

MINERALOGY GEOCHEMICAL STUDY OF GRANITE ROCKS IN ALAWAINAT MOUNTAIN, SOUTH-EAST OF LIBYA

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ABSTRACT

This paper discusses the most important characteristics and types of granite rocks in Jabal Alawainat, which is located on the border in southeastern Libya. The study showed the description of four samples manually and petrographic description of eleven microscopic thin sections. The petrographic study of the granite rocks found that there are several types: Granodrite, Porphyry Granite, Red Granite, which is the most recent. The research highlighted the mineral content of these types, supported by a number of microscopic pictures. The study showed an inverse relationship between Silicon oxide and the other oxides: Aluminum, Titanium, Phosphorus, Magnesium Ferric and Calcium oxide, whereas there is a direct proportion between the silicon oxide and the other oxides: Sodium oxide, Potassium, and Manganese oxide. The geochemical study showed that the quality of the magma, which made the granite, was mostly calcite alkaline and far from theoliitic, that means the granite was produced in a continental environment. Because of geochemical exploration, a high percentage of gold is in the study area precipitated in the veins of quartz and many other materials such as oxides of iron, and the region is rich in ornamental stones and economically good.

Keywords: *Geochemical, Petrographic study Granite rocks.*

1. INTRODUCTION

Jabal Al-awainat is considered the eastern edge of the Kufra basin, which is limited by Nugi mountain at the western side and Adalma Mountain at the northern boundary. Jabal Alawainat consists of pre-Cambrian rocks (granite and ring complexes). Pre-Cambrian rocks are underlying Paleozoic and Mesozoic sedimentary rocks, this sequences of rocks are cut

and penetrated by Tertiary volcanic rocks and finally the quaternary rocks are spreading over the whole area. The geological history of the area began with the sedimentary and volcanic rocks that formed the pre-Cambrian rocks as a result of their metamorphism and folding. These rocks were cut by the calcite-alkaline to alkaline granite injectors, as well as dykes with northeast-southwest direction which extend tens of kilometers. Erosion and settlement processes took place at the beginning of Paleozoic age (Goudarzi, 1980).

In order to know the components of the rocks, the analysis was carried out on the study area by the Industrial Research Center (IRC) in 2007. To compare the results, another data set of chemical analysis were used, this analysis were made by (IRC) in 2000 on Morzidi Mountain or region, which lies to the west of the study area.

1.1 Aim of the study

This paper describes the mineralogical composition of four granite samples as well as the bulk geochemical analysis for major oxides only for those samples. A small part of this study will focus on the economic characteristic of this granite for the commercial point of view.

3. MATERIALS AND METHODS

3.1 Geographical location of the study area

The study area is located in the southeastern part of Libya, between two longitude ($24^{\circ} 40'$ to $25^{\circ} 00'$) east and two latitudes ($21^{\circ} 35'$ to $22^{\circ} 00'$) north. The location of the study area is illustrated in (Fig. 1) and covered approximately 600 km².

3.2 LABORATORY STUDIES

Granite samples were subjected to a hand-specimen description. Granite samples were collected from (I.R.C) storage and were prepared for microscopic analysis using polarized microscope. Bulk geochemical analysis for major oxides were performed.

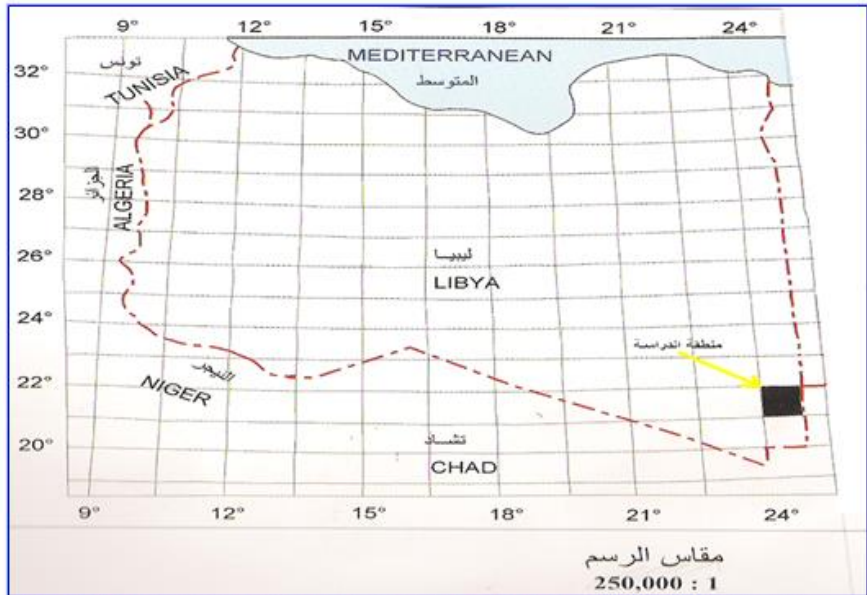


Figure (1) Location map of the study area (Industrial Research Center (IRC) 2007)

3.4 Geomorphology of the study area

The study area covers an area of approximately 600 km² and is limited between latitudes $21^{\circ} 35'$ and $22^{\circ} 00'$. Most of the basement rocks are located in the eastern part of the study area. It is composed of the ring complex of Jabal Al-awainat. Several valleys, such as Karkur Idris and Karkur Ibrahim, inclined from the east to the west. These valleys indicate a long period of rain led to form these wadis in previous periods.

