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Original scientific paper

MINERAL PROCESSING OF THE DOLOMITES FROM DEPOSITS IN THE REPUBLIC OF NORTH MACEDONIA

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A b s t r a c t: Dolomites are used as a raw material in various industries such as construction, inorganic chemical technology, metallurgy, agriculture, etc. In the Northwestern Region of the Republic of North Macedonia, there are several deposits of dolomite that are exploited. In this research, the dolomites from the localities of Čajle, Ogledalec and Suvodol were examined. The aim of the research is to define the mineral processing of the dolomite raw materials. The basic parameters of the grain size reduction were optimized, with a comparison between the deposits. Therefore, the dolomite raw materials were processed on a jaw crusher, a roller crusher and in a porcelain mill with balls. A wet sieve analysis was conducted to define the efficiency of size reduction. Various size fractions of grains were observed on a binocular microscope. The discussion of the obtained results defines the relation between material pressure strength and the efficiency of the grain size reduction process, as well as the electricity consumption.

Key words: dolomite; mineral processing; Čajle; Ogledalec; Suvodol

ТЕХНОЛОШКА ПОДГОТОВКА НА ДОЛОМИТИ ОД ЛЕЖИШТА ВО РЕПУБЛИКА СЕВЕРНА МАКЕДОНИЈА

А п с т р а к т: Доломитот се користи како суровина во различни индустрии – градежништво, неорганска хемиска технологија, металургија, земјоделио, итн. Во Северозападниот Регион на Република Северна Македонија постојат повеќе лежишта на доломит од коишто се врши експлоатација. Во ова истражување се испитувани доломитите од локалитетите Чајле, Огледалец и Суводол. Основната цел на истражувањето е да се дефинира процесот на технолошката подготовка на суров материјал. Оптимизирани се основните параметри на обработката на суровиот материјал, со соодветна компарација на лежиштата. Притоа е применето дробење во челусна дробилка и дробилка со валјаци, како и мелење во порцеланска мелница со топки. Направена е и ситова анализа за да се согледа ефикасноста од процесот на уситнување. Фракциите со различни димензии на зрната се набљудувани под бинокулар. Добиените резултати ја дефинираат релацијата помеѓу цврстината на материјалот и ефикасноста на процесот на уситнување, а со тоа и потрошувачката на електрична енергија.

Клучни зборови: доломит; технолошка подготовка; Чајле; Огледалец; Суводол

1. INTRODUCTION

Limestones are widespread in the Republic of North Macedonia [1–4]. There are several dolomite deposits in the Northwestern Region. Previous explorations suggest that there are significant reserves of dolomite deposits in the localities of Čajle, Ogledalec and Suvodol [5–8]. As a raw material, dolomite has potential applications in various industries. Dolomite is mainly used as a raw material for refractory bricks production. Dolomite rock sand is used as fine aggregate replacement in construction activities. In inorganic chemical technologies, dolomite is used as a raw material for production of liquid fertilizer, as an alternative to limestone in cement manufacturing, etc. Dolomite is also used as an additive in animal feed

[9–14]. For efficient productivity, the mineral processing of dolomite is crucial. Therefore, the basic parameters of the size reduction process were defined [15–21] with a comparison between the deposits.

2. MATERIALS AND METHODS

In this research the dolomite raw materials from the localities of Čajle, Ogledalec, and Suvodol were examined. Within the mines there are processing plants where the raw material is crushed and separated by size into various dimensional fractions. The dolomite samples of 20 – 60 mm were collected for analysis (Figure 1).

In the mineral processing, the materials were primarily crushed. At first on a jaw crusher Blake (Figure 2). Then the materials were treated three times (at different distances between the rollers of 8.3 and 1 mm) on a roller crusher Denver B7141A (Figure 3). As the last stage of grain size reduction, the raw materials were processed into a porcelain ball mill (Figure 4). The material : ball ratio is 1 : 2,5 and the velocity of rotation is ω = 65°/min. The duration time of milling was 10, 20, 30, 60, and 120 min. In order to define the grain size reduction a wet sieve analysis was conducted. Set of standard sieves with a perforation size of 0.032 mm to 0.1 mm were used. Also, the various dimensional fractions of grain were observed on a binocular Carl Zeiss Jena [22–25].

