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MINERALOGICAL AND CHEMICAL CHARACTERISTICS OF MARBLE OF BELA POLA DEPOSITE

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A b s t r a c t: This paper presents mineralogical characteristics of marbles from the Bela Pola deposit. We have made mineralogical-chemical analyses of marbles and associated minerals in them. The investigation was carried out at the Faculty of natural and technical sciences – Štip. Marbles from Bela Pola are dolomite and dolomite-calcite types. Microscope investigations have shown that marbles from Bela Pola have granoblastic structure but at some places it can be found with porphyroblastic structures. Percentage on calcite and dolomite is: 94.08% dolomite, 6.25% is calcite in white marbles. On the other hand calcite is present with 93% in gray marbles. Except dolomite and calcite also appear the following accessoring minerals: quartz, fluorite, corundum and paragonite. In general, after summarizing all the facts, which have resulted from this research we could say that, the Bela Pola marbles are massive, compact and white with high quality. In accordance to all formerly mentioned features, this marbles can be classified in the commercial group of marbles suitable for external application or internal design.

Key words: marble, calcite, corundum, fluorite

INTRODUCTION

The Bela Pola locality is situated near the village of Nebregovo at 19 km from Prilep. It is situated at the base of the Babuna mountain massive in north part on Prilep.

This locality has good infrastructure connected with Prilep across locally road Prilep–Nebregovo and Prilep–Sivec mine.

Bela Pola marble belongs to the Pelagonian marble mass. This marble mass is situated between Prilep anticline on the south–west and intensively folded mountain mass Mukos on north–east. (Fig. 1) Marble mass is sinking to the north–west under Pliocene sediments on periphery at the Pelagonian basin. It also appears near Cave locality and Kozjak syncline (Marik 1940; Stojanov 1958, 1960).

Lithostratigraphic and tectonic characteristics of this mass are pointing out to multistage process of sedimentation, regional metamorphism and late tectonics deformation.

White small grains dolomite marbles are appearing on the south–western part of the marble mass, but calcite marbles are situated on the north–east higher parts of the marble mass.

Hydrogeological characteristics of marble deposit have shown presence of few smaller water sources. All of them are situated at 910 – 930 m above sea level.

The presence of the water is very important element, because technology of marble exploitation is impossible without water.

RESULTS AND DISCUSSION

Microscopic investigations have shown that these marbles have small grains structure and porphyroblastic structure at some places. In the crushing zones were determinated cataclastic and milonitic structures. Dolomites grains are 0.1–0.5 mm in size. They are rounded and have pronounced cleavage. Accessories minerals like, fluorite, corundum and paragonite are appearing in the crushed system in marble mass.