Alawainat Mount rises about 1934 meters above sea level surrounded by some hills with a medium height, the low areas are always filled with Aeolian sediments and fluvial fans near the foot of mountain where the slope is getting lower as we move away from the mountain, sand dunes are deposited in the western part of the study area in the form of chains with north east- south west direction, Saif Awinat is the major sand dune with 90km long and 20km width (EGSMA and IRC, 2007)

The ground water in the study area is minor because of the presence of hard rocks. However, there are some water springs at the edge of the mountain like An Zwia and Ain Duwa.

3.5 Geological setting of the study area

The stratigraphic column of the study area is presented by the geological map made by the research group of IRC & EGSMA for geological survey and is showing in (Fig.2)

3.6 Granite description

Hand specimen description of granite is a plutonic rock formed at depth of the ground. The solidification occurs as a result of slow and continuous cooling under high pressure and temperatures with the presence of volatiles which allows the crystals of the minerals to grow forming the volcanic rock as shown in Fig. (4).

It is characterized by coarse texture, and sometimes characterized by porphyritic texture which indicate that it crystallization in two phases of temperature, under slow and fast cooling conditions.

It is chemically classified as acid rock because it consists of metals with a silica content of more than 66%.



Figure (4) shows the coarse-grained, pink granite and rich of potassium feldspar

3.7 Types of granite in Jabal Alawainat

Thin sections were prepared and described under the microscope, two types of granite rocks were found:

- Calcium-Alkaline Granite:

It appears in the eastern part of ALawainat Mountain, which is porphyritic granite (Fig. 5 and 6) and granodiorite, which sometimes contains associated iron oxide (Fig. 7).

- Alkaline to Alkaline Granite

It is located in the southern part of Jabal Alawainat, contains a high percentage of feldspar, and known as red granite.

3.8 Petrographic description of granite rocks.

Based on the thin section description under the microscope using polarized light, the samples containing the following minerals:

Quartz: SiO_2 is a base mineral of granite rocks, exists in full-faced crystals with fractured edges (Fig. 8). In some thin sections, quartz crystals show the phenomenon of wavy extinction (Fig. 9) due to the applied stress. Beside quartz, the following minerals and mineral groups are found:

- **Pyroxine:** A group of minerals found in the rocks of granodiorite to diorite, consists of Augite and other mineral like hypersthene (Fig. 10).
- **Potassium feldspar:** It is dominated by orthoclase and a small percentage of other minerals (Fig. 11).
- **Plagioclase:** Plagioclase is a major constituent mineral in the volcanic rocks and most of the plutonic igneous rock, characterized by zoning phenomenon (Fig. 12), Plagioclase in the study are transformed into other minerals like Sericite and epidote (Fig. 13,14).
- **Biotite:** is the predominant mineral in the granite rocks that is formed in the late stage of crystallization. (Fig.15)and contains iron precipitation (Fig. 15). In some cases, Biotite is changed or converted to chlorite because of hydrothermal solutions (Figure 16).

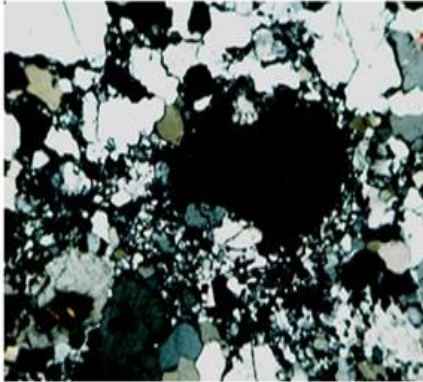


Figure (5) shows the crushing edges of quartz crystal crystals

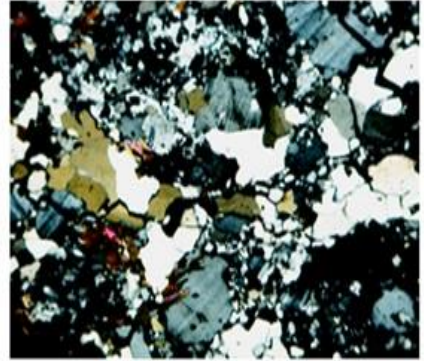


Figure (6) illustrates the porphyritic texture in granite rocks

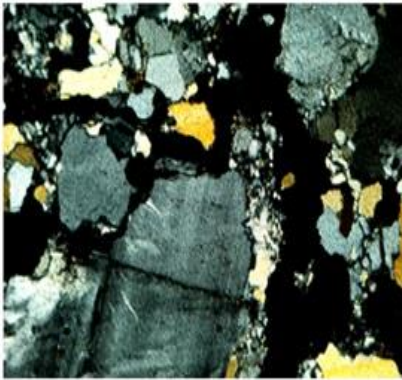


Figure (7) shows an iron rich iron oxide image under Nicole - Enlarge 10.

