
RESEARCH ARTICLE

Internal Structure, Petrography and Mineralogy of Beryl in Bahr-e-Abad Area, East of Afghanistan

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ABSTRACT

This paper deals with the study of beryl, its variety, petrographic, and gemological specifications in the Bahr-e-Abad area of Jalalabad city. Beryl is a relatively rare silicate mineral, cyclo-silicate, with a chemical composition of $\text{Be}_3\text{Al}_2(\text{Si}_6\text{O}_{18})$ and a hexagonal crystal shape. It is found in igneous and metamorphic rocks in many parts of the world. In order to achieve the aim of this paper, three methods, namely; library work, fieldwork, and lab work, were conducted, and about 20 specimens were collected from the above-mentioned area and taken to the Afghanistan Geological Survey (AGS) for making the thin sections and spectrometry analysis. Bahr-e-Abad area is related to the tectonic zone of Jalalabad. Jalalabad zone is located in the eastern part of Afghanistan and southeast of the Nuristan zone. Correspondingly, this zone is related to the upper Cambrian or younger Cambrian. In this area, the age of rocks is related to Archean- Middle Proterozoic AR-PR2. Beryl mineral is mostly found in Europe, Norway, Austria, Germany, Sweden, Ireland, Russia, Brazil, the US, Colombia, and Pakistan. Afghanistan is counted as one of the world's leading countries in having rare-metal pegmatites, which are present in Afghanistan's pegmatite belts in Afghanistan. This mineral is widely available in the pegmatite veins of Nuristan, Sistan, Panjshir, and Laghman. All pegmatite groups of Afghanistan are related to intrusive rocks. This study found that the rocks which are situated within pegmatite veins, besides beryl mineral, generally have the same composition and contain plagioclase, feldspar alkali (sodium-potassium), and mica (phlogopite and biotite) minerals. This is a microcline – albite type.

KEYWORDS

Albite, Beryl, Microcline, Pegmatite, Pegmatite belts, Specimens.

ARTICLE INFORMATION

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1. Introduction

Beryl is a relatively rare silicate mineral, cyclosilicate, with a chemical composition of $\text{Be}_3\text{Al}_2(\text{Si}_6\text{O}_{18})$. It is found in igneous and metamorphic rocks in many parts of the world.

Beryl has served as a minor ore of beryllium, and color varieties of the mineral are among the world's most popular gemstones. Emerald, aquamarine, heliodor, and morganite are the most well-known varieties of beryl. They are resistant to acids. In beryl species, there are mixtures of iron, chrome, magnesium, sodium, lithium, cesium, rubidium, manganese, vanadium, nickel, bismuth, scandium, and gallium. In addition to that, in the chemistry of natural beryl, there is capillary water, and its total quantity reaches up to 2.8%; In temperatures 900-1200 ° C, the water separates from beryl.

Afghanistan has had complex geology throughout its history and has been undergoing great changes for a long time. These changes arise from the forces and pressures of the earth's interior part, which occasionally tear out the outer crust of the earth. The changes appear on the earth's surface and sometimes cause the fabrication and separation of the great continents and oceans, which cause dislocation and alteration of people's settlement over long distances. This process causes the annihilation of animals and the immigration of human beings to other places.

Nangarhar, an eastern province of Afghanistan, is one of the zones which is less investigated for its richness in mines. Based on the plotted tectonic map of Russian geologist W. P. Kalchanov and Afghan researcher Sayed Hashim, Jalalabad city of Nangarhar province is related to the Alp folds, and Russian geologist, Weprit relates this zone to the Nuristan Block of Paleozoic era. In Jalalabad tectonic zone, three zones are isolated, which are Kunar, Spinghar, and Jalalabad depressions.

There are also pegmatite regions, which are included in pegmatite belts of Afghanistan that root from the southwest parts of Afghanistan (northeast border of Sistan Depression), including the central parts of the country, and in the southeast, they exit from Afghan borders and enter into countries, namely China, Pakistan, and Tajikistan.

Evidence indicates that pegmatite belts are rich in minerals, which are further investigated; however, this study will mainly focus on the existence of beryl mineral, particularly in pegmatite belts in the Bahr-e-Abad area of Jalalabad city. This study provides concrete evidence of the existence of beryl and other useful minerals that have economic and industrial importance and suggests that further research is needed to investigate the excavation of beryl mineral for beneficiation of the Beryllium element.