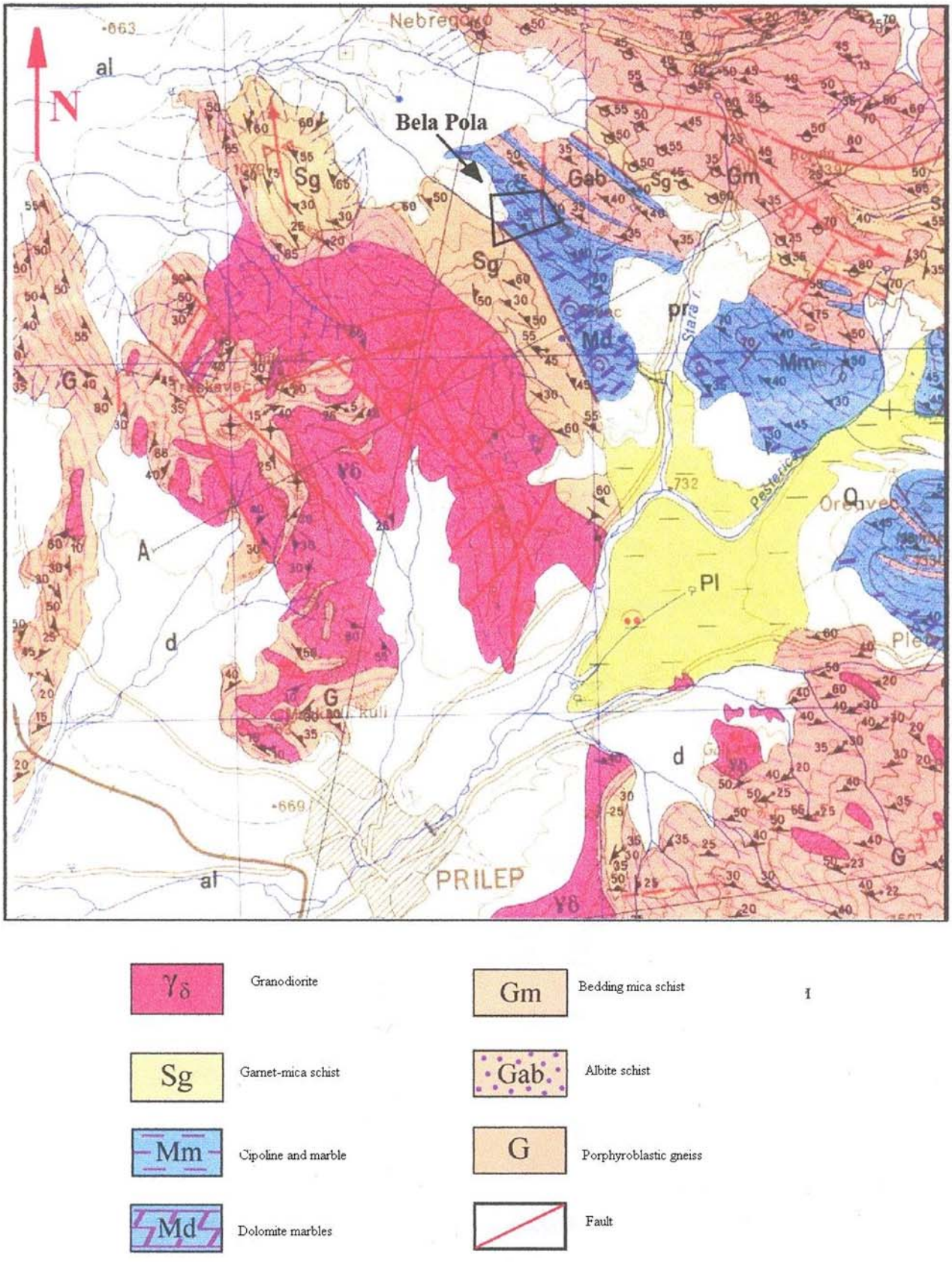

Fig. 2. Detal geological map on Bela Pola marble deposite

Marble mass has been classified in few categories based on: appearance form ,system of the crushing, degree of compactness and crushing.

I. Massive marbles with low degree of crushing. They are relatively compact, white, saccharoses, poorly stratified with or without presence of calcite. On some places, which are exposed on erosion, were formed dolomites gravels thick above 1 m.

II. Marbles with bank form – were classified as the second category and extends in form of stripes width from 75 to 100 meters. Those are saccharoses white marbles with or without calcite. The crushed of marble mass is slightly larger than the previous, which gives the impression that it is of worse quality.

III . Plate slaty – clear stratify marble. Thin layeres white marbles are occupying the north–eastern parts with expressed foliation which is on distance between 10 and 30 cm. This category still does not represent interest.

IV. Crushed marble without clear stratification. These marbles are found around marbles of I and II category. These marbles are not interesting for exploitation.

Beside the classification of marbles towards the degree of compactness and crushing, for the white marble of the zone of Bela Pola–Sivec mineralogical composition and its impurities, or color are important. Also, on the basis results of previous studies, exploitation and set aside blocks of marble there are three categories of marbles:

– Bela Pola extra white category – pure white saccharoide dolomite marbles without presence of calcite. Their spatial determination of surface-based mapping is impossible to define. It was made only by the results of exploration drilling.

– Bela Pola white category – white marbles with saccharoide dolomites and calcite occurrences that are chaotically arranged in the mass and not very common.

– Bela Pola gray saccharoide dolomite marbles with more frequent runs of calcite occurrences. High presence of calcite in this type of marble gives gray-white color.(Fig. 2).

