



Scandic Journal of Advanced Research and Reviews

ISSN: 2703-965X CODEN (USA): SJARCA
Cross Ref DOI: [dx.doi.org/10.55966/sjarr](https://doi.org/10.55966/sjarr)
Journal homepage: www.sjarr.com

Petrological, Geochemical and Mechanical Characteristics of Afghan White Marble.

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Scandic Journal of Advanced Research and Reviews, 2022, 3(02), 001–015

Article DOI: <https://doi.org/10.55966/sjarr.2022.3.2.0050>

Abstract

The aim of this article is to examine the Geological, Geochemical, Mineralogical, and Physical-Mechanical characteristic of Afghan White Marble deposit in Nangahar province Afghanistan. The objective of the article includes information about the value, quantity & quality of the marble mine. In addition, this study summarizes information related to the marble mining methods, Processing and production tools technologies used for extracting of Marble in Afghanistan.

To achieve, the aim of the research, library, field and Laboratory methods have been used. The library result shows the general information related to Geology, Tectonic and Magmatic of the study areas. A fieldwork was conducted in the study area and appropriate measurements i.e. Geographical location and reserve estimation were taken and also 10 sample of marble were collected from the mine of Ghondy n Mamakhail for lab analyses. The collected samples were analyzed by using different analytical methods such as XRF, Electron polarizing microscope and mechanical tests such as compressive strength, specific gravity, absorption, and unit weight. ASTM standard is used to interpret and compare the results from the above mechanical analyses.

The XRF and microscopic analyses show that the marble from Nangrhar Province Shirzad district Kodikhel have dolomite composition. The results from different mechanical and physical tests showed that these marbles have

high consistency against any types of applied pressure, and have high value, which can be used in various construction's affairs. In Summary, you need to focus on the results and interpretation of those analyses.

Key words: Marble, Jalalabad, Kodikhel, AfghanWhite, Spinghar Complex

Introduction

Marble is commonly used as construction and dimensional stone in Afghanistan especially in eastern part of Afghanistan such as KodiKhel's Afghan White Marble. There are different varieties of marble (be consistence in writing) in different provinces such as Kunarr, Bamiyan, Kabul, Balkh, Kandahar, Herat, Paktia, Parwan, Helmand, Nangrhar, Faryab, Wardak, and Samangan which are extracting and supplying to different countries and are prized for its purity, strength, composition and uses since the advanced technology was not present. Afghan White Marble is world famous marble due to its best quality. The reveres exist in eastern part of Afghanistan Khogyani Shirzad district, Kodikhel village. The constituent rocks of these marbles are mostly carbonate and Talc rocks (Mirzaie, 2019).

Methodologies

The purpose of this article is to find out the mechanical characteristic, quality and mineral composition of marble. (bring the purpose to introduction section) In this research desk study was conducted before field visit and laboratory analyses to collect the prehistoric studies of the marble for Thin sections were prepared in Ministry of Mine & Petroleum for microscopic analysis and a proper amount of rock sample was crushed and pulverized

such purpose, books and different articles were studied along with Wikipedia information. samples were collected from the Marble mine for laboratory analyses and then completely studied the area with taking the GPS point and toke samples from exact mine. The field work data and analytical data was interpreted to come up with the conclusions.

for geochemical analyses. The third part of the research consists of GIS mapping of the mine area.

Geology of the Region

It is necessary to consider the geological structure of this Tectonic Zone. The Tectonic zone of Jalabad is located in eastern part of Afghanistan and the southeastern part of Nuristan zone. for the first time this was separated by Prof. Slavin and Syed Hashem Mirzad in year (1969) and Kalchanof and Sayed Hashem Mirzad added this zone in Tectonic map and relate this zone with Alf Core.

visible on the ground and the central part of the Jalalabad zone is covered by Neogene Deposit.

In the Jalabad zone there are sediments ranging from Archean Protozoic to Quaternary system. The Archean Protozoic structure are composed of various Gneisses, Quartzite, Amphibolite and crystalline slabs including the white Marble layers of Marble. The thickness of the Marble layers inside the Gneisses is from 300 to 600 meters.

Jalabad Tectonic Zone (Spinghar Block) Geological map

The Jalabad zone is a part of the depth of the past Cambrian which trace minerals lies above the ridges of the past Cambrian that form base of Geosyncline. These ridges appear in the mountain to the surface of the earth.in the eastern part of Zone and in the southeastern part of Jalabad city, on the left bank of the Kabul river and on the banks of Kunarr river the upper Paleozoic and lower Mesozoic sediment are

The Paleozoic group formation are relatively extensive in the Jalabad zone including the Ordovin, Silurian, Divionin and Carboniferous formation. These formations are composed of Quartzite. Sediment Sandstone and Limestone the relationship between which is not clear in some places. The sediment of the Neogene system is present on the top of the sediment disconcordantly which include Conglomerate Sandstone and Clays. The sediment of

Quaternary has filled the shore of the river and their thickness is also high

In the zone of Jalabad relatively Magmatic rocks are present in large amount that are visible on the ground of the left of Kunarr river and in the Spin Ghar mountain range which differ from one another in age and in composition and are divided in to two different complexes.

1: Granite, Gabbro, Amphibolite Complex

2: Granite, Granodiorites Complex

And Albite that are spread in different part of the Zone. And these Magmatic rocks are interesting according to Mines presence.

Tectonically Jalabad zone is associated with the Cambrian structure with three structural formation layers separated by

O-T, AR-PR and N-Q

in a tectonic map in 1973 the department of Geology and Mines has divided Jalalabad zone to three further sub zone in this region (Waizy, July 2020).