1.1. Objectives of the Research

There are no previous works and research that have been conducted in such an area, so the main objective of this study is to determine the petrographic and gemological properties of beryl mineral as well as its mineralogical composition in pegmatite veins of the Bahr-e-Abad area of Jalalabad city in Nangarhar province.

The specific objectives of the study are as follows:

- To inspect the existence and different varieties of beryl mineral within pegmatite veins in the Bahr-e-Abad area.
- To interpret the petrographic and gemological characteristics of beryl accurately under a microscope.
- To gain knowledge of the new and rare minerals and find their specifications under a microscope.
- To investigate the percentage of minerals in pegmatite veins.

1.2. Importance of Research

This study was conducted through extensive fieldwork and sampling from the main veins of beryl. The interpretation and findings of this study can effectively be used as an authorized reference for the Afghanistan Geological Survey (AGS) and relevant research entities.

1.3. Research Questions

- 1) Which variety of beryl is present in pegmatite veins, and from the point of gemological investigations, can it be used in jewelry or not?
- 2) What are the adjacent rocks in the Beryl of Bahr-e-Abad area?
- 3) What is the chemistry of Beryl?
- 4) What are the mineralogical and petrographic properties of Beryl in the study area?
- 5) Does Beryl of the Bahr-e-Abad area have economic value?
- 6) What are the petrographic, gemological properties, and mineralogical composition of beryl and country rocks within pegmatite veins?

1.4. Research Limitations

Every research has its own constraints and challenges. In this study, due to the security problems, lack of geological work in this area, and lack of previous excavation work by the government, geological information was not enough prior to research, and one of the big challenges was the coronavirus pandemic.

In order to analyze and make thin sections of the specimen in AGS and other private companies, enough facilities and standard laboratories at Kabul Polytechnic University were not available, which can be counted as a major constraint for in-depth.

2. Study area

Nangarhar, an eastern province of Afghanistan, is one of the zones which is less investigated for its richness in mines. Based on the plotted tectonic map of Russian geologist W. P. Kalchanov and Afghan researcher Sayed Hashim Mirzad, Jalalabad city of Nangarhar province is related to the Alp folds, and Russian geologist, Weprit relates this zone to Nuristan Block of Paleozoic era. In Jalalabad tectonic zone, three zones are isolated, which are Kunar, Spinghar, and Jalalabad depressions.

There are also pegmatite regions, which are included in pegmatite belts of Afghanistan that root from the southwest parts of Afghanistan (northeast border of Sistan Depression), including the central parts of the country, and in the southeast, they exit from Afghan borders and enter into countries, namely China, Pakistan and Tajikistan.

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The specimens for this research have been collected from the Bahr-e-Abad area located near Behsood District and on the opposite side of Chaknowri village in Jalalabad city. The geographic coordinate of this area depicts that its latitude is 34° 27' 11.13" N, and its longitude is 70° 25' 46.07" E. This area is one of the areas, which has several pegmatite veins containing beryl minerals, and locals for construction purposes in Bahr-e-Abad village have identified these veins due to the excavation of land (Figure 2.1).



Figure 2. 1: Aerial photos of Bahr-e-Abad pegmatite veins.

3. Geological Setting

3.1 Tectonic

Jalalabad zone is located in the eastern part of Afghanistan and the southeastern part of the Nuristan zone. It was first identified in 1969 by Prof. Slavin called the Tectonic Zone of Jalalabad and is located above the base of the Massive Middle Block of Nuristan. Correspondingly, this zone is related to the upper Cambrian or younger Cambrian. The basic metamorphic rocks are exposed in Spinghar Mountains, and they can be observed in the eastern part of that zone and in the southeastern parts of Jalalabad city on the left bank of the Kabul River and Kunar River. In the central part of this zone, the Neogene sediments (N) have been positioned in a new tectonic depression. In the tectonic map of 1976, in this area, sub-zones are isolated, which are called Kunar, Spinghar, and Jalalabad depressions (Figure. 3.1).

As previously mentioned, in terms of tectonics, the Jalalabad zone is divided into three sub-zones, namely the Spinghar, Jalalabad depression, and Kunar folds.

