Deposol) was published by Limstrom *and* Deitschman (1951), and is proposed on the basis of the chemical reaction of the soil (pH value) and is divided according to the description of the material in five groups:

1) toxic material, pH < 4.0 and > 75% extent on the area;
2) marginal material, pH <4.0 and the extent on the area 50%-75%
3) acid material, pH 4.0 – 6.9 and the extent of the area 50%-75%
4) calcareous material, pH > 7.0 and the extent of the area >50%; and
5) mixed material, changeable relative to classifications stated above.

According to the same authors, Deposols for reclamation based upon the texture can be divided into three groups:

1) group A – chiefly sand, sandstone, or sandy shales;
2) group B – chiefly loamy materials and silty shales, and
3) group C – chiefly clay and clay shales.

Knabe classification is being used in Germany (1975, cit. Mujačić, 2013), whereby materials are divided according to physical and chemical characteristics into five groups:

1) very good materials for reclamation (loess and argillaceous),
2) materials similar to the first group,
3) satisfying materials suitable for forest reclamation (non toxic sand, argillaceous and clinker),
4) bad materials (quartz gravel and sand), and
5) very bad materials (toxic materials with pyrite and other toxic materials).

In former SFRY republics, while evaluating technogenic substrates, based on reclamation convenience, classification system according to Resulović (1980) is still being used approximately whereby the materials are divided into three main groups and seven classes:

- group 1: recyclable materials (I, II and III class, convenient for reclamation);
- group 2: non recyclable materials (IV, V and VI class, less convenient for agricultural reclamation, but more convenient for forest reclamation); and
- group 3: toxic materials (VII class).

The Deposols in big surface open pit in Republic of Srpska and Bosnia and Herzegovina are formed from geolithological sediments from overburdens of three types of mineral raw materials: coal, bauxite, and ironstone. Sufi-Mićić (1999) divides all overburden covering on surface coal mines in B&H in two groups:

1) group of marl materials, and
2) group of sand materials.

Overburden covering or lignite overburden is made of partly softer and loose lithological parts, mostly sands of tertiary age, argillaceous Pliocene sediments of the upper pont, marl, and sporadically marls, limestones, gravel, sandstone, conglomerate. In the brown coal overburden prevail harder and more compact litostratigraphic parts: marls, marl, limestones, sandstone, gravel, clays and others.

3. INFLUENCE CHEMICAL REACTION IN TECHNOGENIC SOILS

The most important chemical characteristics of Deposols are pH value and content of nutrients in Deposol. In their research of the reclamation of Deposols of acid reaction Maiti and Ghose (2005) induce that an increase of pH value and organic substance is necessary for sustainable reclamation of mining dumpsite. Active acidity is used the most frequently as an indicator of dumpsite Deposols' quality. A chemical reaction of the Deposols' is a variable dimension in material fragments, time interval, and oxidation correlation. When pH values in Deposols are reduced below 5.5, an increase of legumes' boost, which happens as a consequence of metals' toxicity (Al or Mn), P fixation follows and a reduction of nitrogen-fixing bacteria, which in their researches induce Sheoran *et al*. (2010). Deposols with a pH value from 6 to 7.5 are ideal for production of stodgy cattle food and other agronomical uses (Gitt *and* Dollhopf, 1991; Gould *et al.*, 1996). When the pH value is less than 5, together with increased concentration of Fe, bioavailability of toxic materials such as Ni, Pb, and Cd is also increased (Maiti, 2003).

Sheoran *et al.* (2010) quoted that an increased acidity in Deposols can be efficiently neutralized at a reclamation treatment using limestones materials, through implementation of calcification, as on natural land for which exist different limestone and other materials (Todorović *et al.* 2003; Kovačević *et al.*, 2011). Tordoff *et al.* (2000) assert examples of the use of organic substances, such as wood chips, compost, siderites etc., in order to increase land pH, land structure mending, water capacity, cation substitute capacity, supplying slower release of nutrients from fertilizers, and they are used as an inoculum for microorganisms. While researching a calcification effect, Kovačević *et al*. (2011) quoted an increase of land pH in KCl from 4.12 to 7.66 depending on a different dosage of hydrated limestone (15-45 t/ha).

All newly created Deposols, like the older ones, require a significant application of the fertilizer as an element for plant community establishment and maintenance (Sheoran *et al*., 2008; Copiin *and* Bradshaw, 1982). The level of organic C over 0.75% indicates good fertility. The content of the organic C in the Deposols and Rekultisols is from 0.35% to 0.85% (Maiti *and* Ghose, 2005).

Thitherward, Chatterjee *et al.* (2009) observed that the soil in a process of reclamation (by establishing sowed lawns and afforestation) could potentially renew fertility and by a certain time, increase C, total N, and that pH value could shift from acid to alkaline environment. Organic C is in positive correlation with available N and K, and in negative correlation with Fe, Mn, Cu, and Zn. The listed metals are soluble in an acid solution and can be diluted to a form of toxic concentration, so that they interfere with growth of plants (Barcelo *and* Poshenrieder, 2003; Das *and* Maiti, 2006).

The type of fertilizer and the dose for use depends on the location, soil type and purpose of use of reclamated soil because of specific characteristics of technogenic soils. In these kind of soils, bigger amounts of fertilizer put close to the plant's root, the most frequent cause damages on the root system and on the whole plant, which is a result of the research published by Ghose, 2005 and Smith *et al.* 1985.

Organic C is an energetic source for soil microbiology, which includes resolution and mineralization of the plant's residues, and in this regard, nutrient release. Accumulation of organic C results in changes of physical and chemical characteristics in technogenical soils, such as water retention and adsorptive capacity, content and accessibility of nutrients, volume mass of the soil, buffer capacity and other (Herrick *and* Wander, 1998). Binding rate of organic C is from 0,1 to 3,1 t/ha annually in grass ecosystems of reclamated mine soils and from 0,7 to 4,0 t/ha annually in forest ecosystems (Shrestha *and* Lal, 2006).

4. THE IMPORTANCE OF ORGANIC SUBSTANCE AND NUTRIENTS IN TECHNOGENIC SOILS

Soil fertility depends a lot on the content of organic substance which has great influence on soil processes, living world inside of it, but also it has influence on fertility, which means productivity. Organic substance contains in itself: N, P, K, S and other biogen elements, which particularly becomes prominent in indigent soils (Maiti *and* Ghose, 2005). The nutrients are available for adoption only in the shape of minerals and that way the organic part (through the process of humification) has to be transformed into the shape of minerals (Živković, 1991; Ćirić, 1991; Todorović *et al.*, 2003). Factors that influence the degradation of organic matter in the soil are: climate, texture, pH, content Ca, saturation with adsorbed bases, water, air and heat regime, values and character of organic matter (C: N ratio), type of crops, and agrotechnical procedures.

Green plant mass contains about 75% of water, and fallen leaves 30%-50%. That water evaporates thanks to drying and the rest is dry mass. About 90% of the dry mass are various organic compounds made of C, N and O, and the rest are mineral elements (Ca, Mg, K, Na, S, P), which stay in ash after burning the organic substance, and whose content amounts from 2% to 10% depending on plant residues (Ćirić, 1991).

The importance of organic medium is in the retention of applied nutrients with less loss of rinsing, particularly in the outset phases (Mercuri *et al.*, 2006). Riesen *and* Feller (2005) in the implemented researches reported the nature of applied nutrient substances and their concentration, which can in certain time have an influence on accumulation of heavy metals, their mobilization and supply in plant parts.

In building up the Deposol fertility level and later Rekultisol there are certain specific measures of improvement mediums for the growth of the plants. In the research with use of sawdust, Uresk *and* Yamamoto (1986) have published positive results on increasing level of subsistence of the major number of the planted phanerophyte.

Gitt *and* Dollhopf (1991) observed similar results in the use of wood residues as an addition (improver) in Deposols. The addition of wood residue with N increases the effect of introduced fertilizers with N, P, K or added plaster, which enhances the level of soluble salts (Vorhees *and* Uresk, 1990). Sawdust and crust-mulch increase the content of the organic substance, but they are in general of low content of N.

Sawdust and drainage mud are widely recognized as efficient and short-term fertilizers and sources of long-term nitrogen release (Sydnor *and* Redente, 2002), and they are also used as a microbiological inoculum. Consequently, use of these materials as an addition in reclamation requires higher dose of fertilizing with nitrogen fertilizers. Maintaining the easy accessible phosphorus in deferred overburden is aggravated by two factors:

1) newly formed Deposols are in general of low content of P_2O_5 and
2) the Deposol becomes by time and oxidation enriched with Fe oxides which absorb water soluble R, and then it remains fixed in inaccessible forms.

Long term productivity for plants and new soil system as a whole is depending on several factors (Daniels, 1999; Ghose, 2005):

- accumulation of organic substance and N,
- maintenance N fixed with legumes in sand, and
- organic P supplies establishment and avoidance of P fixation.

The most of N which is needed for plant nutrition and soil microflora comes from fixed N and later mineralization of organic N. Since Deposols mostly do not contain the natural population of essential bacteria of nitrofixators, Sheoran *et al*. (2010) point out that the seed inoculation deserves special attention in new crops breeding and seedings. According to Liendemann *et al.* (1984), replacement of the surface soil layer with the hay and treated sewage mud may be more effective in the proces of direct reclamation in comparison with the application of inoculation and stimulation of growth and activities of bacteria in alluvial surface soil layer (indirect type of reclamation), particularly in comparison with the bacteria that oxidate the ammoniak. The bacteria present in soil require a source of easy oxiding C, which is obtained by using hay and mud as a fuel for metabolic activity and circulation of N. Dželetović *et al.* (2009) quoted, in the implemented researches of biological reclamation by planting species from the kind *Populus*, the different types of mud as a significant source of N.

Surface soil horizons or topsoil (which are being used in reclamation for forming the finish layer across the infertile overburden) contain C, which is often found in the form of coal or other humus materials mixed during the soil replacement (displacement) and thus it is not always easy accessible (Moynaha *et al.*, 2002). Humus substance are the most important carriers of organic compounds N in the soil, therefore they are the main source of N for the plants. There are about 95% of N in organic form in the soil and only 1%-5% in a form of non organic compounds, which plant can use directly.

In the practice, lignite could be used as an improver (fertilize) in reclamation, but according to Baumann *et al*. (2006), there are two reasons why it should be avoided. The first one is because of lignite particles often contain a lot of pyrites, which causes a strong acidification. The other one is that the lignite particles also contain only limited amounts of organic substance for resolution and as a source of nutrition (Rumpel *and* Kögel-Knabner, 2004).

On the contrary, Fettweis *et al*. (2009) observed that organic C from lignite and its derivative can partly compensate the lack of organic substance in Deposols. The significant role in this have microorganisms which surely can decompose lignite particles, but in the longer time period. In implemented researches of reclamation by establishing the lawn, that a significant increase of organic C and total N in reclamated soils at a depth of 0-10 cm are provided as quoted in Chaterjee *et al*. (2009).

Improving incorporation of organic substance in reclamation of technogenic soils can be an alternative to the replacement (applying more fertile material) of the surface Deposol layer on a dumpsite (Olsen *and* Jones, 1989). Accumulation of organic substance in Deposols and Rekultisol directs to an increase of fertility and stimulates microbiological activity, helps transformation and circulation of N and accelerates renewing of ecosystems (Coyne *et al*., 1989).

Forming soil and accumulation of organic carbon in the process of reclamation are conditioned by the plant layer development and by mineralization of plant residues. On the other hand, growth of the plants and mineralization are the most frequently limited by the lack of N and P (Liendemann *et al.*, 1989; Vimmerstedt *et al.*, 1989; Stojanović *et al*., 1977).

5. THE TECHNOGENIC SOILS MICROBIOLOGY

The activities of microorganisms (fungus, bacteria and other) are very significant for reclamation and development of technogenic soil. These organisms have three basic functions:

1) decomposition of organic matter and plants,
2) nitrification or accumulation of nitrites in the soil as the result of decomposition of organic matter, and
3) fixation of nitrogen by symbiotic and non-symbiotic bacteria.

The reproductive mycorrhizal fungus population is quite low at the non-inoculated locations immediately after the reclamation but it may be re-established after several years (Williamson *and* Johnson, 1991). This matches the occurrence of host-plants (seeded grass types) more appropriate for the colonization by mycorrhizal fungus than „common species" as quoted in Gould *et al*. (1996) and Gould *and* Hendrix (1998). The growing of mycorrhizal fungus existing in the surface layer may be stimulated by the existence of host plants. Liendemann *et al*. (1984) confirmed that the covering of infertile dirt with the layer of surface soil 30 cm thick horizons (without inoculation by mycorrhizal fungus) also stimulates the colonization by mycorrhizal fungus more than inoculation of topsoil or usage of mud as a fertilizer.

According to Ghose (2005), the soil microorganisms have significant role in stabilization of aggregative structure substantial for porosity and crop breeding. According to Nannipieri *et al*. (2000), 80%–90% processes in the soil are effected by microorganisms. These microorganisms include several types of bacteria as well as fungus with its symbiosis with many other plants facilitating the nitrogen and phosphor absorption in carbon exchange. They produce polysaccharides that improve the soil aggregation and positively impact the growth of plants as shown in the results of surveys conducted by Williamson and Johnson (1991). Furthermore, Harris *et al*. (1989) conclusion that the microbiological activity declines from the aspect of profile depth and time of perseverance of surface soil horizons in the course of mineral raw exploitation is very important. The microbiological activity measured in ATP (adenosine triphosphate) concentration drops down to the very low level within several months. The glucose response is slower than microorganisms at all depth levels indicating the fact that the metabolic processes are decreasing with time (Visser *et al*., 1984).

In 2013, Golic *et al.* (2014) performed the basic survey on deposol microbiological activities at the overburden disposal area in Stanari lignite mine (Republika Srpska, BiH) as well as reclaimed surfaces with the biological reclamation performed by lawn planting. The survey activities noted down that the total number of bacteria, oligonitrofiles, ammonificators, azotobacters, actinomicetes and activity of enzymes of dehydrogenases in deposol in the process of reclamation constantly grows compared to deposal (control). These authors quote minor representation of fungus at the surface in the reclamation process; number of oligonitrofiles is bigger than number of amonnificators thus indicating the process of nitrogen fixation to be more intensified in comparison to the process of decomposition of organic matter. According to them, the monitoring proved the slight difference between the number of oligonitrofiles and ammonificators, i.e. decomposition process and process of nitrogen fixation are at the level of their minimum performance.

6. CONCLUSION

Management of newly-formed technogenic soil after the completion of mineral resources exploitation represents the main goal of reclamation. The applied measures for technical planning of technogenic surfaces, agrotechnics, plant sorts selection for reclamation aim at the stabilization of technogenic soil and establishment of normal pedogenetic processes. Major deposol heterogeneity at the overburden mindump and other excavated surfaces is often reflected by very adverse basic pedological properties of soil. Types of plants used for reclamation need to have multifunctional purposes: selection based on their adaptability, growth and development in new ecological conditions and possibility to improve the soil structure and overall fertility improvement.

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GROUNDWATER MONITORING AFTER THE CESSATION OF LEACHINGOF COPPER ORE IN THE OPEN-PIT MINE KAZANDOL MACEDONIA

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ABSTRACT

Mining Institute of Belgrade has conducted the project of recultivation and landscaping of the area after the permanent cessation of mining operations of the copper cathode production complex Kazandol in Macedonia. The specific feature of the mine Kazandol is the exploitation of copper by ore leaching. The subject of this paper is one of the most important tasks within the project - a solution to the establishment of groundwater monitoring after the termination of the mining complex operations.

Key words: Monitoring, Groundwater, Leaching of copper ore, Kazandol

1. INTRODUCTION

Open-pit mine Kazandol is located in the southeastern region of Republic of Macedonia. The specific feature of the mine Kazandol is the exploitation of copper by ore leaching.

The groundwater level measurement (GWL) is conducted monthly in piezometers.The collected data transferred to a hypsometric model of groundwater levels, and the direction of groundwater currents. According to these measurements the average GWL is 15-30 m, at 6 measuring points there are registered depths greater than 35 m, even over 50 m. Considering that the exploration field is dominated by compact impermeable rocks, it is not expected any disruption of natural conditions and currents of groundwater.

The assessment is that the low level of drainage of the mine field and hydrogeologic conditions do not require facilities to protect against groundwater. The geometry and spatial position of the mining facilities (quarries, heap leaching pad and overburden dumpsite) is such that during and after cessation of mining activities, these facilities will not be affected by groundwater.

Therefore, the area of the mining complex Kazandol is characterized with low amount of rainfall, high air temperature, great evapotranspiration, small surface run-off, and therefore no significant inflow of groundwater is expected that would endanger the mining facilities and activities.

After the permanent cessation of work in Kazandol follows the reclamation and landscape work on the mining area, and the fact that specific exploitation technology has been applied, the monitoring is highlighted as a very important and complex activity for surveillance of waters.

The aim is to protect the environment, prevention of potentially adverse impacts on the environment, and if in some circumstances it comes to it, creating conditions for their efficient and successful removal. The complex monitoring measures start at the beginning of the work with opening the mine and construction of the processing plant, up until the successful completion of the reclamation and landscaping, with full respect of the legal regulations.

2. GROUNDWATER MONITORING

In order to determine the zero reference, or the initial state of water quality, the first monitoring sample of the groundwater should begin before the initial start of the mining activities and construction of the complex for processing. Water monitoring is performed continuously during the exploitation activities as well as during the reclamation and landscaping of the area, with possibility to be prolonged.

The facilities for groundwater monitoring will be used after cessation of mining activities and the leaching process, during the three-year biological reclamation and landscaping of the area, with possibility to be prolonged. There is no need of new facilities for water monitoring during the reclamation and landscaping of the area.

The monitoring of effluents is indicator of the successful neutralization of the acidity of the heap leaching pad, in order to prevent pollution and hazards.

During the process of neutralization, it is necessary to introduce a monitoring system of the quality of the effluents that flow of the landfill. Samples of the effluents should be taken before, during and after the neutralization.At the beginning the findings should be alkaline, and over time the alkaline would be reduced to a certain level.

The cycle of the neutralization has five stages, including the monitoring:

1. Sampling for monitoring.
2. *Active – 2 months. At the end of this stage, samples are taken for monitoring.*
3. *Passive – 2 months. The heap is not treated with solution. During this period neutralization process occurs, the metals are sedimented and hardened. At the end of this stage, samples are taken for monitoring.*
4. *Active – 2 months. At the end of this stage, samples are taken for monitoring*
5. *Passive – 2 months. The heap is not treated with solution. At the end of this stage, samples are taken for monitoring.*

After the neutralization, when the alkaline effluent will reach its stability, the monitoring is done once to twice a year (usually after rainy period) in the following two years, using the ISO 5667 and ISO 11885 standards for water quality.

The monitoring network for chemism sampling and possible chemical changes in the water, envisions four boreholes with piezometer installation: piezometer S-1 in the heap leaching pad zone, S-2 at the operating pond, S- 3 at the emergency pond and S-4 in the raffinate pond. Apart piezometers, the monitoring network includes two shafts (SH-1 and SH-2) under the heap leaching pad, designed to track the effect of the impermeable foil on the bottom of the heap.

If the final results of the water quality monitoring are satisfactory up to the beginning of biological reclamation, the monitoring of the quality (chemism) of groundwater will continue with sampling only from piezometer S-3.

In the first year, during three months, four water analysis will be performed. If the results of the first year are satisfactory and show minor deviations, during the second and third year the water chemism will continue to be monitored every six months, twice a year.

The decision on termination of monitoring the groundwater chemism depends on the comparative analysis of the results of all chemical analysis, in terms of "zero reference" and the current situation.

3. CONCLUSION

Groundwater monitoring after the permanent cessation of leaching in the complex Kazandol is important and complex task to do. The complexity lays in the two-staged implementation (exploitation and reclamation) and more functional monitoring of the groundwater. The establishment and effective implementation of all functional monitoring forms is imperative to the implementation of the project for the exploitation of copper ore at Kazandol, with direct effects on safe production, execution of works, environmental safety and environmental protection.

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PROPOSALS FOR THE COMPLETE MINING OUT OF ASAREL DEPOSIT

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ABSTRACT

The author discusses some considerations for applying a combined system of mining of deep-seated deposits in Bulgaria. The aim is to mine more reserves from these deposits. Special attention is paid to the limited time for research and design of the combined mining method and the transition from opencast to underground mining of the copper ore.

The peculiarities of the combined system of mining are discussed. There is a special focus on ensuring the stability of the rock mass during the driving and supporting of the mining workings.
Potential schemes for combined mining of Asarel mine are presented.

Some recommendations for the significance of the transition from opencast to underground way of mining of deep-seated deposits are given.

1. INTRODUCTION

The practice for designing and mining out of deep deposits of mineral resources (Elatsite, Asarel, Kremikovtsi, Medet, etc.) shows that there is a need for periodical reconstruction. It is especially necessary in case of extending their boundaries, proving of new reserves and transition to new system of mining. For example, the transition to combined mining (opencast and underground) in Asarel mine will be made after the costs for the stripping operations become greater than the costs for underground mining, i.e.:

$$S_o \geq S_M, \qquad (1)$$

where S_o – costs for opencast mining of 1 t of ore, in BGN;
S_M – costs for underground mining of 1 t of ore, in BGN.

The reconstruction is characterized by high material and labour costs and a lot of time for preparation. The world experience shows that they can be significantly decreased if the reconstruction is planned in advance, during the construction and extraction of the pits.

In such cases, it is desirable not to allow the remaining of ore deposits under the bottom of the opencast pit as in Medet and Kremikovtsi.

In the near future such reconstruction will also take place at Asarel mine which is characterized by relatively low quality indicators and complex mining and geological conditions which determine the high operating costs of the enterprise.

2. STATE OF THE MINING WORKS AT ASAREL MINE

At present (end of 2016) approximately 300 mln. t. copper and pyrite ore has been mined from Asarel mine.

The design project (2016) foresees about 242 mln. t. ore still to be mined out till level 465 (Fig. 1).

