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DISTRIBUTION OF THE QUALITY PARAMETERS (CaCO_3 and SiO_2) IN THE CARBONATE DEPOSIT (LIMESTONE AND CHALK) SPASINE - BRDJANI NEAR UGLJEVIK

Abstract

For the needs of desulphurization of flue gases, the Mine and Thermal Power Plant Ugljevik have found the necessary absorbent (limestone) in the immediate vicinity. The deposit of carbonate mineral raw materials (limestone and chalk) Spasine - Brdjani is defined by detailed geological exploration in which the sodality in distribution the main quality parameters (CaCO_3 and SiO_2) is observed.

Keywords: *flue gas desulphurization, detailed geological explorations, quality parameters, distribution*

INTRODUCTION

The Thermal Power Plant Ugljevik, installed power of 300 MW, uses the brown coal as a fuel for the production of electricity that is exploited by the open pit Bogutovo Selo. The brown coal of the deposit of Bogutovo Selo is characterized by the increased sulfur content (5-6% S). By the coal combustion, as one of the flue gases, sulfur dioxide is released; whose concentration in the air exceeds the allowed limit. From the aspect of environmental protection, primarily the air pollution, the process of flue gas desulphurization (FGD) in the dependent company Mine and Thermal Power Plant has become inevitable. After providing the financial resources for these activities, a Conceptual Study was developed in which one section explores the possibility of supply the limestone (absorbent) for the mentioned process and where it is proposed to find the solution in the surroundings of Ugljevik, known for the presence of a huge carbonate massif.

After this, the preliminary explorations have begun, which in the end resulted in a

fact that it is completely justified to conduct the detailed geological explorations.

Taking into account a number of important factors (level of exploration, distance, density, connectivity with the open pit and landfill, transport, etc.), a commitment was to perform the detailed geological explorations at the site Spasine-Brdjani which is close to the Mine and TPP.

The explored area is 1x1km. Detailed geological explorations were carried out in two phases on a larger surface with the aim to separate the deposit segments with the good quality indicators that were pre-set. Already after the first phase of the exploration where the net of drill holes was 160x160 m, it was noticed that the essential parameters of the quality were better in the northern part of the deposit. Then, in the second phase, the dense network was used to reexplore this part of the deposit. The results justified the needs, so in the end, the area of the deposit with the good quality indicators was defined, which significantly exceeded the required quantities of car-

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bonates (absorbent) in reserves, but provided the possibility for leveling the quality as well as the possibility of starting the exploitation in the best part of the deposit.

All exploration works, types of tests, as well as the subsequent separation of the ore bodies that are not only expressed to their geological differences and specificities, but also the qualitative characteristics that determine them, have been designed and processed, that is, analyzed in a function of carbonate similarity for the FGD process.

The Ugljevik Mine and Thermal Power Plant is located in the northeastern part of the Republic of Srpska at the place where the Semberija plain passes into the hills of the Majevica Mountain, about 20 kilometers from the town of Bijeljina.

GEOLOGICAL STRUCTURE OF THE DEPOSIT

Based on the data of exploratory drilling and field geological mapping, it has been found that the explored deposit is mostly built by the Badenian chalk and limestone (M_2^1), and Sarmatian limestone (M_2^2) as an interesting mineral resource, and from an economic point of view the productive area and quartar formation (Q): eluvial-deluvial sediments of insignificant thickness, which for these reasons are not shown on the geological map.

Badenian chalk and subordinate limestones (M_2^1)

The deposits of the Badenian chalk and limestone were deposited over the Upper Badenian massive and laminated marls. This is a clearly defined unit that is mostly built by three lithologically different members (ore bodies): dusty, compact and solid chalk that is often permeated by layers to the sandy limestone.

Dusty chalk M_2^1 - krd(p) is in the surface, whereby changing the color and con-

tent of calcium carbonate gradually shifts from gray marls into this article, characterized by the fact that "the content of silicon in limestones with depth is increased, due to the presence of siliceous spicules sponges in the older parts of the explored profiles" (Vrabac, 2014). It contains lithotamian, shellfish: *Corbula* cf. *gibba* Olivi., *Venus* cf. *Multilamela* (LAMARCK), *Tellina* sp., *Martinottiella* sp., *Xestoleberis* sp. and spicules *Spongiae*, as well as a very large association of benthic foraminifers and ostracodes. Thickness of this type of chalk reaches 30 meters.