1: The Kunarr Tectonic Zone

2: The Spinghar Tectonic Zone

3: The Jalabad Basin

Uses of Marble

Marble is a metamorphic rock and use as a construction and dimension stone. The use of this rock (marble is a rock not a mineral) on a large scale depends on a number of properties which include strengthens, low abrasion and high whiteness. In addition, marble is used in paper rubber paint cosmetics and pharmaceutical industries.

Petrographic, Geochemical and Mechanical Characteristic of AfghanWhite Marble

The Kodikhel Afghan White Marble Mine exploration is located in Nangrhar province Khogyani Shirzad district. The percentage of the Magnesium in these Marble are seen not on the surface but at depth of 3 meters. And there is Magnesite near the Afghan white marble and their percentage reaches to 35% and the percentage increases at the center part of the mine. According to the structure these marbles has granoblastic structure and smooth texture during the microscopic description. The rocks of the region are consisting of Serpentinized Diabase and Amphibolite Dikes Chrysotile aggregates and Antigorite

In Kodikhel Afghanwhite marble Mine the Magnesite layer is 1 to 2 m thick and in some places these layers varies up to 5 m thick. and the Marble layers are 35 to 90m thick and the Talc layer is 20m thick. On the sloping side of the Marble northeast, the Marble layer is slightly thicker and in some areas is reflected in the form of lenses which form a clear boundary between Magnesite and Marble. In some places the Amphibolite Dikes have increased the tendency of Marble to cut the Magnesite layers. Those Amphibolite which are derived from the Albite

Plagioclase. Amphibolite (0.3mm in thickness) and Alkaline Hornblende are present and Epidote Minerals in the form of leaflet. And it grows to (0.01mm) in Plagioclase.

Exposure of Marble has been implicated in Carbonate rocks that in terms of age correspond to PR2 in the upper Proterozoic. The most abundant in the area is Dolomitic Marble to which the Talc minerals are attached. it is mainly inclined to the south and southeast with an angle of inclination of 5 to 7 degree. The Dolomite Marble correspond to the structural and texture characteristics and the composition of the sediment. In regional metamorphism grayish color bright crystal of Metamorphic marble are seen very clearly minerals have grown unevenly throughout the region. Amphibolite have a magmatic origin that's why it has an Ophitic Structure characteristic. The Province of Nangrhar Khogyani district Kodikhel area is very interesting in terms of the presence of Marble and Magnesite on the basis of Petrographic and geochemical studies we have taken the samples from Kodikhel, mining areas.

Nangrhar Province Khogyani district Kodikhel area is rich and interesting according to the presence of Marble, Talc and Magnesite. So, on the base of Petrographic and geochemical research on Khogyani district Kodikhel area we have taken the 10 samples and made their slide with the size of 0.027mm and studied those slides under microscope.

Kodikhel mine region is located 50Km southeast of Jalalabad city with coordinate (N: 34 1519.1 E:6956 6.2). You just copied the data and pasted it here. petrographic analysis result has been conducted in Ministry of Mine & Petroleum Petrological Laboratory while thin sections were prepared and studied in the Polytechnic University of Kabul. The petrographic results are given below.

Table 1: Geological description of the sample (no number of the sample?)

Samples description	
Rock name	Dolomitic marble
Classification	Metamorphic rock
Geological formation	Khogyani Proterozoic formation
Color	White & gray
Structure	Compact massive
Weathering degree	Fresh
Acid Test	Vigorous

Table 3: Composition of AfghanWhite Marble

Microscopic properties & Mineral Composition	
Major	Minor
Talc	Chlorite
Calcite	Muscovite
Dolomite	Hornblende
Tremolite	
Magnesite	

Petrographic description of the Samples

M2-2: the color of the sample is greenish, structure is granoblastic and texture is massive. The minerals content is Iron, Dolomite and Calcite. The fragments of the sample are granular in which the most amount is Dolomite and Fe. (figure 1)

M3-3: the color of the sample is grayish, structure is granoblastic and texture is massive. The minerals are Muscovite, Dolomite, Iron and Calcite. The fragments of the sample are granular in which the most amount is Dolomite and Calcite. (Figure 2)

Note: Calcite Mineral can be seen with interference color in every sample and Tremolite are elongated and Muscovite and Chlorite are with bladed and flaky shape.

M4-4: the color of the sample is grayish, structure is granoblastic and texture is massive. The minerals are Muscovite, Dolomite, Quartz, Tremolite and Calcite. The fragments of the sample are granular in which the most amount is Tremolite. (Figure 3)

M5-5: the color of the sample is light and dark, structure is granoblastic and texture is massive. The minerals are Muscovite, Chlorite, Quartz, Tremolite and Calcite. (Figure 4)