(a)

(b)

(c)

Fig. 1. Dolomite samples of 20–60 mm:
(a) Čajle, (b) Ogledalec, (c) Suvodol

Fig. 2. Jaw crusher Blake

Fig. 3. Roller crusher Denver B7141A

Fig. 4. Porcelain mill with balls

The pressure strength is a significant characteristic for the mechanicaly preparation. Therefore, the pressure strength was determined on a compression testing machine (Figure 5).

Fig. 5. Pressure strength testing

3. RESULTS AND DISCUSSION

The pressure strength of the dolomite raw materials is presented in Table 1. The highest value of 174.2 MPa has dolomite from Čajle, and the lowest value of 131.5 MPa has dolomite from Suvodol. Dolomite from Ogledalec has a pressure strength of 167.4 MPa.

T a b l e 1

Pressure strength of the dolomite

Čajle	174.2 MPa
Ogledalec	167.4 MPa
Suvodol	131.5 MPa

The jaw crusher uses compressive force to crush the material pieces. The compressive force is applied by two jaws, one of the jaws is fixed while the other is movable. The material is fed into the top feed opening (gape) and gradually moves downwards towards the lower discharge outlet. As the material passes towards the outlet, it is crushed between the fixed and movable jaws. Because the distance between the two jaws decreases towards the discharge outlet, the size of the pieces is progressively reduced (Figure 6).

During the mechanical destruction process, fractures are formed in the direction of the cleavage plane. Consequently, the dolomite aggregates have a flat and sharp shape (Figure 7). This phenomenon is also present to the finest fraction of grains.

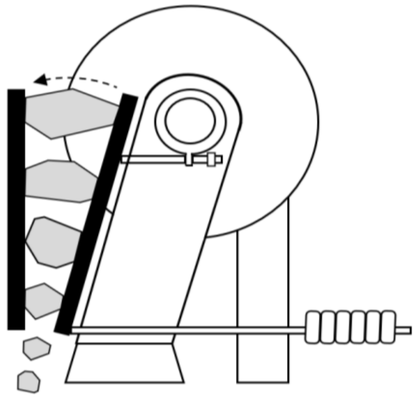


Fig. 6. Jaw crusher

Čajle

Ogledalec

Suvodol

Fig. 7. The raw materials after treating on a jaw crusher

The roller crusher consists of two heavy rollers placed in parallel, which are rotating in opposite directions (toward each other) and crush the material pieces (Figure 8). The size of crushed pieces is determined by the gap (the distance) between the rollers, which can be adjusted to suit the specific application requirements of the material.

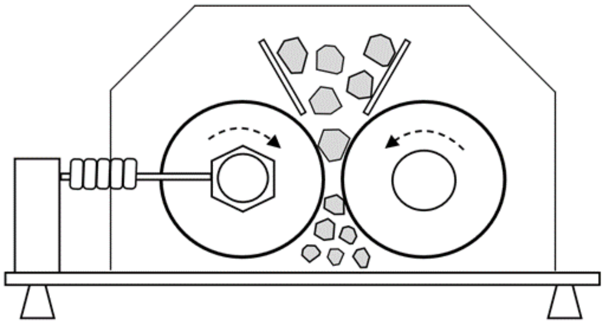


Fig. 7. Roller crusher

The granulometric composition of the dolomite raw materials after processing on the roller crusher is presented in Table 2.

Table 2

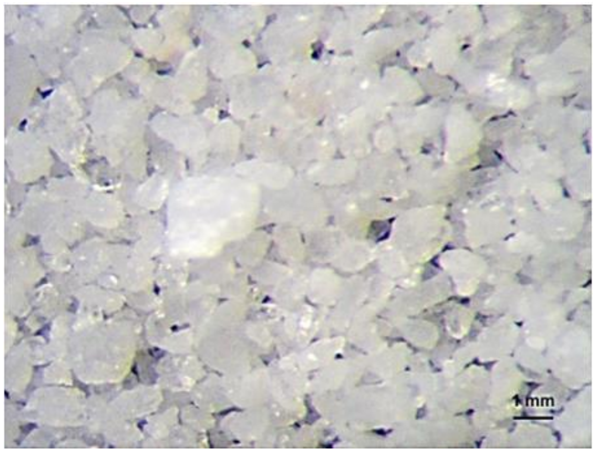
Granulometric composition of the materials after processing on the roller crusher (mass %)

