UNDERGROUND MINING ENGINEERING 43 (2023) 17-25 UDK 62
UNIVERSITY OF BELGRADE - FACULTY OF MINING AND GEOLOGY ISSN 03542904

Original scientific paper

GEOLOGICAL CHARACTERISTICS OF THE LIMESTONE DEPOSIT "DOBRILOVIĆI"-LOZNICA AND ITS PREPARATION FOR USE IN AGRICULTURE

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Received: March 29, 2023 **Accepted:** June 5, 2023

Abstract:

The paper presents the geological characteristics of the limestone of the "Dobrilovići" deposit and the characterization of the trench sample. The technological scheme of limestone preparation, which is used to obtain suitable sizes for use in agriculture, is presented in the paper. Chemical analysis showed the presence of CaCO3 above 80% and CaO above 44.80%. The content of trace metals is low: Cr 21 mg/kg, Pb 3 mg/kg, and Ni 7 mg/kg. The mean value of the loss of ignition is 39.40%, and the pH is 8.47. Based on the obtained results, it was concluded that the chemical and mineral composition of limestone meets the requirements necessary for the calcification of acidic soils. The results of the determination of the granulometric composition showed the dominant presence of large classes above 50 mm (68%). To obtain a class of 100% -2 mm that meets the requirements for application in the calcification of acidic soils, a technological scheme for the preparation of trench limestone is given, which includes crushing, grinding, and grading.

Keywords: limestone, geological characteristics, agriculture, soil calcification

1 INTRODUCTION

Soil acidity is an important factor that affects the growth of plant crops and can significantly reduce their yield. Most cultivated plants require slightly acidic, neutral to slightly alkaline soils (Jelić et al, 2015). Due to the reduced solubility of biogenic elements (phosphorus and molybdenum) on acidic soils, the yield of plant crops is low. On such land, the content of toxic elements in compounds, especially aluminum, is also increased (Sumner, 2006). The acidity of the soil and the high content of aluminum and heavy metals can be reduced by applying ameliorants based on limestone, this procedure is called calcification. Compounds of calcium and magnesium can neutralize the acidity

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of the soil, which is why limestone-based material is classified as an effective ameliorant (Adams, 1984). Numerous researches in our country and the world indicate that the adequate application of these materials, in combination with organic and mineral fertilizers, is the most effective way of eliminating the unfavorable production characteristics of acidic soils. That is why it is necessary to define amelioration measures when growing most agricultural crops on acidic soils, which will be adapted to both soil properties and climate conditions (Jelić et al, 2015; Jovanović, 2013; Jovanović, 2015).

To apply limestone for the neutralization of acidic soils, the Institute of Agriculture from Loznica carried out geological research and characterization of the limestone of the "Dobrilovići" deposit (Kašić, 2011). Research was started in 2000 by Geozavod - Nemetali from Belgrade and continued in 2001-2004 by the Institute for Technology of Nuclear and Other Minerals from Belgrade. The "Dobrilovići" limestone deposit is located about 150 km southwest of Belgrade, and about 20 km southeast of Loznica, in the atar of the village of Tršić, where it administratively belongs to the Mačva district. The deposit area belongs to the transitional zone of the mountains of the Dinaric system towards the southern peripheral parts of the Pannonian basin.

The "Dobrilovići" limestone deposit is part of the carbonate sedimentary series, formed as part of the sedimentary process on the southern periphery of the former Pannonian Sea. According to the genetic classification of the deposit, it belongs to the exogenous series, the sedimentary group, and the biogenic deposit class. The geological structure of the wider area of the "Dobrilovići" deposit is made up of Palaeozoic, Mesozoic, and Cenozoic formations. Palaeozoic formations are represented by Devonian limestones, sandstones, and shales, followed by Carboniferous limestones, shales, and argillophillites, and Permian carbonate and terrigenous formations. Mesozoic formations are represented by Triassic limestones, sandstones, and clays, subordinated to dolomites, then Jurassic serpentinites, gabbro, and limestones, and Cretaceous massive limestones, sandstones, and quartz-conglomerate-sandstone formation. Cenozoic formations are represented by Neogene and Quaternary formations. Neogene formations consist of Miocene sediments, of which Helvetic sandstones, tuffs, marls and limestones, Tortonian sandy-clay facies and Lajtovac-lithotamnian limestone facies, as well as Pliocene sands, clays, and gravels. Quaternary formations are represented by gravel, sand, and alluvial deposits.