Compact chalk M_2^1 - krd(κ) is made by lithotamian limestone (calcarettes) with shall fish *Flabellipecten* cf. *besseri* (ANDRZEJOWSKY), *Lucinoma* cf. *borealis* (LINNE), *Amphistegina* sp., *Elphidium crispum* (Linne), *Planostegina* sp., *Hydrobia* sp., *Turitella* sp., *Xestoleberis* sp., and fragments of *Ostrea* sp., many remains of microcfauna foraminifera, ostracoda, coral and *briozoa*. The largest thickness of this type of chalk is 30.2 m.

Solid chalk M_2^1 - krd(č) was not found in any drill hole. However, it was discovered in sections of human-made activity (open pits) in the far western part of the exploration area. It is a variety of chalk, extremely solid, from which the blocks are made as a fundament, or bearing parts of residential buildings.

Lower Sarmatian limestone, chalk, sandstone and clay (M22)

Deposits of the Lower Sarmatian (ore body) lie, most likely, concordant on the Upper Badenian in a greater part of the field. The boundary is noticeable because the Lower Sarmatian limestones are deposited over the Upper Badenian deposits of chalk, which is a correctness found both in the drill holes as well as in the field.

Figure 1 Geological map of the deposit ($R \approx 1:10\,000$)

The older portion of the Lower Sarmatian is made of make Mohrensternia layers while the younger part of the Lower Sarmatian is proven by molluscs *Poliaptes cf. tricusps* (EICHWALD), *Obsoletiforma absoleta cf. vindobonensis* (LASKAREV), *Cardiidae*, *Modiolus* sp., *Granulolabium* sp., *Gibbula cf. picta* (EICHWALD) and *Hydrobia* sp (Vrabac,S. 2014).

It was observed that the Lower Sarmatian mollusks are preserved in the form of

prints eyelids and molds, while largely preserved mollusks are present in the Cre-taceous sediments of the Upper Badenian.

Quaternary deluvial-eluvial sediments (Q)

These rocks are represented by the surface clays and clays with the limestone debris whose thickness reaches almost 15 meters.

Figure 2 Litostratigraphic column of the Badenian and Lower Sarmatian sediments

It can be said that the carbonate rocks, generally, mild (up to 10 degrees) fall to the north-northeast, making a mild monoclinic structure, too.

Geological explorations of the deposit

Methodological observations of the field explorations of the deposits were done by the geological mapping of the field, exploratory drilling, and development of trenches and open mining works.

Detailed geological mapping has selected the prospective members of the carbonate series of sediments, defined for practical reasons as the ore bodies. The results of laboratory tests have fully confirmed this determination of the ore bodies, because they, apart from the geological ones, also possessed the characteristic qualitative parameters in which they differed.

Thus, under the carbonate raw materials, in geological terms, they include:

- sediments of chalk (ore body 3 - dusty to sandy chalk, ore body 2 - compact chalk - lithotamian limestone),
- as well as the deposits of hard, compact Sarmatian limestones (ore body 1).

During explorations, the 27 exploratory drill holes, 26 exploratory trenches and two test-exploitation excavations were carried out. The total of 1,066 partial and 212 complete tests were tested from the laboratory testing for the purpose of testing the quality of mineral raw materials.

In addition to these, the test of grain size distribution, factors of looseness and cohesion, determination the physical-mechanical and deformation characteristics, determination the volume mass, petrographic, diffractometric and paleontological tests, reactivity,

Bond index, Mn, Zn, Cu, Co and Cr metals were analyzed and realized the experimental technological tests.

The activities that preceded the phases of detailed geological explorations and which included the calculations of coal combustion, theoretically calculated and measured values of the emission of harmful gases, obtaining a corrective factor, and finally the measurement of flue gases (degree of flue gas flow and amount of pollutants (2012) are shown in Table 1:

Table 1 *Designed requirements regarding the quality of absorbents
(Main Desing of construction the FGD plant)*

	Unit measure	Range	Designed
CaCO ₃	wt-%	85 – 100	< or = 94.0
MgCO ₃	wt-%	< 2	< 2
SiO ₂	wt-%	< 5	< 3
Fe ₂ O ₃	wt-%	< 1	< 1
Other	wt-%	difference to 100	difference to 100
H ₂ O	wt-%	to approx. 10%	
Bond index	Wi	3.0 – 10.0	5.0
Particle size (delivered)	Mm	max. 20	max. 20
Reactivity	--	Be determined by the contractor	
• Only as information	Titration of HCl at a constant pH value after 3 minutes	> 50%	

The basic parameters of quality were:

- Available Ca or reactivity
- Low content of inert elements
- Impact on the quality of obtained product
- Impact on wastewater treatment
- Particle size/grain size (less = better)
- Special grinding facilities depend on the limestone grindability (Bond Working Index)

Considering the content of inert elements, the same must be below 5%. Particularly important is the share of MgO. Namely, a part of MgO is inert, especially if it is in the form of dolomite, but a part is soluble, and the presence of MgO ions in solution improves the process, so that the content of this element of 0.8-2% is preferred. The other inert components such as Al, Si and Fe adversely affect the sulfur recovery process so that their presence should be in the following limits:

Al₂O₃ 0.4-0.8%. SiO₂ 0.8-1.5%. Fe₂O₃ 0.1-0.7%.