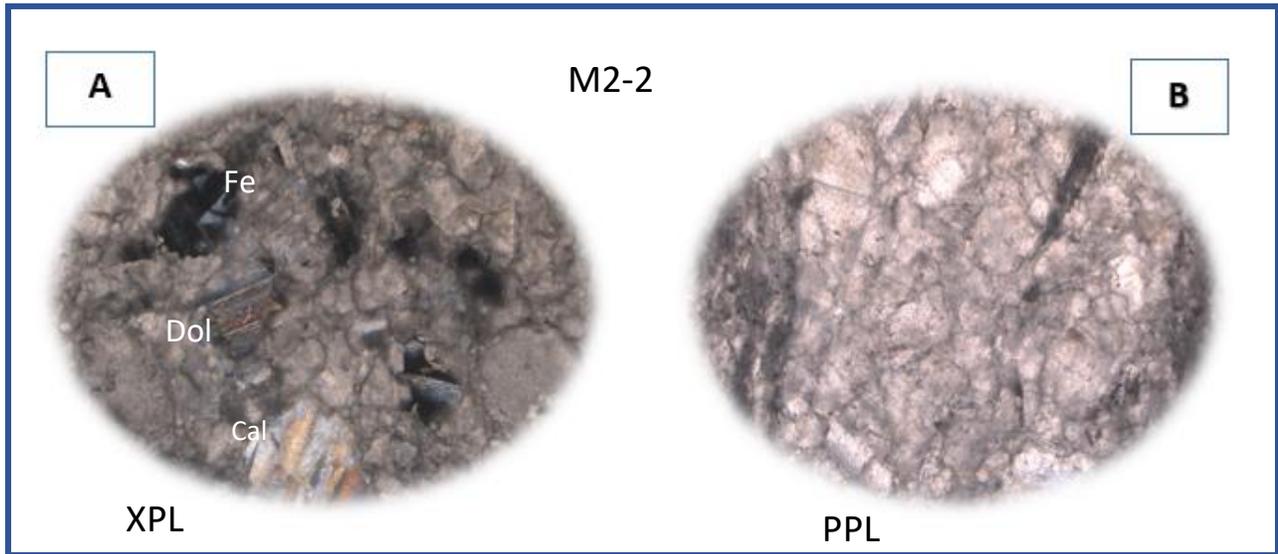


Figure 1: M2-2 sample photo and mineral assemblage under microscope

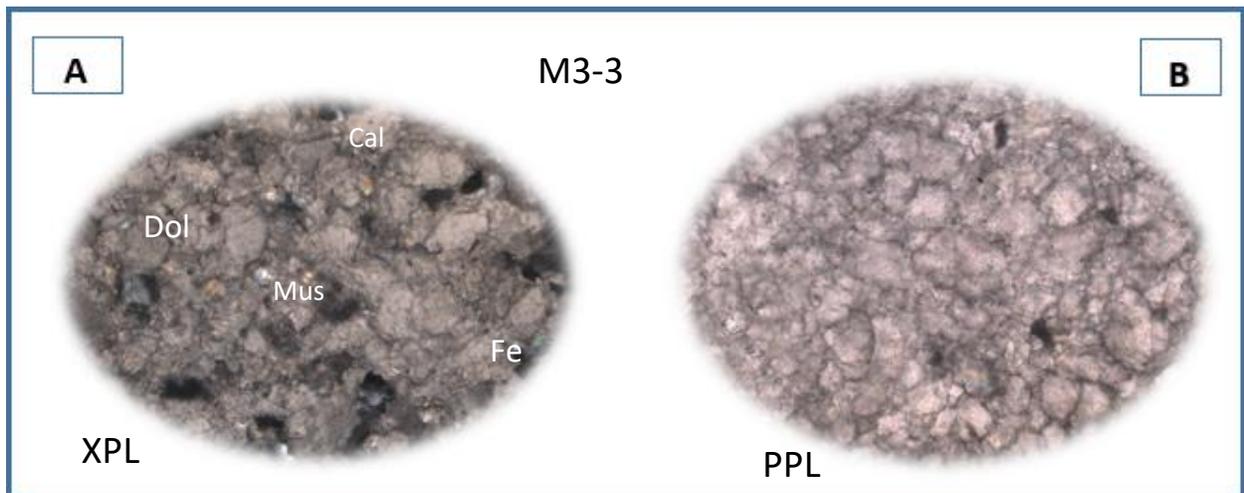


Figure 2: M3-3 sample photo and mineral assemblage under microscope

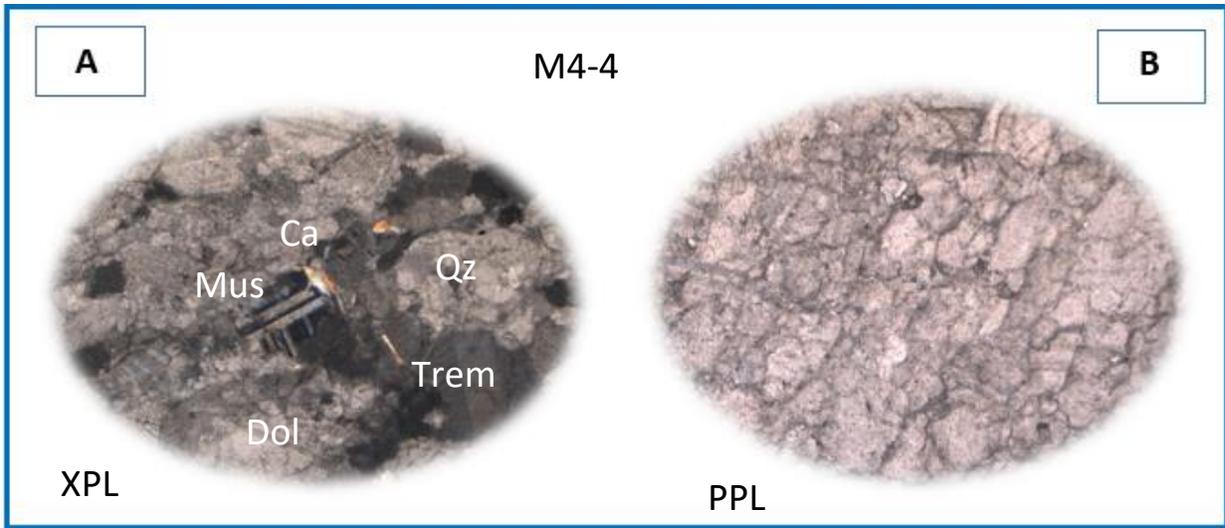


Figure 3: M4-4 sample photo and mineral assemblage under microscope

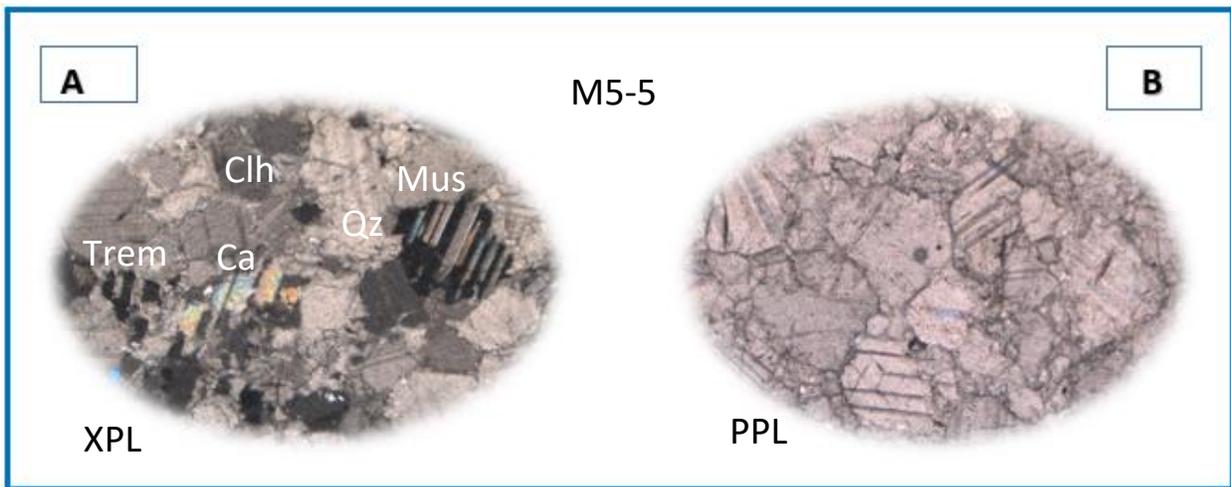


Figure 4: M5-5 sample photo and mineral assemblage under microscope

Geochemistry

The spectrometric analysis shows that the sample M2-2 has 7.9% to 11.1% Al₂O₃ and also a large amount of MgO 15.7 to 25% percent whereas the MgO percentage is 29.4 to 34% percent.

Table 4: the XRF result of oxides in the Marble.

Oxides	
Oxides	Percentage
MgO	15.2850703
Al 203	7.1633716
SI02	89.012121