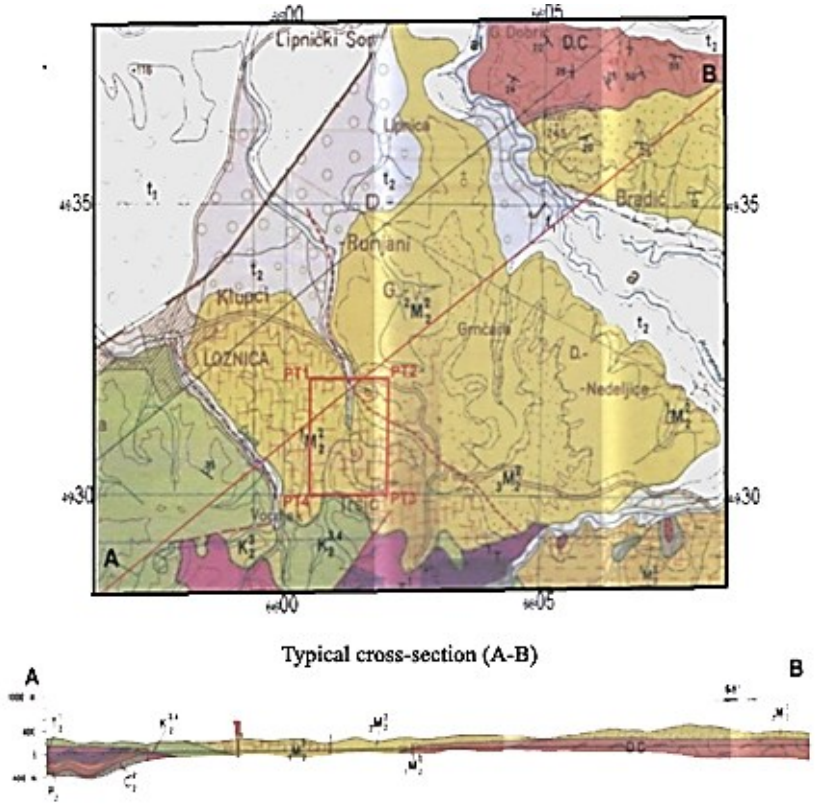

Figure 1 Geological map of the Jadar basin with the investigation area (red box) of the Dobrilovići deposit, Legend: al: alluvium; ${}_3M^2{}_2$: clays, sands, and gravels; ${}_2M^2{}_2$: marly sandstones and marly limestones; ${}^2M^2{}_2$: sandy loams and marls; ${}^1M^2{}_2$: lithotamnian limestones; ${}_1M^2{}_2$: sandy and carbonaceous clays and marls; $K^{3,4}{}_2$: limestones with rudists; $C^2{}_2$: dark gray limestones; D.C.: sandstones; Pz: sandstones, quartzites, phyllites

1.1 Geological structure of the limestone deposit "Dobrilovići"

The "Dobrilovići" limestone deposit was explored in an area of 30 ha. It consists of Middle Miocene sediments, which in the productive part belong to the Lajtovac limestone formation (Mojsilovic, 1968.). In the Middle Miocene deposits of the Jadar basin, to which this area belongs, four facies were observed: (1) gravel, rubble, and larger blocks; (2) layered sandy clays and (3) fine-grained and coarse-grained sands and plastic gray clays with interlayers of coal, remains of plants and molluscs and (4) lithotamnian limestone - Lajtovac. More detailed stratigraphic and paleontological investigations have shown that it is a sparitic limestone with remains of fossil microfauna: Lucina incrassata, Glycimeris pilolus and Solenocurtus sp.

Three layers can be observed in the deposit. The first, youngest layer is represented by clayey carbonate sediments, which contain up to 80% of shells and snails in a gray pelitic

base and thinner interlayers of compact gray limestones. Its greatest thickness is in the central part of the deposit, where it is about 10 m, while it curves around the perimeter. The second layer consists of gray, dark gray to black limestones, which are hard and compact in one part and soft and crumbly in the other. In the central part of the deposits, they have an average thickness of 10 m, with the thickness increasing towards the north and decreasing towards the south. The third deepest and oldest layer consists of typical Lajtovac limestones, which are yellow-white, usually hollow, porous, and soft and with occurrences of decimeter-size compact layers. The greatest thickness of this layer is about 26 m.

1.2 Morphological characteristics of the deposit

The Dobrilovići limestone deposit has a plate-like, layered shape. In the narrowly explored area, the layers are sub horizontal with a northward dip of 3 to 5°. The carbonate stone mass is characterized by significant fissures.

The average thickness of the deposits in the investigated part is about 28 m and in the deepest hole about 45 m. According to OGK data, the thickness of the carbonate series in the wider area of the deposit ranges from 50 to 150 m. The average concentration of reserves in the deposit is about 14.8 m^3 of limestone per m^2 of surface.

The Dobrilovići deposit as a part of the carbonate sedimentary series, was formed as part of the sedimentary process on the southern periphery of the former Pannonian Sea. According to the valid and generally accepted genetic classification of the deposit, it belongs to the exogenous series, the sedimentary group, and the biogenic deposit class.

