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Зборник радова
XVI Конгреса геолога Србије

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ОПТИМАЛНО ИСТРАЖИВАЊЕ И ОДРЖИВО КОРИШЋЕЊЕ ГЕОЛОШКИХ РЕСУРСА

OPTIMAL RESEARCH AND SUSTAINABLE USAGE OF THE GEOLOGICAL RESOURCES

Donji Milanovac, 22-25.05.2014.

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САДРЖАЈ / CONTENT

QUALITATIVE-QUANTITATIVE CHARACTERISTICS OF THE MARBLES FROM TUMBA AREA (MK) AND OPPORTUNITIES FOR THEIR EXPLOITATION

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Key words: architectural-building stone, dolomitic marble, exploitation, ore reserves, rock quality, structure.

Abstract: The use of marbles as a building - architectural stone for their aesthetic - technical characteristics has a long tradition in Macedonia from ancient times until today. Dolomitic white marbles are most prevalent in studied area and clearly different from the gray-white and gray dolomitic marbles. The samples were determined as a fine-grained dolomitic marble, which mineralogically and chemically are quite pure. According petrological, mineralogical and microscopic tests and chemical analysis of these dolomitic marbles, can find wide application in construction and in civil engineering, the concrete mixtures, and other hydrotechnical works. It can also be used as architectural stone allows removal of larger blocks. Based on calculations performed on mining stocks can be concluded that the investigated area is promising in terms of exploitation of white dolomitic marble. The fact that within the field are calculated geological ore reserves more than of 50 milions m^3 is a sufficient indicator of perspectivnes in this area.

INTRODUCTION

The Tumba area is situated near the village bearing the same name some 20 km from Prilep. The site is situated 0,5 km south of the village in the marble series which is part of the Pelagon metamorphic complex.

The use of marbles as construction-architectural stone has had a long tradition, from early times to the present day, owing to its aesthetic and technical characteristics.

The white marbles are also used in the making of art statues, colonnades, caryatids etc. This is can be seen in many Roman archaeological sites such as Stobi, Heraclea and others.

The search for white marbles in a number of sites were the subject matter of investigations. The best known in the country are those of Sivec, Bela Pola, Pletvar, Kitka and others. The highest interest has been in the white marble in the Pletvar –Sivec - Bela Pola zone. Besides its whiteness, the marble has been in use for such a long time due to the fine-grained structure, which helped sculptors make their master pieces.

In Macedonia marble has been used as building material continuously, but with variable intensity.

The first large undertakings and organized economic interest in excavation and processing started after 1956.

The greater use of marbles called for intense geological investigations, starting with opening new quarries and construction of new facilities for processing. Thus, in 1956 production of marble blocks amounted to 8.000m^3 and processing of 6.000m^3 slabs. In 1983 new mines emerged whose block output reached 22.000m^3 along with new facilities in Prilep, Gostivar, Cer and Kumanovo were built. The entire annual nominal capacity of slab processing amounted to 500.000 m^2.

However, this trend of increase was folloed by a period of stagnation in 1990 and in 1997 production reduced to 10 to 12.000m^3 of blocks and processing of 80.000m^2 slabs annually. At

the same time the period was also characterized by the establishing small processing plants almost in every towns. Products were used mostly in erecting monuments.

The first investigations in the Belovodica marble started during the 1930s. Later (Maric,1940) carried out mineralogical-petrographic examinations on the rocks in the vicinity of Prilep with special emphasis on the marbles around Prilep and Pletvar. The compiling of the basic geological map of SFRY the authors of the page for Prilep the scale 1:100 000 (Rakicevic, Stojanov and Arsovski, 1965a, 1965b) in the explanation gave a detailed description of the lithological composition of the rocks near Prilep. In their description on the rock composition they included an account of the dolomite marbles from the vicinity of Belovodica.

In the same period, during compiling the basic geological map of SFRY, the authors of the page for Vitoliste, the scale 1:100 000 (Dumurzanov, Hristov, 1976) in the explanation gave an account on the lithological composition. The study included the dolomite marbles of the extension Tumba, Belovodica, Veprcani and Dunje (Dzolev, 2007). The same authors indicate that the marbles were an important raw material for obtaining marble blocks. They described them as white, massive with sugary white appearance and that blocks could be extracted for future processing.

Since 1970 to the present time, special detailed investigations were carried out for the calculation of ore reserves in Sivec for the writing of the main project for marble excavation from the deposit.

Paskalev (1983) in his doctor's dissertation under the title Specific Methods for Economic Assessment of the Architectural - Dimension Stone in S.R. Macedonia and Long Term Development offered a special analysis of the marbles in Sivec.

