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LABORATORY TESTING THE GRINDABILITY OF CARBONATE MINERAL RAW MATERIAL OF THE SITE SPASINA BRDJANI – CHALK SAMPLES**

Abstract

This work presents the results of the Bond work index in a ball mill on samples of carbonate mineral raw material (chalk) of the site Spasina - Brdjani. Determination of the Bond Work Index was carried out on total of six samples of chalk from different exploration drill holes, as well as two samples of chalk from the exploration trenches. Comparing the results, it was found that in most cases the value of the Bond Work Index is between 2 and 3 Deviations, which means slightly higher values of Bond work index, were achieved in samples where the presence of alevrolyte interlayers was observed as well as a large concentration of calcified fossils. Very low value of the Bond Work Index 1,520 kWh/t was determined in chalk samples with high content of soft silty clayey component.
Keywords: *Bond work index, chalk*

INTRODUCTION

Considering the overall energy consumption in the exploitation and preparation of mineral resources, it was established that the major part (even 65 - 80%) is spent in the grinding process. Therefore, the assessment of energy consumption in the grinding process is of great importance, not only during the design of future plants, but also for monitoring the changes in grindability of mineral raw material whose processing is in progress. The Bond Work Index is used as an indication of this energy consumption [1,2]. In the case of carbonate mineral raw material from the site Spasina – Brdjani, the Bond Work Index is determined in the ball mill.

The explored area Spasina - Brdjani (narrower locality the Prokos hill) is situated at the extreme northeast hills of the mountain Majevica, at a distance of about 20 km southwest of Bijeljina. It was found that this area is characterized by limestone and associated sediments belonging to the Marine Middle Miocene of Central Paratetis - Baden and Sarmatian, and Quaternary formation – deluvial and proluvial sediments.

In the engineering - geological terms, this site is characterized by a complex of carbonate of different physical and mechanical properties. Higher areas are hypsometrically covered by compact rock

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masses of sand, loose to limestone cores, which in depth lean on a package of compact and loose chalk. In general, these carbonate sediments in terms of stability provide a solid rock mass and belong to the group of stable to conditionally stable terrains. In places of unstable slopes, where the sediments are subject to erosion and slipping, these environments are converted from stable into conditionally stable terrains in notches [3].

Detailed geological explorations of carbonate on the site Spasina - Brdjani included a series of exploration works which among other things included the exploration drilling and mining works (exploration trenches).

For the needs of determining the Bond Work Index, eight composite samples of chalk were selected, wherein the 6 samples were tested from the exploratory drill holes (in designation KR-2 to KR-14) and 2 samples from exploratory trenches (in designation R-13 and R-14). Table 1 shows the coordinates of corresponding drill holes or trenches.

Table 1 *Coordinates of realized exploration drill holes/trenches*

Designation of drill hole/trench	Coordinates			Interval of drill hole
	X	Y	Z	
KR-2	4 948 845.900	6 578 222.810	327.08	40.50-61.00
KR-3	4 948 990.670	6 578 212.520	331.88	36.00-76.00
KR-6	4 948 959.360	6 578 388.030	329.22	30.00-68.00
KR-9	4 948 981.690	6 578 503.420	330.01	30.30-60.60
KR-13	4 949 024.580	6 578 742.280	325.67	34.00-76.00
KR-14	4 948 970.650	6 578 870.220	320.67	30.00-70.50
R-13	4 948 856.670	6 578 861.800	270.67	/
R-14	4 948 975.520	6 578 962.490	283.57	/

EXPERIMENTAL PROCEDURE

Characterization and Preparation of Samples

Chemical analysis of samples from drill holes and trenches at subsequently intervals determined their chemical composition shown in Table 2.