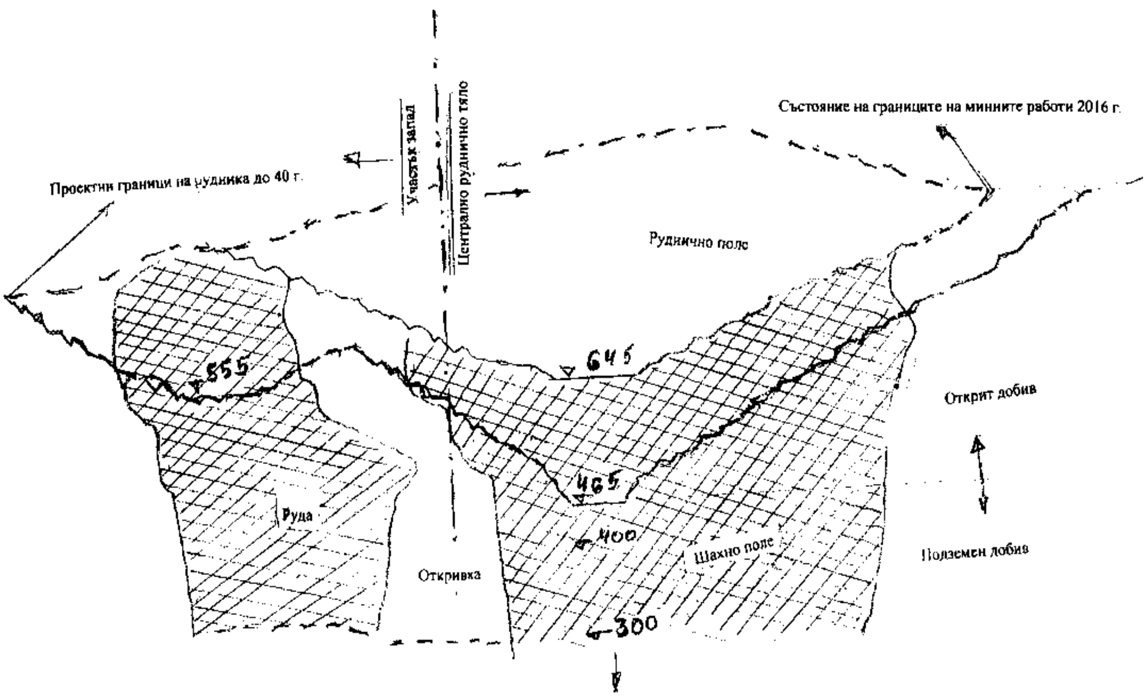

Figure 1. Transverse profile of Asarel deposit“

From a mining and technical point of view it is possible in the future to develop the mine with three new working horizons (till level 400) and thus to mine out more ore in an opencast way (Fig. 1).

The results from the preliminary geological prospecting show that there are about 230 mln.t. of ore till level 300. This ore should be extracted in the most effective way as it is necessary for Asarel Medet JSC and the country.

This can be done by gradual introduction of a combined mining system and extraction of the remaining part of the reserves from the deposits, i.e. to make a transition from opencast to underground way of mining.

There are three ways for extraction of the reserves through a combined way of mining of a given deposit: 1) the upper part of the deposit is extracted in an opencast way and the lower part – in an underground way (e.g. the pits Elatsite, Asarel, Kremikovtsi, Medet); 2) initially, the reserves of the lower part are mined out in an underground way and afterwards, in an opencast way (e.g. the mines Hristo Botev, Bobov dol); 3) the deposit is mined out simultaneously in an opencast and underground way. This technology can be applied in the transition period in the development of Asarel mine (2027-2040). However, the transition to such system requires serious preparation – additional prospecting, development of different variants, working design and its confirmation, training of specialists for underground work, review of the legislative regulations, etc. Therefore, the time should be sufficient (8-10 years) in order for the company to prepare for these types of work.

3. CHARACTERISTICS OF THE COMBINED MINING

a) Use of two different technologies – opencast and underground mining in one and the same deposit;

b) Extraction of much more reserves from the deposit;

c) Better drainage of the underground waters, improving the conditions for mining, decreasing the costs for dewatering and ventilation of the mine;

d) Reducing the volume of overburden and the transportation costs for the mined mass;

e) Part of the overburden or tailings from the processing factory can be used for backfilling the empty spaces in the underground part of the mine.

During the design and construction stage of the combined system of mining some other difficult tasks should also be considered:

- Defining the parametres of the pillar between the bottom of the opencast mine and the underground pressurised water logged horizon;
- Calculation and protection of the thickness of the ore pillars between the benches of the opencast mine and the underground mining workings;
- Calculating the parametres of the vertical and inclined shafts and their retaining pillars;
- Protection of the common opencast and underground technological space and their mutual influence;
- Selection of the most suitable (skip, conveyor, etc.) transport, the place for the crushing and sieving facility (CSF), shafts, galleries, the type of the machines and equipment, etc.;
- Ensuring the stability of the mining workings, especially in the period 2027-2040;
- Reclamation of the damaged areas by the mining works.

It is necessary to ensure sufficient time for preparation as there are many tasks which should be implemented in the transition period.

4. STAGES IN THE DEVELOPMENT OF ASAREL MINE

a) Stage from 2022 to 2027

During this stage the rubber conveyor belt CFT-3 (Cyclic Flow Technology) is eliminated in Asarel mine. The ore and overburden are transported only with auto transport to the crushing site of the processing factory and the north waste dump, respectively. Thus, the transportation distances are increased almost twice (from 2.79 km to 4.25 km), the number of the dump trucks is increased with 3 more trucks to 7; respectively, the number of drivers increases 3 to 4 times, i.e. the price of 1t mined ore is increased. At the same time, the equipment for CFT-3 remains idle at the repair site while there is a possibility to place it at a new site in the mine.

From the analysis which was made, CFT-3 can be built at a new place and to form CFT-4. Our opinion is that the most appropriate place is the north-east part of the mine (Fig.2). In fact, it can be situated from level 735 in the middle of the mine to level 905 – close to the lump crusher. It is built with slope of 15-16° and length of 600 m. In order to move it, appropriate trenches, roads, CSF and other necessary measures should be implemented. The new CFT-4 should be placed taking into consideration the place of CSF_{555}.

b) Stage from 2027 to 2040.

One of the most important periods is the gradual stopping of the mining operations in Asarel mine. In fact, this is the transition stage for the preparation of the combined way of mining (from opencast to underground mining).

The current design of the mine [4] till 2027 foresees the extraction of more reserves from the western section of the deposit. Thus, a working site is formed at level 555 (Fig.3). An inclined or vertical shaft for the underground operations is constructed from it.

Figure 2. State of the mining and transportation operations by 2022

At the same time, the future CSF_{555} is constructed. During this stage the driving of the necessary underground workings and equipment is implemented – loading and unloading sites, galleries, etc. (Fig.3 and Fig. 4). The ventilation shaft is also constructed. The most appropriate place is the east board of the mine since it guarantees better stability of the facility. The transportation of the mining mass from the underground faces to CSF_{555} is carried out with the help of skip or conveyor transport. The crushed ore is transported from CSF_{555} by auto transport to the lump crusher in the Processing factory and the overburden is transported to CFT-2 where it is crushed to 300mm and transported with conveyors to the west waste dump (Fig.4). All calculations for the driving of the mining workings and equipment are made on the basis of the mine productivity and the selection of the stope machines and equipment. After the construction of all these facilities (till the end of 2040) the mining of the ore under the bottom level 465 of the central body of the deposit can begin, i.e. to start the underground mining in Asarel mine.

Of course, many other options for extraction of all reserves from Asarel deposit are possible, this is a subject for long research, design and construction**.**

c) Stage after 2040.

Asarel deposit is mined out in underground way.

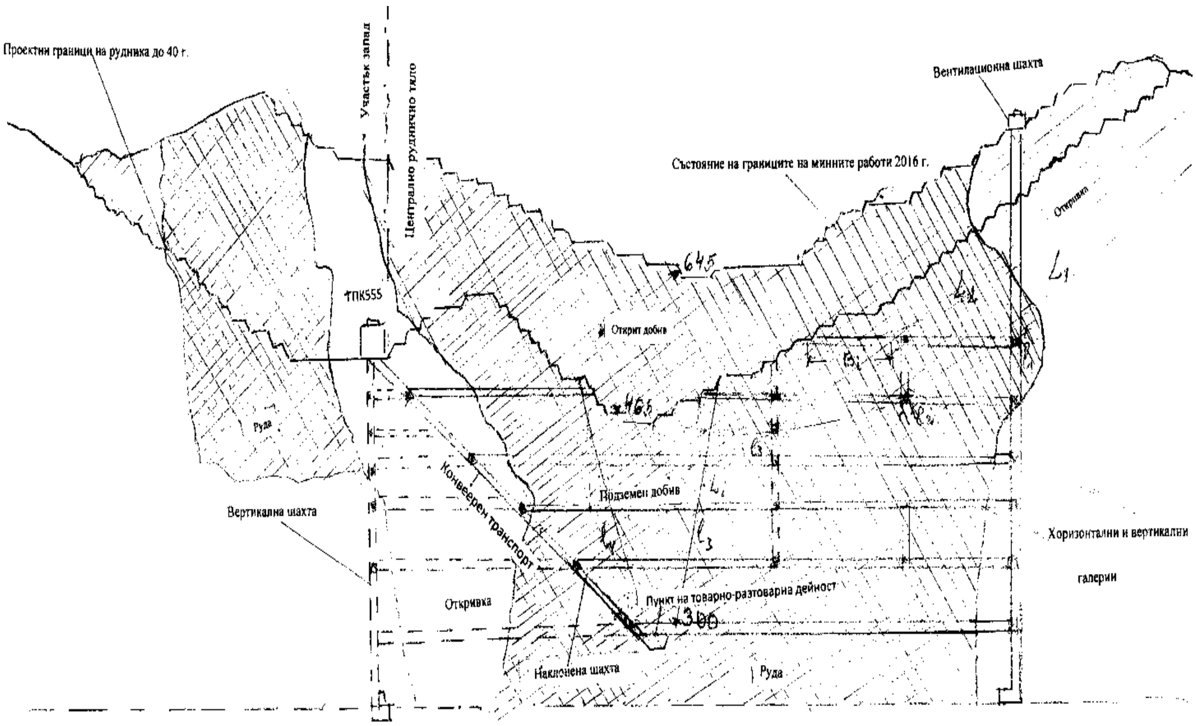

Figure 3. Variant for combined mining of Asarel mine

Figure 4. Technological and transportation scheme of Asarel mine after 2027

5. STABILITY OF THE MINING WORKINGS DURING THE UNDERGROUND MINING OF THE DEPOSIT

One of the most difficult and responsible tasks during the combined mining of Asarel deposit is ensuring the slope's stability of the opencast mine and the stability of the underground mining operations. This task is quite important, complex and insufficiently studied.

It is known that the decreasing of the board's angles leads to increasing the overburden coefficient, worsening of the technical and economic indicators of the enterprise and early transition to underground mining. On the other hand, the increase of the boards' angles leads to landslides and negative consequences during the underground operations. The retaining rock pillars should be strengthened and built in order to protect the underground workings from destruction. The situation is especially serious in the sections where there are waters, faults, fractures and other disturbances. As a result of them, potential surfaces of sliding L_i occur. The resistance forces of the rock ΣN_i and more specifically, its cohesion C_i, decrease in these zones.

With the simultaneous development of the mining operations in the two parts of the ore field (opencast and underground) there are instances when the constructive elements of the opencast mine can be placed upon the underground mining workings and thus we can have a combined way of mining. Open and underground limited spaces are formed where the physical, mechanical and strained stress condition of the rock significantly influence the further development of the mining operations. This is especially the case when the slope's stability in the opencast pit is disturbed as a result of the undermining by the underground mining operations. Thus, the area of the surface of sliding L_i and the rock cohesion C_i, which so far has sustained its stable condition, are reduced. For example, the driving of gallery B_i in proximity to the potential surface of sliding L_1 reduces the coefficient of reserve of stability $\eta \leq 1$ (Fig.3).

$$\eta = \frac{\sum N_i}{\sum T_i} = \frac{\sum_1^n P_i \cos\alpha_i tg\varphi_i + C_i \ell_i}{\sum_1^n P_i \sin\alpha_i} \qquad (2)$$

where φ_i, C_i – the angle of internal friction and cohesion of rocks, angles and N/m^2;

$L = \Sigma l_i$ – the length of the surface of sliding, m;

ΣNi – restraining forces, KN/m;

ΣTi – sliding forces, KN/m.

The increasing of the lost restraining forces of the slope $\Delta T_3 = \sum T_i - \sum N_i$ can be achieved by flexible mining, strengthening with pillars, anchor bolts, retaining walls, etc.

According to the scheme for the distribution of the strengthening measures they can be situated parallel, vertically, horizontally, inclined under a certain angle of the slope, mixed, etc. This distribution depends most on the mining and geological conditions of the deposit and the means at our disposition [1].

The above-mentioned shows that the volume, assessment and maintenance of the stability of mining workings when developing deep deposits is a difficult, responsible and expensive task.

6. CONCLUSION

The implementation of combined mining of Asarel deposit requires:

1) A lot of time for preparation for the transition from opencast to underground mining of copper ore;
    a. Moving the CFT-3 to a new place;
    b. Setting up of new CSF $_{555}$;
    c. Driving of shafts and workings;
    d. Training of specialists;
    e. New working designs, etc.
2) Widening of the theoretical and practical research and elaboration of new normative regulations and instructions for safe work;
3) The full extraction of the reserves within the boundaries of the Asarel ore field cannot be implemented without the use of combined mining;
4) The combined way of mining has its future and development for the conditions in our deposits Elatsite, Medet, Kremikovtsi, etc.

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ASSESSMENT OF NATURAL RADIOACTIVITY IN LIGNITE MINING

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ABSTRACT

Energy is one of the most important tool of civilization. The lignite is probably the most important source of fossil fuel. But some elements in *lignite* are natural *radioactive*. The natural *radioactive* elements such as radium (^{226}Ra), thorium (^{232}Th) and potassium (^{40}K) is important in lignite mining. The present work was investigated the radioactive elements including ^{226}Ra, ^{232}Th and ^{40}K in Tuncbilek lignite mining, Kutahya (Turkey).

Keywords: Energy, natural radioactivity, Tuncbilek lignite mine, Turkey.

1. INTRODUCTION

Energy is one of the indispensable elements in securing the economic development of a country. Because coal has been produced and used for many years, it is indispensable among other energy sources [1-3].

Natural radioactivity is common in the earth. The radioactivity is become in soil, water etc. Natural radiation is composed from terrestrial and cosmic sources [4]. Environmental natural gamma radiation is the most important participant to the external dose of the world's population [5].

In this paper natural radioactivity elements including radium (^{226}Ra), thorium (^{232}Th) and potassium (^{40}K) was assessed in Tuncbilek lignite mining, Kutahya (Turkey).

2. MATERIAL AND METHODS

2.1. Sample collection

Turkish lignite has been widely used in Turkey. Reserves are concentrated in Kutahya, Zonguldak, Sivas, Nevşehir, Afşin Elbistan etc. .

Kutahya province is located in the western part of Turkey. Kutahya covers approximately 1.5 % of the terrain of Turkey [6-7]. Kutahya region is one of the important lignite regions of Turkey. In this study, a total of three lignite samples were collected Tuncbilek region in Kutahya, Turkey. These lignite sample names are Tuncbilek A panel 82. m. lignite (ST1), Tuncbilek A panel 140. m. (ST2) and Tuncbilek A panel 260. m. (ST3).

2.2. Gamma-ray spectroscopy analysis

Gamma-ray spectroscopy is a method in which radionuclides are determined and analyzed by the gamma rays. Gamma ray spectrometers are beneficial in the analysis of energy spectra [8]. In this paper, gamma-ray spectroscopy method were examined of ^{226}Ra, ^{232}Th and ^{40}K in three Tuncbilek lignite samples (ST1, ST2 and ST3).

3. RESULT AND DISCUSSION

Three lignite samples (ST1, ST2 and ST3) were collected Tuncbilek region in Kutahya were crashed and homogenized in the laboratory. These samples were analyzed by Gamma-ray spectroscopy. Gamma-ray spectroscopy results show that the Table 1.

Table 1. The natural radionuclides of ^{226}Ra, ^{232}Th and ^{40}K in lignite (Bq/kg)

Sample no	Natural radionuclides		
	^{226}Ra	^{232}Th	^{40}K
ST1	22.9±2.4	39.4±2.2	109±15
ST2	71.1 ±3.7	28.5±2.1	88.3±19.4
ST3	25.3±4.2	38.5±7.1	71.3±27.7

The concentration of ^{226}Ra in the lignite samples is as follows; ST1 is 22.9±2.4 Bq/kg; ST2 is 71.1 ±3.7 Bq/kg and ST3 is 25.3±4.2 Bq/kg. The concentration values of ^{232}Th in lignite samples; ST1 is 39.4±2.2 Bq/kg; ST2 is 28.5±2.1 Bq/kg and ST3 is 38.5±7.1 Bq/kg. and the values of ^{40}K in lignite samples are given below; ST1 is 109±15 Bq/kg; ST2 is 88.3±19.4 Bq/kg and ST3 is 71.3±27.7 Bq/kg.

4. CONCLUSION

Gamma-ray spectroscopy analysis is the widely used method for investigating natural radionuclides in soil, lignite etc. samples. The natural radioactivity of ^{226}Ra, ^{232}Th and ^{40}K were analyzed in three different lignite samples by using the gamma- ray spectroscopy. The concentration of ^{226}Ra in the lignite samples is as follows; ST1 is 22.9±2.4 Bq/kg; ST2 is 71.1 ±3.7 Bq/kg and ST3 is 25.3±4.2 Bq/kg. The concentration values of ^{232}Th in lignite samples; ST1 is 39.4±2.2 Bq/kg; ST2 is 28.5±2.1 Bq/kg and ST3 is 38.5±7.1 Bq/kg. and the values of ^{40}K in lignite samples are given below; ST1 is 109±15 Bq/kg; ST2 is 88.3±19.4 Bq/kg and ST3 is 71.3±27.7 Bq/kg. Finally, the gamma- ray spectroscopy analysis show that the analysis of the radioactivity in lignite mine.

Acknowledgement

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RISKS IN ELIMINATION OF EXPLOSIVE GELS WASTE FROM THE MANUFACTURING LINE - CASE STUDY –

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ABSTRACT

At the production of explosives, inevitably results a quantity of explosive hazardous waste which cannot be reintroduced into the processing circuit and that must be eliminated. Explosive gels respectively waste products considered jetsam of these are eliminated commonly by different methods such as: blast by applied explosive charges, reprocessing and chemical neutralization or by burning. Explosive residue burning is a very simple and cheap mode of elimination but wearing a serious risk to be carried out. The study case presented relates to an accident technically investigation made by INSEMEX Petrosani, accident resulting in death of two persons, due to disposal consisting in transition from burning to detonation of waste and jetsam of explosive gel resulted from production line.

Key words: explosive waste, burning, unexpected detonation.

1. INTRODUCTION

The gel type explosives cartridges, cap sensitive are used in the mining industry, civil engineering works, blasting works for surface / underground, in non-explosive / non-flammable environments, dry/ wet environments, with / water infiltrations.

The gel type explosive involved in accident is an explosive "explosive gel" (Hydrogel), embedded in a polyethylene film and closed at the ends with metal clamps. The composition of the explosive and the physicochemical parameters are specified in the document specification of manufacturer.

The gel explosive is a mixture of substances that form a thermodynamically labile system having a large amount of energy and which, under the influence of an external action, have the property of suddenly and violently decomposing with heat release and formation of heavily heated gases, able of forming a mechanical work.

Based on the criteria documented in the literature, the explosive gel is classified as follows:

- After physical condition: explosive gel (solid paste).
- After chemical composition: explosive mixture of chemical compounds.

The gel type explosive is a mixture consisting mainly of the following components: Oxidants (Nitrogen), Fuel (aluminium powder, monomethyl amine nitrate), Sensitizers, Stabilizers, Phlegmatized additions that reduce sensitivity to mechanical action; Explosive substances which reduce the heat of explosion, inert materials and additives which are intended to give the explosive a particular property or to facilitate its manufacture (egg water associated with a gelling substance which provides good resistance to humidity of explosives in the form of gels).

- Following the velocity of the explosive transformation process: detonating explosive (at velocities greater than 4000 m / s).
- After practical use and areas of use: secondary explosive.

The gel type explosive it used in the mining industry, civil engineering works, blasting works for surface / underground, in non-explosive / non-flammable environments, dry / wet environments, with / water infiltrations, [1].

2. METHODS OF DESTRUCTION APPLIED BY MANUFACTURER

SC SPAROMEX S.R.L. Victoria has documented the activities of treating waste explosives and combustion of explosive waste in the firing range, developing several documents as:

-PO-RO-1011 "Explosive waste treatment" procedure, approved on 26.10.2006;

Working Instructions, Edition 8/25.10.2006, entitled "Burning of explosive waste in the firing range", for: workstation: Destruction of residues; Basic function: Preparation and burning of explosive waste resulting from various manufacturing and / or service processes, [1], [2].

PO-RO-1011 "Explosive waste treatment" specifies the working method for the treatment of explosive and non-explosive residues handled in the manufacture of Hydrogels. With regard to the treatment of explosive residues, the following are foreseen:

Precautions:

- The weight of the bags should not exceed 25 kg.

Task 3: Transport the containers filled with the forklift to the crematorium to be destroyed later. If the forklift operator in the area does not have time to transport the waste to the crematorium, this will be done by the operator, who will be designated for this purpose and who has a forklift license. Explosive waste should be transported as soon as possible and taken to the crematorium to be destroyed. In Working Instructions, Issue 8/25.10.2006, titled "Burning of Explosive Residues in the Fume Burning", the preparation and burning of explosive residues resulting from various manufacturing and / or service processes are documented.

3. TESTING OF GEL TYPEEXPLOSIVE AFTER ACCIDENT

Samples subjected to tests

For tests performed at INSEMEX Petrosani headquarters, there have been received the following samples:

- Explosive gel, conforming[1] to ø x L: 65 x 500, 50 kg, of lot 868 Y 028.
- Explosive gel, waste 52 kg.

A reception report (Annex 1.22) was prepared for the samples collected.

Tests performed

Both samples of gel and explosive samples, as well as waste, were subjected to laboratory and polygon tests.

Laboratory tests were performed at INSEMEX Petrosani, Laboratory for Blasting Techniques, accredited by RENAR:

- Determination of the appearance and mass of explosive cartridges.
- Density Determination.
- Determination of water content.
- Determination of chemical stability (Abel) at 75^0.
- Determination of friction sensitivity.
- Determination of impact sensitivity.
- Determination of the detonation velocity.
- Determination of the sensitivity to the detonation transmission.
- Determination of the relative working capacity of explosives by ballistic pendulum method.

In the INSEMEX Petroşani testing facility, the explosive gel - waste, 60 to 70 mm in diameter, underwent tests to study the behaviour of burning destruction. Four tests were performed with different amounts of explosive (2.5, 5, 10, 25 kg).
In all four tests, the explosive-waste was placed on a bed of wood fuel, the flame being fired open at a distance of 5 m.

At each test, the burning mode was checked one hour after starting the fuel bed.