According to unconformity and formations, the Jalalabad zone is separated into the following areas;

- Structural formation area (AR-PR)
- Structural formation area (O-T)
- Structural formation area (N-Q)

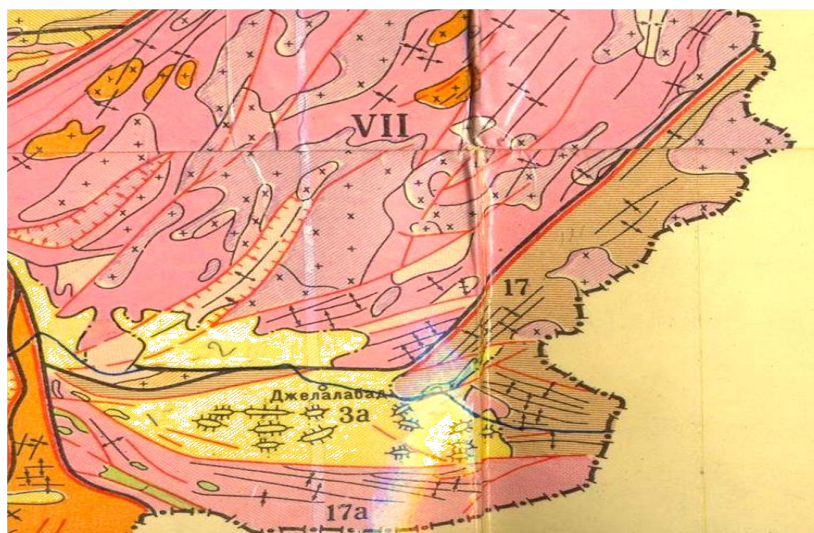


Figure 3. 1: The Stratigraphic Map of Jalalabad.

3.2 Magmatism

Magmatic rocks are vastly developed in the Jalalabad zone, and they are outcropped along Kunar Valley and the Spinghar Mountain series. In the Jalalabad zone, the following magmatic complexes can be separated:

- Granites and gabbro amphibolite complex, Upper Proterozoic (PR3)
- Granite and granodiorites complex, Upper Paleogene (PZ).

3.3 Mineralogy

The mineralogy of a pegmatite is, in most cases, dominated by some form of feldspar, often with mica and usually with quartz, being altogether "granitic" in character. Beyond that, pegmatite may include most minerals associated with granite and granite-associated hydrothermal systems, granite-associated mineralization styles, for example, greisen, and somewhat with skarn-associated mineralization.

It is, however, impossible to quantify the mineralogy of pegmatite in simple terms because of their varied mineralogy and difficulty in estimating the modal abundance of mineral species, which are of only a trace amount. This is because of the difficulty in counting and sampling mineral grains in a rock, which may have crystals from centimeters to meters across.

Garnet, commonly almandine or spessartine, is a common mineral within pegmatites intruding mafic and carbonate-bearing sequences. Pegmatites associated with granitic domes within the Archean Yilgarn Craton intruding ultramafic and mafic rocks contain red, orange, and brown almandine garnet.

Tantalum and niobium minerals (columbite, tantalite, niobite) are found in association with spodumene, lepidolite, tourmaline, and cassiterite in massive green bushes pegmatite in Yilgarn Craton of Western Australia, considered a typical metamorphic pegmatite unassociated with granite. Syenite pegmatites are quartz depleted and contain large feldspathoids crystals instead.

3.4 Mineral Deposit

From the point of view of mines, the Jalalabad zone is not that rich in mines. In this zone, the Achin talc mine is located in the eastern part of the Spinghar Mountains. This mine is associated with upper Proterozoic rocks. The talc is composed of an intense alteration of dolomite rocks in the nucleus of the anticlinoria of the Spinghar Mountains. In the eastern parts of the Jalalabad tectonic zone, there are pegmatite veins containing beryl minerals, in which the presence of micas and piezo quartz is predicted. In addition, Triassic marble can still be used in construction.

4. Material and Methods

This study was carried out using the following three methods:

1. Library Research is one of its three research strategies. It refers to any study aiming to get an overview of existing work. As such, it is roughly equivalent to Desk Research or (systematic) literature review. In fact, these terms guided me to more specific methodological resources. I have studied the following references regarding pegmatites to collect information about the origin and types of pegmatites. In library research, I performed the following steps;

- Analysis of historical research records such as Recording of notes, Content analysis, Tape and Film listening, and Research records analysis.
- Analysis of documents such as Statistical compilations and manipulations, reference and abstract guides, contents analysis
- Furthermore, the study of literature, research papers, reports, article reviews, Documentaries, Journals, magazines, books, web reporting, and pertinent references was also conducted.