Fe2O3	0.937258
Cr2O3	0.094084
CaO	37.2373188
K2O	0.3392685
SO3	2.6946867

figure1 :the graph shows the Ca and Si element increases in neighbor rock. What data did you

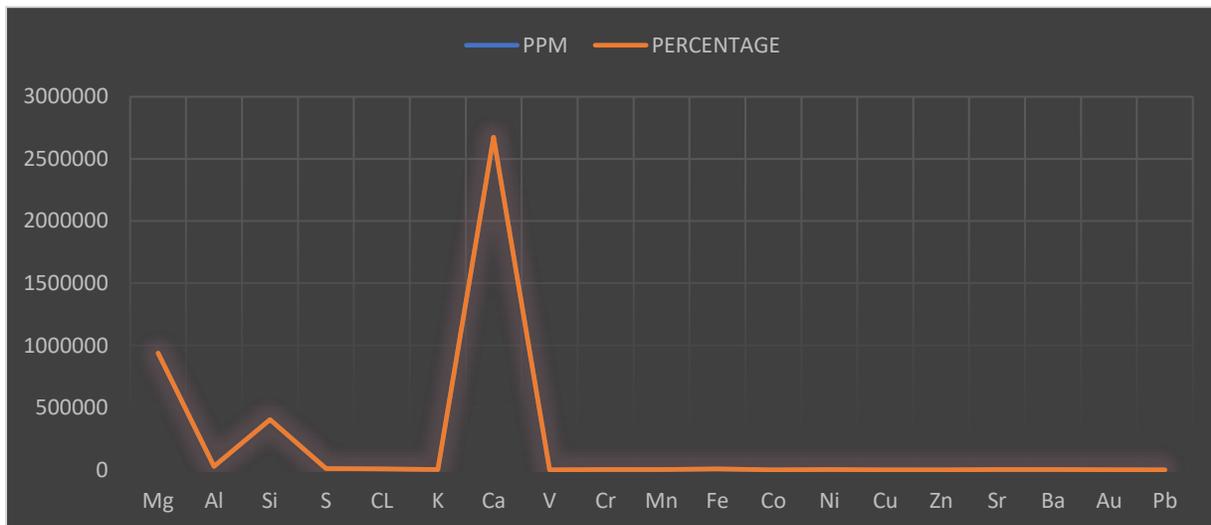
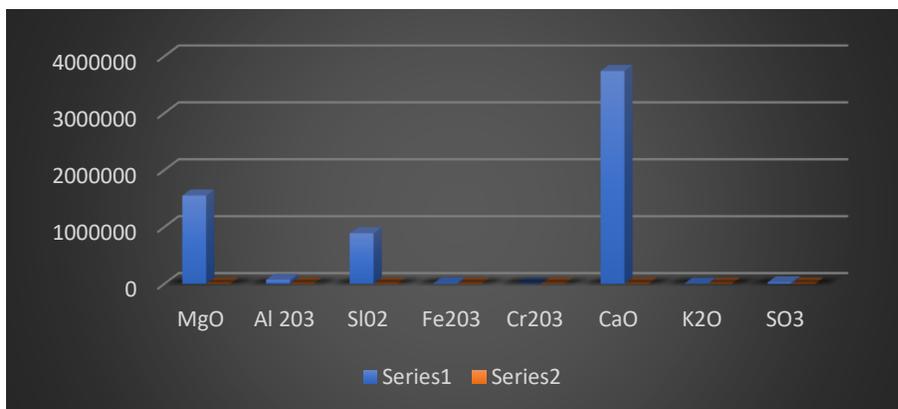


Figure 2: The graph shows the result of MgO SiO2 and CaO



And the percentage of Al₂O₃ and Fe₂O₃ is also less than 1% but in some sample such as M2-2 and M1-3 the amount reaches to 2.5% only in one sample which are taken from the exact pure Marble body. The percentage of Al₂O₃ and Fe₂O₃ reaches to 12.52 and 3.76% .and in the neighbor rocks the percentage of CaO in Talc sample less than 1% but the cover rock of the Complex which is in Carbonate form it reaches from 18 to 26% and can vary mine to mine.