Latest data regarding the geological composition, petrographic - mineralogical and physical - mechanical characteristics of the marbles in close proximity to Tumba can be found in the documentation of the Dumigal Marble Company. Namely, the company has the concession for marble excavation close to the area under investigation and has started an open Tumba marble quarry which is in opescalen.

GEOLOGICAL CHARACTERISTICS

The Tumba marbles are part of the marble mass in the south part of the Pelagon. The mass is located in the marginal part of the Pelagonian metamorphic complex in the west and the Vardar zone in the east. It is a fairly narrow zone with two marble types: calcite in the eastern marginal part with the Vardar zone and dolomite in the western in immediate contact with the gneiss series of the Pelagonian metamorphic complex. The basic structural characteristics of the metamorphic phase in the Pelagon are the result of syngenetic processes of high regional metamorphism and folding with plastic flow mechanism with contemporaneous intrusion of granodiorites of the first phase when large fold structures were formed. It is worth mentioning that an important role played the second granitoid phase which manifested as major magmatic activity whose products, in addition to the metasomatic changes and homogenization of the metamorphic rocks, in some parts of the Pelagon caused refolding and developed new large foldings when distruction of earlier fold structures took place.

The whole Tumba site is situated in the eastern wing of the larger Dren anticline shape which is adome like elongated structure of N - S strike. The composition of the Dren anticline consists of

the rocks of both mixed and marble series. Of importance for the marble mass in Tumba is that, in its lower part, homogenization, whitening and dolomitization of marbles took place. These processes are related to the granitoid rock intrusion into the Dren anticline. Namely, the lower portions of the marble mass are made up of white sugary to flouery massive dolomite marbles in which, only locally, traces of foliation and micro folding and a small occurrence of calcite veins can be seen. Going far from the contact with the Dren anticline to the east, dolomite marbles grade into banded and further on into schistose calcite-dolomite marbles.

For the structural composition of the marble mass an important role played the rupture tectonics which are present as faults, fault and fissure zones. Of course, some of the structures are older, but the main rupture tectonics is of later age and related to the processes of formation of the neotectonic graben in the Pelagonian valley in the Pliocene as well as the processes of younger foldings and faults during the Alpine orogeny.

The marbles of the locality Tumba, which were subject of the research from the south-western side, are limited with series of dolomitic marbles which belong to the surface dig 'Tumba', a property of Pavlidis, in the south direction this marble mass continues to Mariovo, from east is limited with series of calcite marbles, while in the northern part this terrain is covered with delluvium made of dolomitic sand, pieces of marbles and clay material (Spasovski, 2011).

The Tumba area with the geological mapping three types of marbles were isolated: stratified to massive dolomitic marbles, tectonized dolomitic marbles and stratified dolomitic marbles (fig 1).

Massive dolomitic marbles are characterized with white colour with occasionally present gray shade. These are massive and solid rocks where no cracks can be spotted and are characterized with absolutely weakly expressed stringed texture.

Tectonic dolomitic marbles meet as a small zone that moves from north-west and south-east and the same add to the massive dolomitic marbles.

As for the mineral content and the colour, among the stratified dolomitic marbles and the tectonic dolomitic marbles, there is no difference at all. These marbles are cracked on the surface and some decimeters' cracks can be noticed in east-west direction and also northwest-southeast and normal cracks in these directions with falling angles from 50-90%.

Layered dolomitic *marbles* lay directly through tectonic dolomitic marbles with clearly defined stratified (picture 6). The rock mass is in direction of spread north northwest-south southeast and with a fall toward east-northeast under the angle from 30-45°. Mineral and these dolomites are identical as well as the stratified dolomitic marbles. They are characterized with white colour and saccharine appearance. Presence of calcite can be found in them, present as a type of very thin stripes. This type of rocks is mostly present in the middle parts of the research space.

With a geological mapping special attention is dedicated to the series of white dolomitic marbles which lay concordantly on mixed series in a wider space. These rocks are characterized with white colour and saccharine appearance, massive, stratified to layered-schistose.

These dolomitic marbles have white colour, but there are also some rare samples with light gray colour. The structure is finer grained, but solid, massive and compact texture with weakly distinguished oriented-stripped texture.

In microscope homeoblastic-granoblastic structure is noticed, but massive and weakly distinguished oriented-stripped texture.