Fig. 1. Bela Pola deposit

Physico-mechanical characteristics

Physico-mechanical characteristics on marbles are:

Strength of the pressure in the dry state – P_{sr} = 148.20 MPa

Strength of the pressure condition – P_{sr} = 132.10 MPa

Strength of the pressure after freezing and thawing 25 cycles – P_{sr} = 117.60 MPa

Water absorption – σ = 0.0792 %

Volume mass – γ = 2845 kg/m^3

Resistance against wear by scraping – A = 31.2 cm^3/50 cm

Chemical characteristics of the Bela Pola marbles

For chemical investigations samples were taken of white and gray marbles from the Bela Pola. Chemical analyses were made with ICP-AES method. Major and trace elements were determinated. The results are shown on table 1

T a b l e 1

Chemical analyses of white and gray marble

	White marble	Gray marble
	%	
CaO	31.89	54.23
MgO	20.56	1.70
Al_2O_3	0.00	0.02
Na_2O	0.01	0.05
K_2O	0.12	0.12
	mg/kg	
As	<5	<5
Ag	0.85	<0.5
Ti	1.70	0.95
Sr	82.72	172.03
Ba	1.30	2.49
Ni	<1	1.89
Mn	9.22	11.57
Fe	128.10	61.24
Cr	1.69	0.57
V	5.40	4.38
P	<5	14.39
Zn	5.11	8.26
Cu	14.02	128.15
Pb	0.02	1.83
Cd	<0.5	<0.5
Co	<1	1.97
Mo	1.62	<1
W	1.24	2.41

The results in table1 and diagrame on (Fig. 3) shows that gray marbles contains high concentration of CaO, but white marbles contain high concentration of the MgO.

We made analyses of percentage ratio on dolomite and calcite in white and gray marbles.

These results have shown that white sample is dolomite marble. Percentage of calcite and dolomite are: 6.25% and 94.08% respectively.

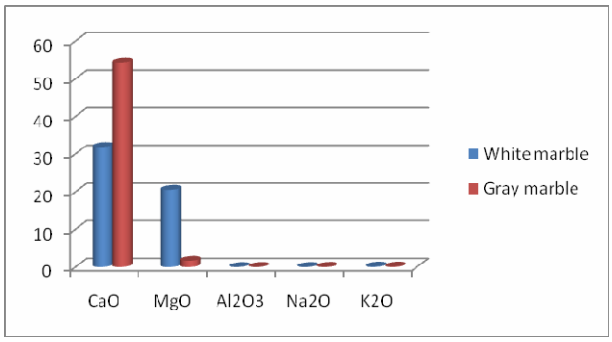

Fig. 3. Concentration of major elements in white and gray marble of the Bela Pola

On the other side results show that gray marble is calcite marble. Calcite is present up to 93%.

Concentration of trace elements is shown on the (Fig 4). Gray marble contains high concentration of Sr and Cu. Concentration of Fe is high in white marble.

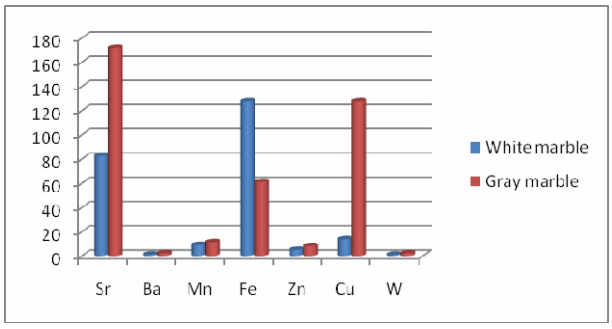

Fig. 4. Concentracion of trace elements in white and gray marble of the Bela Pola

Proportional dependence between trace elements in white and gray marbles of Bela Pola is shown of (Fig. 5).

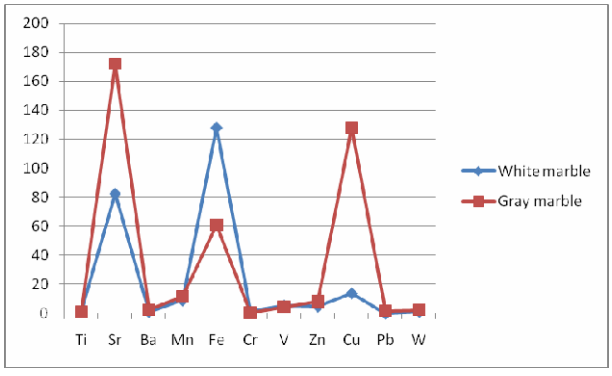

Fig. 5. Proporcional dependence between trace elements in white and gray marble of the Bela Pola

In crushed marble mass system, are present individual crystals of calcite fluorite, and corundum.