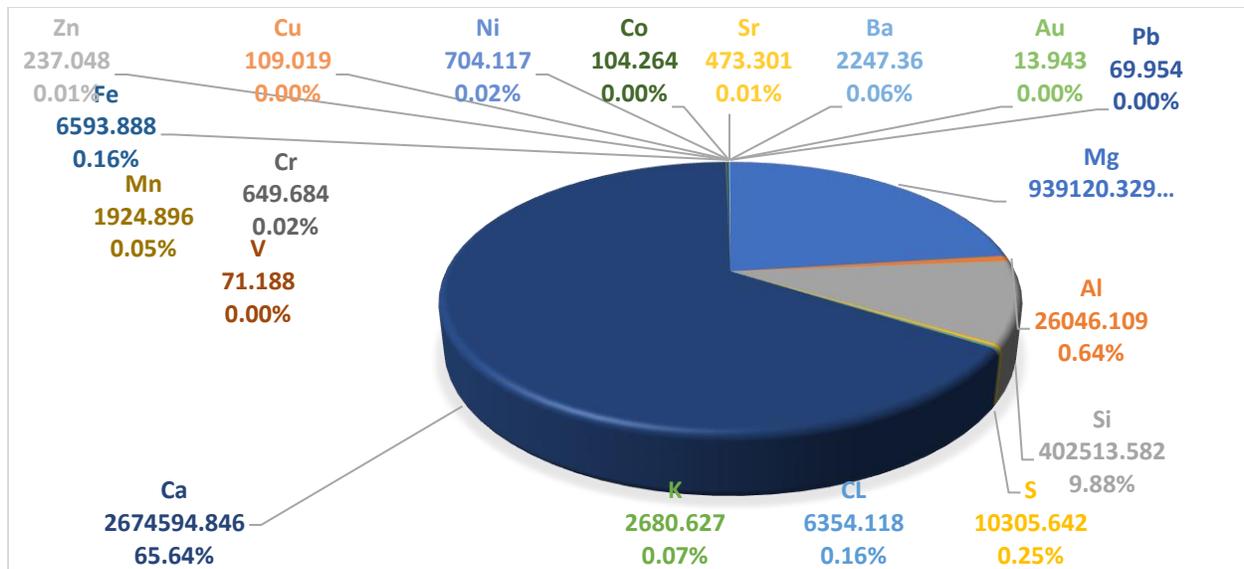


Table 5: shows the element result of the AfghanWhite Marble.

XRF		
ELEMENT	PPM	PERCENTAGE
Mg	939120.329	23.05
Al	26046.109	0.64
Si	402513.582	9.88
S	10305.642	0.25
CL	6354.118	0.16
K	2680.627	0.26806
Ca	2674594.846	65.64
V	71.188	0.0071188
Cr	649.684	0.0649684
Mn	1924.896	0.1924596

Fe	6593.888	0.6593888
Co	104.264	0.0104264
Ni	704.117	0.0704117
Cu	109.019	0.0109019
Zn	237.048	0.0237048
Sr	473.301	0.0473301
Ba	2247.36	0.224736
Au	13.943	0.0013943
Pb	69.954	0.0069954

Mechanical studies of Afghan White Marble

The Afghan White Marble mechanical studies consist of the following tests which is completely described with their result done in Nangrhar Alfalah University Engineering Laboratory.

Compressive strength

Uniaxial unconfined compressive strength is the amount of load a stone can tolerate before it breaks in to pieces, such measure of stone's ability to support load bearing structures

According to the table below the dry to wet conditions, uniaxial compressive strength of Afghan White Marble is between 55 to 61 Mpa. Such value is set in category of strong rock break by hammer in hand based on strength recognition and description (Mirzaie, 2019).

Material Description		Crushed Aggregate of SHIRZAD Marble			Material Source		SHIRZAD MARBLE		
Cube No	Testing Date	Dimension (mm ²)		Area (mm ²)	Load (KN)	Compressive Strength			
		Length	Diameter			KG/CM ²			
1	18-Apr-2022	71.5	71.5	5112.25	420.0	82.2			
2	18-Apr-2022	71.3	71.7	5112.21	200.0	39.1			
3	18-Apr-2022	70.0	74.0	5180	306.3	59.1			
Total Average of strength					Mpa	Kg/cm ²	Psi		
					60.1	613.2	8722.2		

Table 6: The Compressive strength result done in Alfalah University Engineering Lab.

Abrasion or Los Angles test of Marble

The test method is gone through a procedure when it can only test the coarse aggregate smaller 37.5 mm (1 1/2in) from the resistance to degradation the Los Angeles testing machine is used.

As stated in the table below abrasion value of marble samples is 20%. And this abrasion values refers to dolomite and limestone rock types. Consequently, the abrasion value of Afghan White is normal and appropriate for the mentioned applications.