Analyzing the obtained quality parameters (CaCO₃, MgCO₃, SiO₂ and Fe₂O₃) and their synthesis, the appropriate maps were made for each of these parameters, as well as for each mining body separately.

DISCUSSION

It was immediately noticed that the percentage share of calcium carbonate rises to the north and that it has the highest (most favorable) values for each analyzed package (ore body). As it increases, the values of the other three parameters are reduced.

The values of the quality parameters for MgCO₃ and Fe₂O₃ are below the above designed units of measure, although they clearly decrease from the middle of deposit to the north. Due to these reasons, these parameters are not the subject of more detailed analysis.

The percentage content of CaCO_3 directly depends on the consumption of carbonates in the FGD process and the amount

of gypsum produced, and from SiO_2 the abrasive effect in the plants for absorbent preparation.

Figure 3 Contour of the CaCO_3 quality for the Sarmatian limestone (ore body 1)

Figure 4 Contour of the SiO_2 quality for the Sarmatian limestone (ore body 1)

Figure 5 Contour of the CaCO_3 quality for the compact limestone (ore body 2)

Figure 6 Contour of the SiO_2 quality for the compact chalk (ore body 2)

Distribution of calcium carbonate and silicon dioxide in the deposit is a product of various palaeogeographic conditions that dominated the Upper Badenian and Lower Sarmatian. Namely, regression in the Upper

Badenian and transgression in the Lower Sarmatian with changing the coastline and sea depth, as well as changes the salinity of the same, caused the distribution of quality parameters as in figures.

The sponges (*Spongie*), whose skeleton was formed from small spicules built of silicon (*silicispongia*), and which massively inhabited in the Badenian sea (eucharistic environment), were by a large part the carrier of SiO_2 in the shallow sea (lithoral-up to 200 m depth) of then Central Paratethicis. During the Lower Sarmatian, there was the sweetening of the sea (brachyaline environment) and a smaller spread of the sponges, until their complete absence (Vrabac, 2014 and 2015). The presence of silicispongi certainly affected the percent-age distribution of SiO_2 in the associated ore bodies. This is also visible on the quality map for SiO_2 of the Lower Sarmatian where the surface area with SiO_2 content is below 1%, than it is in Badenian (ore body 2).

Changes in the quality of CaCO_3 are small (the order of a few percent), but they are not random and are the product of very subtle changes caused by either the yield of some terrestrial material or certain difference in the types of organisms that inhabited the lithoral, or the difference in the constitution of their carbonate skeletons.

The mutual dependence of CaCO_3 and SiO_2 for the ore bodies 2 and 3 is evident on the quality maps. Their isolines of maximum values of CaCO_3 are almost identical to the contours of minimum values for SiO_2 within the same ore body.

In the initial phase of exploration, the realization of two test-exploitation excavations is planned. Only one was made due to the justified reasons, with the intention that the exploitation of carbonate mineral raw material starts from already open benches of the coal open pit. The first results were not favorable in that part of the exploration field, so in the second phase, the trial-exploitation excavation 2 was carried out, in the segment of the deposit where very good quality indicators were already indicated.

The place of opening of the open pit (quarry) is immediately imposed, because the easiest way to access the limestone and chalk of the best quality and with the least overburden is from the east side of the deposit from the benches of the northern land-fill, from the PEO-2 space. The opening of

the same from the west and north sides is excluded because this terrain is falling steeply, and the inhabited areas are in the foot.

CONCLUSION

The two phases of detailed geological explorations were carried out on the deposit of carbonates (limestone and chalk) Spasine-Brdjani with the aim of establishing their quality and reserves, which would serve as an absorbent in the desulphurization process of flue gases of the Thermal Power Plant.

It has been determined that for the pre-determined values of certain qualitative parameters there are spaces within the deposit that satisfy these qualities in their integrity.

Analyzing the quality maps for individual ore bodies, those areas with the best quality indicators are precisely defined, and their location in the space is a product of the paleogeographic circumstances that ruled in previous sea and its sweetness.

At the same time, the location from where the exploitation would start was also determined.

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