Dimensional fraction	Čajle	Ogledalec	Suvodol
+1 mm	47.62	37.46	27.76
–1 +0.5 mm	21.16	20.16	19.66
–0.5 +0.25 mm	10.10	12.46	14.60
–0.25+0.1 mm	6.22	6.40	7.48
–0.1 mm	14.90	23.52	30.50
Σ	100.00	100.00	100.00

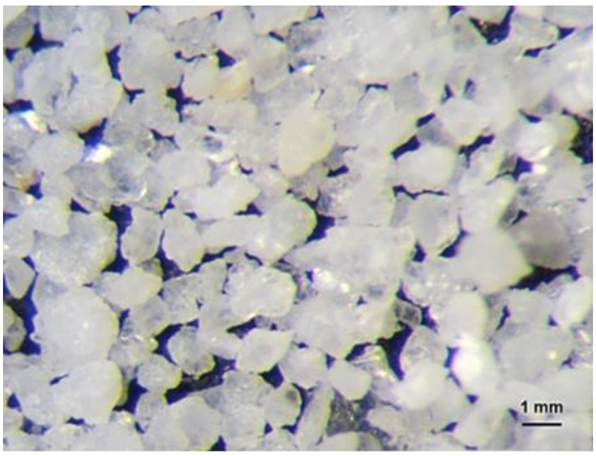
The results correlate with the pressure strength. Accordingly, the dominant mass content of the coarse fraction (+1 mm) of 47.62 % has the dolomite from Čajle, while the dolomite from Suvodol has the highest mass content of the smaller fraction (–0.1 mm) of 30.52 %. This effect is explicitly observed on Figure 8.

In the final stage of the size reduction process, dry milling was applied into a ball mill. The ball mill consists of a drum that rotates around its axis. The drum is filled in the range of 30 – 50% with balls that grind the materials. As the drum rotates, the balls are held on the inner surface of the drum by centrifugal force. At a certain angle (depending on the velocity of rotation), the weight of the balls overcomes the centrifugal force and then they cascade down or drop from top of the drum (Figure 9). Analogically, the material pieces are ground by impact and attrition.

Čajle



Ogledalec



Suvodol

Fig. 8. The raw materials after treating on a roller crusher

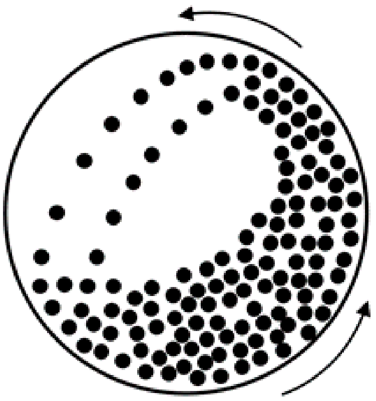
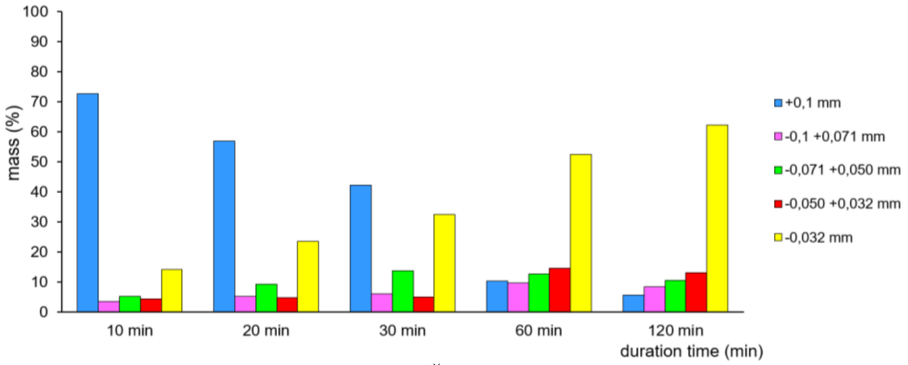


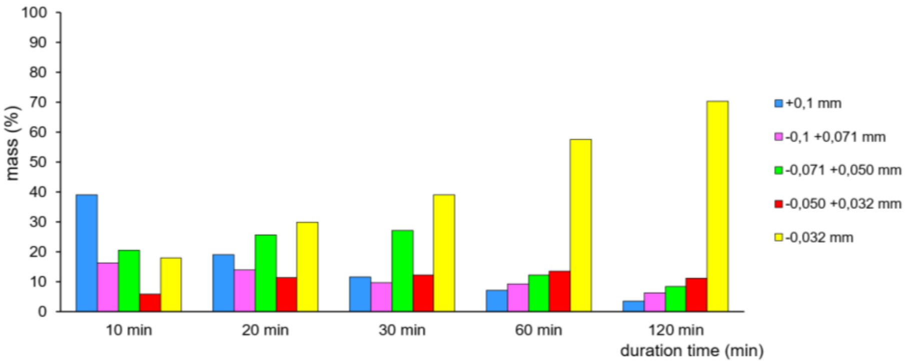
Fig. 9. Ball mill

The histograms of the mass content of various dimensional grain fractions at different milling phases are presented on Figure 10.