2. Field Observation Method: Identically, this method is used to view the details, geological location, and determination of some geological characteristics in pegmatite veins of the Bahr-e-Abad village located in Jalalabad city near Behsood district, which contain beryl. Instruments that are used in fieldwork for sampling, including GPS, compass, loop, geologic hammer, camera, ballpoint, field notebook, bags, or sags for carrying specimens, were present.

The remote area of Bahr-e-Abad pegmatite veins containing beryl is located on the left side of the Kabul River opposite the Dronta. The studied area starts from the outskirts of Bahr-e-Abad village up to one kilometer in the left part of the River and the main road of the Behsood district, which consists of various pegmatite veins containing beryl with different thicknesses in size. In addition, in this area, pegmatite veins were located in between the schists and are covered by schists in order not to let volatile matters and compounds transit from one place to another.

There were numerous pegmatite veins containing beryl, but I carefully studied five major veins, and these veins were located from each other by 10m or 12m in the distance. The thickness of the veins ranged from several centimeters to several meters, the veins of which were outcropped several hundred meters to the surface of the earth by erosive processes.

These pegmatite veins are located in between the schists along the southwest and have a slope angle of about 51° some minerals such as quartz, feldspars, micas (muscovite and biotite), garnets, and beryl crystals are present within these pegmatite veins. In some parts, pegmatite veins are stripped off by water and are completely eroded by water, physical and chemical agents, and these are found as nests in the area. Henceforth, the size of mica (muscovite and biotite) was up to 7cm.

The size of the garnets was up to eight mm. Beryl crystals within these pegmatites were spotted in different sizes, ranging from 4mm to 3cm. There were also large crystals of beryl from which one crystal was cut and polished for gemological properties determination. Their results and interpretations are mentioned in a specific part of this article (Figure. 4.1).



Figure 4.1: Observation point #1 Bahre Abad.

Notably, in this area, beryl crystals, plagioclase, feldspar alkali (microcline), quartz, and phlogopite were present. The size of beryl crystals, under the microscope, is (0-6 mm), plagioclase is (1-9 mm), feldspar alkali (microcline) is (2-5 mm), quartz is (0.2-0.4 mm), and phlogopite is (1.3-9 mm). Adding that, its texture is massive, which has large particles, and its structure is heteroblastic, which is a type of pegmatite structure. The name of the such rock is pegmatite (Figure. 4.2).



Figure 4. 2: Sample containing visible beryl crystals

3. Lab work: Mainly, two tasks were performed in the laboratory
 - a) Spectrometry analysis
 - b) Sample preparation method for thin sections and petrographic microscope analyzes

5. Results

5.1 Petrographic analysis

The petrographic analysis identifies the origin where igneous, sedimentary, or metamorphic and the mineral content are used for the classification of rock. Analysis usually comprises the description of the macroscopic aspects of the rock, such as fabric, color, grain size, and other relevant characteristics that may be visually observed in hand specimens or in outcrops, and chiefly the identification and description of microscopic characteristics of the studied material in thin sections such as mineral composition, texture, grain size, and evidence of alteration and/or deformation (Maria, 2018). The petrographic characteristics of different samples that were collected from the desired area and studied under the petrographic microscope are listed below:

#1: Its texture is schistose, and its structure is Lapidogranoblastic; its rock name is Di-mica schist (Bi-Mus); accessory minerals are zircon, sillimanite, and magnetite, its Principal minerals are plagioclase, feldspar alkali (microcline), quartz, biotite, phlogopite and finally it's Geologic formation is Metamorphic rock as shown in (Figure. 5.1 (A1, B1)).

#2: Its texture is massive, and its structure is heteroblastic; its rock name is pegmatite; accessory minerals are garnets and magnetite; its Principal minerals are plagioclase, feldspar alkali (microcline), quartz, and phlogopite, and finally, it's Geologic formation is post-igneous rock as shown in (Figure. 5.1 (A2, B2)).