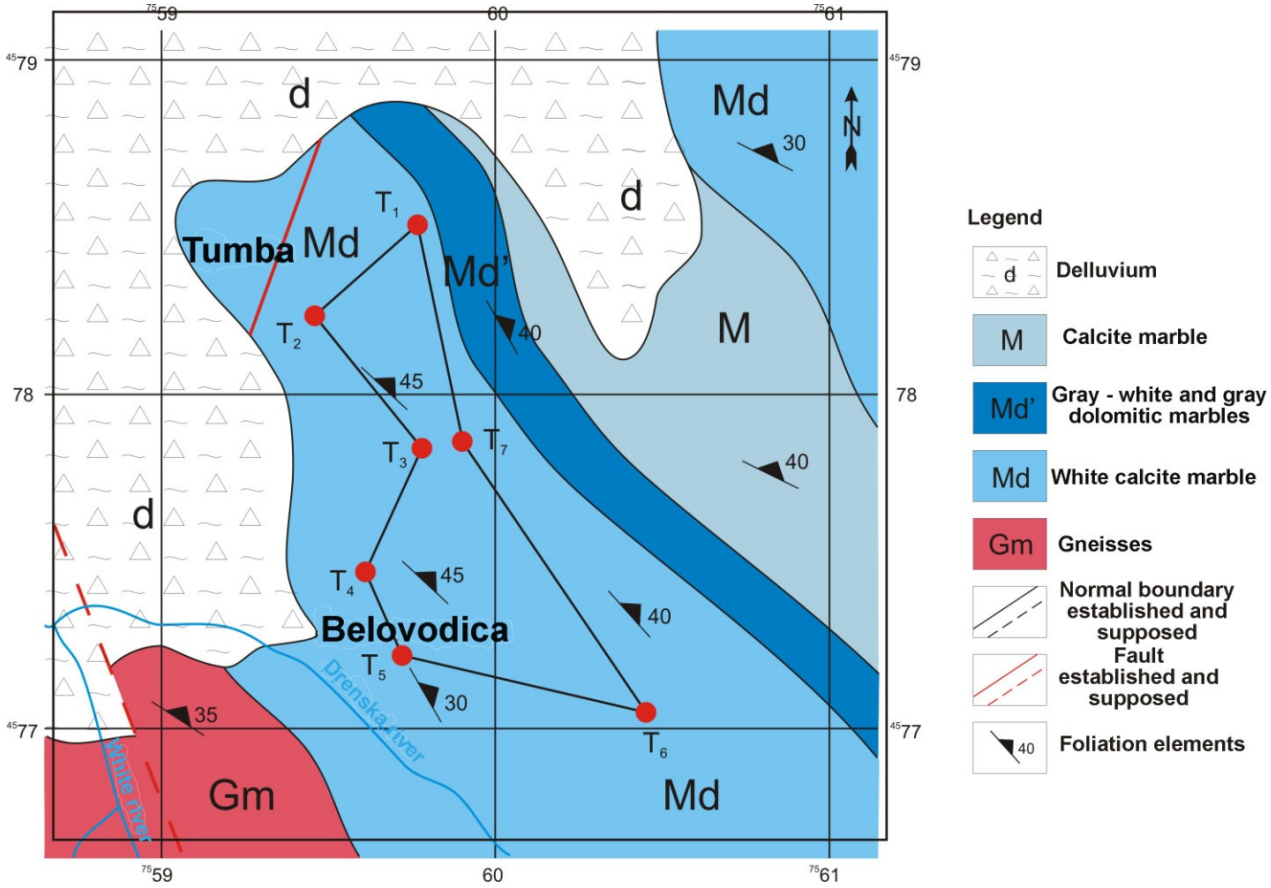

Figure 1. Geological map of "Tumba" area (avter Spasovski, 2012)

MINERALOGICAL – PETROGRAPHIC AND CHEMICAL EXAMINATIONS

Representative samples of marbles from the Belovodica locality are selected for the mineral-petrographic research as well as for the chemical analyses.

A complete trituration, grinding, pulverization and automatic shortening is performed on the selected samples by receiving the samples for analysis and a duplicate of the sample weighing 50 grams.

The method of chemical analyses the standard Atomic emission spectrometry with inductively engaged plasma (AES-ICP) which provides high accuracy for the majority of the chemical elements but only the elements that are of high importance for the chemical characteristics of the marbles are defined.

The purpose of the chemical examination is to determine the chemical content of the present rocks in the researched area with a special attention to the white dolomite marbles.

From the performed mineralogical-petrological examinations, the microscopic analyses as well as the chemical analyses of the samples in the area around Prilep it can be stated that:

The samples are determined to be finely grained dolomite marble with are very clear in both mineralogical and chemical content. The presence of MgO is over 19,52% only in the sample marked T-6 MgO is present with 17,89% (Table 1).

These dolomite marbles have white colour and the samples with light grey colour are very rare. The structure is finely grained but with solid, massive and compact texture with weakly distinguished oriented-striped texture. A homeoblastic-granoblastic structure is visible with microscope with massive and very weakly distinguished oriented texture (Spasovski, 2012).