Table 7: the Abrasion test result is shown in the following table

Material Description	CRUSHED AGREAGTE OF SHIRZAD MARBLE				MATERIAL SOURACE				SHIRZAD MARBLE			
Date of Test	7-Apr-22											
Gradation	Passing with mm	19	12.5		37.5	25	19	12.5	9.5	6.3	4.75	
	Retained with mm	12.5	9.5		25	19	12.5	9.5	6.3	4.75	2.36	
Designation /No of Balls		B/11										
Weight	g	2500	2500		1250	1250	1250	1250	2500	2500	5000	
Designation/ No of Balls					F				B/11			
Weight	g				5000	5000		2500	2500			
Designation / No of Balls					G							

Weight		g			5000	5000	
1	Designation			A			
2	Revolution (30 + 33 r.p.m)			500			
3	Number of Balls			12			
A	Total Mass of Sample g			5000			
B	Mass of tested sample Retained on 1.7 mm sieve g			3830			
C	Abrasion (A-B) /A*100			23.4			

Water Absorption and Specific gravity

Water absorption is the amount of water which can be absorbed under some proper immersion states of rock. According to the attribute data mentioned above in the table 1, the absorption of marble stone is between 0,003 to 0.195% with the average percentage of 0.082. That mentioned value of absorption is considered very low based that quality it resists against humidity.

Table 8: The Table shows the Absorption and Specific gravity of the Afghan White Marble.

DESCRIPTION	CRUSHED AGREAGTE OF SHIRZAD MARBLE	MATERIAL SOURCE			SHIRZAD MARBLE
Date of Test	17-Apr-22				
	Description				Average
1	Trial No	1	2	3	-
2	Temperature of water	26.8	27.5	28.0	-
3	Mass of oven dry sample in air (W1)	1030.0	1042.0	1026.0	-
4	Mass of sample (w2)	1030.03	1042.5	1028.0	-
5	Mass of Sample in water (W3)	672.0	682.0	674.0	-
6	Specific Gravity (SG) (a) Bulk SG (oven dry)	2.877	2.890	2.898	2.889
	(b) Bulk SG (SSG)	2.877	2.892	2.904	2.891
	(c) Apparent SG	2.877	2.894	2.915	2.895
7	Absorption	0.003	0.048	0.195	0.082

Unit weight

That test is used to measure the quality of aggregate through determining the placed materials volumes the hallows within the distant range. When the scale of the aggregate reaches to 25(5inch) mm so the mold is used to measure unit weigh.

Table9: The Unit weight result description is shown in the table below.

Material Description	CRUSHED AGREGATE OF SHIRZAD MARBLE	MATERIAL SOURCE	SHIRZAD MARBLE	
Date of Test	16-Apr-2022			
UNIT WEIGHT OF COURSE AGREGATE				
Test No.		1	2	3
Mass of material + Container	g	4756	4760	4758
Mass of Empty Measure	g	3052	3052	3058
Mass of material	g	1704	1708	1706
Volume of Measure	Cm3	928.9	928.9	928.9
Bulk Density	g/cm3	1.834	1.839	1.837
Average UNIT WEIGHT g/cm3			1.839	

GPS Coordinates GIS and Mapping

The exact location of each sample is accurately mentioned with its coordinates and with its tolerance of 0.5 meter in the table below attributably in The Geographic system.

Also, the Geological Maps are designed with the help of ArcGIS concluding (Geological Map, Tectonically Map, Magmatism Map, Lithological and Hydrological Map)

Altitude (m)	Latitude	Longitude
1790	69° 57' 54 "	34° 16' 20"
1789	69°54' 56"	34° 14' 29"
1767	69° 50' 55"	34° 13' 21"
1735	69° 47' 52"	34° 13' 22"

1734	69° 57' 61"	34° 17' 24"
1775	69° 55' 52"	34° 16' 27"
1710	69° 61' 56"	34° 18' 30"
1755	69° 57' 54"	34° 16' 31"
1790	69° 63' 52"	34° 10' 27"
1734	69° 57' 55"	34° 14' 31"

Note: The GPS Coordinates are taken using German GPS connected with 17 Satellites

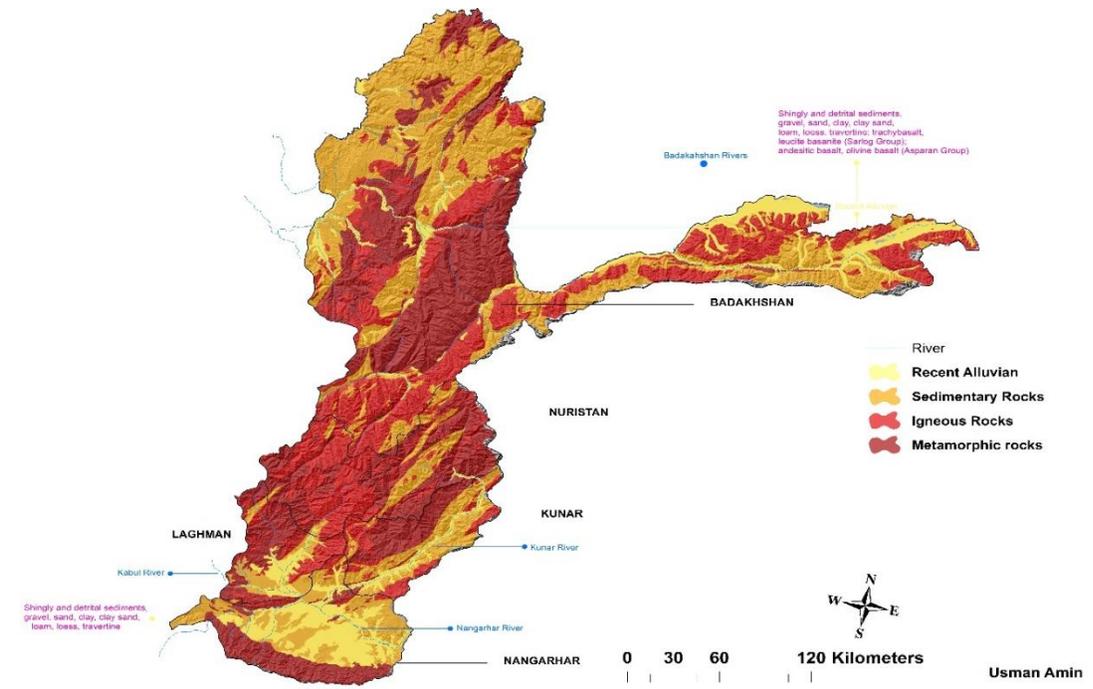


Figure4: the eastern part of Afghanistan contains 4 provinces where our research area is Nangrhar.