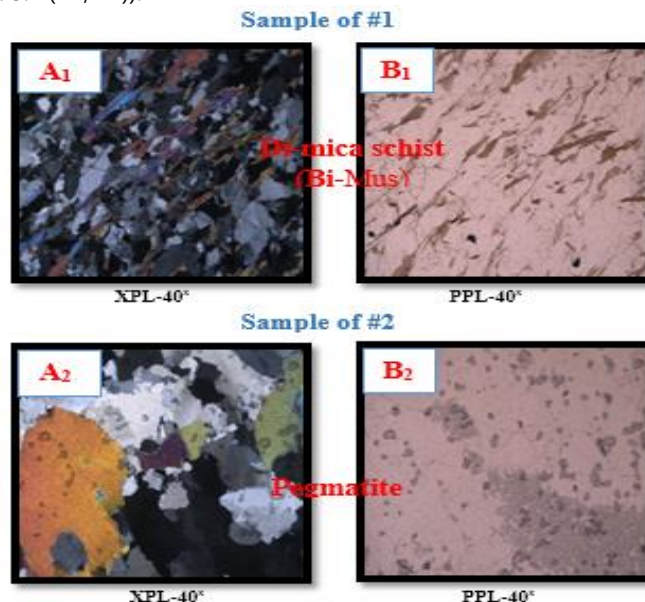


Figure 5. 1: Photographic images

#3: Its texture is massive, and its structure is heteroblastic; its rock name is pegmatite (plagioclase), its Principal minerals are plagioclase, feldspar alkali (microcline), quartz, phlogopite, and finally, its Geologic formation is post-igneous rock as shown in (Figure. 5.2 (A1, B1)). #4: Its texture is massive, and its structure is heteroblastic; its rock name is pegmatite; its Principal minerals are quartz, muscovite, and phlogopite and finally, its Geologic formation is post-igneous rock as shown in (Figure. 5.2 (A2, B2)).

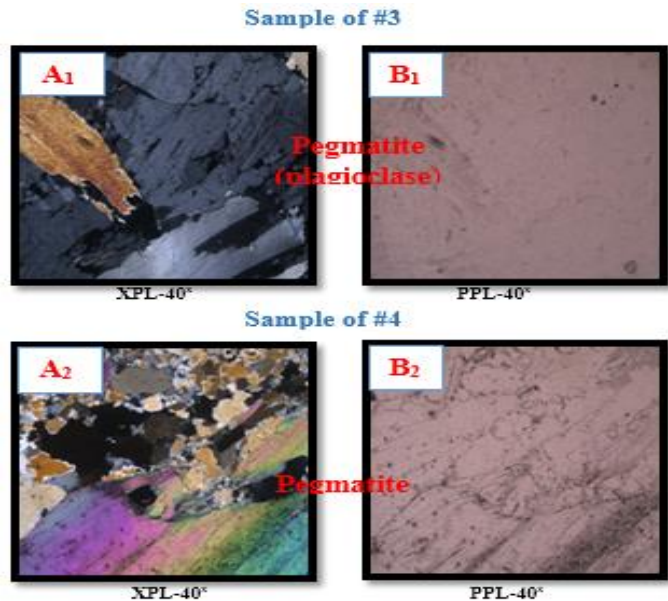


Figure 5. 2: Photographic images

#5: Its texture is periferi (holocrystalline), and its structure is heteroblastic; its rock name is pegmatite, it's Principal minerals are plagioclase, feldspar alkali (microcline), quartz, and phlogopite, and its Geologic formation is post-igneous rock as shown in (Figure. 5.3 (A1, B1)).

#6: Its texture is massive, and its structure is heteroblastic; its rock name is pegmatite, it's Principal minerals are quartz, feldspar alkali (microcline), phlogopite, and its Geologic formation is post-igneous rock as shown in (Figure. 5.3 (A2, B2)).