[1]The gel explosive manufactured by S.C. SPAROMEX S.R.L. Victoria conforms to the EC type-examination model which led to the Certification under Directive 93/15 / EEC by the Notified Body No. 1453 (Central Mining Institute - Poland), attested by the documents "Certificate of Quality / Conformity, No. 92/2008, concerning the gel product "(Annex 1.20) and" EC Declaration of Conformity concerning the gel product "Annex 1.21).

4. COMPARISON OF TEST RESULTS WITH THE REQUIREMENTS OF THE GEL TYPE SPECIFICATION

In order to check the detonation capacity of the explosive-waste from the manufacturing line involved in the event, a comparison was made between: the characteristics of the gel explosive, determined; The characteristics of gel explosives - according, determined; The quality requirements of the gel product, as specified in the technical specification.

Interpretation of results

- Density, water content and impact sensitivity differences between the explosive and explosive waste were found;
- From the point of view of Abel's chemical stability at 75^0C, both types of samples (also produced as waste) were stable at 75^0C for 30 minutes;
- For ballistic tests: detonation velocity, detonation transmission, relative work capacity no differences were found with respect to the parameter that was determined for the two types of explosives (also waste). The gel type - Waste Explosive has completely transmitted detonation at distances between cartridges larger than the distance specified in the technical specification.
- Given that the explosive - waste was involved in the event, attempts to verify burning behaviour on a wood bed were performed only for it. Four tests were performed, using increasing amounts of explosive waste. It has been found that no quantity of explosive subjected to combustion has been found to have passed from burning to detonation, subject to compliance with the normative provisions in force, namely: limit to max. 25 kg explosive subject to destruction by burning; single layer layout of explosive cartridges; pre-packaging the packaging.

5. CASE STUDY ON THE OCCURRENCE OF AN UNWANTED EVENT FOLLOWING THE DESTRUCTION OF EXPLOSIVE GELS ON THE SITE

Event produced at the factory, on 26.05.2008, was determined by:

- Detonation of 500 kg of gel explosive waste disposed on two sites, namely:
- A quantity of gel explosive waste on the hearth inside the crematorium (concentrated soil type applied to the soil);
- A quantity of explosive waste gel, outside the crematorium, on the concrete platform of the northern crematory beach platform (concentrated ground load applied to the soil).

With regard to the location of the amount of explosive-waste outside the crematorium, the hypothesis of its position on the trailer floor (suspended load) was also accepted. However, this hypothesis was rejected on the following grounds:

- Most of the fragments resulting from the dismantling of the tractor and trailer were designed in the following directions: north, northwest, northeast and east, which supports the location of the explosive between the crematorium and the trailer;

- The crater formed in the area of the concrete platform in the northern part of the crematorium would not have the dimensions found. Detonating the suspended load at a height of 1.2 m would result in the formation of a smaller crater due to the main dissipation of the energy released by the explosion horizontally above the ground.

The detonation of the total quantity of 500 kg of explosive waste gel took place successively, producing two successive detonations, namely:

- The initial detonation of the amount of gel explosive waste placed on the hearth inside the crematory, followed by
- Dismantling the amount of gel explosives debris located on the concrete platform of the beach in the northern part of the crematorium.

The production of two successive detonations, the support of which was the 500kg gel explosive waste, disposed on two different sites, is evidenced by the formation of two distinct craters at a distance of about 1 m, [3].

The detonation of the 500kg explosive gel, distributed on two different sites, resulted in the formation of two craters, of equal size.

Analysis of hypotheses

a. Analysis of hypothesis 1: This hypothesis was based on the following premises:

- For the burning destruction of the blast-waste batch, a single fuel bed was built on the hearth of the crematorium by stacking wooden pallets. The fuel carrier was supplemented with tree branches placed under pallets, supported by the finding, in the vicinity of the crater formed on the crematorium site, of branches with fresh combustion traces.
- The destruction by burning in a single batch of a large amount of explosive waste, namely 184 kg (estimated quantity by calculation), involved the placement of the cartridges without spaces between them and stacked in the form of a pile. Depending on the surface used to place the cartridges (the surface of a standard pallet being 1.44 m^2), and the stacking mode of the cartridges, the number of layers could be 3 ÷ 6. In this way, a load was concentrated on the pallet bed.
- Explosive-waste cartridges have not been cut on generators.
- The heating of explosive cartridges at the top could also be favoured by placing above them unused stacks of unused polyethylene foil for the purpose of amplifying the fire to accelerate burning of the explosive. On site, such piles were found in the Northwest side of the craters.
- Polyethylene characteristics that give the packaging a tear and heat resistance, namely: tensile strength: 215- 400 kgf/cm^2; Elongation at break: 15-100%.
- b. Analysis of hypothesis 2: The circumstances that could favour the initiation of the detonation carried out within the crematorium by the shock wave generated by the explosion of an explosive-waste cartridge are considered as follows:
- Large quantity of explosive - waste (184 kg) subject to burning destruction in a single batch;

- Arrangement of explosives-waste cartridges in the form of a pile on the pallets bed made on the hearth of the crematorium, thus obtaining a concentrated explosive charge;
- Separation of explosive cartridges that have been closed at the ends;
- Non-cutting of a long-lasting cartridge (2 m and possibly even more (Photo 49, 50 → Appendix 2)), which was not closed at the ends, it was considered that there is no need to cut the packaging generators;
- Place the long, non-segmented cartridges on the fuel bed, in a packed form (spiral: Photo 50), between the other cartridges;
- Objecting the free ends of the cartridge, un-mounted, by the adjacent cartridges, as well as the long cartridge length, could provide conditions for priming and propagating self-sustaining decomposition inside the explosive mass.

The initiation of the detonation produced inside the crematorium by the action of the pressure wave generated by the detonation of an explosive-waste cartridge is supported by the following arguments:

- Hydrodynamic theory that allows the detonation to be transmitted from one explosive charge to another by means of shock waves;
- High sensitivity of secondary explosives to shock waves;
- The detonating capacity of the explosive-waste, ascertained during the tests carried out at INSEMEX Petrosani;
- Identification, in the explosives warehouse of S.C. SPAROMEX S.R.L. Victoria Făgăras of explosive cartridges - large waste (over 2 m);
- Explosive explosion-intensive decomposition of explosives in closed space is known and treated in the literature[2].

c. Analysis of hypothesis 3: Discharging a quantity of diesel fuel over the combustion fuel material in order to develop the fire would have caused its instantaneous vaporization and ignition of the formed vapours. The mode of ignition would have been a "blast". Burning processes are at the lower limit of deflagrations and are characterized by the formation of a combustion wave at speeds of the order of 10 m / s. These types of combustion processes do not generate dynamic effects. In the case of combustion waves, combustion is maintained due to diffusion phenomena, whereas in the event of an explosion a shock wave is formed which is maintained by the energy (heat generated) of the chemical reaction. As a result, it is unlikely that such a process would have generated a pressure wave capable of initiating the detonation of the explosive placed on the fuel bed for combustion.

[2]Sources:
a. C. D. Nenițescu, General Chemistry, Technical Publishing House, Bucharest, 1963.
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6. CONCLUSIONS

6.1. The explosion event of 500 kg in volvedgel removed from the explosives storage site for burning destruction occurred as a result of a succession of phenomena in the following order:

- bringing the entire quantity of 500 kg explosive into the firing area, in the crematorium or in the immediate vicinity of it (the tractor platform of the trailer with trailer).
- Burning the explosive in a closed space (crematorium).
- Burning more than the quantity specified in the operating instructions (25 kg).
- The detonation energy of the explosive in the crematorium is very high, the mass of explosives left in the trailer detonated by sympathy, the phenomenon perceived by the witnesses as a single instantaneous explosion.

6.2. Arguments supporting the mechanism of producing the event mentioned above:

- the very intense dynamic effects of the explosion and the fact that no debris was found to support the detonation of the entire 500 kg explosive waste gel;
- the very similar size and volume of the two craters resulting from the explosion indicates that in the crematorium at the start of the explosion there was much more explosive than what had to be destroyed in a batch (25 kg);
- the large amount of explosive and the short time available to workers between the release of the explosive from the storage site and the time of the explosion, are arguments that for the quantities of product not compliant with ϕ 60 ÷ 70, no cutting of the coating was done before laying on the bed of material woody.
- Following the tests carried out at INCD-INSEMEX - LTI Laboratory, it was found that gelas waste (non-compliant) had very similar or identical characteristics to the product. Ballistic tests performed argue the proper detonation properties even for waste.

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[2] Law 319 (2006) on Occupational Safety and Health, Risk Assessment has become a family concept for the organization of workplace prevention, and consequently a growing number of Economic operators from the community space have resolved the issues of the field of labour protection by implementing the risk assessment on a regular based.
[3] GD 971 (2006) Decision on the minimum requirements for the signalling of safety and / or health at work.

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MAPPING THE ENVIRONMENTAL DAMAGES CAUSED BY MINING IN "DAJTI" NATIONAL PARK, ALBANIA USING GIS TECHNOLOGY

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ABSTRACT

The protection of natural resource is of a very high priority for Albania. "Dajti" Park is one of the most important areas in Albania due to the rich heritage and diversity of wildlife. This is due to the specific position (latitude and altitude above sea level), the diversity of its natural landscapes, plant associations, and variations on traditional land cultivation, which have shaped today's natural scenery. Many areas of the "Dajti" National Park are of a national and international conservation importance, with some species found only in a few habitats around the world. This paper presents damages in "Dajti" National Park in Tirana, Albania caused specifically by mining exploitation (opencast mine). The exploitation and granting of permits without clear criteria and no consultation with community have caused damages to the landscape, flora and fauna, forests, air and water, soil, putting at the same time in danger the life of the community. The paper identifies damages, presents digital map of damages area, using GIS technology. The paper proposes also the rehabilitation scheme, and gives recommendation for decision makers for future actions.

Key words: Environment protection, mining, GIS!

1. GENERAL INFORMATION

Mountain of Dajti, in Albania reaches a height of 1613 meters. Located about 26 km from Tirana there are about 26 species of woods and shrubs that cover about 80% of the area. In addition to vegetation Mali Dajti is also distinguished by the diversity of wildlife and wildlife. The National Park "Mali i Dajtit" lies in the mountain ranges of Scanderbeg, mainly in the district of Tirana, with little touch on the district of Kruja. This Park has an area of 29384.18 ha, extending into a totally mountainous terrain, starting at 300 meters high and reaching the highest, the peak of Mceks of Saint Mary at an altitude of about 1827m. The specific representatives of Flora and Fauna are: Beech, oaks, pines, chestnuts, wild cherries, blackheads, blackheads, hornbeams, sea basses, sharks, etc. As far as the fauna of Dajti Mountain are concerned, there are: White bear, wolf, fox, wild boar, coat of arms, squirrel, squirrel, iris, bats (several species), turtles, eagles, falconers (some species) the mountain, the wild dove, the woodpecker, the lamb, the whale, and many kinds of reptiles and flies. Within the area of Mali i Dajti there are cultural, religious sites, such as: Dajti Castle (Cultural Monument); The Old Bridge in Brar; Mosque and Infrastructure Objects such as: Cable Car of Tirana - Dajti; Visitor Center; Tirana Water Supply and Bovilla Water Collection. Nowadays the National Park is endangered by external human influences, such as: (1) Fragmentation and loss of habitat; (2) Uncontrolled grazing; (3) Uncontrolled cutting of trees from a largely rural population; (4) Exploitation of minerals; (5) Uncontrolled hunting; Murder and persecution of animals; (6) Increasing and out of control of tourism; (7) Fires; (8) Industrial activities.

Figure 1. View of Dajti mountain

2. MINING WORKS AT THE "DAJTI" NATIONAL PARK

The mining works developed at the National Park of Dajti Mountain are open cast and underground works. Surface works are quarrying (quarrying) in order to extract construction materials. Underground works are tunnels, developed for the purpose of crossing the pipelines of the power plant and water supply of Tirana (Fig.2).

Figure 2. Qafë Priskë opencast mine and tunnel of Tirana water supply

Until now, there are some opencast mines working at the Dajti National Park for lime stone extraction. At present they have planted the mountain near Priska peak..

Practically, an environmental massacre continues to be carried out in this area. Heavy machinery eradicates Dajti National Park every day. This environmental massacre can be clearly distinguished even in "Google Maps", where areas that have been stripped of forests appear (Fig.3a). The Dajti National Park has been proclaimed a government decision since 2006 as a protected area (Fig.3,4).

3. ENVIRONMENTAL DAMAGES

The Dajti National Park, proclaimed by a Government Decision in 2006, as a protected area, is being destroyed every day by opencast mines that are being exploited massively and stripping the mountain slopes from greening. For years it has been discussed about the removal of mining activities from the Park, but instead of being reduced, they have been added. The quarry damage in the Dajti National Park is colossal. *(Fig.4*). In fact, there are 6 damaged areas numbered by (1-6), including the small lake of Qafë Priska. (*Fig.6)*

The main damages are as follows: ***Air Quality***: Due to mass explosions, heavy machinery works in areas where mining works are built up large dust that is deposited in the surrounding forests, agricultural lands meanwhile hurt the health of people.

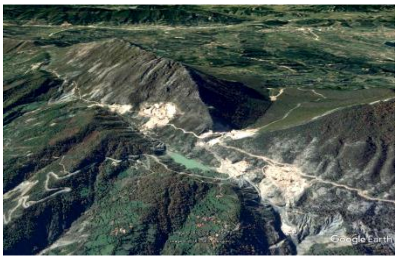

Figure 3. Satellit image of opencast mines in Dajti [Source: Google Earth];

Figure 4.
View of opencast mines in back part of Dajti Mountin

Water quality: Due to the exploitation of opencast mines near them are deposited stockyards that slid into the water springs and small lakes of the area causing their pollution, damaging the quality of water used for livestock but also for agriculture.

Landscape: Landscape damage is very serious. Throughout the area are created pits, abysses and new stocks that have changed the natural profile of the mountain. Figure 5 shows two images of the damaged area in 2003 and 2017, where it is clearly the major damage caused.

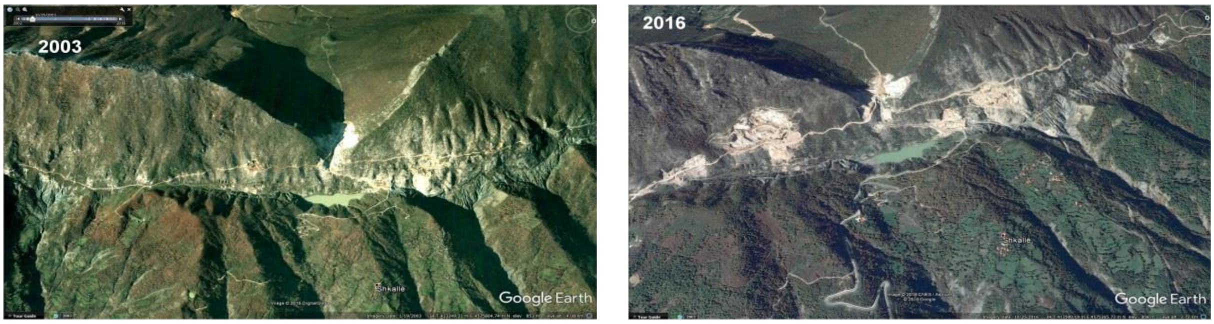

Figure 5. Images of the damaged area of 2003 and 2016 [Source: Google Earth]

Forest Damage: Comparison between the two images of 2003 and 2017 shows a damage to a very large area of forests mainly with shrubs and small trees. Figure 6 shows the comparison of two images of damaged areas. It is clear that damage has increased triple over the years and the lack of rehabilitation measures.

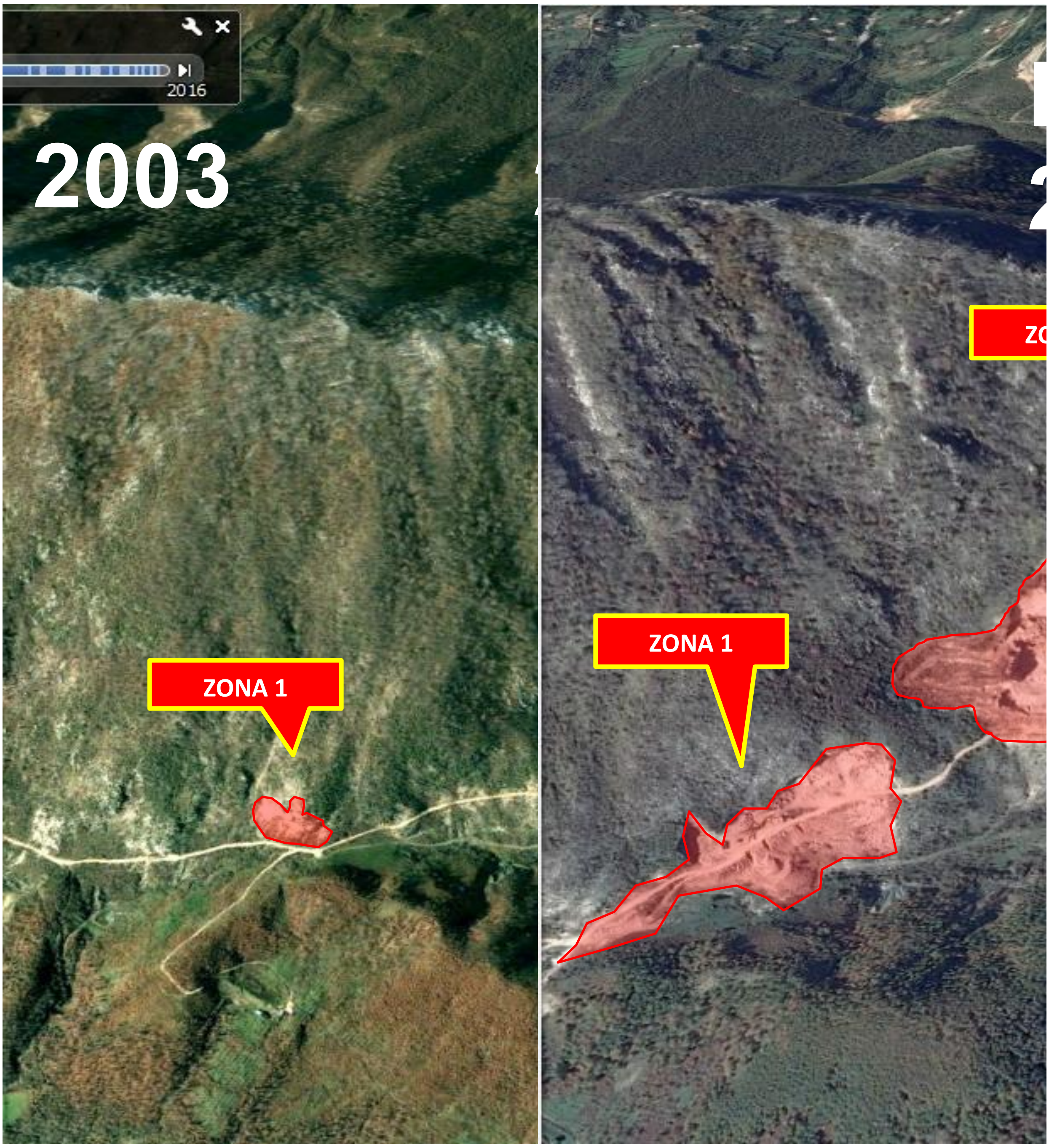

Figure 6. Comparison of damaged areas, 2003 and 2017

Damage to pastures and vegetation: Due to massive outbreaks and mountain erosion, the pastures have also been severely damaged. Likewise, the pollution of the small lake of Qafë Priska has caused concerns for the livestock farmers who use this lake for their livestock. The vegetation is very small. Dasts is the main cause of vegetation breakdown in this area, as well as dumping unnecessary soils. Tourism Damage: Before developing these works the landscape was very interesting. Now there are only abysses, pits, and dusts deposited without criteria. ***Damage to Flora and Fauna***: A large number of plants have been destroyed by excavation and deposit of deposited soil. While due to noise, massive outbreaks, water and air pollution, many animals have left the area, bringing the impoverishment of the fauna and flora of the area. ***Acoustic pollution***: From a quiet and relaxed area, Priska's Neck has turned into a noisy pitch where the noise level is out of any standard, thus causing the disturbance of tranquility and natural equilibrium. Major explosions in winter time can also be the cause for the creation of avalanches and slides. Well-being and health of the inhabitants: All this destruction of the environment certainly has a negative impact on the residents of the area, who have lost their former tranquility. The area is depleted by the tourist and its natural resources.

4. USING GIS

Given the experience of using GIS in similar cases, the ArcGIS 10.3 program was used to build Digital Maps. Some of the steps followed by problem identification to the final map of the damaged areas are as follows: (1) Collection of existing materials; (2) Determining the location of open cast mines; (3) Contact with state institutions; (4) Field visits and measurements (point coordinates were taken with GPS Garmin Oregon 600t; (5) Layout of field data in ArcGIS 10.3 and BaseCamp; (6) Building GIS maps for damaged areas, Protected Areas, Mining Licenses, etc. The following are the GIS and BaseCamp maps of the area: Protected Areas; Mining Licenses; Plant Cover; Damaged Areas and a Comparative Image of 2003 and 20017 (Figure 7,8,9). As can be seen from the Mining Permit Maps, almost all the part that is used by the quarries is located within the protected area.

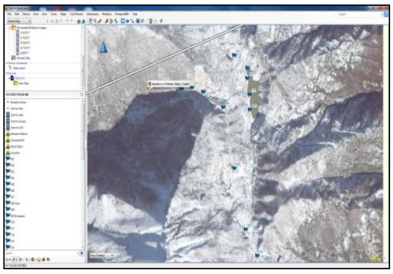

Figure 7.
Harta BaseCamp

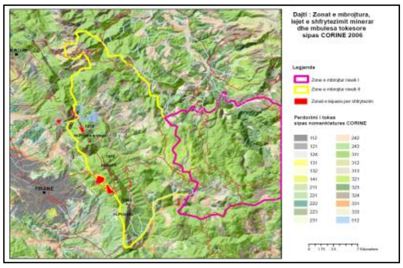

Figure 8. Harta e Zonave të mbrojtura, Lejeve të Shfrytëzimit dhe mbulesës tokësore

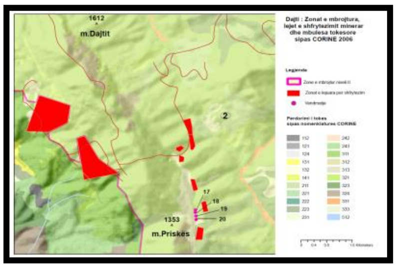

Figure 9.
Harta e Zonave të mbrojtura, Lejeve të Shfrytëizimit

5. REHABILITATION OF DAMAGED ENVIRONMENT

Due to the severe environmental situation in the National Park of Dajti Mountain, urgent rehabilitation measures are needed. Practically, rehabilitation of a small part of the environment is mainly affected by what appears to the public (Fig.10). Rehabilitation measures should include: (1) Soil transport; (2) Soil and stockpiling; (3) Covering stocks with and as well as shrub and grass planting; (4) Scale opening; (5) Digging and filling; (6) In order to preserve the flora and fauna, there should be ambushes and walls to prevent eventual leakage of the soil as a result of precipitation and consequently the discharge of sterols into the waters (streams, watersheds, lakes); (7) Planting of seedlings is recommended for slope adjustment.