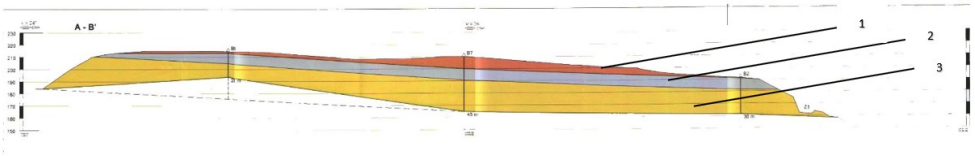

Figure 2 Longitudinal vertical geological cross-section, Legend: 1 - carbonaceous yellow-gray and humic clays; 2 - limestones light to dark gray, of different hardness; 3 - Limestones yellow-white compact, more often hollow and porous

1.3 Tectonic characteristics

Tectonics is not pronounced in the geological area of the Dobrilovići deposit. The primary sub horizontal position of the carbonate layers has been preserved. Only cracks appear and structural elements are layered. There are no traces of fault tectonics in the deposit area.

2 CHARACTERISTICS OF THE MINERAL RAW MATERIAL

The studied characteristics of limestone that are important for application and final valorization include chemical composition, mineral composition, and granulometric composition of the raw material.

Chemical analysis of the Dobrilovići limestone composition showed that the $CaCO_3$ content is higher than 80%, and the CaO content is higher than 44.80%, and the other values are shown in Table 1.

Table 1 The most important components in the limestone of the Dobrilovići deposit (Kašić, 2004)

Component	*content (%) interval (average value)*
CaO	44.20-53.58 (49,51)
MgO	0.25-0.48 (0,39)
SiO_2	2.52-15.78 (8,74)
Al_2O_3	0.49-2.87 (1,10)
Fe_2O_3	0.23-1.24 (0,57)
Na_2O	0.02-0.14 (0,07)
K_2O	0.051-0.51 (0,14)
Loss on ignition	37.80-42.40 (39,40)
$CaCO_3$	80.52-98.05 (90,60)

It was observed that a few metals have a low content: Cr - 21 mg/kg, Pb - 3 mg/kg, and Ni - 7 mg/kg. The presence of Cd was not determined, and the sensitivity of the measurement was less than 0.01 mg/kg. Considering such low contents, these metals do not adversely affect the quality and application of this limestone. The pH value of the limestone showed an interval from 8.2 to 8.7.

The mineral composition of the limestone of the Dobrilovići deposit includes calcite, then quartz, clay minerals, limonite, and others. The most abundant mineral is calcite, which is of organic origin. The granulometric composition of the raw material shows the highest percentage of coarse classes above 50 mm, and the content of the class between 50 and 30 mm is smaller (table 2).

Table 2 Granulometric composition of the raw limestone from the deposit Dobrilovići (Kašić, 2004)

Class of grain size (mm)	*M (%)*	*∑M ↑ (%)*	*∑M ↓ (%)*
- 200 + 100	34	100	34
-100 + 50	34	68	68
-50 + 30	12	32	80
- 30 + 0	20	20	100

Based on the obtained results of the characterization of the limestone of the "Dobrilovići" deposit, it can be concluded that it's chemical and mineral composition meets the requirements necessary for application in agriculture (Sekulić, 2011). The required grain size for these purposes (below 2 mm) requires an adequate technological scheme for its preparation to obtain the appropriate granulometric composition.

3 TECHNOLOGICAL SCHEME OF LIMESTONE PREPARATION OF THE "DOBRILOVIĆI" DEPOSIT

Limestone from the Dobrilovići deposit is intended for correcting the quality of acidic soils, i.e. for increasing its pH value. The best effects are achieved by gradually neutralizing the soil by adding 25 to 50% of the amount needed for complete neutralization of the soil. It is used for basic, deep meliorative, and regular tillage of the soil by spreading evenly over the surface of the dry soil in windless weather. To achieve the full effects of the high productivity of treated soil, it is recommended to use it in combination with organic fertilizers, as well as good homogenization with the surface layer. The size of the particles must be <2 mm. A commercial product of this type made of limestone from the Dobrilovići deposit is called Kalkomel - L.