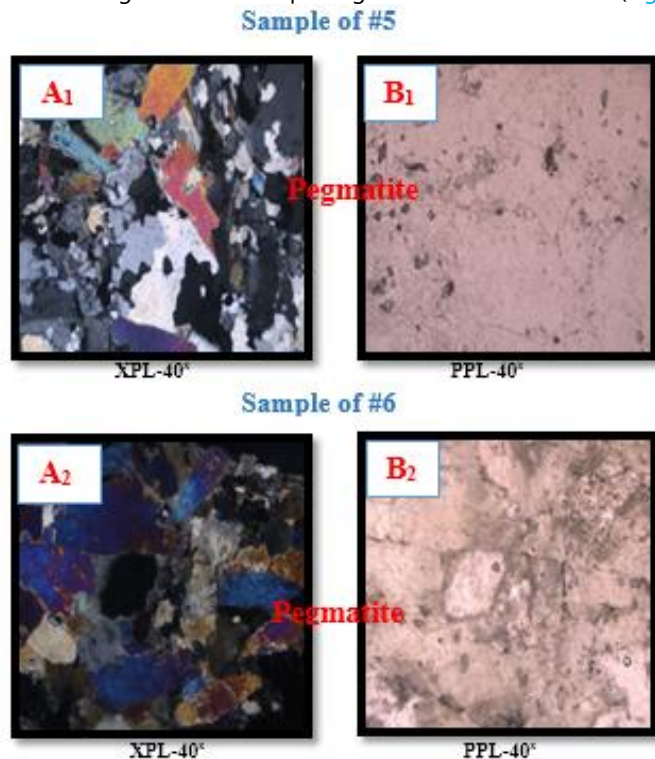


Figure 5. 3: Photographic images

#7: Its texture is massive, and its structure is heteroblastic; its rock name is pegmatite, its Principal minerals are plagioclase, feldspar alkali (microcline), quartz, and its Geologic formation is post-igneous rock as shown in (Figure. 5.4 (A1, B1)).

#8: Its texture is massive, and its structure is heteroblastic; its rock name is pegmatite, its Principal minerals are plagioclase, feldspar alkali (microcline), quartz, phlogopite; sub-principal minerals are Garnets; finally, its Geologic formation is post-igneous rock as shown in (Figure. 5.4 (A2, B2)).

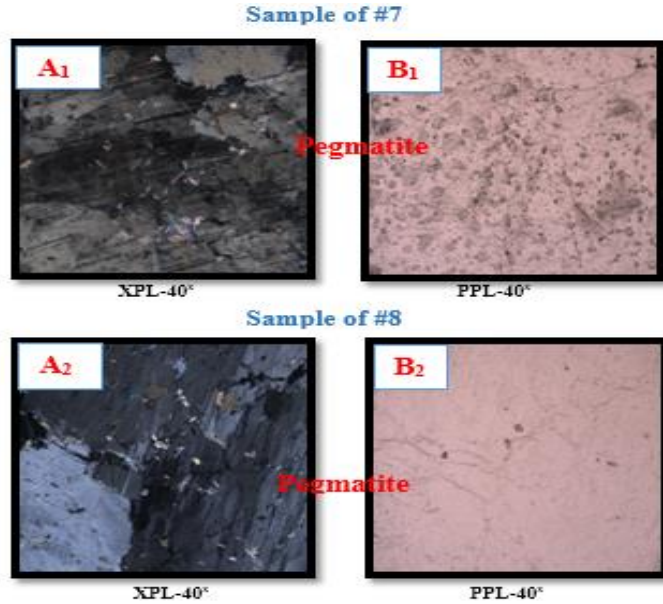


Figure 5.4: Photographic images

The mineral composition of such specimens is approximately the same but is different in percentage. In all specimens, plagioclase, feldspar alkali (microcline), quartz, and phlogopite contribute as the principal minerals. Plagioclase has an inverse relation with feldspar alkali (sodium-potassium); if plagioclase increases, feldspar alkali (sodium-potassium) decreases and vice versa. Other minerals have different percentages in these specimens.

Table 5. 1: Mineral composition with their percentage and size in Beryl of Bahr-e-Aabad

Number of Samples	Minerals															
	Plagioclase		Feldspar alkali (microcline)		Quartz		Phlogopite		Biotite		Garnets		Muscovite		Beryls	
	%	size (mm)	%	size (mm)	%	size (mm)	%	size (mm)	%	size (mm)	%	size (mm)	%	size (mm)	%	size (mm)
#1	8	1.8-2	7	1.8-2.1	50	0-1.2	15	1-14	20	0.5-2.5	0	0	0	0	0	0
#2	30	0.5-3.1	30	0.5-6	30	0.1-2	9.7	1-8	0	0	0.3	0.2-0.5	0	0	0	0
#3	60	1.7-6	27	0.2-2.3	3	0.1-0.02	10	0.5-4.3	0	0	0	0	0	0	0	0
#4	0	0	0	0	35	0.3-1	40	1.2-6.5	0	0	0	0	25	0.5-2	0	0
#5	30	1-3.5	15	1.4-6	40	0.2-2.9	15	0.5-7	0	0	0	0	0	0	0	0
#6	0	0	40	1-3	10	0-1.1	50	1.4-8	0	0	0	0	0	0	0	0
#7	71	2-6	14	0-1	15	1-2	0	0	0	0	0	0	0	0	0	0
#8	54	1-9	25	2-5	1	0.2-0.4	8	1.3-9	0	0	0	0	0	0	12	0-6