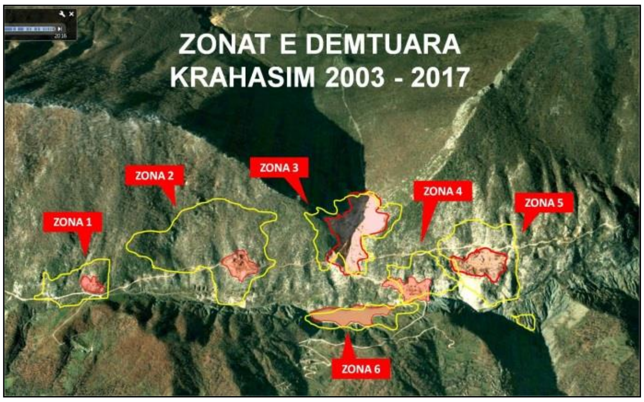

Figure 10.
Damaged areas. Year 2003 (red), Year 2007 (yellow)

Figure 11.
Rehabilitated opencast mining area

6. CONCLUSIONS AND RECOMMENDATIONS

Conclusions: (1) The scale of environmental damage due to mining in Albania is extremely high and extends across the country. These damaged areas require the taking of urgent technical and administrative measures to eliminate irreparable consequences in the future; (2) The existing legal framework for environmental protection from mining is not correctly applied and therefore does not provide for effective protection of the environment; (3) The mining exploitation methods do not sufficiently consider the protection of the environment from mining; (4) Mining risk to human life and the environment due to mining is evident, high risk and neglected by everyone. (5) Damage to the environment, water, infrastructure, forests, agricultural lands, flora and fauna in the National Park of Dajti Mountain is very high, affects a considerable area and requires emergency interventions; (6) Figure 9 shows that the level of quarry expansion, Zone 2, has reached nearly half the height of the mountain. This is a period of about 14 years. If these works will continue with this rythmes after about 20 years, the opencast mine will reach the top of Mount Dajti.

Recommendations: (1) It is recommended to immediately stop the mining activity in the National Park of Dajti Mountain in the Protected Area; (2) It is recommended to conduct a full scientific study to determine the exact level of damages caused to the National Park of Dajti Mountain, and to take environmental rehabilitation measures, reforestation, animal breeding and conservation, reservoirs, cleaning of water. (3) It is necessary to set up a Task Force to monitor the implementation of the existing Law on Mines, Environment and Protected Areas, with the objective of preserving the environment in accordance with European Union norms; (4) It is recommended to draft and approve new mining quarrying methods and regulations.

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MEASURING THE WEIGHT OF THE LOAD OF CARREER DUMPERS

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ABSTRACT

Using GPS dispatch systems in the past two decades was obtained very accurate data on the times and distances covered. For a complete picture of loading and transportation it is necessary to obtain as accurate data of weight of mine masses. In most cases it is calculated with statistical methods, using the average load and realized haulages. The article describes the design, the mathematical model, the implementation problems and the results, obtained by installing scales on dump trucks working in real time, including during loading.

1. INTRODUCTION

Tasks, solved by dumper scales according to the frequency of encounters by the authors in the different mines are as follows. They are roughly ranked by importance for managers and mining engineers.

1. Control of overload and underload of dumpers
2. Report of the mine production - there is no other way to be measured in tons. The volumes could be measured by surveyors, but the specific weight varies considerably. Also daily weights results help the surveyors for "incremental" reports
3. Operator productivity report
4. Machine productivity report - excavators, dumpers, FWL
5. Dosing of productions – concentrate, fractions
6. Determining the number of haulages
7. Creating realistic load standards
8. Creating multidimensional models of fuel consumption
9. Shock absorbers monitoring

2. TYPE OF SCALES

Various ways to measure the weight of dumper load have been proposed and implemented. These are listed according to the frequency of encounter in the different mines.

1. On-board scales that measure the pressure in the basket lift cylinders. It has an advantage over the shock absorbers scales for easier installation and maintenance because it uses only one pressure sensor instead of 4. It is a disadvantage that the result is obtained only on dump, there is no information to shovel operator during the loading.

2. On-board scales that measure the pressure of the dampers. Most common, with the most accurate measurement. Hard to install and maintain. Allows load control, damping control, road quality control, adherence of masses and other additional features. Most ample signal information.
3. FWL scales - often used for dosing fractions and concentrate.
4. scales on excavators. Hard to mount, difficult to maintain. The solution is different for rope and hydraulic excavators. Problem is the measurement of rope excavators and draglines. Hydraulic excavators are a little easier to measure. FWL's are used rarely to load heavy dumpers.
5. weighbridges. A costly solution. Very uncommon for dumpers over 40 t. Can not control the loading. Leads to an increase of the distance and time of the haulages.
6. belt scales in the hopper of the primary crusher. It is difficult to separate the individual dumpers, and impossible to control the load or overload. The accuracy of the measurement is low, some of the material remains on the walls of the hopper. It can not be used to measure other masses except ore. Could be used to control on-board scales.

Scales on shock absorbers are available from many manufacturers - Belaz, Caterpillar, Komatsu, Hitachi. Those scales are:

1. difficult to maintenance,
2. have a dissimilar data format,
3. remote access to data are rarely offered,
4. have different tare procedures, if any,
5. they are options and are rarely ordered.

In most manufacturers solutions, the indication from the scale to the excavator operator is by lamps that ignite when load reach some level, typically up to 95%, from 95% to 105%, over 105%. Disadvantages is one-time setting of the load limit.
The scales, presented in the article have the following advantages:

1. works under a slope in -7°÷+7°
2. remote access to data. Indications are in front of the driver, the excavator operator and the dispatcher
3. shows the weight in real-time on a side display
4. visual control of the load from managers and engineers managers without need of computers, tablets and other tools.
5. there is embedded control of shock absorbers
6. allows dosing of the last bucket

Mathematical model

The equation of vertical damping reactions (spring model) includes the equation:

$$2*Rf + 2*Rz = G + Gp \quad (1)$$
$$kp*Sp + kz*Sz = G + Gp$$
$$G = kp*Sp + kz*Sz - Gp$$

The reaction of the two bridges balances the weight of the load and the weight of the overhead masses. It is assumed that the two bridges are balanced, the shock absorbers on one bridge are the same, and the sum of the shock absorbers reactions of each bridge is constant at a slope along the longitudinal axis.

Model variables

Gp	weight of the overweight masses, t
Rf	front shock absorber's response, t. Directs perpendicular to the ground.
Rf	rear shock absorber's response, t
Sp	sum of the pressures in the front dampers, measured parameter, bar
Sz	sum of the pressures in the rear dampers, measurable parameter, bar
Gi	calculated weight on the "spring model", only from the damping reactions. No correction for inclination angle entered, t
G	measured weight with correction for inclination
α	angle between the chassis and the horizon. Measured by inclinometer, degrees
lz	arm of the shock absorber's to the beginning of the coordinate system (center of mass), meters. Some virtual point defined by the rear axle lever.
lp	arm of the front damper, meters. It is considered to be just above the axle of the front axle due to the constructional design.
lt	The arm of the load, m
Mt	moment of load, ton-meters
Mf	moment of the front shock absorbers
Mr	moment of the rear dampers
kp	coefficient of the front dampers - the response of the shock absorber to the pressure, t/m^2. It is considered to be linear. There is a time dependency. It is fully set about 10 seconds after a stop or start. Friction is neglected
kz	coefficient of rear dampers. Average value determined by the rear axle lever.

Equation of the balance of the moments along the longitudinal axis

The equation (1) is valid only when the dumper rests on a flat landing. Unfortunately, this condition is almost always violated in the complicated conditions of the face. The angle of inclination should be take into account. The slope is measured with an embedded scale inclinometer. The inclination of the dumper chassis is measured against the horizon. The equation is derived from the equality of the turning points.

$$Mf + Mt = Mr \qquad (2)$$
$$Rf * lp + G * lt = Rr * lz$$
$$Rf * lp + G * (c*G + d) * \cos((a*G + b) - \alpha) = Rr * lz$$
$$kp * Sp * lp + G * (c*G + d) * \cos((a*G + b) - \alpha) = kz * Sz * lz$$

The system of equations that is obtained is:

$$kp * Sp + kz * Sz - G - Gp = 0 \qquad (3)$$
$$G * (c * G + d) * \cos((a*G + b) - \alpha) + kp * Sp * lp - kz * Sz * (lo-lp) = 0$$

The unknown variable is G. The variables in the equation are Sp, Sz, α - the pressure in the dampers and the angle of inclination. The constants in the equation are lp, lz, kp, kz, a, b, c, d, Gp. Constants are determined by regression.

The linear approximation

The system of equations (3) is non-linear, with trigonometric functions. The solution can be done by the sequential approximation method with repeated calculation of trigonometric functions. The on-board microprocessor has to solve it about 10 times per second, which almost completely loads it. For simplicity of calculations, an approximate linear formula can be used:

$$G = a * \alpha * Gi + b * Gi + c * \alpha + d \qquad (4)$$

The coefficients are determined by regression analysis. One solution for the Komatsu HD405 dumper is for example:

Gp=32.38000
kp= 0.26600 kz= 0.23900 a = 0.01295 b = 1.00256 c = 0.32862 d = 0.76812

Another solution, including determination of the kp and kz:

Gp=30.38017	kp= 0.17698	kz= 0.27460	
a = 0.00880	b = 1.01032	c = 0.15980	d= 3.99950

Quadratic approximating

Even better results yield a quadratic approximation. The coefficients are based on a regression analysis of the data at speed 0.0 - the dumper is at rest but located at a different slopes. The free member who is taken over by Gi's value is rejected

$$G = e*Gi*Gi + f*\alpha*\alpha + a*\alpha*Gi + b*Gi + c*\alpha \qquad (5)$$

Angle α is measured in '%'. Exemplary coefficients of the Komatsu HD405 machine polynomial:

e = 0.0003241 f = 0.0059584 a = 0.0081838 b = 0.9946782 c = 0.1636173

3. IMPLEMENTATION

The model described is realized in scales, installed on dumpers types Komatsu HD405 and Caterpillar 771D. The board computers of the previous installed dispatch system was used. Damping pressure sensors and side displays was added.

Depending on the condition of the dumper - loading, driving, staying, the side display shows different data - current weight, ride load, average speed, waiting time. In addition, they are displayed for the driver during a stop:

- fuel level
- the voltage of the battery
- the condition of the damper, etc.

Figure 1. Front shock absorber of CAT 771D sensor mounted

Figure 1 Side display

Figure 2. Display indications on load. Video on. https://www.drpobox.com/s/29a6abvuu3p30i7 sgd005.avi?dl=0

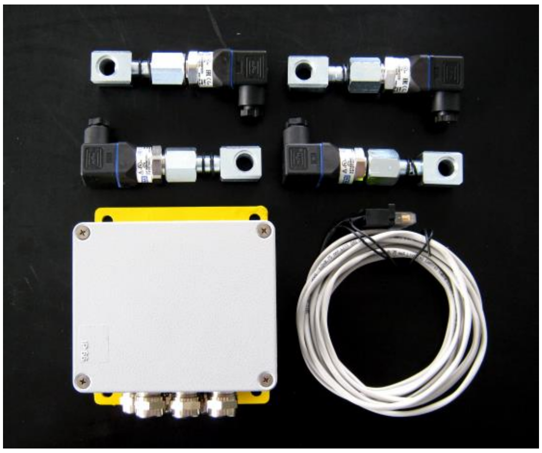

Figure 3. Pressure sensors of shock absorbers

4. RESULTS

On Fig 6 is shown a signal from scales – 4 cycles. Each bucket is visible. Signal from dump is very clear and recognizable.

On Fig 6 is shown a pace of loading and signal from dispersion filter. The dispersion signal is very strong and is used for recognition of the buckets.

On Fig 7 is shown a histogram of dumps of one dumper, mass is ore. The distribution is almost normal, with tails to high and low values. Overloading and under-loadings are quite probable. Approximately 25% of haulages are out of bounds -10%÷+10%. A special program prepares a table report of load distribution for each machine, mass and operator.

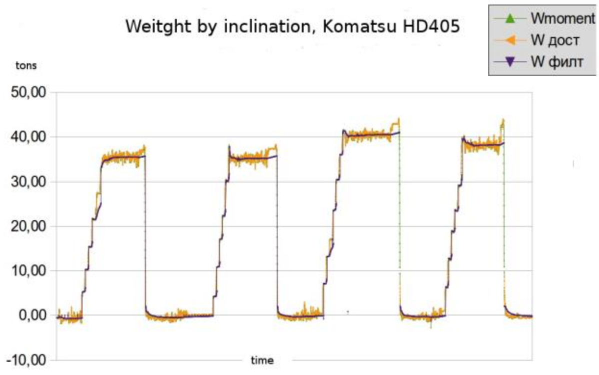

Figure 5. Cycles of the weight signal

Figure 6. Recognition of buckets by dispersion of the signal

5. CONCLUSIONS

1. There is a significant dispersion in loading
2. In real production conditions it is impossible to achieve loading "by specifications", although unrealistic expectations of some managers
3. nevertheless a control of loading and protection of overloading could be achieved using scales with real-time measure and display
4. The "specification norm" must not be chased, realistic norms should be created with realistic mean value and some acceptable range

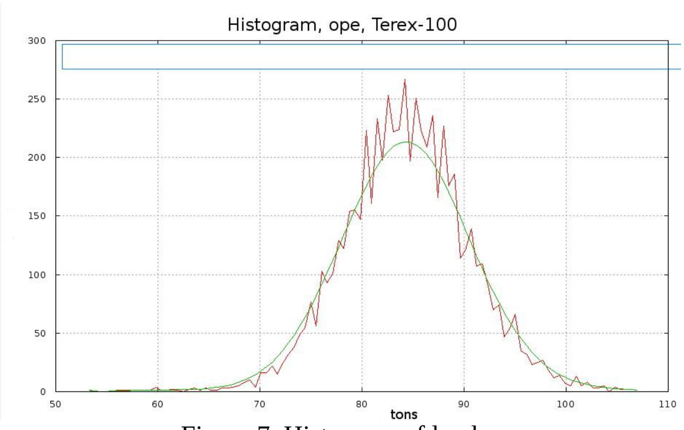

Figure 7. Histogram of loades

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INTERACTION OF MINESAND SURROUNDING ENVIRONMENT

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ABSTRACT

Landscape as a natural composite of soils, rocks and plants together with artificial impacts is very destroyed around mining locations. However, mining companies has to rebuild landscape after miningoperations; it is not possible in practice. The most significant artificial impact is subsidence. It is a three-dimensional displacement of surface massif above the underground mine. As a result of this displacement, the compressive and tensile deformations occur in the massif. On the terrain surface, the foundation structure, more rigid than soil, is exposed to significantly larger stress due to deformations in the soil. The intensity of the stress depends on rigidity of both, the surrounding soil and the structure.

Soil-structure interaction in mining landscapes is not always depended of subsidence. It is very often pseudo-mining damages on structures. But, in subsidence processes of a massif, foundation structure is exposed to passive pressures of soil, whose course of action depends on type of soil deformation. The foundation structure is elongated by tensile deformation of soil. Also, in other zone, the other foundation structure is pressed by compressive deformation of soil. In addition, type of foundation structure and soil's geotechnical parameters affect the intensity of passive pressures.

On the other side, open pits impacts to structures with decomposition of natural stress state. Landslides around open pits and soil deformation impacts to rigid structures by passive pressures.

For instance,the cause of damage may be landslide, poorly executed building construction, earthquake, etc.The most difficult task is to distinguish the mining from pseudo-mining damage.

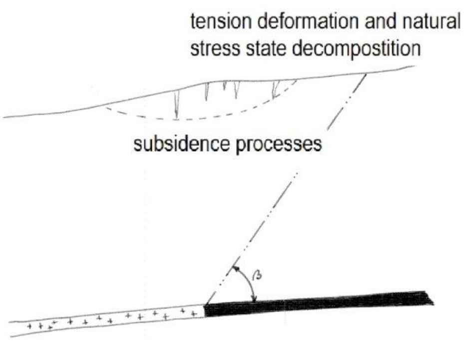
Key words: landscape, subsidence, interaction, foundation.

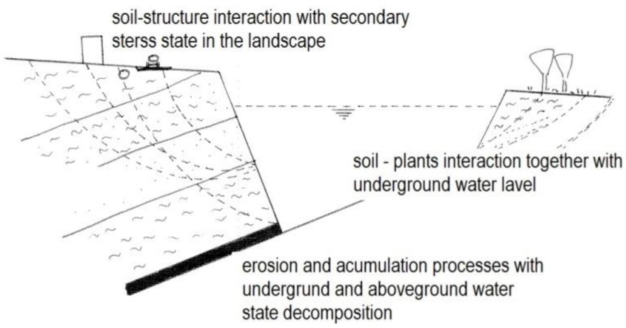
1. INTRODUCTION

Underground and aboveground mining causes strata movement and subsidence valley occurs at terrain above or around mine location. Hollows, trenches, cracks and abrupt steps are formed in a landscape. Mining subsidence can make damages to buildings, roads, infrastructure facilities and agriculture fields. Damages are the result of ground displacement, horizontal deformations and differential subsidence or tilt.

When there are important facilities, such as roads, industrial and residential buildings, on the surface, the protective pillars must be left underground. Protective poles are part of the rock mass and they are not subject to displacement due to ore exploitation. They are placed under the object that needs to be protected. However, when mine does not want to ensure the facilities by protective pillars, the subsidence damages will occur on the ground surface in the form of cracks or completely demolished buildings. The major damagesoccur on poorlyrigid structure, masonry structure, large and high buildings, buildings with improper foundations and line structures. Damage to buildings is the result of the relative movement of object and ground. The difference in the ground and building's rigidity leads to different deformations.[1,2,4]

Movement of rock massif generates tensile or compressive deformationsin the subsidencevalley.

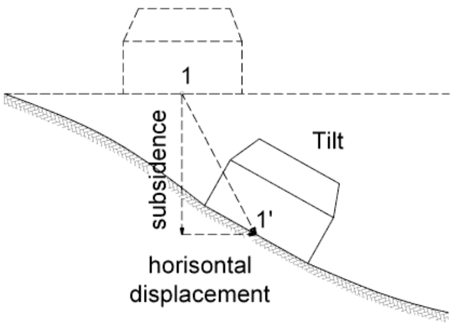


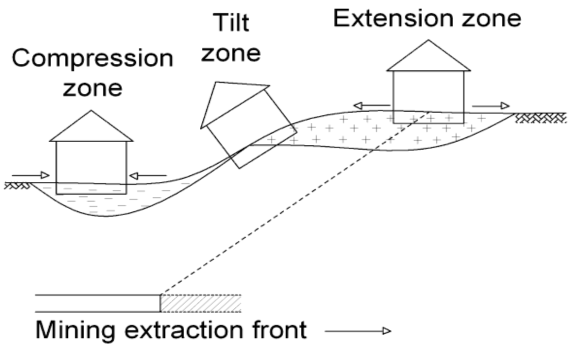


Figures 1,2 Underground and aboveground surrounding process in mining areas

2. SOIL-STRUCTURE INTERACTION IN SURROUNDING MINING SURFACE

Secondary stress state as a mining impact to surrounding space produces deformations and displacements into massif. Structure as a solid bodycannot be deformed as surrounding soil. Subsidence process impacts the objects via horizontal and vertical deformations in soil mass. In general, foundations of all artificial structures cannot be deformed same as soil can. Soil has an impact on structures with its passive pressures, friction forces and eccentric gravity forces.





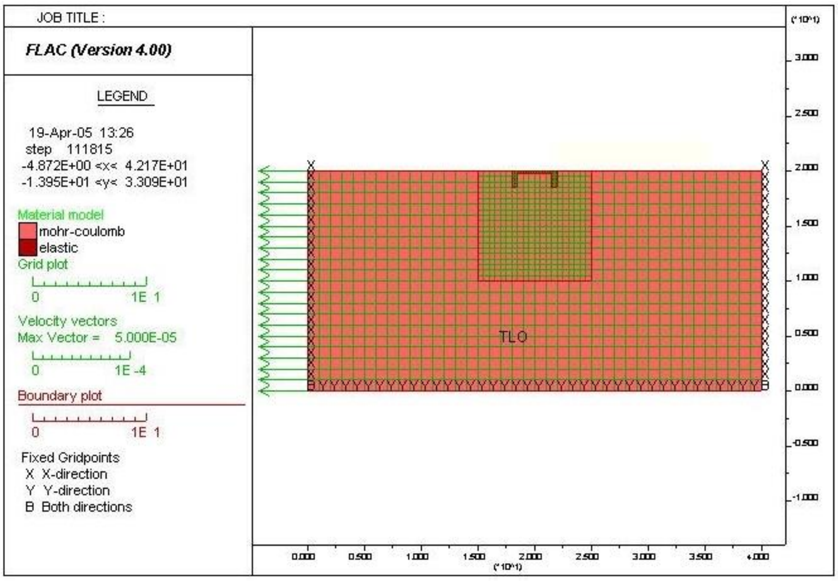
Figures 3., 4.: Movement of object and deformations on subsidence terrain [3]

There are four basic parameters of subsidence: vertical movement, horizontal deformations (tension and compression), tilt or differential subsidence, curve or differential tilt. On the pictures 5-8 is presented some kinds of soil deformation as a subsidence process.


Figures 5.,6. Compression (left) and tension (right) deformations, salt mine (Tuzla, B&H) [4]


Figures 7.,8. Compression (salt mine, Tuzla), tension (coal mine, Tuzla)[4]

Amodel of foundation structure in the area of terrain subsidence, described in this paper, consists of two main straps and one beam. Horizontal deformations were initiated, while the vertical movements were equal to zero. Values of passive pressures were obtained for different amounts of horizontal deformations. The tensile and compression deformations were observed in the intensity of 2.4, 4.0, 6.0 i 12.0 mm/m. It has been concluded that when there are tension deformations in soil, passive pressures and friction forces occur on the inner surface of the foundation structure. On the other hand, when there are compression deformations in soil, passive pressures and friction forces occur on the outer surface of the foundation structure.



Figures 9. Modelling of foundation structure in tension deformations of soil, [2]

3. PSEUDO-MINING DAMAGES

Pseudo-mining damages are those which appeared in surrounding mining surface but originated from other or non-mining impacts. In this regard, most often it comes to litigation between the owner and the mine. The cause of structure's damage needs to be determined by judicial expertise based on professional opinion.