Table 2 *Chemical composition of chalk samples*

Element, %	KR-2	KR-3	KR-6	KR-9	KR-13	KR-14	R-13	R-14
SiO_2	11.44–19.9	0.83–17.26	0.40–15.76	0.90–11.44	3.24–10.70	0.10–15.52	1.36	0.22
CaO	38.6–44.60	40.76–53.99	42.83–52.74	45.87–54.00	45.18–51.89	40.56–55.44	52.40	54.50
Al_2O_3	0.81–0.91	0.21–1.00	0.34–0.68	0.28–0.62	0.32–0.72	0.26–1.62	0.57	0.43
Fe_2O_3	0.47–0.76	0.17–0.54	0.21–0.39	0.19–0.40	0.24–0.39	0.15–0.89	0.34	0.28
FeO	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
MgO	0.64–3.52	0.43–0.80	0.20–0.27	0.35–0.51	0.34–0.52	0.40–1.70	0.60	1.00
SO_3	0.06–0.53	0.030–0.095	0.033–0.055	0.03–0.43	0.03–0.07	0.04–0.05	0.068	0.08
Na_2O	0.09–0.11	0.054–0.181	0.065–0.16	0.11–0.26	0.062–0.066	0.034–0.16	0.051	0.051
K_2O	0.14–0.15	0.039–0.19	0.095–0.016	0.088–0.15	0.060–0.15	0.058–0.35	0.10	0.077
MnO	0.014–0.015	0.012–0.014	0.004–0.008	0.006–0.022	0.013–0.017	0.006–0.025	0.013	0.009
P_2O_5	0.035–0.057	0.050–0.071	0.044–0.055	0.044–0.055	0.050–0.057	0.044–0.082	0.066	0.046
TiO_2	0.028–0.035	0.012–0.042	0.012–0.027	0.011–0.025	0.015–0.033	0.015–0.082	0.027	0.015
S	0.024–0.21	0.012–0.038	0.013–0.022	0.012–0.017	0.013–0.028	0.014–0.019	0.027	0.032
LOI	32.36–35.56	34.96–40.59	36.26–40.80	37.14–41.89	37.34–41.14	34.98–42.40	41.76	42.04

The starting samples of chalk (Figure 1) were dried at room temperature, and then on each of the samples the grain size distribution was determined according to the standard ISO 2591-1:1992. Preparation of samples for testing included crushing in a closed cycle, and sieving on a sieve, mesh size of 3.35 mm.

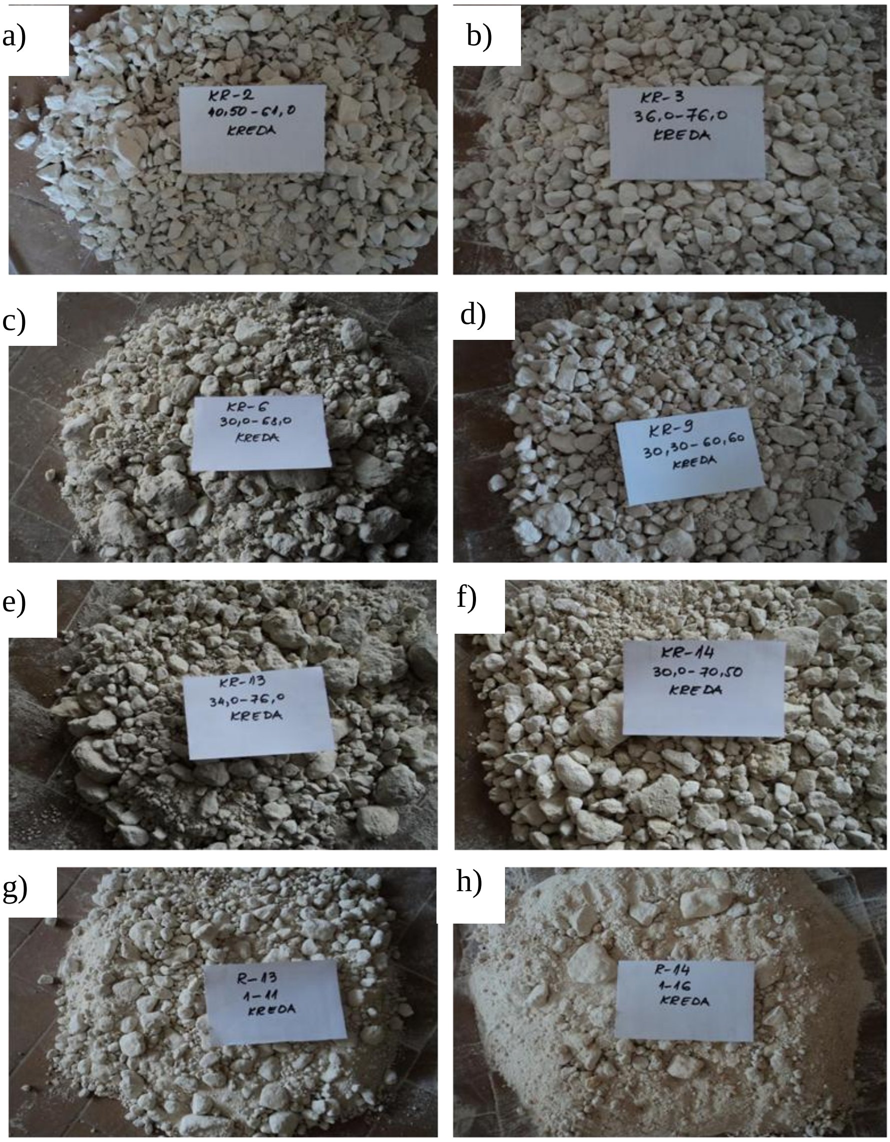

Figure 1 *Starting samples of chalk: a) – f) samples from drill holes; g), h) samples from trenches*

Testing the Bond Work Index

Testing the Bond Work Index was performed in the laboratory Bond ball mill, according to the established procedure, whereby the sieve is selected as a comparative sieve, mesh size 212 µm.