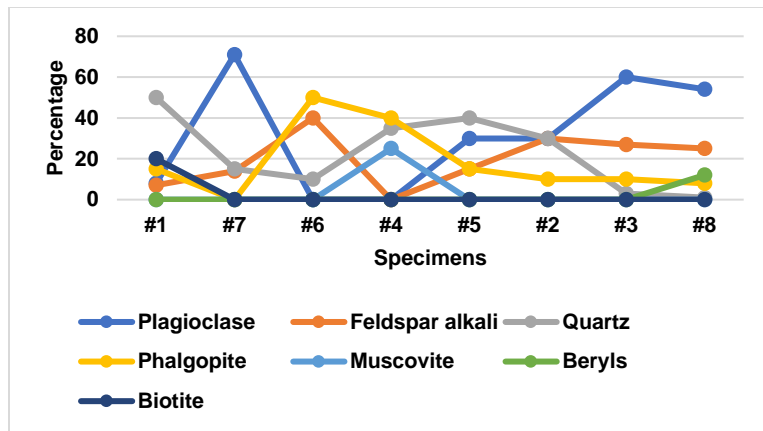


Fig 5.5: The percentage of different minerals.

The above figure shows the percentage of different minerals in the Bahr-e-Abad area. It can be concluded that the rocks, which are located within the pegmatite vein, besides the beryl mineral, generally have the same composition and contain plagioclase, feldspar alkali (sodium-potassium), and mica (phlogopite). Schist rocks cover these pegmatite veins, and their adjacent rocks are schists.

5.2 Chemical analysis

The chemical analysis of samples as follows; **#1**: Na₂O 3.632%, MgO 0.0790%, Al₂O₃ 13.77%, SiO₂ 64.54%, K₂O 3.252%, CaO 2.525%. **#2**: Na₂O 3.595%, MgO 1.544%, Al₂O₃ 13.87%, SiO₂ 61.28%, K₂O 2.445%, Fe₂O₃ 3.809%, CaO 2.355%. **#3**: Na₂O 1.926%, MgO 1.151%, Al₂O₃ 11.75%, SiO₂ 68.79%, K₂O 1.683%, Fe₂O₃ 3.703%, CaO 2.489%. **#4**: Na₂O 1.065%, Al₂O₃ 9.899%, SiO₂ 62.41%, SO₃ 1.134%, K₂O 2.116%, CaO 6.902%. **#5**: Na₂O 2.491%, Al₂O₃ 10.06%, SiO₂ 59.14%, SO₃ 1.021%, K₂O 2.927%.

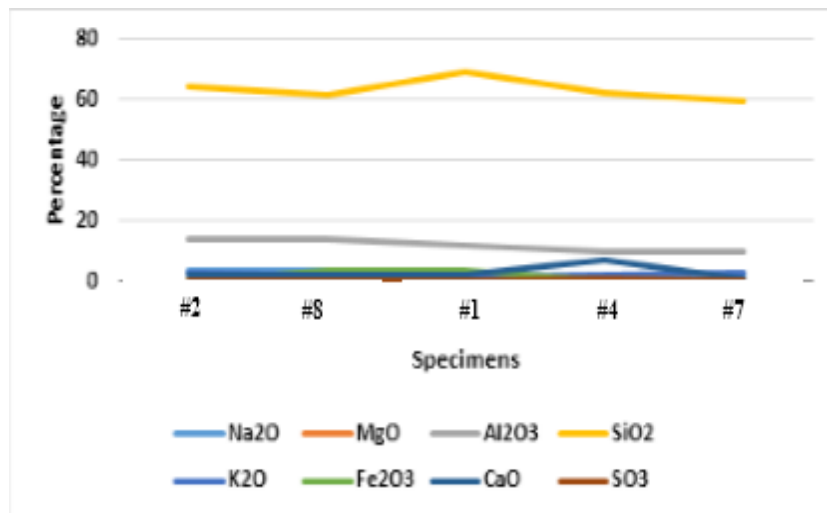


Fig 5. 6: Oxides present in different specimens.

Table 5.2: Chemical composition of same samples.