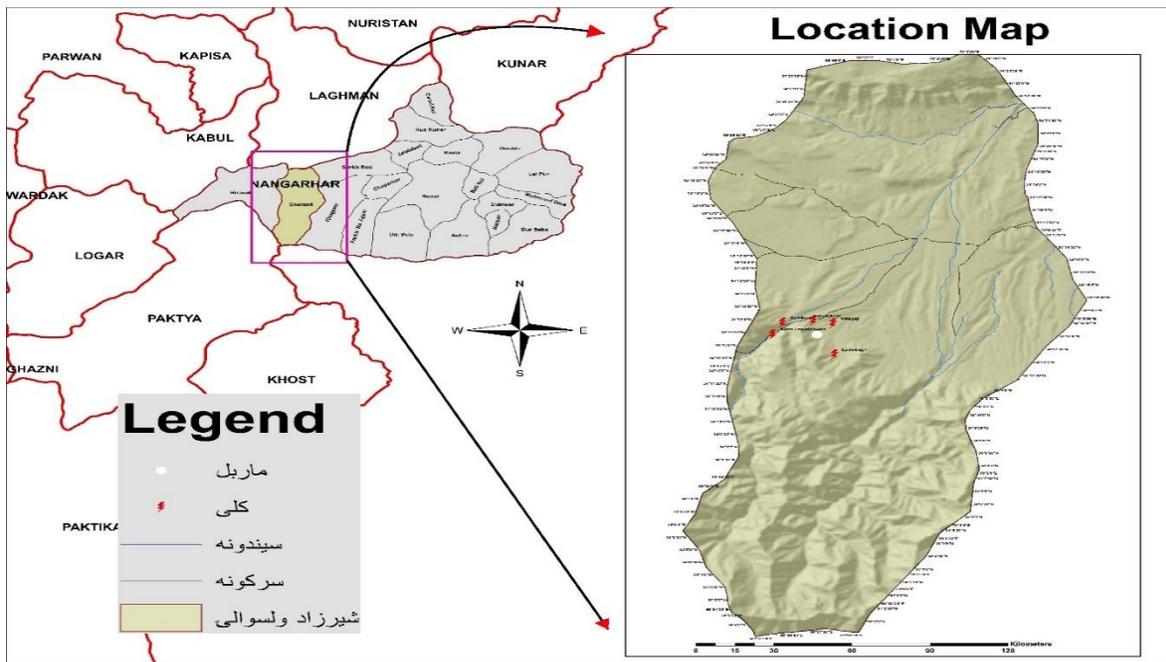


Figure5: Location map of the Khogyani Shirzad district Kodikhel Marble.

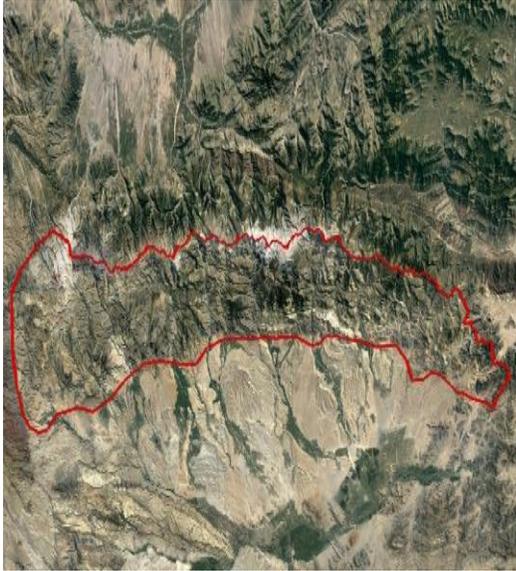


Figure6: Google earth map of the Spinghar complex of Nangrhar province.