Figures 2 - 9 show the grain size distribution of crushed chalk samples (prepared for testing) as well as the grain size distribution of undersize of the comparative sieve.

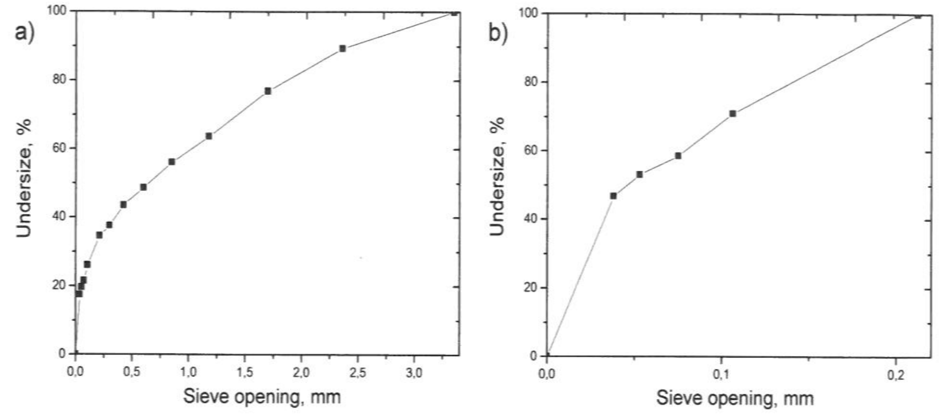

Figure 2 *Grain size distribution of sample KR-2: a) crushed starting sample, b) undersize of comparative sieve*

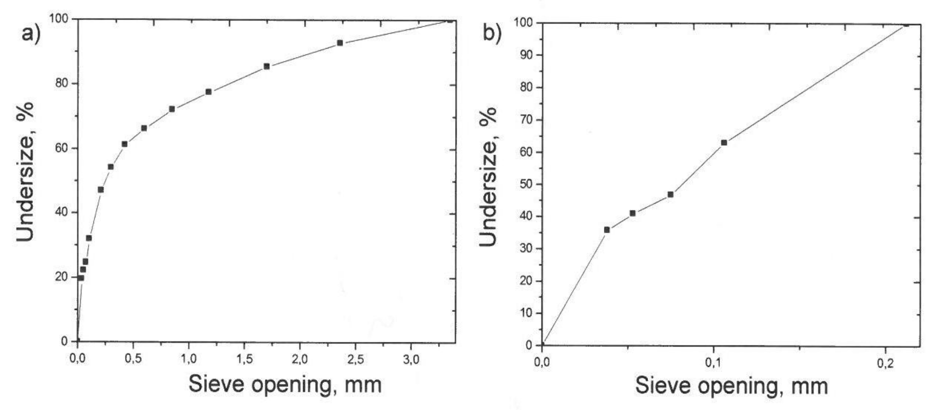

Figure 3 *Grain size distribution of sample KR-3: a) crushed starting sample, b) undersize of comparative sieve*

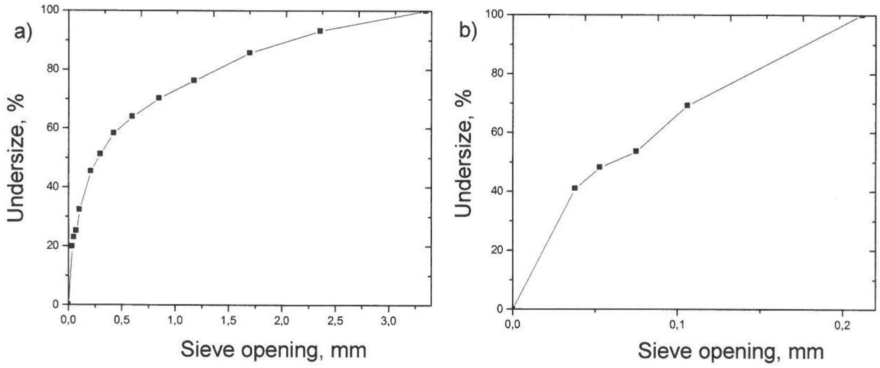

Figure 4 *Grain size distribution of sample KR-6: a) crushed starting sample, b) undersize of comparative sieve*