Number of samples	Weight of analyzed (gr)	Chemical composition (%)								Name of rock
		Na ₂ O	MgO	Al ₂ O ₃	SiO ₂	K ₂ O	CaO	SO ₃	Fe ₂ O ₃	
Value of #2	4	3.63	0.079	13.77	64.54	3.252	2.525	0.0	0.0	pegmatite
Value of #8	3.7	3.595	1.544	13.87	61.28	2.445	2.355	0.0	3.809	//
Value of #1	3.9	1.926	1.151	11.75	68.79	1.683	2.489	0.0	3.703	//
Value of #4	3.8	1.065	0.0	9.899	62.41	2.116	6.902	1.134	0.0	//
Value of #7	4	2.491	0.0	10.06	59.14	2.927	0.0	1.021	0.0	//
Analysis Method	XRF									
Specimen Collected Date	09/03/2022									
Specimen Analysis Date	18/05/2022									

6. Discussion

All specimens, which have been collected from the Bahr-e-Abad area, were carefully studied through library work, fieldwork, and lab work, and later, such specimens were tested by three methods, which are microscopic investigations, gemological assessments, and spectrometry analysis.

From fieldwork, it can be concluded that the rocks in the Bahr-e-Abad area are pegmatites and are covered by their adjacent rocks, which are schists. The pegmatite rocks in that area have heteroblastic structures and massive textures. Their adjacent rocks have schistose texture. There are alterations of many feric and silic minerals, which can be seen by a loop in some places; these alterations are ranged from several centimeters to several meters. In pegmatite veins, besides beryl, minerals such as plagioclase, feldspar alkali (microcline), quartz, muscovite, biotite, phlogopite, garnets, sillimanite; accessory minerals like zircon, and sphene; mineral ores like magnetite are present and exist in good percentages.

From the assessment and study of eight slides, it can be inferred that those slides, which have been collected from the Bahr-e-Abad area, are located on the left side of the Kabul River and the opposite Behsood district; they contain beryl minerals and other useful rare-metals within pegmatite veins. The alteration of dark and light color minerals can clearly be seen under a polarized microscope. It can be stated that the texture of rocks is massive and have a heteroblastic structure. Many of these minerals, which exist in these pegmatite veins, have similar textures, structures, and compositions. Minerals such as plagioclase, quartz, feldspar alkali (microcline), phlogopite, and biotite are the principal minerals. Accessory minerals are zircon and sphene, and in some parts, they have approximately euhedral forms. In slide #4, phlogopite contains a great percentage that represents low-temperature metamorphism. The area, which we have researched, has such specifications, and if we investigate such a useful mineral one kilometer far from this area, we can find more beryl with a high percentage that can be used for the beneficiation of beryllium.

7. Conclusions

The study on Beryl in the Bahr-e-Abad area of Jalalabad city found that the rocks which are located within the pegmatite vein, besides the beryl mineral, generally have the same composition and contain plagioclase, feldspar alkali (sodium-potassium) and mica (phlogopite and biotite).

In addition, the Microcline-albite type of pegmatite belt determined during the study is rich in Beryl. This result is similar to observations of Mosazai Amir et al. regarding pegmatite belts of various areas in Afghanistan. The study also recommends that two upper pegmatite belts, namely 'Oligoclase-albite-microcline type' and 'Muscovite-albite-microcline type, which are very useful, should be excavated and studied. However, two lower pegmatite belts, namely, 'Spodumene-microcline-albite and spodumene-albite type' and 'Lepidolite-spodumene-albite type' are not useful compared to other belts and may not require excavation.

The microcline–albite type is of great economic and industrial importance and contains useful elements and oxides. The Beryl in these pegmatite veins cannot be used in jewelry and does not have jewel quality due to having many inclusions and cleavages. If the percentage of beryl is great in these pegmatites, it can be used for the beneficiation of beryllium, which is a valuable element.

8. Recommendation

Upon the completion of this article on geochemical, petrographic, and mineralogical- characteristics of Wolay nephrite occurrences in Kunar province. The following points are recommended:

- 1). The beryl crystal that has undergone the gemological test has been collected from the surface of pegmatite veins, which have a pale blue color and has relatively lost their quality. I suggest that if AGS excavates some canals and investigates deeper, beryl will have better quality and quantity relative to the surface.
- 2). For the purpose of precise consolidation of mineralization and economic importance mentioned pegmatite, a geologic mapping should be plotted having a scale of 1:100,000.
- 3). It is suggested that, for better investigations of quality and the economic importance of present garnets within these pegmatites, necessary research and tests should be taken place.
- 4). It is recommended that the head of Polytechnic University provide the geologic instruments and devices for the fieldwork to resolve the problems of students of this department and to establish an equipped petrographic lab, slide preparation lab, and spectrometry analysis lab.
- 5). It is also recommended that for the precise determination of beryl percentage within these pegmatites, a careful massive sampling should be carried out in order to use this kind of beryl for the beneficiation of beryllium.

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