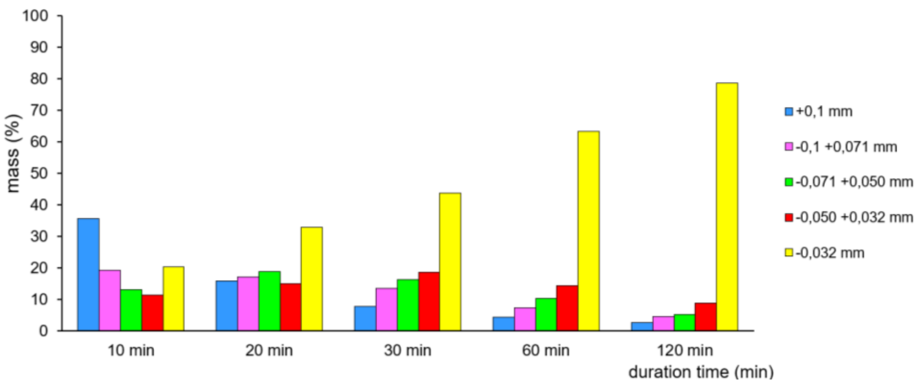
Simply, as the duration of milling time increases, the content of the finest fraction (–0.032 mm) continuously increases. Inversely, the content of the coarsest fraction (+0.1 mm) continuously decreases. The other size fractions have a minimum content. According to the granoblastic texture of raw materials, which are dominantly composed of fine grains, the size reduction is not affected by grinding, but is a consequence of the release of bounded fine grains in the aggregates.



Čajle



Ogledalec



Suvodol

Fig. 10. Histograms of the mass content of various dimensional grain fractions at different milling phases

On Figure 11 are presented the curves of cumulative mass content of the finest fraction (–0.032 mm) at different milling phases. The asymptotic direction of curves indicates that the size reduction is insignificant after 60 minutes of milling time. Therefore, the optimal duration of milling time is in range of 50 – 60 minutes, where there is an optimal ratio of the duration time (electricity consumption) and size reduction.

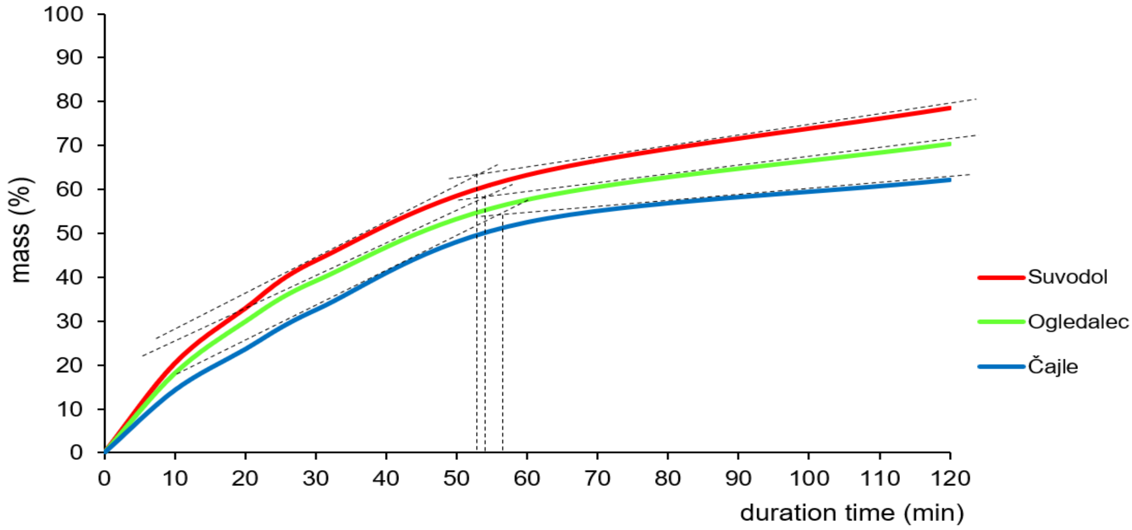


Fig. 11. Curves of cumulative mass content of the finest fraction (–0.032 mm) at different milling phases