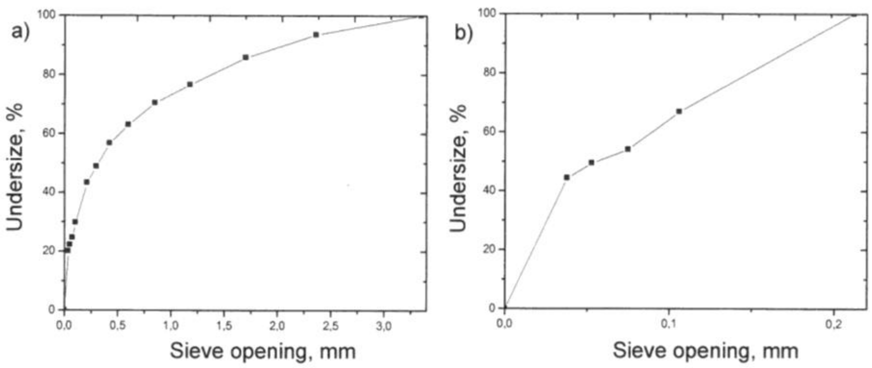

Figure 5 *Grain size distribution of sample KR-9: a) crushed starting sample, b) undersize of comparative sieve*

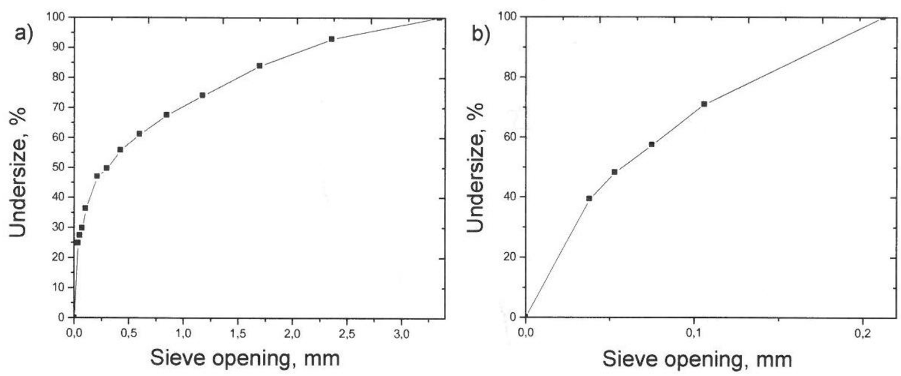

Figure 6 *Grain size distribution of sample KR-13: a) crushed starting sample, b) undersize of comparative sieve*

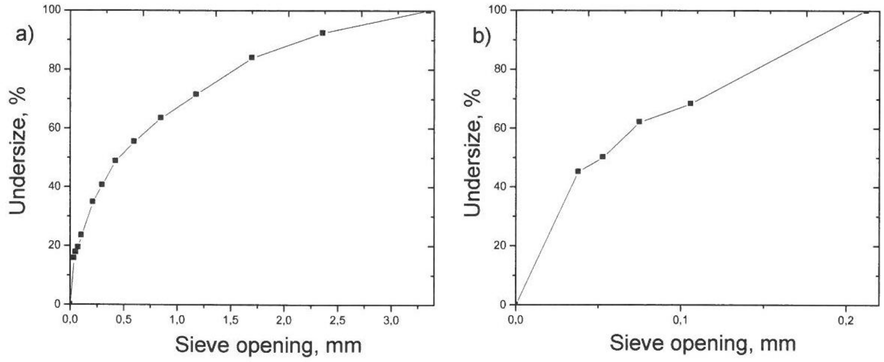

Figure 7 *Grain size distribution of sample KR-14: a) crushed starting sample, b) undersize of comparative sieve*