There are other works that may be performed in the exploitation field zone that may cause damage on building's structure with out owner's or mine's guilt. Such works or effects may be: road, tunnel or bridge construction, local infrastructure, reclamation works, cutting of forest vegetation, artificial water reservoirs, landfillsof ash from thermal power plants, garbage or earth, water-flow regulation, military exercises or war activities, fires, unplanned buildings construction, etc. These phenomena usually occur in non-urban areas, without urban plans due to war and crisis conditions, or lawlessness in general and public services non-functioning. The construction of poor residual settlements, erected without planning and with low quality building material should be particularly emphasized. [1,2,4]

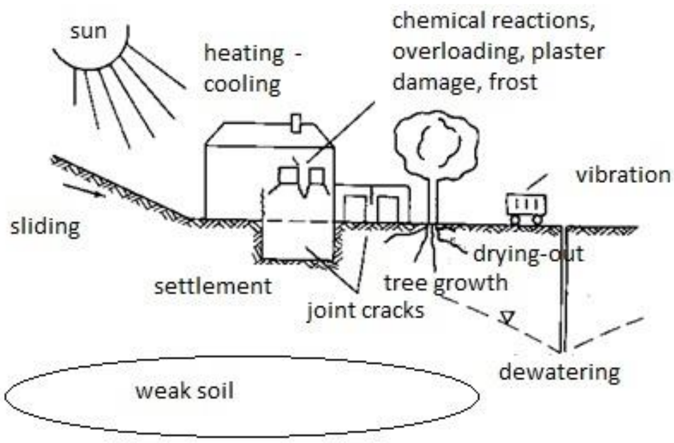


Figure 10. False-mining damages [1]

In regard to time, false mining damages may occur suddenly or gradually. The influence that causes damage may last a shorter or longer period of time or it may change its intensity in periodic cycles. For example, structures near the river banks, especially if with foundations built on incoherent and permeable soil, are exposed to the periodic raising and lowering of the water level. Lifting and lowering of the water level depends on the seasons and water inflow. Also, the river banks are very exposed to erosion, and may undercutthe foundation.

4. STRESS-STRAIN RELATIONS BY SOIL-STRUCTURE INTERACTION

Foundation structure as a concrete material is more rigid than soil and can't deform as soil. Compression and tension deformation in soil and rigid concrete over the soil was simulated. There were interface elements between the foundation and soil. Interface elements have a role to simulate sliding of one body over second body.

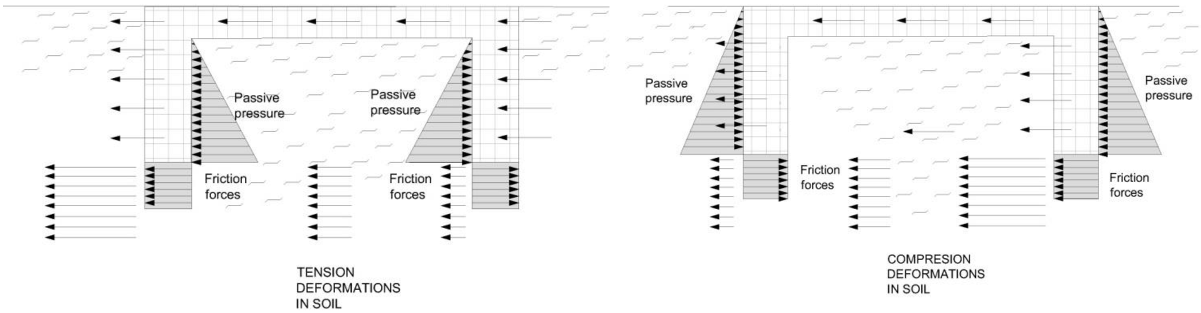


Figure 11. Passive pressure exposed to foundation structure[4]

The intensity of passive pressures depends on foundation depth and soil strength. Passive pressures increase with an increase of depth and soil strength. The intensity of friction forces depends on vertical load to the foundation joint and the internal friction angle of concrete and soil.

Passive pressures in coherent soil by Rankine:

$$E_p = \gamma \cdot h \cdot k_p + 2c\sqrt{k_p} \qquad (kN/m^2)$$

Based on Rankine's theory, passive pressures significantly increase with an increase in soil's depth and cohesion. Therefore, it is preferable to use shallow foundations, structures in smaller dimensions and regularly shaped foundations. [4]

5. CONCLUSION

Mining operations in underground mines or open pits can produce secondary stress state in a surrounding landscape. Especially, by underground mining, subsidence can be occurred. Subsidencemay cause damages to buildings, roads, infrastructure objects and agriculture fields. There are false mining damages resulting from non-mining activities. For instance, the cause of damage may be landslide, poorly executed building construction, earthquake, etc. The most difficult task is to distinguish the mining from false mining damage.

It has been revealed that when there are tension deformations in soil, passive pressures and friction forces occur on the inner surface of the foundation structure. On the other hand, when there are compression deformations in soil, passive pressures and friction forces occur on the outer surface of the foundation structure. Research has proved few rules that should be applied in the case of construction of new buildings' foundations or reconstruction:

a) small and simple, stiff structures are more resistant to deformation in the subsidence base,
b) high buildings are not favourable because of the tilt,
c) long objects can be placed on the terraces, between parallel tension cracks,
d) in the case of weak soil, mat-slab foundations construction is recommended, with material replacement,
e) piles foundations construction is not recommended,
f) in order to reduce passive pressures, cohesive soil should be replaced with non-cohesive fine grain sand, with small friction angle and cohesion equals zero,
g) large-scale and complex structures should be built with dilatations.

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ENVIRONMENTAL PROTECTION OF THE EFFECTS OF DUST FROM THE VELIKI KRIVELJ TAILINGS DUMP

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ABSTRACT

Air quality in the area of Bor (Eastern Serbia) is monitored continuously in the urban, suburban and rural areas. Considering the three measuring points (Institute, Jugopetrol and City Park) of the environmental air quality, it was indicated that the dominant emission source of pollution over the last ten years (and earlier) is Mining and Smelting Combine Bor. Flotation tailings dumps have become source of pollution, not only due to degradation of the terrain where tailings are located, but also for other reasons, such as: raising dust that pollutes the air and surrounding soil; leaching of hazardous elements from flotation material through the rain and infiltration of contaminated water into the soil; drainage of such a water into watercourses, etc. Flotation tailings dump Veliki Krivelj consists of two symmetrical dumps – Field 1 and Field 2. Their dams were reconstructed as flotation dams 1A, 2A and 3A. The main objective of this paper is the selection of geological - mining methods for long-term solution for reclamation of flotation tailings dam 3A Veliki Krivelj, and protection of the environment from the dust form Veliki Krivelj flotation tailings dump.

Keywords: Flotaion tailings, air quality control in the area, sand cyclone, artificial factors, dust, reclamation

1. INTRODUCTION

Copper flotation tailings is obtained as a by-product from the processing of copper ore from the open pit mine Veliki Krivelj. Flotation tailings is disposed at the special place near the flotation plant, in the valley of the Kriveljska Reka. By the disposal of this waste material it was formed the degraded area – Flotation tailings dump Veliki Krivelj. The new degraded area consists of the areas where the flotation tailings is disposed (Field 1 and Field 2) and 3 elevations (internal and external slope of the embankment). On the other words, there are three dams 1A, 2A and 3A that surround the degraded area of the flotation tailingss dump Veliki Krivelj. Reclamation process, conducted through several phases, is covered only dams 1A and 2A so far.

Hydrocyclone underflow from the dam 3A has unfavorable soil properties due to the lack of clay particles and organic matter, which would activate soil processes and microflora working.

The sources of air pollution in the Municipality of Bor are numerous and diverse. The most important are: 1) Mining in Bor (dust); 2) Metallurgy in Bor (sulfur dioxide and dust); 3) Base chemistry in Bor (sulfur oxides); 4) Energetics - Heating plant and individual furnaces (soot, carbon and sulfur oxides); 5) Traffic and 6) field and forest fires.

Mining and industrial plants are located directly next to the settlement, which as a result has frequent high concentrations of pollutants. Pollution levels are primarily dependent on plant capacity. Last Cadastre of emission was done at the end of the eighties (when the plants worked at full capacity) within the project "Protection and improvement of the environment of the Zaječar region" (Table 1).

Table 1. Cadastre of emission from all sources in Bor

	SO_2	SO_3	NO_X	CO	HCHO	CH_4	dust	Pb	As
t/day	323.98	0.165	5.981	8.197	0.074	1.55	148.76	0.089	0.939
t/year	214874	18.19	1444.2	2734.5	27.66	514.97	30031.3	31.13	137.1

2. EXPERIMENTAL

One of the types of environmental pollution from the flotation tailings dump Veliki Krivelj is air pollution (besides pollution of water and soil). The dominant winds on the tailings dump are from the north-west and north-east direction. The dams 1A and 2A were recultivated and rising of dust from their surfaces was prevented. The exact amount of dust emission from flotation tailings dump Veliki Krivelj has never been measured on the daily or annual level.

Samples of materials from the dams of flotation tailings dump Veliki Krivelj (for laboratory tests of physical properties) were taken under the disrupted and undisrupted conditions, marked on the terrain and conserved in order to preserve mechanical and water-physical characteristics.

On this samples, among the other physical properties, granulometric tests were performed. The particle size of a material is very important, bacause of the dust rising and its transmission by the wind (wind speed and direction).

On the location map (Figure 1), the locations and sampling number of the material from dam 2A are shown. The material is sampled from the surface of the terrain and at a depth of 20 centimeters. This is also a real depth to which erosion can be expected – in the sence of the elevation of degraded material through the aeolian process.

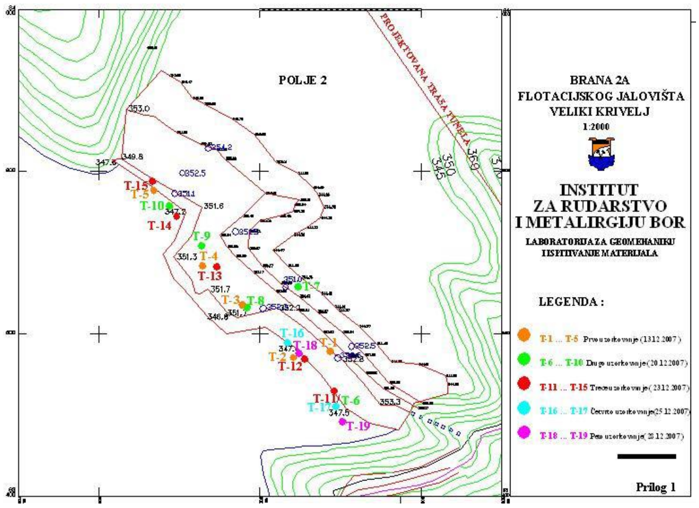

Figure 1. Situation map of sampling dam 2A.

3. RESULTS AND DISCUSSION

Based on the examined physical characteristics and granulometric composition of the flotation tailings, we can see the very favorable natural moisture and particle size distribution of the composite (hydrocyclon underflow used for bank the dam) (Table 2). The difference in moisture content of the composite and the optimum moisture is about 10%, and from particle size distribution curves we can see that the grain size does not exceed 0.5 mm. The largest amount of bulk material is in the range of so called sand. The chemical composition of the material from flotation tailings dump Veliki Krivelj is shown in Table 3.

Table 2. Granulometric composition of the material from flotation dam Veliki Krivelj in Bor

Granulometric content						
Material of the flotation dam 3A			Flotation tailings		Material of the flotation dam 2A	
mesh sieve (mm)	Content M%	Cumulative content K%	Content M%	Cumulative content K%	Content M%	Cumulative content K%
0.417	0.00	0.00	0.00	0.00	0.00	0.00
0.295	16.47	16.47	0.00	0.00	0.00	0.00
0.208	23.17	39.64	1.37	1.37	12.98	12.98
0.147	23.91	63.55	3.00	4.30	24.77	37.75
0.134	15.60	79.15	5.25	9.62	10.43	48.18
0.074	7.83	86.98	5.40	15.02	10.67	58.85
0.034	6.54	93.52	11.32	26.34	10.75	69.60
<0.034	6.48	100.00	73.66	100.00	30.40	100.00

Table 3. Chemical composition of the flotation tailings from Veliki Krivelj dump in Bor

Element	SAMPLE	
	Material taken "in situ" from the surface	Material taken "in situ" at a depth of 20 cm
As (mg/kg)	0.32	0.20
Pb (mg/kg)	<1.0	<1.0
Cd (mg/kg)	< 0.2	< 0.2
Ni (mg/kg)	1.30	<1.00
Cu (mg/kg)	480.0	185.7
Zn (mg/kg)	8.0	12.0
Cr (mg/kg)	3.33	3.32
Mn (mg/kg)	34.04	23.83
Fe (mg/kg)	4421.05	1789.47

4. CONCLUSION

Flotation tailings dump Veliki Krivelj is one of many sources of pollution, because of the dust raising that pollutes the air and spreads to the surrounding land. Besides that, dust is washed by the rain, and the contaminated water penetrate into the ground, as well as into the watercourses.

Flotation tailings dump Veliki Krivelj can be environmentally friendly if the reclamation of degraded area of dam 3A is performed. In that case, the environment will be protected from dust from the flotation tailings dump Veliki Krivelj. For these reasons it is necessary to pour the soil on the surface in a layer of at least 10 centimeters (technical recultivation, that is, the first stage of recultivation). This addition of organic matter will provide the necessary minimum for the development of grass cover and trees (which belongs to biological recultivation, or the second stage of recultivation).

The total costs of recultivation are 114,034.06 €, and the expected benefit of the recultivation of the dam 3A of the flotation tailings dump Veliki Krivelj is multiple, primarily: 1) Environmental protection of the villages Veliki krivelj and Oštrelj; 2) The possibility of ending the existence of a sanitary protection zone and compensation of the Mining and Smelting Combine Bor to farmers for lost profits; 3) Profit from sale of acacias when conditions are met (after 40 years). Expected profit from acacias is calculated according to the current situation of 6.380 €/ha, or the total profit from the trees is expected to be 14.705 €/ha.

5. ACKNOWLEDGMENTS

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MULTYDISCIPLINARE DRAINAGE PROCEDURES APPLIED AT FLOODED TAMNAWA WEST LIGNITE MINE IN KOLUBARA BASIN

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ABSTRACT

Lignite is a strategic and dominant energy source for Republic of Serbia and the Kolubara coal basin of clearly contribute to the country's stable, secure energy supply and remains one of the main fuels for power generation within the long-term energy development plans of EPS Group.

In May 2014 heavy rains had hit Serbia's energy sector, lignite basins Kolubara and Kostolac. The worst situation was in Kolubara lignite basin, at open pit mine Tamnava. West where artificial lake of 20 squaring kilometers was formed, with depth of more than 50 meters.

Flooding had cut Serbian power generation by 40 percent, forcing the country to boost electricity imports. Estimated damage was over € 100 million. In Tamnava West and V. Crljeni fields were flooded 9 bucket wheel escavators, belt conveyors, a few spreaders, auxiliary machinery and mining equipment. Urgent demand was high capacity pumping stations, drainage pipelines with different diameters, energy supply facilities, stable floating pontoons and many other material recourse.

Considering the fact that 2014 annual coal production was seriously threatened, all activity – dewatering and pumping objects and facility positioning, river bed water quantity monitoring and area aquifer water levels, water and mud quality monitoring analysis, river bed morphologicall changes analysis and monitoring, ground water level monitoring, open pit benches and internal overburden dumps stability analysis, additional on-site survey works were carried out. During the water pumping additional geotechnical stability improvement procedures and assessment were obtained in order to avoid open pit mine slope instability. Likewise the new embankments, preventive walls, overflow places had built in comply with all civil engineering, geotechnical and coal mining standards.

First lignite coal quantity from partially recovered open pit mine Tamnava West was delivered on 26th of December 2014.

Key words: lignite, flood, drainage, methodology, regeneration.

1. INTRODUCTION

Serbian coal production is focused on two mining basins: Kolubara (Field D, Field C, Tamnava West) and Kostolac - open cast mine Drmno. Both basins are in range of 90 km from Serbia capital Belgrade.

Annual coal production in 2016 was 37,65 million tons of lignite, while total overburden production was 98,8 million cubic metters. In 2016 was produced a total of 28,5 million tonnes of lignite in Kolubara basin and was used to generate approximatelly 45 % of total electricity produced by EPS. Average calorific value of the supplied lignite to the thermal power plants of MB Kolubara subsidiaries is about 7850 kJ/kg, respectively.

2. TAMNAVA-WEST LIGNITE MINE MASSIVE FLOODS IN 2014

During the third week of May 2014, exeptionally havy rains fell on Serbia which caused by a low-presure system that formed over the Adriatic.

Record-breaking amounts af rainfall are recorded more than 200 mm of rain fell in Western Serbia in a week's time, which is equivalent of 3 moths of rain under normal conditions. The heavy rainfalls led to a rapid and substantial increase of water levels in the main rivers. In the Sava river watershed where most of the rainfall was received, flash floods occurred in the tributaries where water levels rose almost immediatelly. In this regard, the water level on the river Kolubara rose by 7 meters between 14 and16 May.

The heavy rainfall and rising water levels increased flow of underground waters leading to widespread embankement and riverside landslides and force, devastating water break-through in the lignite open cast mine Tamnava West where artificial lake of 20 squaring kilometers is formed, with depth of more than 50 meters.

Under the water there were 9 bucket wheel excavators, a number of machinery, mining and auxiliary equipment. Urgent demand was high capacity pumping sations in order to drain open pit mine, drainage and dewatering pipeline disposition, design and construct acess roads, energy and fuel provision and multy-task monitoring proces of all engineering and environmental

3. MULTYDISCIPLINARY DEWATERING AND DRAINAGE METHODOLOGY APPLIED

Technical assessment was that the TW.F. flooded with 185 million cubic meters of water and V. Crljani was flooded with over 25 million cubic meters of water. Along with the water, huge mass of mud had enetered in open pit fields caused by erosion and destructive flooding wave. During the summer 2014, M. B. Kolubara drained 25 million cubic meters from open pit field "V.Crljeni" and dewatered water from T.W.F. with pumps available in Serbia. Dewatering was carried out with 24 pumps. The average pumping capacity was about 8.3 m^3/s.

Considering that in Serbia were not any available high capacity pumps and that was urgent demand on behalf of dewatering and drainage from T.W.F. in a short period of time. Decision was made to engage the foreign contractor in order to provide an additional at least 30 m^3/s capacity, meaning at least about 40 m^3/s capacity pumped water in total.

Considering the fact that pumping activity process had launched by Kolubara's own dewatering resources, time relevance and drainage practise complexity, all activity harmonization have been required in order to provide compatibility rating a dewatering method and environmental an impact accessment monitoring.

Equally the real time accessment the all relevant data have passed through the potential restrictive factors and possible terms of references for dewatering program correction and reconcilition.

Terms of reference comprised an information and techniques diversity, as follows:

- geomorphological and hydrological terrain accessibility on behalf of equipment setting up,
- flooded area transpiration analysis,
- T.W.F. water balans calculation methodology,
- T.W.F. and hinterland geotechnical and hydrogeological conditions appraisal,
- dewatering pumps, pipelines and equipment best and serviceable positioning,
- dewatered flow rate and volume system and facilities disposition,
- T.W.F. water flow balance sheet equipment monitoring spot positions,
- flooded open mine and Kolubara river water quality appraisal,
- surface and ground-water flow level monitoring,
- river bed Kolubara morphological changes monitoring and appraisal,
- T.W.F. open pit benches and internal overburden dumps stability analysis and monitoring,
- additional geotechnical survey and drilling due to dewatered gradual slump a benches new embankments, preventive walls, overflow places design and building in comply with all civil engineering, geotechnical and coal mining standards.

4. GEO-MORPHOLOGICAL, HYDROLOGICAL CONDITION AND RIVER DEVIATIONS OVER THE T.W.F. EXPLORATATION AREA

This area covers the central and the lower course of the Kolubara and its tributaries. Kolubara's riverbed penetrated ino the valley and reaches the depth that ranges from 4 to 7 m. Its interception capacity amounts at the to a biennial runoff.

The riverbank is equaly unstable as the riverbed due to meander irregularities and other reasons. The period from February to May is characteristic for the highest water content that participates with 42 % in total annual flow. The highest average floe is reached im March, April and the lowest in September.

The rivers in Kolubara Basin are mostly of torrent type and therefore there is real danger of flooding the area, which had to be before prevented. The refore, a system of water reservoirs had planned and some of them are already had constructed. The most important is Paljuvi Vis. The criteria for the flood prevention was the maximum water flow with probability af at least 0.2%, which is equivalent to 1:500 years or better.

The river Kladnica crosses T.W.F. from south west to north east direction. The river Kladnica had a connection to the reservoir Paljuvi Vis for the case of any discharge.

The reservoir Paljuvi Vis on Kladnica river is positioned at obout 4 km. from the West border of T.W.F.Before the flood the active volume of the reservoir was about 7 million m^3, which could prevent flood from the waters with probability 1:100.

The area permanently taken for the event of floods waves and for flood protection, occupies about $4.2x10^6$ m^3.This had to be an important role for the flood prevention.

The coal exploitation in Kolubara Basin has already caused river deviations. For production-completed Tamnava East Field the Kolubara river had to be deviated in three phases. The two phases had realised.

Plan was that the river Kladnica had a connection to the reservoir Paljuvi Vis for the case of any discharge.

5. DEWATERING FACILITY POSITIONING AND ASSEMBLING STRATEGY, WATER FLOW RATE AND QUANTITY MEASURING

The first dewatering stage started in July 2014 when the water was drainaged from both small and big flooded lakes.

Due to water lowering on the end of Decembar 2014, flooded T.W.F. water surface was divided by two parts: east part – shallow part and wastern part –deeper part.

Because of the terrain conditions and on behalf of further dewatering implementation activity with positiv and pro-activ scale,it was decided to build overburden barrier-tiling in order to subdivide the flooded open pit mine space. Beneficial circumstances was that natural reef had already existed, thus an artificial barrier upgrade corresponded with.

When flooded open pit mine space was subdivided on two parts, water drainage had been done as follows: part number of high-capacity pumps pumped-out the water first from western part in eastern part and rest of number pumps was pumping-out water in local recipient – river Kolubara.

T.W.F. dewatering activity was comprehended four water drainage pipeline location designed in compliance with specification as follows:

- Positioning as many as much possible pumping stations
- Disposition distance between flooded space and local recipient – river Kolubara was as short as possible (additional benefit was the water pipeline lenght saving)
- Communicable pumping location acces due to simplified pumps, pipeline and additional equipment dislocation
- Accessible pumps and pipeline repairing and maintenance procedure

In September 2014 all scheduled drainage pipeline were assembled – 17 drainage pipelines and dewatering process has begun.