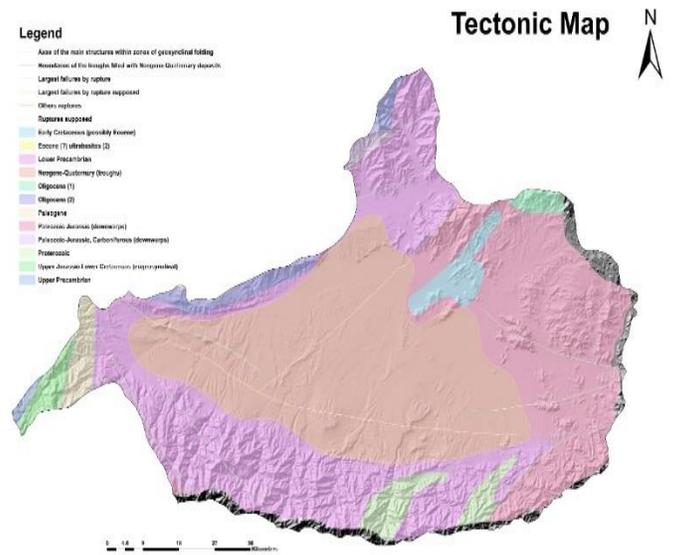


Figure7: Tectonically map of Nangrhar Province

Magmatism

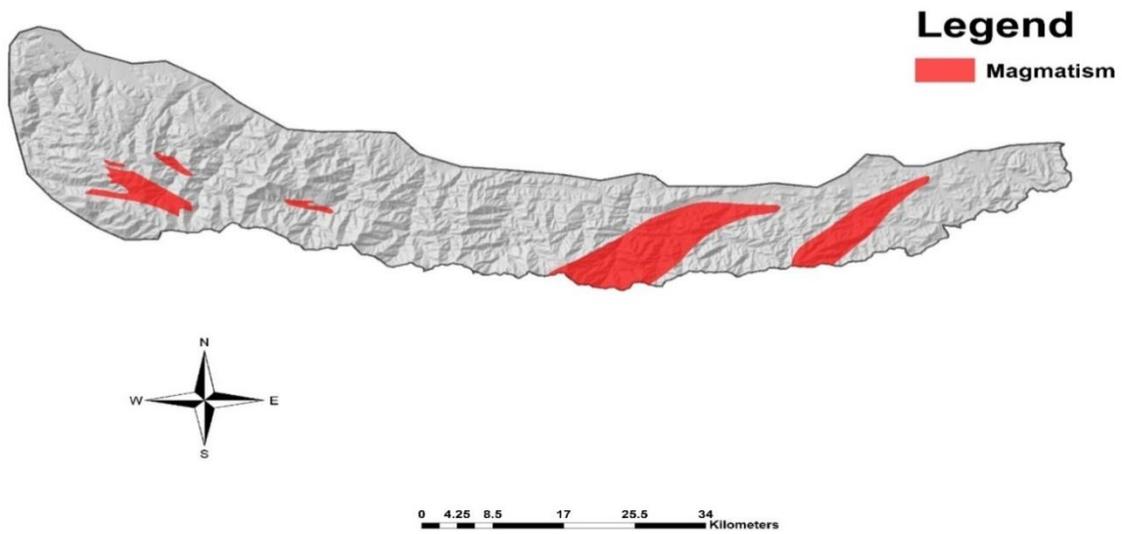


Figure 8: Magmatism map of Nangrhar province.

Result and Discussion

According to the petrographically examination under microscope all the specimens of Afghan White marble had 99% of dolomite mineral because of the over abundancy of dolomite mineral in the composition of Afghan White marble gave the white unadulterated color, and the second obvious factor is the absence of other minerals and elements, which usually give different colors. The structure of these marble is blocky this sort of marble compute in the first category of marble. The XRF (X-Ray Fluorescence) analysis precisely gave that the Afghan White marble has 0.5% slightly other elements for instance (Iron, sulfur, aluminum, chromium, silicon, magnesium). But the worth mentioning thing is that, that these tiny percentage of elements can occur any alteration and variation in the color of Afghan White marble and also in other properties. Regarding to the mechanical and physical experiments the compressive strength of Afghan White marble is 60.1 Mpa. It's a high compressive strength against pressure and it account in the upward category. The specific gravity of Afghan White marble is 2.895 furthermore in the dry form is 2.889 and in the wet form is 2.891. 0.082 is the water absorption, this slightly percentage indicate that the Afghan White marble is suitable for constructions and ornamental purposes. Resistance to degrading of small-size coarse aggregates and impact in the Los Angeles machine is 23.4 and the Unit weight of marble is 1.837 g/cm³, its quite precise to ASTM standard. All in all, Afghan White marble in one of the well-known marbles in the world because of its high quality, stunning color, low absorption of water, High compressive strength and resistance against pressure and load.

Conclusion

The main purpose of this study was to evaluate Geochemical, Mechanical and Petrographic properties of afghan white marble. The general conclusions are presented in below:

1. The physical characteristics of this stone such as white color, homogeny texture, free of cracks and fresh surface define it as decorative and sculptural stone with very high quality.
2. Due to the low water absorption Afghan white stone is highly resistant to weathering, erosion and freezing conditions.
3. On the basis of the abrasion tests results, abrasion resistance of afghan white marble is favorable to use this stone as a decorative and building stone.
4. having the strong rocks grade of Afghan white compressive strength value is acceptable for different applications of building material.
5. Based on mineralogy, the Afghan White Marble contain high resistant minerals such as Mica Muscovite, Biotite, quartz,
6. To review on the Geochemical part the Afghan White Marble the highest percentage of SiO₂ which has given the beautiful Lustrous and shining color to this stone.

Suggestion

1. Since Afghan White Marble has very good quality and beauty, it is recommended to the government to conduct systematic exploration of this mine.
2. Research boreholes of different depths should be drilled for accurate exploration and verification of marble deposits in the fractured area.
3. Expansion of the marble layers that continue in all parts of the Spinghar Complex series must be surveyed and mapped.
4. All parts of the studied area that have good blocks are used for structural work and marbles that do not have good blocks could be used in floor chips and others decoration.

5. As can be seen from the area, marble has been extracted from the mine and is being used in construction. Since there is no systematic extraction system, a large amount of marble is wasted during the extraction process, which is a huge financial loss to the government.

6. In order to reduce waste during production, all factory owners must employ professional and

Acknowledgements

we would like to express our deep gratitude to Professor Khairuddin (Rasikh) and Professor Ziarahman (Alemi), our research supervisors, for their patient guidance, enthusiastic encouragement and useful critiques of this research work. we would also like to thank Dr. Abdul Bari (Qanit), for his advice and assistance in keeping our progress on schedule. our grateful thanks are also extended to Professor Irfanullah (Noorzai) for his help during the mechanical data analysis, at the University of Alfalah. we would also like to extend our thanks to the Dean of Science Faculty Nangrhar University Rafiullah (Rafi) and the dean of Engineering Faculty of Alfalah University Mohammad Mukhlis (Behsoodi) that they help us to complete this research paper.

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knowledgeable miners to improve quality and ensure safety.

7. Encourage traders by the government to expand the marketing of processed marble exports, such as eliminating customs duties on fully processed marble or other similar assistance.

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