Calcite ($CaCO_3$)

Individual crystals of calcite are 2–3cm in size (Fig. 6). They are also distinguished with regular growth crystal form. Calcite is discolored (Fig.7a), but it can be found as yellow ones (Fig 7b). Cleavage is clear (1010). Crystallize hexagonally, 3m. Hardness 3, specific gravity 2.71. g/cm.

Fig. 6. Calcite crystal from Bela Pola

a)

b)

Fig. 7. Form on apearence on calcite from Bela Pola

Table 2

Chemical analyses of calcite

	Calcite 1	**Calcite 2**	**Calcite 3**
		%	
CaO	55.56	54.22	55.74
MgO	0.39	1.626	0.182
Al_2O_3	0.01	0.0076	0.013
Na_2O	0.01	0.0094	0.009
K_2O	0.03	0.115	0.012
		mg/kg	
As	<5	<5	<5
Ag	<0.5	<0.5	<0.5
Ti	0.78	0.44	0.64
Sr	29.30	107.52	61.62
Ba	5.32	3.61	4.07
Ni	2.22	3.04	1.74
Mn	1.96	3.50	10.35
Fe	14.73	504.10	24.00
Cr	0.74	0.59	0.85
V	1.48	2.97	1.80
P	<5	<5	<5
Zn	6.17	8.17	9.62
Cu	7.41	6.01	16.39
Pb	7.44	3.80	8.93
Cd	0.70	1.24	0.87
Co	<1	,1	<1
Mo	1.13	<1	<1
W	2.52	1.45	1.57

The results in table 2 have shown that the concentrations on CaO in sample 1 nad 3 are similar. In sample 2 concentration of CaO is smaller as a result of the higher MgO concentration. (Fig. 8) shows proportional dependence between Ba, Cu and Pb. Also, there is proportional dependence between V, Cd, Ni and Ti (Fig. 9).

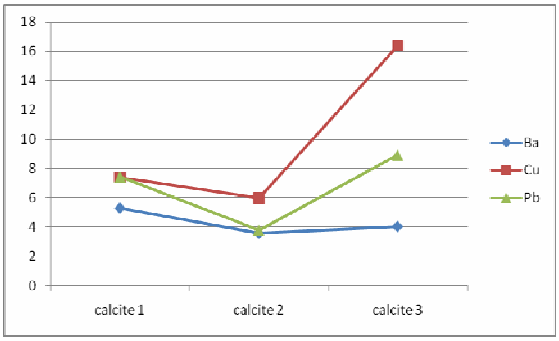

Fig. 8. Proporcional dependence between Ba, Cu, Pb

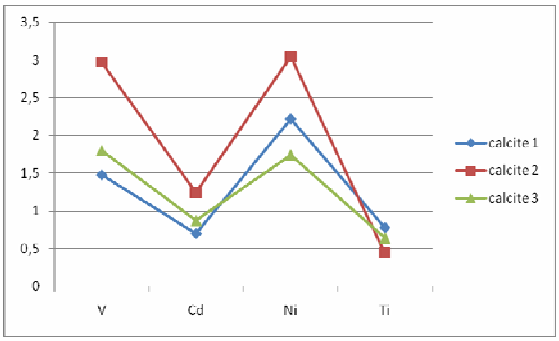

Fig. 9. Proporcional dependence between V, Cd, Ni and Ti

Corundum (Al_2O_3)

Corundum occurs in thin plate crystals or rounded grain. Grains are 1 – 2 cm in size. Ideal crystal form is very rare. Pure sample has vitreous lustre and irregular fracture. Colour is pink in the different hues (Fig. 10, 11) Pink colouring derives from chromium impurities. The content of Cr^{+3} is 10.11ppm. It is shown in table 3. Specific gravity is 4 – 4.01 g/cm^3, optical is anisotropic, pleochromatic colour is blue-dark purple. Interference colour is gray first order, Ne – 1.768, No – 1.760, No – Ne – 0.008. The chemical analyses of corundum is shown in table 3.