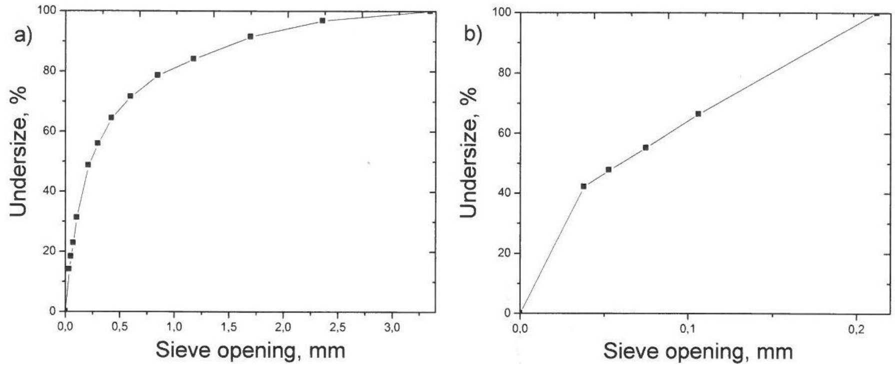

Figure 8 *Grain size distribution of sample R-13: a) crushed starting sample, b) undersize of comparative sieve*

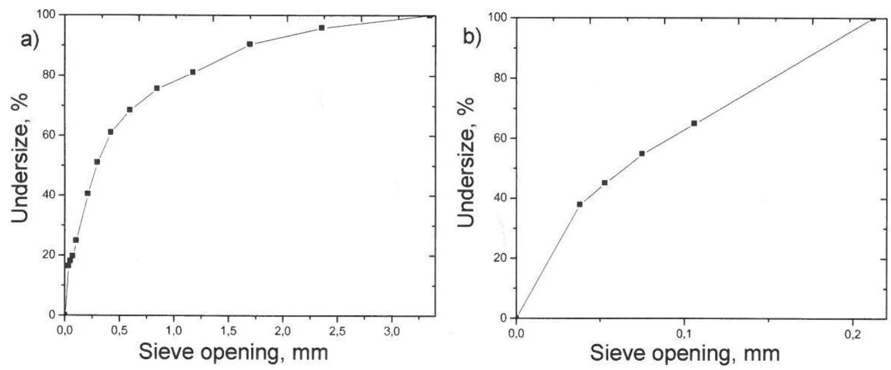

Figure 9 *Grain size distribution of sample R-14: a) crushed starting sample, b) undersize of comparative sieve*

RESULTS AND DISCUSSION

The Bond Work Index was calculated according to the formula:

Where:

P_k – mesh size of comparative sieve, µm

G - new-created undersize per one revolution of mill, g/rev.

P - mesh size through which 80% of undersize of comparative sieve passes, from the last experiment, µm

F - mesh size through which 80% of starting sample passes whose the Bond Work Index is determined, µm

Table 3 shows the values of characteristic parameters, and values of the Bond Work Index for all 8 tested chalk samples.

Table 3 *Characteristic parameters and the Bond Work Index for chalk samples*

Samples	**KR-2**	**KR-3**	**KR-6**	**KR-9**	**KR-13**	**KR-14**	**R-13**	**R-14**
Pk, µm	212	212	212	212	212	212	212	212
G, g/rev.	7.985	20.484	19.973	13.272	18.288	10.684	36.279	7.648
P, µm	138	153	142	148	138	147	148	152
F, µm	1840	1320	1390	1381	1487	1510	930	1120
Wi, kWh/t	4.244	2.251	2.146	3.099	2.226	3.608	1.520	5.256

Based on the test results shown in Table 3, it is evident that in most cases the value of the Bond Index ranges between 2 and 3. Deviations, which mean slightly higher values of the Bond Index were realized in samples with designations KR-2, KR-14 and R-14. These deviations are explained by a greater presence of interlayers of alevrolyte in the samples KR-2 and KT-14, or high concentration of calcified fossils in the sample R-14.

Sample R-13 has the lowest value of the Bond Work Index, which amounts to 1.520 kWh/t. Such low power consumption in milling in a ball mill was expected, since it was observed that the sample R-13 had the increased participation of soft silty component. The correlation between the Bond Work Index and spatial position of explora tory drill holes in the deposit was established in this case.

CONCLUSION

The site Spasine - Brdjani is characterized by a complex of carbonate of different physical and mechanical properties. Higher areas are hypsometrically covered by compact rock masses of sand, loose to limestone cores, which in depth lean on a package of compact and loose chalk. In general, these carbonate sediments in terms of stability provide a solid rock mass and belong to the group of stable to conditionally stable terrains.

The values of the Bond Index mainly ranges between 2 and 3 with certain deviations. Therefore, the samples KR-2, KR-14 and R-14 are characterized by the Bond Index higher than 3 due to the presence of interlayers of alevrolyte, or high concentration of calcified fossils. On the other side, large presence of dusty component in the sample R-13 resulted in a very low value of its Bond Work Index. The explicit relationship between the spatial position of drill holes and the Bond Work Index was not established.

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