From a mineralogical aspect these are carbon rocks made of mostly dolomite. The calcite is not very present – that is sample T-6. The dolomite crystals are mostly present in irregular to hypidiomorphic form and are slightly extended in a direction to orientation of the rock. The extension of the crystals is more strongly pointed in sample T-2 (light grey dolomite marble). The average granulation of the dolomite crystals is from 45-65 microns seen in all samples. Microcavities are noticed at the sample marked T-33 but are very rare, while microcavities are also visible at sample T-24.

Table 1. Chemical analysis of the marble the Tumba area

Components (%)/sample	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Loss of ignition	Total
T-2	0,80	0,40	0,10	31,13	20,34	46,67	99,44
T-6	0,70	0,36	0,05	33,96	17,89	46,65	99,61
T-24	0,06	0,22	0,07	31,18	20.74	47,05	99,86
T-33	1,20	0,38	0,05	30,08	20,80	46,62	99,13
T-39	0,80	0,35	0,05	32,83	19,52	45,65	99,20

According to the petrological, mineralogical-microscopic examinations and chemical analyses of these dolomite marbles they can be widely used in the civil engineering mostly in low-building, concrete mixes, hydrotechnical works, etc. It can be also used as an architectonic stone while allowing macrotectonics to be able to excavate larger blocks.

PHYSICAL - MECHANIC EXAMINATIONS

At the department of geotechnical engineering at the Faculty of Civil engineering certain examinations for the strength of monolith parts of white dolomite marble from the locality Tumba – Prilep were made.

A great number of samples to test the pressure strength, strength on one point, volume weight and the absorption of the dampness, as basic classification parameters.

The results from the examination of the point load are presented in encl. 1. According to the examinations the value of the physical - mechanical characteristics is in the following frame:

- Average value Js(50)=2,72 to 3,63 dependent on the testing
- The volume weight is in a diapason of =27,87-28,24 kN/m^3
- Absorption of dump is in the frame of U=0,15-0,16 %
- The strength of the pressure is sp=134-171,1 MPa, but in separate number of samples there are also values of sp=65,2-65,5 MPa.

In accordance with the performed examinations it can be stated that the dolomite marble has favorable characteristics to be used as an architectonic-building stone (Spasovski, 2012).

The present lower values point that the surface areas have weaker parties which should be taken into consideration in the process of exploitation.

It should be also noted that the samples are taken from the surface of the field and usually the more authoritative results are from the deeper zones, where the results are got through research drilling, testing and examination.

THE MINING RESERVES

Based on the performed evaluations of the mining reserves it can be noted that the research space is promising in a perspective of exploitation of white dolomite marbles. The very fact that within field I were estimated 9.586.976 m^3 geological mining reserves
from category B and 16.826.333 m^3 from C_1 category and geological mining reserves in the field II 8.688.725 m^3 from category B and 21.346.275 m^3 from C_1 category or a total of B+C_1 56.448.309 (m^3) is a real indicator for the possibilities of the researched area. In this opportunity it is necessary to note that the performed evaluations of the geological mining reserves are made without deep research drilling which is necessary for separating reserves from category A and of course confirming the reserves from B and C_1 and also the possibilities of the researched space.

CONCLUSION

Based on the presented detail end geological research on the concessive area in the location Tumba, the following conclusions can be made:
With the geological mapping three types of marbles are selected: stratified to massive dolomite marbles, tectonized dolomite marbles and stratified dolomite marbles.
The separated rocks represent dolomite marbles characterized with white color and saccharine, sugar like appearance, massive, stratified to bedded - sheet like With the geological research the massiveness and compactness of the marbles was completely defined.
According to the color, on the geological map mostly predominate the dolomite marbles with clearly apparent white color and dolomite marbles with grayish-white color.
Dolomite marbles with white color are mostly found in the research space and can clearly be differentiated from the grayish-white and grey dolomite marbles.
From a mineral point, the carbon rocks are mostly dolomite. The samples are determined as finer grained dolomite marble, which are very clear in their mineral and chemical content. The presence of MgO is over 19,52 %, only in the sample marked T- 6. MgO is present with 17,89 %.
According to the petrologic, mineral – microscopic testing these dolomite marbles can be widely applied in the civil engineering, mostly in low-construction, for concrete mixtures, hydro-technical works, etc. They can also be used as an architectonic stone provided the micro-tectonics allows larger blocks to be detached.
In the researched field, three promising parts are selected that will be the research subject in the second phase i.e. a research drilling is planned in the selected parts. These promising parts will be presented afterwards with the supplement on topographyc base where the designed research drills will be presented.

In accordance with the completed research, the dolomite marble is evaluated with favorable characteristics for its use as architectonic-building stone.
Notable lower values point out that areas even have weaker components, which needs to be taken into account before eventual exploitation.
It is noted that the samples are taken from the surface of the field, even though the more trustworthy results are usually from deeper zones normally that data is received with research drilling, sampling and examination.
The research space has a good perspective merely for exploitation of white dolomite marbles.

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