Fig..10. Corundum from the Bela Pola

Fig. 11. Corundum from the Bela Pola

The amount of trace elements in corundum can vary considerably within the same deposit. The differences in chemical compositions of corundum from one deposit type to another are sometimes smaller than the variation within the same locality. Therefore it is difficult to assign a typical trace element pattern of ruby and/or sapphire to a specific deposit. Nevertheless, some elements may be useful for deducing a possible geological setting of formation. A completely different picture is given by the oxygen isotope composition (Dufour, M at. all. 2007). The geological setting determines the isotopic compositions: (1) corundum from ultramafic xenolites have 2–3 ‰. $\partial^{18}O$. Corundum xenoliths in basalts have an isotopic signature in the range of typical basaltic rocks, which is between 4 and 6 ‰. Corundum from amphibolites, where a gabbro or basalt is the precursor rock also have an isotopic composition around 5 – 6 ‰ $\partial^{18}O$. Rubies of metamorphic and/or metasomatic origin have ~12 – 14 ‰ $\partial^{18}O$. Rubies and sapphires which are associated to marbles have a typical sedimentary signature with 18 – 24 ‰ $\partial^{18}O$ (Okrusch, M at al. 1976). The lower values probably indicate some interaction with a metamorphic fluid.

Fluorite (CaF_2)

Fluorite from the Bela Pola occurs in crystal forms with different sizes (from very small to samples with sizes up to 2 – 3 cm.) on which are grown hexahedral and octahedral forms. Cleavage is perfect. Streak-white. Usually has light purple colour (Fig. 12). Crystal system – cubic, lustre-vitreous, hardness 4, specific gravity is 3,18 g/cm^3. Optical is positive. The refractive index is 1.433. Chemical analyses of fluorite are shown in table 3. Yttrium and cesium may substitute for calcium (Klein and Hurlbut, 1993). The yttrium and other trace impurities in fluorite are thought to be the activator causing fluoresces in fluorite (Robbins, 1994).

Fig. 12. Fluorite from Bela Pola

Table 3

Trace elements of corundum and fluorite (mg/kg)

	Corundum	Fluorite
Mn	4.81	2.12
P	16.75	13.45
Sr	2.62	18.33
Ba	13.51	18.74
Ni	1	5.01
Cr	10.11	1.26
Zn	8.31	14.30
Cu	7.74	8.92
Pb	1.61	9.00
Co	<1	<1
Cd	<0.5	<0.5
V	7.312	1.946
Mo	5.78	1.19
Ag	1.37	<0.5
As	<5	<5

CONCLUSION

Based on these investigation we came up with the following conclusions.

Marbles from Bela Pola deposit are dolomite–white marbles and calcite – gray marbles. Dolomite marbles occurs in south–western parts of the marble mass, and calcite marbles occurs in north–eastern higher part of the marble mass.

Microscopic investigations have shown that marbles from Bela Pola have granoblastic structure, but at some places it can be found with porfiroblastic structures.

Percentage on calcite and dolomite is: 94.08% dolomite, 6.25% is calcite in white marble. On the other hand, calcite is present with 93% in gray marbles.

Except dolomite and calcite appear individual crystals of calcite fluorite, corundum and paragonite.

In general, after summarizing all the facts, which have resulted from this research we could say that, Bela Pola marbles are massive, compact and white with high quality.

In accordance to all formerly mentioned features, this marbles can be classificated in the commercial group of marbles suitable for external application or internal design.

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Р е з и м е

МИНЕРАЛОШКО ХЕМИСКИ КАРАКТЕРИСТИКИ НА МЕРМЕРОТ ОД НАОЃАЛИШТЕТО БЕЛА ПОЛА

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Клучни зборови: мермер; доломит; калцит; корунд; флуорит

Мермерот од Бела Пола во основа е доломитски и доломитско калцитски. Доломиотски мермери се појавуваат во југозападниот дел на мермерната маса, а калцитските мермери ги градат североисточните повисоки делови на мермерната маса.

Со микроскопските испитувања е утврдено дека мермерот има ситнозрнеста гранобластична структура со преоди кон порфиробластична. Процентуалната застапеност на доломит и калцит кај белиот мермер е 94.08% доломит и 6.25% калцит, додека кај сивиот мермер калцитот е застапен со 93%.

Врз основа на сите претходно споменати минералошко-хемиски карактеристики овој мермер може да се класифицира во групата на комерцијални мермери и може да се користи за надворешни апликации или како материјал за внатрешно уредување.