The second stage was started in December 2014 after the flooded area was subdividedon two parts. In January 2015, because the water had lowered, there was demand for drainage pipeline deplacement and new dewatering position instalation.

On every drainage pipeline the contactor was assembled 2 pumps which were set up on pontoon or platform at flooded surface. In this moment was essembled 9 drainage pipeline and 18 pumps. The pumps were assembled on two technical manner –collateral and serial pump connection.

Drainage pipe linelenght was about 1300 meters with 1000 mm.in diameter. During the second stage, caused by drained water level lowering and morphology terrain changing, therefore the drainage pipeline was lenghtened and supplementary new embankment was constructed.

Next stage T.W.F.dewatering activity was pefrormed in Ferbuary 2015, when drainage pipeline assembled on the West side on flooded surface, where 2 drainage pipeline were set up,500 and 600 meters lenght, with 400 mm.in diameter.

Contractor's 18 high capacity drainage pumps were branded „CaterpillarC18“ diesel powered,430 kW strong with 2100 r.p.m.

Additionaly were operational at least 20 electrical drainage pumps with different strenght and capacity, provided from EPS.

Water flow rate and quantity measuring was performed on three way:

- stationary measuring points installed at contractor's pipelines – instant water flow rate measuring and finaly pumped out water volume
- ordinary instant water flow at one of the contractor's pipeline performed by EPS Group
- special inspection instant water flow rate volume at one pipeline performed by Independent Consulting firm engaged by EPS Group

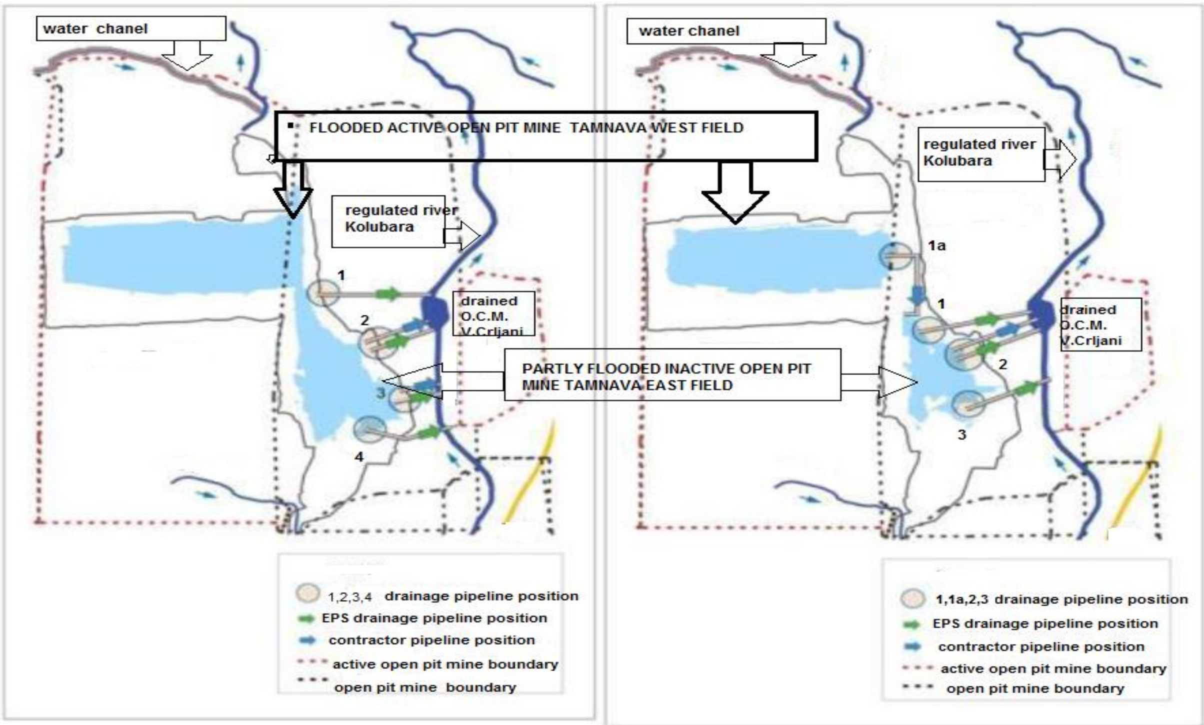

Figure 1. Drainage pipeline positioning

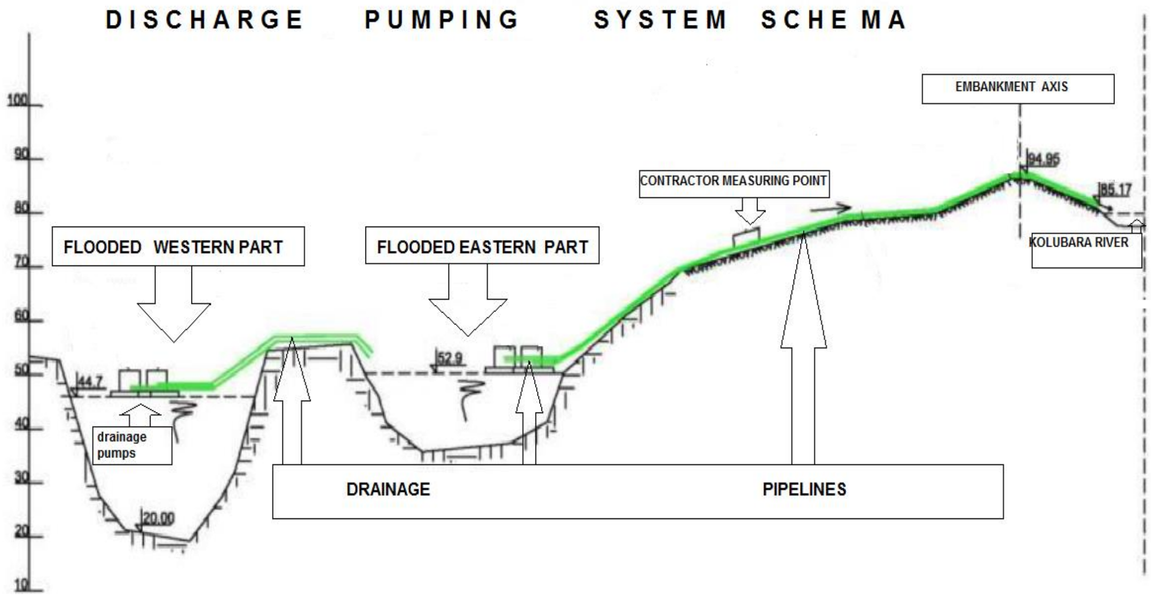

Figure 2. Discharge pumping system schema

6. RIVER AND TRIBUTARIE BEDS MORPHOLOGY CHANGES, MUD DEPOSITED ANALYSIS,WATER QUALITY ASSESSMENT

Simultaneosly with dewatering and drainage processes, flooded open mine poluted water, river Kolubara and tributaries water poluted and mud deposit monitoring had been operated in accordance with full environmental and ecological standards in order to possible water sources supplying threatening and impact assessment evaluation.

Coal basin Kolubara experts department, Governmental Environmental Protection Agensy were carried out the "Water quality monitoring program from flooded area“, like us from T.W.F. the mud deposited. The Program anticipated a in week monitoring schedule during the water drainage activity. Monitoring spot selection was carried out, considering the geographical position, geomorphological and hidrological property and poluted water transport.

Considerinf the fact that lokal recipient,the river Kolubara average annual alluvium deposit was about 300.000 tons per year, was conluded that flooding deposit quantity is going to be as much as 10 times larger than average. Additionaly, during the dewatering activity mud deposited could not be separated completely and redirected.It could caused to unpropried river bed morphological changes by water traffic capacity redusing for big protect water and coastal control area.

In order to riverbed changes be monitored during the dewatering activity, the riverbed morphology change monitoring Programme was contained as follows:

- sereval series of riverbed Kolubara morphology geodetic survey specified in advance to cross-sections managed.
- deposited alluvium sempling
- physico-chemical properties assessment
- granulometry assessment.

Programme was predefine a balance method marking an aplication and periodical geodetic survey every 20 days, later on even denser (every 10 days).

7. STABILITY T.W.F ZONE ANALYSIS METHODOLOGY

T.W...F. bench and internal overburden instability were corresponded with the first massive open pit mine flooding and later on with dewatering and drainage activity applied.

Flooded open pit mine benches and internal overburden disposal instability could had a negative impact not only to dewatering and drainage activity, but also an open pit fields working zone and internal overburden disposal.

On behalf of more reliable stability analysis, slopes and benches monitoring around T.W.F. zone, as well as on internal overburden disposal, additional geotechnical prospecting survey and works had performed. The T.W.F. south final slope prospection was involved.

A few months after flooding there were not massive T.W.F. bench instabilities, but since end of November 2104,internal overburden disposal slopes instability occured. Because the evident slope deformation, additional getechnical survey, works and calculation on disposal zone was applied. Final south slope,where the coal production activity would be continuied, paticulary was in slopesliding risk.

Geotechnical survey and calculation assessment timing schedule, reference survey template map were evaluated. Additional more 10 boreholes on internal overburden disposal and 4 on T.W.F. south final slope had been performed. At the same time piezometers construction were installed and dynamic penetration prospect work are performed. Within this analysis, safe stability factors calculation was carried out for future scenario when T.W.F.when the open pit mine is going to be complitelly drained within 60 – 80 and 120 days since November 2014.With reference to this analysis, there was the high ground water levels presented on hinterland draining it slowly as surface water level had been lowered. Result was lower benches stability.

Benches stability analysis was carried out in „Slide“ software package as 2D calculation. First filtration calculation was done and than slope cut-off balance analysis.

Permeability calculation methodology had regarded to ground water movement caused by water lowering on T.W.F. Filtration analysis was carried out in order that piezometer levels will be determined. In accordance with methodology the inputs – material permeability and boundary flow potential were defined. Filtration analysis calculation was carried out considering the two an assumptions:

- soil on TW.F. hinterland after flooding as far as begining the mine dewatering activity – is completely watered.
- Soil on th T.W.F. hinterland was partially watered

For both of these assumptions a head or potential equivalent to the water level on T.W.F. was predefined. Soil specification was added an appropriate a permeability coefficient.

8. CONCLUSION

In May 2014 heavy rains hit Serbia's energy sector – lignite basins Kolubara and Kostolac. The worst situation was in Kolubara lignite basin, at open pit mine Tamnava West where artificial lake of 20 squaring kilometers was formed, with depth of more than 50 meters.

In T.W.F. and V. Crljeni field were flooded 9 bucket wheel escavators, belt conveyors, a few spreaders, auxiliary machinerz and mining equipment.

Urgent demand was high capacity pumping stations, drainage pipelines with different diameters, energy supply facilities, stable floating pontoons and many other material resource.

Considering the fact that 2014 annual coal production was seriously threatened, multydisciplinary dewatering and drainage methodology application wasrequired in order to rehabilitated the demaged open pit fields and provide production continuance. Term of reference comprised an information and techniques diversity as follows: geomorphological and hydrological terrain accessibility assessment, T.W.F. zone and hinterland geotechnical and hydrological conditions appraisal, dewatering pumps, pipelines and equipment best and serviceable positioning, flooded T.W.F. and Kolubara river water quality appraisal, mud deposite analysis, river-bed Kolubara morphological changes monitoring and appraisal, T.W.F. open pit benches and internal overburden dumps stability analysis and monitoring, the new embankments, preventive walls, overflow places design and construction in comply with all civil engineering , geotechnical and coal mining standards.

During the water pumping, additional geotechnical stability improvement procedures and assessmnent were obtaned in order to avoid an open pit mine and internal overburden disposal slope instability.

First lignite coal quantity from partially recovered open pit mine T.W.F. was delivered on 26th of December 2014.

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THE EFFECT OF FERTILIZATION ON CHANGES IN PHYSICAL CHARACTERISTICS OF DEPOSOL IN ARTIFICIALLY ESTABLISHED STANDS OF BLACK PINE

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ABSTRACT

The subject of this study are artificially established 12-year-old stands of black pine on marly deposollandfills in Ugljevik, established in the spring of 1992 by planting three year oldseedlings. These black pine stands had not been subjected to any changes in physical and chemical properties of the soil prior to the beginning of this study.

The aim of the study is to analyse the possibility of improving the physical and chemical properties of deposol through increasing the availability of basic nutrients through fertilization, thus enhancing the growth of black pine. In accordance with the objectives of the study, the process entailed the use of special scientific methods and corresponding techniques.

All samples of marly deposol at baseline (prior to fertilization) are granulometrically classified as the textural class “clay”. Fertilization was carried out on two occasions (in 2003 and in 2004). The textural class of the soil, according to the results of this study (2005) shows a high percentage of clay soil, and the dominant textural class is silty clay.

Key words: deposol, fertilization, physical properties

1. INTRODUCTION

As a consequence of mining, large swathes of former soil are now classified as “technological deserts”, and very little has been reclaimed. Open pit mining of "Bogutovo selo" in Ugljevik degraded a significant area, and mine tailing from this open pit is deposited primarily in two external landfills (Northern and Great Western Landfill).

The deposols in these landfills, as technogenic soil, were formed by dumping soil resulting from land work (planning, dumping, etc.), i.e. by depositing the material resulting from mining, and pertaining to different subtypes, depending on the material being dumped (soil, ore, slag, etc.). The type called "recultisol" is deposol that has been biologically recultivated. Resulović, H. et al further divide it into two subtypes: "trophogenic recultisol" in cases when the barren soil is covered with top soil (indirect recultivation) and "geogenic recultisol" without applying a layer of topsoil over the barren soil (direct recultivation).

If the amount of nutrients is insufficient, deposol productivity can be improved by changing the soil properties. Negative physical and mechanical deposol properties can be improved by using fertilizers. The procedure of applying fertilizers is called fertilization. There are two types of fertilization: ameliorative and regular fertilization. There are several ways to apply fertilizer, depending on the goal of fertilization, the amount and form, the age of the stand, surface area, incline, type of landscape, etc. Fertilizers can be applied manually, by using machinery or planes, spraying, injecting, spreading over surfaces, using plows or special machinery, and through irrigation. Fertilization can include the entire surface or an individual tree (Baule, H, Friker, K, 1978).

2. RESEARCH SUBJECT, GOAL AND METHODS

The subject of this study are artificially established black pine stands (Pinus nigra Arn.) planted on marly soil of the Ugljevik landfills, in spring 1992 (in advanced copse stage at 12 years of age) using three year seedlings (2+1). At the landfills, we studied the "geogenic re-cultivated deposol" formed through the process of depositing several subtypes of deposol (soil, mine tailings and slag from the thermal power station), transported by dumpers with load baring capacities from 90 to 120 tonnes (Milošević, D. 2005). These black pine stands had not been subjected to any changes in physical and chemical properties of the soil.

The study was conducted from 2002 to 2005, by setting up trial plots at 165-215 m above sea level, of NE and NW expositions, with 1-25% inclines. Each trial plot (of around 1000 m^2) was sectioned into 4 trial subplots (of 236-275 m^2), with 63-130 trees in each subplot.
The goal of this study is to analyse the possibility of inducing positive changes in the soil, primarily concerning the physical characteristics, along with chemical characteristics of deposol, with basic nutrients administered via fertilization, in order to improve the growth of black pine. During research, specific scientific methods were used with appropriate techniques. Special scientific methods include standard measures for determining the physical and chemical characteristics of soil (0-40 cm deep), concerning the following:

a) Physical properties of soil

- Mechanical soil composition –international B-pipette method, using sodium as the peptizing agent,
- Textural class(according to Ehwald et al.) –using the textural triangle;

b) Chemical properties of soil

- Active and reserve acidity –electrometrically in water and potassium chloride,
- Total $CaCO_3$content – by using a calcimeter, according to the Scheibler method,
- Total topsoil content – Tyurin method modified by Simakov,
- Carbon content–Tyurin method,
- C/N -calculation,
- Total nitrogen content – macro-Kjeldahl method,
- Content of easily available phosphorus and potassium – extraction using the Al method.

Textural elements were sorted into fractions using the BSI (British Standards Institution) classification, i.e. Aterberger classification with a slight modification since medium- (0.6 - 0.2 mm) and large-grained sand (2.0 - 0.6 mm) was listed as one fraction: 2.0 - 0.2 mm).

The techniques used include: 1. cutting branches with a handheld tree saw and handheld shears, 2. manual application of mineral fertilizer (spread along a circular trench dug around the tree crown) and 3. collecting samples of soil with a spade.

3. RESEARCH RESULTS AND DISCUSSION

During its pedogenesis, the deposol in Ugljevik's landfills of mine tailings from the open-cast mine acquired physical properties different from the physical properties of the deposol prior to the planting of black pine stands.

In order to determine realistic initial information about soil quality and properties of deposol 8 years after the planting of black pine stands, physical (Maksimović M., 2000) and chemical analyses (Maksimović M., 2010) were conducted in 1999 and 2002, respectively. Biogenic elements had to be introduced into marly deposols, since they were in short supply, as shown in the analysis of physical and chemical properties of the soil (Tables 1 and 2).

Table 1. – Physical properties of soil, 1999 (Maksimović M, 2000)

No.	Locality	Trial plot	Depth (cm)	Hygros. water (%)	Granulometric composition (%)						
					2,0-0,2 (mm)	0,2-0,06 (mm)	0,06-0,02 (mm)	0,02-0,002 (mm)	Clay+ coll. < 0,002 (mm)	Total Sand	Total Clay + silt
1	Great Western Landfill	OPI	0 - 10	5,98	2,93	11,67	7,50	31,40	46,50	22,10	77,90
2			11 - 38	6,78	4,81	8,49	11,40	41,60	33,70	24,70	75,30
3			38 - 70	3,83	2,66	4,14	3,00	38,40	50,80	9,80	90,20
4		OPII	0 – 12	4,43	6,99	18,11	11,30	28,80	34,80	36,40	63,60
5			12 - 49	5,92	3,40	9,10	8,10	35,90	43,50	20,60	79,40
6			49 - 86	5,57	5,02	12,28	5,40	34,30	43,00	22,70	77,30
7	Northern Landfill	OPIII	0 – 13	5,72	2,11	12,90	9,60	39,40	36,00	24,60	75,40
8			13 - 44	4,72	2,36	15,94	10,20	37,30	34,20	28,50	71,50
9			44 - 78	5,11	2,76	19,44	9,10	37,30	31,10	31,30	68,70
10		OPIV	0 - 11	3,55	0,89	19,71	10,30	39,00	30,10	30,90	69,10
11			11 - 36	4,37	0,95	10,85	11,10	39,10	38,00	22,90	77,10
12			36 - 66	7,61	1,70	13,00	11,50	37,90	35,90	26,20	73,80

At the beginning of the research period, the analysed soil was poor in nitrogen and active phosphorus, and had somewhat higher, although still insufficient, amounts of active potassium. In order to transform the first 20 cm of this soil into soil with a medium to good supply of N, P_2O_5 i K_2O, it required the addition of the following: 0.15-0.25% N, 140 to 170 kg/ha P_2O_5 and 130 to 160 kg/ha K_2O.

Table 2. – Chemical properties of soil, 2002 (Maksimović M. 2010)

No.	Trial subplot	Depth (cm)	pH		$CaCO_3$ %	Topsoil %	C %	N %	C/N	Easily available	
			H_2O	$CaCl_2$						P_2O_5	K_2O
1	OPI/1	0 - 10	7,75	7,30	39,27	6,00	3,18	0,27	12,9	2,80	30,0
2		11 - 20	7,81	7,40	50,95	4,82	2,80	0,22	12,7	1,70	18,6
3		21- 40	7,85	7,42	44,58	4,89	2,84	0,19	14,9	1,10	18,6
4	OPI/2	0 - 10	8,05	7,46	29,70	4,87	2,83	0,22	12,8	2,00	28,5
5		11 - 20	8,10	7,63	24,2	2,21	1,28	0,10	12,8	0,70	29,6
6		21- 40	8,10	7,64	25,47	1,99	1,15	-	-	1,70	33,3
7	OPI/3	0 - 10	7,80	7,50	29,70	5,60	3,25	0,21	15,5	2,50	32,0
8		11 - 20	8,07	7,62	-	3,85	2,23	0,18	12,4	1,80	31,5
9		21 - 40	8,02	7,60	27,60	3,26	1,89	0,16	11,8	0,40	>40.00
10	OPI/4	0 - 10	7,85	7,65	27,60	5,54	3,21	0,23	13,9	0,80	34,8
11		11 - 20	8,10	7,56	33,96	1,72	1,00	0,08	12,5	0,70	30,5
12		21 - 40	8,12	7,60	31,85	1,17	0,68	-	-	0,30	30,0
13	OPII/1	0 - 10	7,92	7,56	29,72	3,90	2,26	0,16	14,1	1,70	22,7
14		11 - 20	7,88	7,58	38,20	3,19	1,85	0,11	16,8	1,80	22,2
16		21 - 40	7,80	7,45	38,20	3,16	1,83	0,11	16,6	0,50	22,2
16	OPII/2	0 - 10	7,80	7,4	30,57	6,11	3,54	0,24	14,7	5,20	32,5
17		11 - 20	8,05	7,50	27,17	1,58	0,92	0,07	13,1	1,30	35,0
18		21 - 40	8,12	7,65	25,47	0,84	0,49	-	-	0,75	>40,00
19	OPII/3	0 - 10	7,84	7,46	34,80	5,68	3,30	0,23	14,3	1,80	22,2
20		11 - 20	7,82	7,50	36,50	5,13	2,97	0,14	21,2	0,90	19,0
21		21 - 40	7,48	7,20	37,36	5,21	3,02	0,14	21,5	0,20	19,0
22	OPII/4	0 - 10	7,80	7,52	29,72	5,55	3,22	0,22	14,6	3,40	>40,00
23		11 - 20	8,00	7,57	16,98	6,25	3,62	0,20	18,1	1,70	39,5
24		21 - 40	8,20	7,55	13,58	3,32	1,92	0,13	14,7	1,60	39,5
25	OPIII/1	0 - 10	7,83	7,23	40,33	5,33	3,09	0,18	17,2	2,00	37,0
26		11 - 20	7,92	7,44	36,50	2,33	1,35	0,10	13,5	0,90	29,0
27		21 - 40	7,92	7,47	29,72	1,67	0,97	0,07	13,8	0,40	21,2
28	OPIII/2	0 - 10	7,76	7,22	38,20	5,37	3,11	0,26	11,9	2,50	37,5
29		11 - 20	7,89	7,36	12,45	3,61	2,09	0,18	11,6	1,50	37,5
30		21 - 40	7,50	7,28	36,50	3,75	2,17	0,15	14,5	0,60	26,2
31	OPIII/3	0 - 10	7,96	7,36	36,08	2,92	1,69	0,15	11,3	1,00	28,4
32		11 - 20	8,00	7,54	31,84	2,16	1,25	0,11	11,3	0,40	22,6
33		21 - 40	7,61	7,34	42,45	4,24	2,46	0,14	17,5	0,80	21,2
34	OPIII/4	0 - 10	7,85	7,30	42,45	4,76	2,76	0,23	12,0	1,90	27,6
35		11 - 20	7,96	7,35	44,15	3,27	1,90	0,16	11,9	1,00	23
36		21 - 40	7,92	7,44	34,80	2,92	1,69	0,15	11,3	0,40	26,2
37	OPIV/1	0 - 10	7,9	7,35	44,58	3,27	1,9	0,16	11,9	1,50	31,0
38		11 - 20	8,00	7,37	41,68	2,74	1,59	0,15	10,6	0,60	24,2
39		21 - 40	7,80	7,43	39,60	2,89	1,68	0,14	12,0	0,30	19,2
40	OPIV/2	0 - 10	7,88	7,30	47,90	0,72	2,1	0,13	16,6	1,00	30,6
41		11 - 20	7,90	7,48	47,90	3,16	1,83	0,11	16,6	0,40	24,2
42		21 - 40	7,59	7,34	49,60	2,64	1,53	0,19	15,3	0,20	>40,00
43	OPIV/3	0 - 10	7,97	7,42	33,35	3,67	2,13	0,21	10,1	1,00	32,0
44		11 - 20	8,00	7,50	35,40	2,78	1,61	0,15	10,7	0,80	24,2
45		21 - 40	7,98	7,44	38,35	1,93	1,12	0,11	10,2	0,40	20,1
46	OPIV/4	0 - 10	7,86	7,27	45,85	4,08	2,37	0,19	12,5	1,80	23,0
47		11 - 20	7,96	7,40	15,85	3,38	-	0,12	16,3	0,60	25,0
48		21 - 40	7,76	7,30	17,90	3,38	1,96	0,12	16,3	0,50	22,2

The soil was fertilized twice, in the spring of 2003, with approximately 2.85 tonnes per hectare or around 300 kg/ha of active matter (170 kg/ha of easily available nitrogen, 95 kg/ha of easily available phosphorus and 35 kg/ha of easily available potassium), and a “local ameliorative fertilisation” was performed around each plant. Local ameliorative fertilization was done with individual fertilizers: superphosphate and ammonium nitrate, and combined NPK fertilizers (20:10:10). This accounts for ameliorative fertilization. Additional fertilization was done in 2004 with N-fertilizers (potassium ammonium nitrate), using approximately 1.0 tonnes per hectare or 270 kg/ha of nitrogen as the active matter.