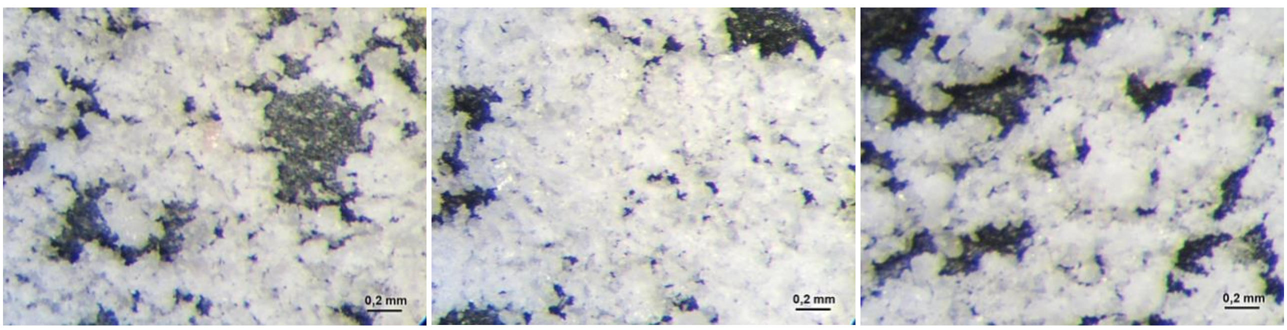
Therefore, in Table 3 is presented the granulometric composition of the materials after 60 minutes of milling time. In addition to the previous results, the dominant mass content of the bigger fraction (+1 mm) of 10.33 % has the dolomite from Čajle, while the dolomite from Suvodol has the highest mass content of the finest fraction (–0.032 mm) of 63.24 %.

After 60 minutes of milling time, the size reduction of the dolomite raw materials is evident (Figure 12). In the finest dimensional grain fraction (–0.032 mm), as a consequence of increased surface activity, an intense aggregation was observed.

T a b l e 3

Granulometric composition of the materials after 60 minutes of milling time, (mass %)

Dimensional fraction	Čajle	Ogledalec	Suvodol
+0.1 mm	10.33	7.21	4.35
–0.1 +0.071 mm	9.76	9.33	7.47
–0.071 +0.050 mm	12.76	12.31	10.48
–0.050 +0.032 mm	14.68	13.52	14.46
–0.032 mm	52.47	57.63	63.24
Σ	100.00	100.00	100.00



Čajle Ogledalec Suvodol

Fig. 12. The finest dimensional fraction (–0.032 mm) after 60 minutes of milling time

4. CONCLUSION

Dolomite has potential applications in various industries. As a raw material, dolomite is mainly used in construction, inorganic chemical technology, agriculture, etc. Therefore, in this research, the dolomites from the localities of Čajle, Ogledalec, and Suvodol were examined. The research defined the mineral processing of the raw materials. The samples with dimensions of 20 – 60 mm were primarily crushed, on jaw crusher and then on a roller crusher. Additionally, the samples were processed into a porcelain ball mill. In order to define the size reduction, a wet sieve analysis was conducted. Also, the various dimensional fractions were observed on a binocular. As a consequence of mechanical destruction, the dolomite grains have a flat and sharp shape.

The pressure strength of the materials was determined, as a significant property of mechanical destruction. The dolomite from Čaile has the highest value of compressive strength, while the dolomite from Suvodol has the lowest value. Therefore, the dolomite from Čaile has the highest mass content of the coarse grain fraction (+1 mm) after processing on a roller crusher. Consequently, the dolomite from Suvodol has the highest mass content of the finest grain fraction (–0.032 mm) after 60 minutes of milling. According to previously obtained results, the milling process can be implemented at specific regime in order to accomplish the previously set requirements for specific size fractions. The optimal duration of milling time is in range of 50 – 60 minutes.

Dolomites are mainly used as a raw material in construction, inorganic chemical technology, in agriculture, as an additive in animal feed, in metallurgy etc. Therefore, the basic parameters of the size reduction process were defined, with a comparison between the deposits.

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