The technological scheme according to which limestone is prepared (Figure 1) includes crushing, sieving, and grinding until the final fraction below 2 mm is obtained. The raw material GGK 200 mm is brought by truck (1) and unloaded at the depot (2). Using the loader (3), the raw material is transferred to the receiving bunker (4). After that, it is transported using a pendulum feeder (5) to an impact crusher (6) and crushed to a size class of 100% -30 mm. The crushed raw material is transported by a conveyor belt (7) to the vibrating table (8) for sieving and material size class -30 + 2 mm is transported to grinding in the vibrating mill (10) using the conveyor belt (9). The ground product (size class 70% -2 + 0 mm) is returned to the vibrating sieve (8) using the screw conveyor (11). Sieving of the vibrating sieve (8), (size class -2 + 0 mm), falls either on the conveyor belt (12) by which it is transported to the receiving bunker of the packaging device (13), or on the conveyor belt (17) by which it is taken to the finished product

depot (18). The packaged product from the packaging device (13) is placed on pallets (14) and loaded into trucks using a forklift (15). A compressor (16) is provided to operate the packaging device (13). A dedusting filter (19) and a centrifugal fan (20) are provided for dedusting the plant. The hanging transmission (100) is intended for serving the plant.

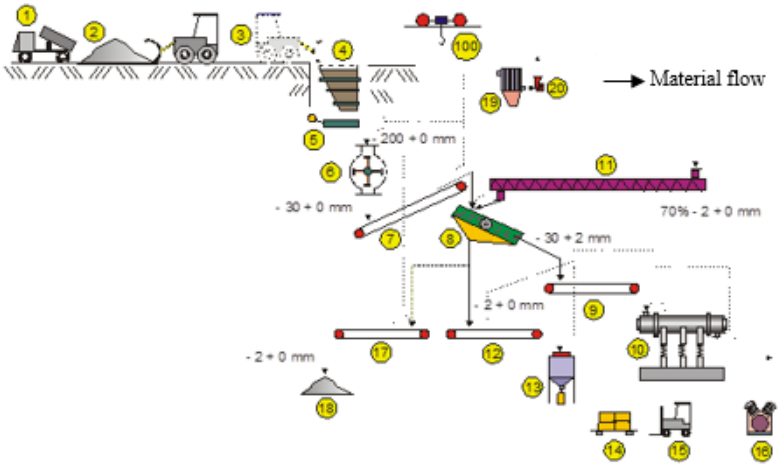

Figure 3 Technological scheme of limestone processing from the "Dobrilovići" deposit, Legend: 1. truck; 2. depot; 3. loader; 4. bunker; 5. dosing table; 6. crusher; 7. conveyor belt; 8. vibrating table; 9. conveyor belt; 10. vibrating mill; 11. screw conveyor; 12. conveyor belt; 13. packing machine; 14. pallets for the finished product; 15. forklift; 16. compressor; 17. conveyor belt; 18. landfill for the finished product; 19. filter for dedusting; 20. centrifugal fan; 100. hanging transmission

The user of this raw material is agriculture, small agricultural producers, as well as large agricultural combines engaged in food production. About 5.1 million hectares are cultivated in Serbia, of which more than 60% belong to acidic soils, with a pH value ranging from 3.5 to 5, so from the perspective of marketing and applying larger quantities of this raw material for the needs of soil calcification, it is very favorable.

4 CONCLUSION

The "Dobrilovići" limestone deposit was explored in an area of 30 ha. The deposit area belongs to the transitional zone of the mountains of the Dinaric system towards the southern peripheral parts of the Pannonian basin. It was formed as part of the sedimentary process on the southern periphery of the former Pannonian Sea. According to the genetic classification, the deposit belongs to the exogenous series, the sedimentary group, and the biogenic deposit class. The geological structure of the wider deposit area is made up of Palaeozoic, Mesozoic, and Cenozoic formations. It is built by Middle Miocene sediments, which in the productive part belong to the Lajtovac limestone formation.

Three layers were observed in the Geological research: the youngest clayey carbonate sediments, then dark gray to black limestones, and older Lajtovac limestones.

Chemical analysis of the limestone of this deposit revealed the presence of CaCO3 above 80%, with the CaO content above 44.80%. The content of trace metals, Cr 21 mg/kg, Pb 3 mg/kg and Ni 7 mg/kg, is low so that they do not adversely affect the quality and application of this limestone. The most common mineral is calcite. The mean value of annealing loss is 39.40%. The pH values ranged from 8.2 to 8.7 with a mean value of 8.47. The results of the determination of the granulometric composition showed the dominant presence of large classes above 50 mm (68%). Based on the obtained results of the limestone characterization of the "Dobrilovići" deposit, it can be concluded that it's chemical and mineral composition meets the requirements necessary for the calcification of acidic soils after the raw material is crushed.

A technological scheme of preparation for obtaining the appropriate granulometric composition (below 2 mm) was conceived. The procedures shown in the technological scheme are crushing, sieving, and grinding. The practical application of the obtained limestone on agricultural plots has shown that the best effects are achieved by gradually neutralizing the soil by adding smaller amounts (25 to 50%) needed for complete neutralization of the soil.

ACKNOWLEDGEMENT

The authors wish to acknowledge the Ministry of Education, Science and Technological Development of the Republic of Serbia for financial support of the research whose results are presented in the paper (contract. 451-03-47/2023-01/200023).

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