All samples of marly deposols in the beginning of the research period (prior to fertilization) are granulometrically classified as “clay” according to the USDA textural soil classification (textural triangle).

The dispersion of the observed deposol contained textural fractions of sand, silt and clay with colloids. The predominant fraction is clay with colloids ranging from 63.60% to 90.20%. The percentage of clay in the upper horizon (0-13cm) is slightly lower and ranges from 63.60% to 75.40%. Hygroscopic water, which is unavailable to plants since it is held by the soil too tightly for the root system to access, is present in percentages ranging from 3.55% to 7.61%.

During research between 2001 and 2005, the analysis of chemical properties of the soil in trial plots and subplots planted with black pine was based on soil samples taken at the end of 2002 (Table 2). This data was used as initial indicators of, primarily, macroelements, nitrogen, phosphorus and potassium, as well at the pH values of the soil solution, the amount of calcium carbonate, carbon content and the C/N ratio.

Table 2 shows a basic, moderately alkaline reaction of the soil solution ranging from 7.48-8.20 in H_2O to 7.2-7.65 in $CaCl_2$ at 0-40 cm. The amount of calcium carbonate ($CaCO_3$) ranges from 12.45% in OPIII/2 at 11-20 cm to 50.95% in OPI/1 at 11-20 cm. Topsoil waspresent at 0.72% in OPIV/2 (at 0-10 cm) up to 6.25% in OPII/4 at 11-20 cm, which is probably due to the presence of larger quantities of coal dust. Nitrogen is present at 0.10% in OPI/2 at 11-20 cm, up to 0.27% at 0-10 cm in OPI/1. The carbon/nitrogen ratio (C/N) ranges from 10.1% in OPIV/2 at 0-10 cm to 21.5% in OPII/3 at 21-40 cm.

Easily accessible phosphorus in the form of P_2O_5 was present in amounts ranging from 0.2 mg per 100 g of soil in OPII/3 and OPIV/2 at 21-40 cm to 3.4 mg per 100 g of soil in OPII/4 at 0-10 cm. Easily accessible potassium in the form of K_2O was present in amounts ranging from 19.2 mg per 100 g of soil in OPIV/1 at 21-40 cm to over 40 mg per 10 g of soils in OPI/3, OPII/2 and OPIV/2 at 21-40 cm and OPII/4 at 0-10 cm.

a. Physical properties of the deposol at the end of the study

Table 3 shows the physical characteristics (features) of soil sampled at the end of 2005 at the more moist version of deposol (Great Western Depot) and the drier version of deposol (Northern Depot) at the following depths: 0-10 cm, 11-20 cm and 21-40 cm. Percentages of hygroscopic water content and granulometric data is shown for each of the 16 trial subplots.

The mechanical structure of the soil, i.e. the composition of soil particles of different sizes was shown using the international soil particle classification by Scheffer/Schachtschabel (1956, according to Otoropec, S, 1991), without showing particles over 2 mm, because there were none in the samples (Maksimović M. 2010.)

Table3. – Physical properties of the soil at the end of research period

No.	Deposol type (landfill)	Trial subplot	Depth (cm)	Hygros. water (%)	Granulometric composition(%)							
					2,0-0,2 mm	0,2-0,06 mm	0,06-0,02 mm	0,02-0,006 mm	0,006-0,002 mm	< 0,002 mm	Total Sand	Total Clay +silt
1.	More moisture (Great Western Landfill)	OPI/1	0 - 10	3,56	0,3	14,0	10,3	20,0	19,4	36,0	24,6	75,4
2.			11- 20	2,88	0,6	10,6	11,9	23,8	17,8	35,3	23,1	76,9
3.			21 - 40	2,63	0,4	3,8	4,1	16,9	21,8	53,0	8,3	91,7
4.		OPI/2	0 - 10	5,95	1,3	7,2	10,8	17,0	15,5	48,2	19,3	80,7
5.			11 - 20	4,14	0,4	5,2	5,2	15,6	18,8	54,8	10,8	89,2
6.			21 - 40	3,08	0,4	1,1	2,9	10,2	21,6	63,8	4,4	95,6
7.		OPI/3	0 - 10	4,11	1,8	8,1	10,3	14,9	17,2	47,7	20,2	79,8
8.			11 - 20	3,49	1,5	3,4	5,7	16,9	17,3	55,2	10,6	89,4
9.			21 - 40	3,66	0,8	6,7	5,2	16,1	18,8	52,4	12,7	87,3
10.		OPI/4	0 - 10	3,83	2,4	11,9	11,8	18,2	13,7	42,0	26,1	73,9
11.			11 - 20	3,83	2,1	7,3	10,0	20,2	14,7	45,7	19,4	80,6
12.			21 - 40	3,47	2,6	12,8	10,1	17,6	14,3	42,6	25,5	74,5
13.		OPII/1	0 - 10	3,28	2,2	12,6	7,2	17,2	16,8	44,0	22,0	78,0
14.			11 - 20	2,91	1,4	5,8	7,1	22,6	19,1	44,0	14,3	85,7
15.			21 - 40	2,70	1,3	9,4	6,8	19,9	18,9	43,7	17,5	82,5
16.		OPII/2	0 - 10	2,95	1,3	7,5	14,4	7,8	19,6	49,4	23,2	76,8
17.			11 - 20	2,93	0,9	5,9	5,0	16,6	25,2	46,4	11,8	88,2
18.			21 - 40	2,99	0,7	1,3	4,1	10,1	25,8	58,0	6,1	93,9
19.		OPII/3	0 - 10	3,25	0,6	5,3	11,3	22,6	23,0	37,2	17,2	82,8
20.			11 - 20	2,86	0,3	6,6	10,0	18,4	25,5	39,2	16,9	83,1
21.			21 - 40	2,66	0,3	8,6	9,8	24,7	21,8	34,8	17,7	81,3
22.		OPII/4	0 - 10	3,92	1,5	13,6	8,7	19,9	17,5	38,8	23,8	76,2
23.			11 - 20	3,35	0,5	11,2	14,4	19,2	19,1	35,6	26,1	73,9
24.			21 - 40	3,44	1,0	11	12,9	20,5	20,9	33,7	24,9	75,1
25.	Less moisture (Northern Landfill)	OPIII/1	0 - 10	3,2	0,6	12,1	10,5	22,9	18,5	35,4	23,2	76,8
26.			11 - 20	3,11	0,6	10,1	15,4	17,9	20,4	35,6	26,1	73,9
27.			21 - 40	3,06	1,3	10,5	12,0	20,7	21,0	34,5	23,8	76,2
28.		OPIII/2	0 - 10	3,46	1,3	10	14,8	19,5	16,0	38,4	26,1	73,9
29.			11 - 20	3,16	1,1	9,5	11,6	22,3	19,5	36,0	22,2	77,8
30.			21 - 40	3,36	2,0	10,9	12,3	22,6	15,2	37,0	25,2	74,8
31.		OPIII/3	0 - 10	3,20	0,7	8,1	15,7	22,5	17,2	35,8	24,5	74,5
32.			11 - 20	3,26	1,0	12,9	13,9	17,4	21,0	33,8	27,8	72,2
33.			21 - 40	3,22	0,3	9,5	13,5	26,7	15,9	34,1	23,3	76,7
34.		OPIII/4	0 - 10	3,84	0,3	9,1	12,4	21,8	17,2	39,2	21,8	78,2
35.			11 - 20	3,81	0,4	5,3	12,5	22,7	16,6	42,5	18,2	81,8
36.			21 - 40	4,00	0,3	5,0	8,8	19,1	15,3	61,5	14,1	85,9
37.		OPIV/1	0 - 10	4,10	0,5	17,8	4,0	22,6	15,5	39,6	22,3	77,7
38.			11 - 20	3,47	2,5	6,8	12,1	22,0	15,8	40,8	21,4	78,6
39.			21 - 40	3,06	1,8	12,6	12,3	22,7	14,1	36,5	26,7	73,3
40.		OPIV/2	0 - 10	3,84	0,7	6,4	13,1	23,7	16,9	39,2	20,2	79,8
41.			11 - 20	3,62	0,9	9,1	11,9	24,2	15,3	38,6	21,9	78,1
42.			21 - 40	3,34	0,7	10,2	13,3	23,7	16,4	35,7	24,2	75,8
43.		OPIV/3	0 - 10	3,62	2,1	6,6	13,3	26,2	14,0	37,8	22,0	78,0
44.			11 - 20	3,73	0,9	7,3	11,2	22,1	15,8	42,7	19,4	80,6
45.			21 - 40	3,67	1,5	6,7	11,3	24,4	20,0	36,1	19,5	80,5
46.		OPIV/4	0 - 10	3,60	0,5	14,4	15,2	23,1	18,0	28,8	30,1	69,9
47.			11 - 20	3,59	0,7	14,1	12,7	25,3	17,2	30,0	27,5	72,5
48.			21 - 40	3,34	1,1	11,2	15,5	18,0	20,0	34,2	27,8	72,2

Table 3 contains physical properties of the soil and shows that hygroscopic water ranges from 2.63% (OPI/1 at 21-40 cm) to 5.95% (OPI/2 at 0-10 cm). The average percentage of hygroscopic water in all samples from trial plots and subplots decreases with increasing depth, showing the following values: 3.73% at the 0-10 cm surface level, 3.38% at 11-20 cm and 3.23% at 21-40 cm.

Table 4. – Soil textural class at the end of the research period, 2005

Deposol type (depot)	Trial plot	Trial subplot	Depth (cm)	Sand (%)	Clay (%)	Silt (%)	Total %	Textural class
More moisture (Great Western Landfill)	OPI	OP I/1	0 – 10	14,3	36,0	49,7	100	Silty clay
			11 – 20	11,2	35,3	53,5	100	Silty clay
			21 – 40	4,2	53,0	42,8	100	Clay
		OP I/2	0 – 10	8,5	48,2	43,3	100	Silty clay
			11 – 20	5,6	54,8	39,6	100	Clay
			21 40	1,5	63,8	34,7	100	Clay
		OPI/3	0 – 10	9,9	47,7	42,4	100	Clay
			11 – 20	4,9	55,2	39,9	100	Clay
			21 – 40	7,5	52,4	40,1	100	Clay
		OPI/4	0 – 10	14,3	42,0	43,7	100	Silty clay
			11 – 20	9,4	45,7	44,9	100	Silty clay
			21 – 40	15,4	42,6	42,0	100	Loamy clay
	OPII	OPII/1	0 – 10	14,8	44,0	41,2	100	Silty clay
			11 – 20	7,2	44,0	48,8	100	Silty clay
			21 – 40	10,7	43,7	45,6	100	Silty clay
		OPII/2	0 – 10	8,8	49,4	41,8	100	Clay
			11 – 20	6,8	46,4	46,8	100	Clay
			21 – 40	2,0	58,0	40,0	100	Clay
		OPII/3	0 – 10	5,9	37,2	56,9	100	Silty clay
			11 – 20	6,9	39,2	53,9	100	Silty clay
			21 40	8,9	34,8	56,3	100	Silty clay
		OPII/4	0 – 10	15,1	38,8	46,1	100	Loamy clay
			11 – 20	11,7	35,6	52,7	100	Silty clay
			21 – 40	12,0	33,7	54,3	100	Silty clay
Less moisture (Northern Lanfill)	OPIII	OPIII/1	0 – 10	12,7	35,4	51,9	100	Silty clay
			11 – 20	10,7	35,6	53,7	100	Silty clay
			21 – 40	11,8	34,5	53,7	100	Silty clay
		OPIII/2	0 – 10	11,3	38,4	50,3	100	Silty clay
			11 – 20	10,6	36,0	53,4	100	Silty clay
			21 – 40	12,9	37,0	50,1	100	Silty clay
		OPIII/3	0 – 10	8,8	35,8	55,4	100	Silty clay
			11 – 20	13,9	33,8	52,3	100	Silty clay
			21 – 40	9,8	34,1	56,1	100	Silty clay
		OPIII/4	0 – 10	9,4	39,2	51,4	100	Silty clay
			11 – 20	5,7	42,5	51,8	100	Silty clay
			21 – 40	5,3	61,5	43,2	110	Clay
	OPIV	OPIV/1	0 – 10	18,3	39,6	42,1	100	Loamy clay
			11 – 20	9,3	40,8	49,9	100	Silty clay
			21 – 40	14,4	36,5	49,1	100	Silty clay
		OPIV/2	0 – 10	7,1	39,2	53,7	100	Silty clay
			11 – 20	10,0	38,6	51,4	100	Silty clay
			21 – 40	10,9	35,7	53,4	100	Silty clay
		OPIV/3	0 – 10	8,7	37,8	53,5	100	Silty clay
			11 – 20	8,2	42,7	49,1	100	Silty clay
			21 – 40	8,2	36,1	55,7	100	Silty clay
		OPIV/4	0 – 10	14,9	28,8	56,3	100	Silty clay
			11 – 20	14,8	30,0	55,2	100	Silty clay
			21 – 40	12,3	34,2	53,5	100	Silty clay

The textural classes of soil determined in 2005 at the end of the study(Table 4) are: silty clay in 34 samples, clay in 10 samples, loamy clay in three samples and silty loam in one sample. These textural classes show high percentages of clay soil (clay, silty clay, loamy clay), with good chemical and poor physical properties, high water holding capacity, low permeability, high nutritional content and high sorption capacity. Therefore, this soil is biologically inactive, difficult to till, cold and favourable for plants with high demands for good chemical more so than physical characteristics.

The most favourable ratio of sand, clay and silt for forest production is 40:20:40. Silty clay is the closest to this ratio, and is dominant in all samples, particularly at the depth of 0-10 and 11-20 cm, and silty loam registered in only one sample at the depth of 0-10 cm (OPIV/1).

4. CONCLUSION

The physical properties of soil under influence of black pine stands in Ugljevik's mine tailings landfills change at a slower rate than chemical properties. The hygroscopic water content decreased slightly and ranges from 2.63% (OPI/1 at 21-41 cm) to 5.95% (OPI/2 at 0-10 cm). The average percentage of hygroscopic water in all subplot trials, contrary to the situation in 1999, decreases with increasing depth: 3.73% at 0-10 cm, 3.38% at 11-20 cm and 3.23% at 21-40 cm.

The determined texture classes of soil at the end of the study are: silty clay in 34 samples, clay in 10 samples, loamy clay in three samples and silty loam in one sample. Silty clay is closest to the most favourable 40:20:40 ratio of sand, clay and silt. The textural class of soil indicated a high percentage of clay soil, whose unfavourable physical properties classify it as a moderately fertile soil, very prone to compaction, siltation and crusting.

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ECOLOGICAL CONSEQUENCES OF DEGRADATION OF LAND IN THE FIELD OF THE CITY OF THE PRIJEDOR AND THE MEASURES OF PROTECTION

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ABSTRACT

The city of Prijedor has significant land areas and mineral resources deposits (iron ore, clay, gravel, etc.). These natural resources represents a significant precondition for the development of primary and processing capacities in the field of exploitation of mineral resources, agriculture, and other forms of economic activities. At the same time, the development of these activities poses a potential danger that unplanned and uncontrolled land use, and failure to comply with the principles of sustainable development, will significantly impede the environment in this area. The use and exploitation of land in the area of the city of Prijedor has so far taken place to a significant extent without planned, organized and systematic implementation of protection measures. One of the most significant forms of land degradation is the unplanned and irrational exploitation of mineral resources without implementing the program of remediation of degraded areas. Other forms of soil endangerment through uncontrolled use of chemicals in agriculture, uncontrolled disposal of solid and hazardous waste, and inadequate land management systems are also significantly present. These phenomena were manifested through the appearance of significant degraded land surfaces after the exploitation of mineral resources and the pollution of the soil through the accumulation of various pollutants leading to significant ecological consequences. Since land represents an extremely important natural resource and ecosystem base and natural values, it is necessary to establish an adequate and high quality protection system. To this end it is necessary to fully respect the principles of sustainable development through the conceptualized and planned development and use of the land, to implement the programs of remediation of degraded areas in a timely manner, to establish control over the use of chemicals in agriculture, as well as to conduct systematic soil monitoring in the area of Prijedor.

Key words: land, degradation, environment, protection measures

1. INTRODUCTION

Economic activities in the area of the Prijedor city are significantly based on the exploitation of the mineral resources and agricultural production. These activities involve the use and exploitation of the land that inevitably leads to endangering of this resource and the quality of the environment. Mineral raw materials and their exploitation with no measures for remediation of degraded areas, represent a significant ecological problem, since the exploitation of these raw materials results in a disturbance of the balance of the environment. Degradation and pollution of the soil are caused by other activities and primarily the use of chemicals in agriculture, uncontrolled disposal of solid and hazardous waste, discharge of wastewater, etc.

The pollution of land is the process of introducing the various solid, liquid and gaseous materials into the soil. This leads to their accumulation in the soil with significant changes in its structure. When the accumulation crosses the critical boundary, there are their harmful manifestations. Land degradation is mainly caused by heavy metals, pesticides, heterocyclic hydrocarbons, etc.

For the successful implementation of the protection measures of land as a natural resource, it is necessary to undertake a whole range of planned and organized measures, and to adopt and implementation of the programs for remediation of degraded areas, controlled use of chemical resources in agriculture, implementation of systematic monitoring of land and remediation of the illegal landfills.

2. METHOD OF WORK

The results of this paper are based on the analysis of the existing state and potential possibilities for degradation and soil pollution in the area of Prijedor. The analysis was carried out on the basis of collecting and processing of data from development and urban planning and spatial planning documents adopted in the area of Prijedor. In order to determine the forms of degradation and soil pollution and their ranking, the empirical method of separation was used. Within the framework of this analysis, interviewing was carried out of individuals who are closely specialized in carrying out certain professional tasks in the field of agriculture, environmental protection, spatial planning, etc. In order to that the results can to be relevant the interviewing was focused on the representatives and managers of institutions and enterprises in the field of agriculture and environmental protection as well as competent inspection from these areas.

3. RESULTS

3.1. The basic characteristics of the land in the area of municipality Prijedor

The land is one of the basic resources and environments for the emergence and survival of life in general and also provides a basis for the immediate development of the plant world, and indirectly the animal world and human civilization.

The municipality of Prijedor has 83,406 ha of land, of which agricultural land covers an area of 48,370 ha (57,99%), with 44,123 ha (52.9%) of arable agricultural land. Lands and gardens as the most fertile land cover an area of 37,333 ha, while meadows, orchards and vineyards cover an area of 7,149 ha (orchards 2,404 ha, meadows 4,740 ha, vineyards 5 ha). Pasture area is 4,263 ha, fishponds 1,300 ha, while 3,974 ha of total land area belongs to infertile land.

The city of Prijedor has relatively small areas where intensive production can be realized, and in the planning process, the need for their protection is imposed. The specific goals and general commitments of the wider social community regarding the protection of agricultural land, as an inseparable resource, are binding on the consistency in the planning of the protection of these areas.

The Ljubija metalogenetic area covers the area of about 1200 km^2, the northwestern part of the Republic of Srpska, with numerous mineral deposits. In particular, deposits of iron ore as metallurgical raw materials are dominant and partly as mineral pigments, then deposits and phenomena of: barite, fluorite, gypsum, limestone, dolomite, clay (kaolin, bentonite, ceramic and brick), quartz sand, coal, etc.

Deposits of mineral raw materials are with different morphogenetic type, origin and time of formation, and they are characterized by different degrees of study and research. In the area of municipality of Prijedor, three important raw material deposits and exploitation fields are existed [3]:

-RŽR- centralna rudišta Ljubija	150 ha
-RŽR- istočna rudišta Tomašica	170 ha
-Novi rudnici Omarska	200 ha
-Glinokop "Crna dolina"	18 ha
-Kamenolom " Drenovača "	18 ha
TOTAL	556 ha

The total area of the exploitation fields is 5,500 ha, with inland planes within, which occupy 556 ha. The total area of exploitation fields of central and eastern ore mines is 4,707 ha, of which 2,554 ha are used for central mining area (Ljubija), of which about 763 ha for the surface mines. The total area of the exploitation fields " Istočna rudišta " at the Tomašica site is 2,157 ha, of which about 520 ha belongs to the surface mines.

Locality Omarska is the only site on which iron ore is currently being exploited and covers an area of approximately 5,567 ha. On this site is intensive iron ore exploitation, which lead in the near future that the degraded areas in this area will be significantly higher, which will result in permanent changes in the natural environment. [5]

In the previous practice, RŽR "Ljubija", the land was mainly exploited for the needs of surface mines and by payment of compensation for the relocation of residential and commercial buildings, while the rehabilitation of degraded areas after the exploitation was completely ignored.

3.2. Land degradation areas in the area of Prijedor

The use of land for exploitation of ore deposits in the area of Prijedor municipality that takes place in open pits present the important ecological problem. The biggest ore deposits on the area of Omarska, Ljubija and Tomašica, so that by their exploitation there has been the significant land degradation in the zones of exploitation. By exploitation of ore deposits on the surface comes to land degradation and threats to the environment as a result of:

- exploitation of ore on the formed surfaces mines, which violates the regime of surface and underground waters,
- formation of waste dump area that leads to change of terrain configuration and disruption of the surface water flows,
- forming accumulation for the mud disposal, which take a large areas and cause change of ecological balance of the space,
- construction of mine infrastructure, the industrial platforms, roads etc., which completely changed the purpose of land.
-

The all these activities completely change the ecological and ambient characteristic of space within zones of exploitation that manifest through: in violation of ambient and spatial characteristics, endangerment of plant cover, violation of the regime of surface and underground water, degradation of air quality due to work of equipment, and process of ore separation.

3.2.1. Present forms of land pollution

Under the land pollution is concerned the process of entering the different solid, liquid and gas material in land. It is coming by their accumulation in land. When this accumulation crosses a critical point it leads to their harmful manifest to the soil characteristics. Soil pollution occurs due to the accumulation of heavy metals, pesticides, heterocyclic hydrocarbons as well as other chemical compounds that result from release of the municipal and industrial waters and uncontrolled waste disposal.

Under the influence of these substances mostly comes to the accumulation of pollutants and toxic substances in soil without visible damage but with the possible effects on the plants. Accumulation in certain parts of the plants has result in toxic effects on humans and animals.

The occurrences of degradation, or violation of quality of the environment because use of the chemical substances in agriculture and exploitation of ore causes a whole range of consequences that manifest in different ways and cause disorder of natural balance and compromise the health of the population. Figure 1 summarizes the causes of land pollution in the municipality Prijedor [2].

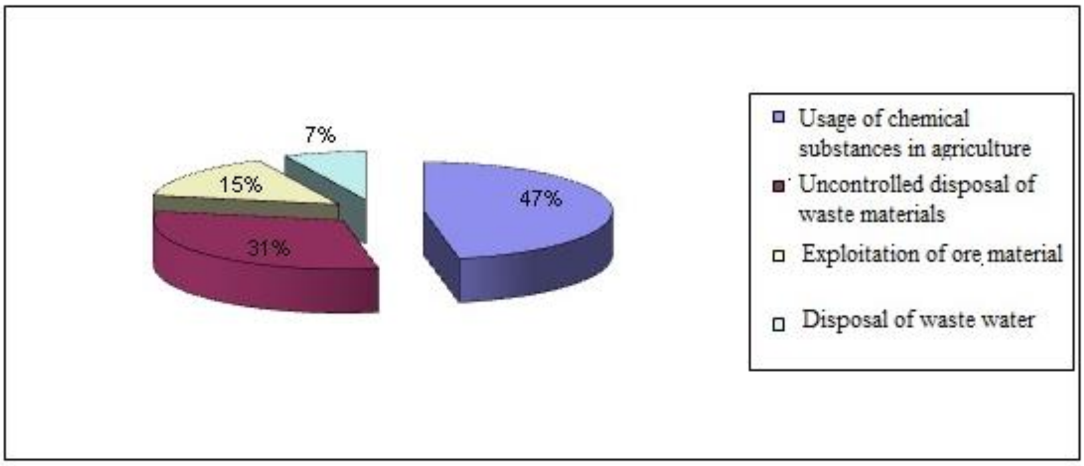

Figure 1. Layout of the most important causes of land pollution in the area of Prijedor

The most common form of damage - soil degradation in our area is the exploitation of ore (Figure 2), then the construction of settlements and industrial facilities in the areas of arable agricultural land.

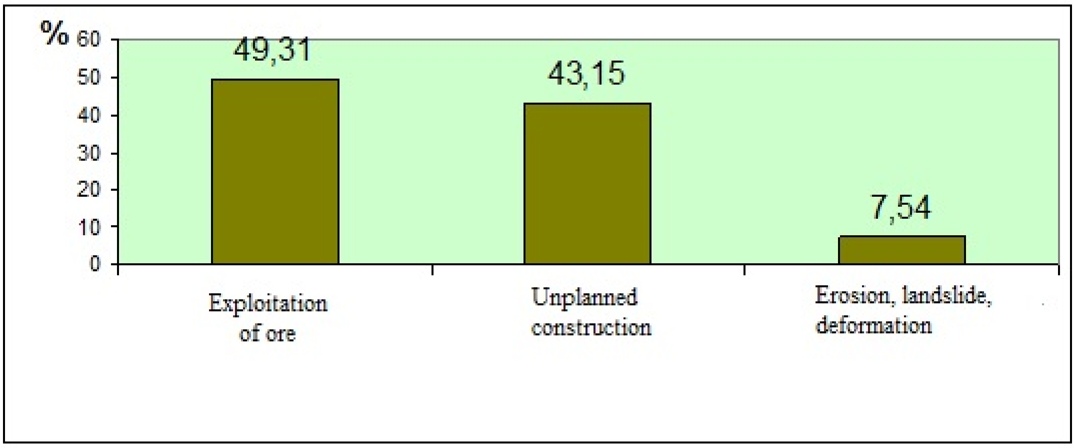

Figure 2. Layout of the most common forms of land damages in the area of Prijedor

When considering the functioning of the institutions responsible for land management or the execution of their tasks in the area of land protection, the most significant problem that manifests itself is the lack of systematic land monitoring (Figure 3), which prevents the adoption of adequate protection measures [2].

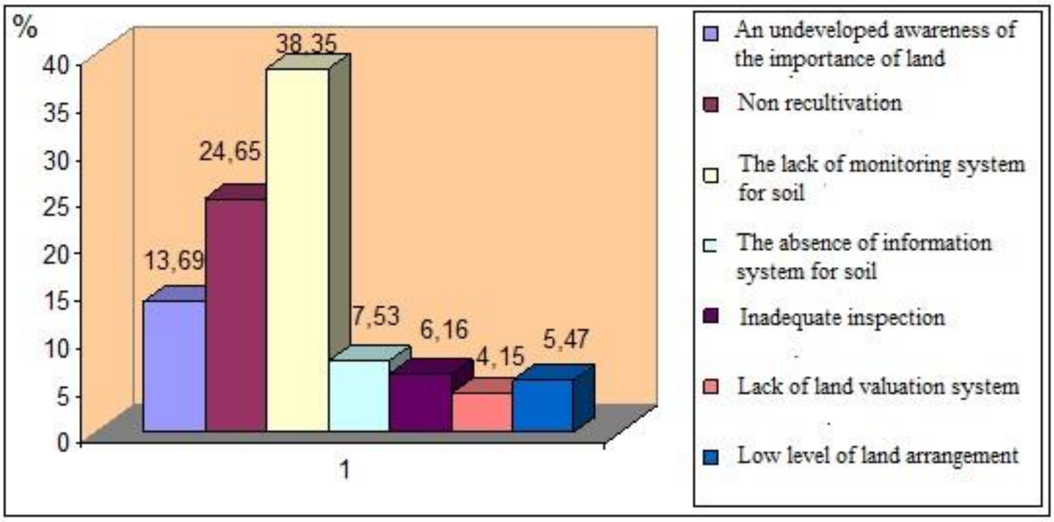

Figure 3. Layout of the current problems in the field of land management in the area of Prijedor

In order to protect the land as a natural resource, it is necessary to undertake a series of planning and organizational measures primarily through the adoption and implementation of the program of rehabilitation of degraded areas and the establishment of systematic monitoring of land. Overview of the measures that represent the most significant development of the land protection is shown in the Figure 4.

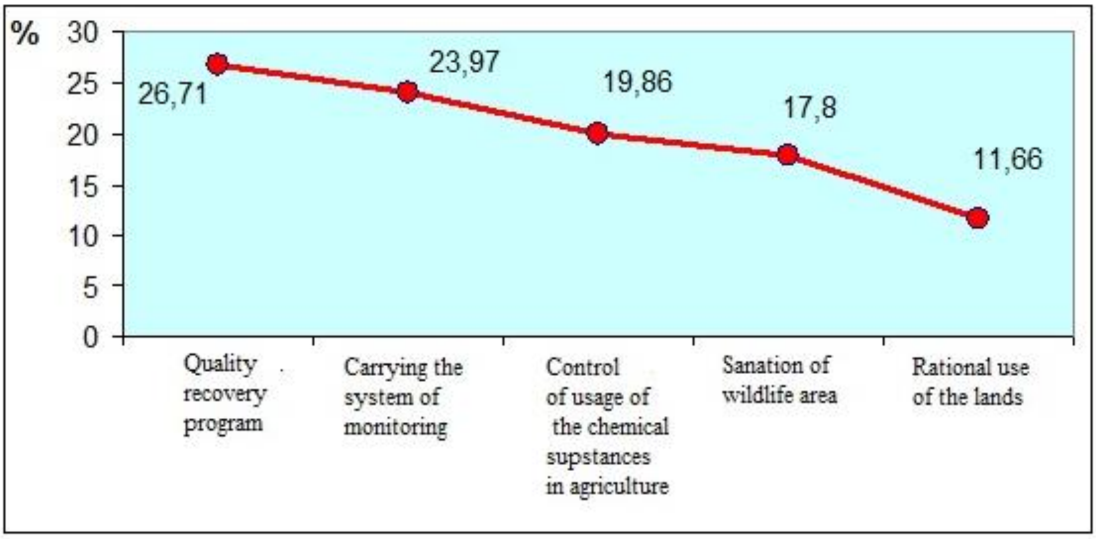

Figure 4. Layout of the measures that can give the most significant contibution of the land protection in the area of Prijedor

3.3. Management of the land and the present ecological consequences

In the area of the city of Prijedor, due to the unresolved issues of land management as a resource the following problems occur [3]:

- degradation of significant land surface, which represents a permanent loss of this extremely important natural resource in the area of Prijedor,
- increased soil contamination due to the presence of toxic substances - heavy metals, pesticides, detergents, etc.,
- increased soil contamination due to uncontrolled disposal of various types of solid and other waste,
- discharge of wastewater, without prior treatment, causes land pollution and significantly contributes to the degradation of its quality,
- increasing the areas affected by ambrosia as a weed plant,
- the occurrence of unplanned transformation of agricultural land into a constructional and permanent loss of quality agricultural land.

3.4. Causes of degradation and soil contamination

Degradation and pollution of land in the area of the city of Prijedor was caused due to unresolved issues of land management and non-compliance of the valid regulations and obligations in this area, as follows:

- entities that have carried out and exploited the mineral resources, after the exploitation, do not mainly have recovery of the degradation of land, causing the appearance of large areas of land unsuitable for agricultural production,
- a large number of resulting depressions are used for disposal of solid waste, which further contributes to the pollution of soil and groundwater,
- water accumulations in degraded areas are also susceptible to pollution, and infiltration pollutes the groundwater (a phenomenon particularly occurs in the protection zones of the source).

- the inexperienced use of pesticides and other chemicals in agriculture significantly contributes to soil contamination.
- the discharge of municipal and industrial waters, without their treatments, causes soil pollution by the various types of pollutants.
- arrangement the quality agricultural land into construction land, causing permanent loss and reduction of agricultural land.
- uncontrolled disposal of the various types of waste - the occurrence of wild dumps, which causes degradation of the quality of the land.
- the constant process of abandoning the rural areas and urbanization is contributed by the emergence of growing areas of infertile land and land that are not suitable for agricultural production, which has been affected by the increase in areas affected by weed plants, in particular by ambrosia.

This attitude towards the land as an extremely important natural resource has the consequence of permanent loss of high quality agricultural land and pollution of land, which can significantly affect the healthy status of the population.

3.5. The protection measures of soil in the area of Prijedor

In order to protect the land as important resource in the area of the city of Prijedor, it is necessary to ensure the implementation of protection measures as follows:

- adoption and implementation of the program for remediation of degraded areas caused by the exploitation of ore,
- the implementation of adequate control and control of the chemical agents used in the protection of agricultural products, and ensure their proper use,
- establishment of monitoring of soli quality, through regular control of parameters that are indicators of soil pollution,
- ensuring the rational use of available arable land and preserving the agricultural land,
- establish complete and high quality management of solid and hazardous waste and, or prevent the uncontrolled waste disposal in the area of Prijedor.
- adopt the normative and program documents in order to control the ambrosia - weed plant that is the cause of allergen emissions that significantly endangers the health of the population.
- ensure the application of the modern agrotechnical measures wherever possible, and by expanding agricultural land increase the utilization of soil for primarily organic food production.

4. CONCLUSION

1. Land degradation and pollution in the area of Prijedor is primarily due to unplanned and irrational use of land, as well as the occurence of various waste and chemical substances in the soil.
2. Degradation and pollution of soil in this area is primarily caused by the exploitation of mineral ore, uncontrolled disposal of solid and hazardous waste, as well as unprofessional and uncontrolled use of the chemicals in agriculture.
3. The occurrence of soil degradation through the exploitation of mineral ore leads to a change in the ecological and environmental characteristics of the areas in the exploitation zones.

4. The introduction of pollutants into the soil leads to their accumulation in soil and accumulation in certain parts of plants, which leads to their toxic effects on humans and animals.
5. Problems of the management of land resources in the area of the city of Prijedor are present due to the lack of systematic monitoring of the quality of the land, the lack of quality plans for recovery of degraded areas and the insufficiently developed awareness of the importance of the land.
6. Soil protection in our area can be achieved through the adoption and implementation of quality programs for remediation of the degraded areas, through the provision of systematic soil monitoring, better control of the use of chemicals in agriculture and through quality management of solid and hazardous waste.

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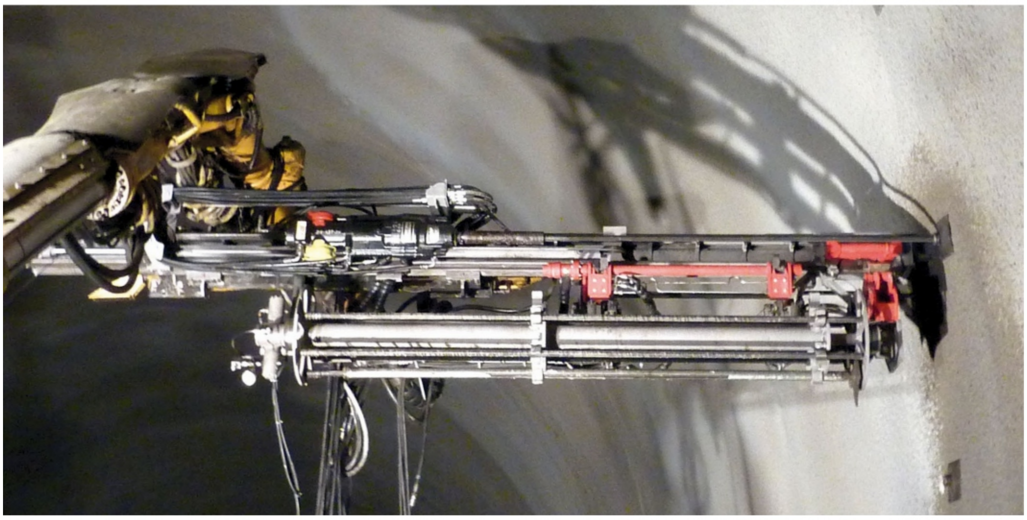

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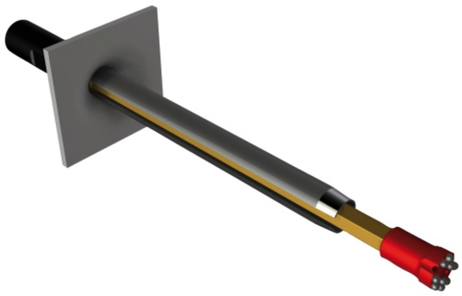

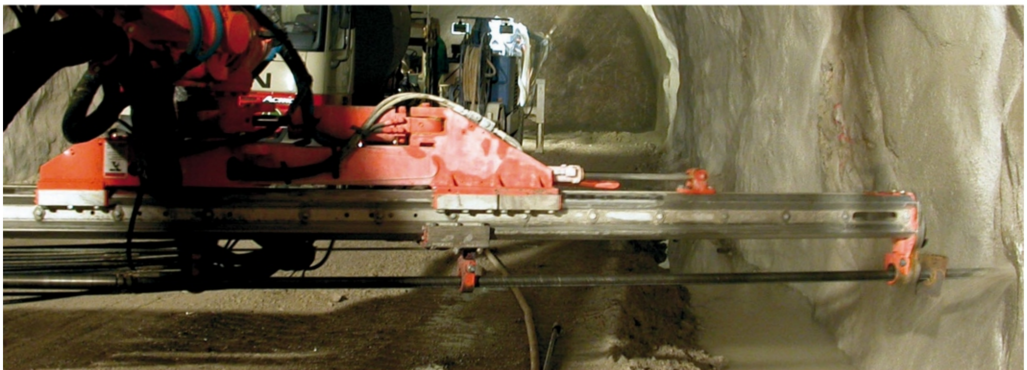

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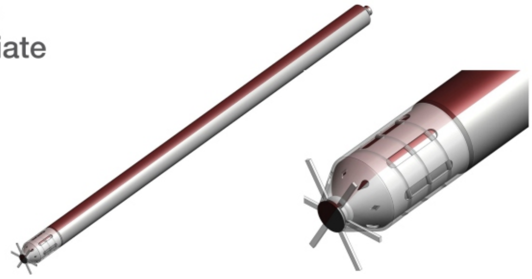

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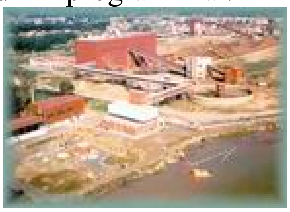
Rudnici željezne rude "Ljubija" a.d. Prijedor posluje kao akcionarsko društvo a eksploatacija se odvijala na tri rudnika, sa zaokruženim proizvodnim programima .



"Centralna rudišta Ljubija"
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"Omarska"
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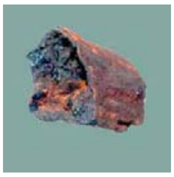
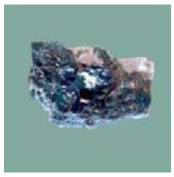
Tri izgrađena rudnika: "Ljubija", "Tomašica" i "Omarska" nalaze se jugozapadno, jugoistočno i istočno od grada Prijedora, na udaljenosti od 14 do 25 km. Rudonosno područje, odnosno Sansko-unski paleozoik, površine oko 1200 km2 zauzima prostor između Novog Grada- Prijedora-Bronzanog Majdana, Sanskog Mosta i Budimlić Japre.





Do 1992. godine Rudnici "Ljubija" su bili glavni snabdjevč željeznom rudom kapaciteta za proizvodnju čelika u Jugoslaviji.

U toku dosadašnjeg rada Rudnici željezne rude "Ljubija" Prijedor, su vlastitim znanjima razvili I proizvodnje: - prirodnih željeznih oksida - obrade metala eksplozijom - mašinskih dijelova i sklopova za strojeve i postrojenja - protektiranje pneumatika za teška-teretna i teretna vozila - sada "PROTECT" i- mjernih instrumenata (termometri, manometri u štednji likvidirano, ampermetri) i dr. .

Sa kompanijom ArcelorMittal osnovano je zajedničko preduzeće 2004. godine na paritetu 51:49 u korist ArcelorMittala i pokrenuta proizvodnja željezne rude koja je i danas aktivna. Dostignuti kapacitet proizvodnje iznosi do 2,2 mil. t/god. koncentrata željezne rude.

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ArcelorMittal Prijedor is a Joint Venture Company founded in August 2004 by ArcelorMittal Holdings and RŽR “Ljubija” a.d. Prijedor, ArcelorMittal Holdings being major shareholder with 51% share. Main activity is production of iron ores, developed in Buvač Surface Pit, in Omarska Mine. Employing 810 people we produce annually 1,7 mt to 2,1 mt. Till date we produced and dispatched 21,5 mt of concentrate. In production improvements, purchase of new equipment, development projects and local communities was invested over 100 million BAM.

Beside iron ores we also produce limestone fractions of various grain sizes, being used internally and externally for civil construction works. We also provide mechanical and electrical maintenance services and transportation of goods and people.

Main focus is on Health and Safety of our employees, long-term sustainable business and care for our communities. ArcelorMittal Prijedor is certified with ISO 9001,ISO 14001 and OHSAS 18001. We have received several awards for business excellence and corporate responsibility from RS Chamber of Commerce, City of Prijedor and International Community.

With our values: Quality, Sustainability and Leadership we are trying to transform tomorrow for our employees, their families, our communities and overall economy of RS and B&H.

The University of Banja Luka

The University of Banja Luka, founded on November 7, 1975 and comprising of 17 faculties today, is the leading higher education institution in the Republic of Srpska and the second largest one in the whole of Bosnia and Herzegovina.

At the moment, there are 811 fully employed professors and teaching assistants, 342 professors working part-time, and 175 visiting professors, the administration of the University totaling 559 employees.

So far, the University has produced 31,500 graduates, 700 hundred specialists, 1,150 MA/MSc and 600 PhD degree holders respectively, with 20,000 students currently enrolled at its study programmes.

University of Banja Luka is a member of the European University Association – EUA and is a signatory of the Magna Charta Universitatum. The University is a member of the International University Network for Academic and Research Cooperation, the General Assembly of Interuniversity Centre for Research and Cooperation with Eastern and South-Eastern Europe (CIRCEOS), UniAdrion universities network with headquarters in Ancona, Italy, EMUNI foundation with headquarters in Slovenia and the Agency for Francophone Universities (AUF).

Faculty of Mining

The Faculty of Mining was established in 2009. It grew out of the Mining Department at the Faculty of Technology, in which the first generation of students was enrolled in the academic year 1997/1998, into the Faculty of Mining Engineering as part of the University of Banjaluka with the headquarters in the city of Prijedor.

The first cycle studies are held at the study program of Mining Engineering while the second cycle studies are held at the study program of Mining and Geology Engineering.

The Mining Engineering study program is based on the three-stage model (4+1+3).

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