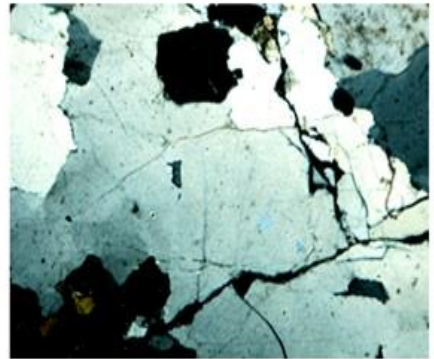


Figure (8) illustrates the quartz crystals covering most of the rock That has a cracking on the edges of an image under Nicole - Zoom 25.

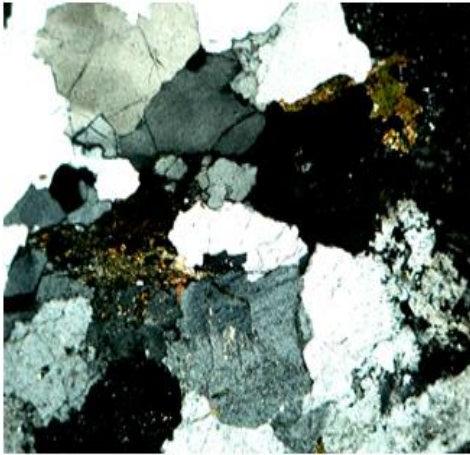


Figure (9) illustrates the phenomenon of darkening wavy quartz crystals - a picture under Nicole - enlarge 25.

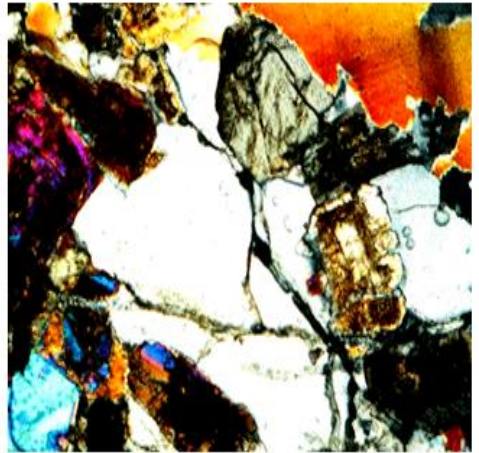


Figure (10) illustrates the correlation of quartz with pyroxene and amphibole crystals.

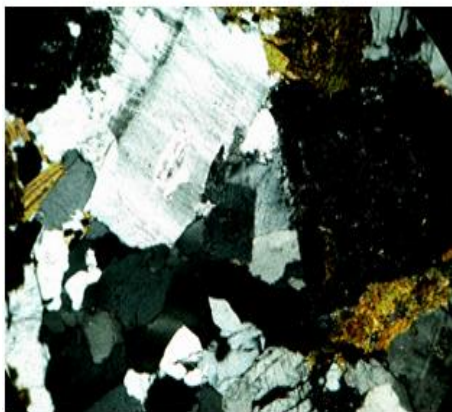


Figure (11) Potassium feldspar top image, photo was taken under Nicole publication - enlarge 25.

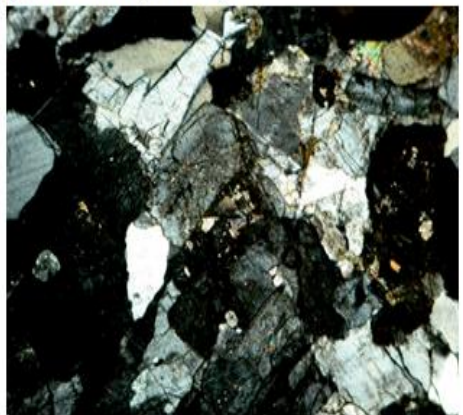


Figure (12) illustrates the phenotype of the plagioclase crystals.

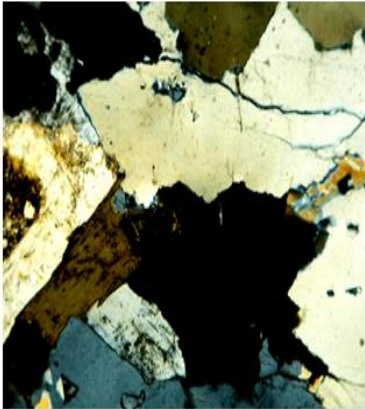


Figure (13) The fully transformed feldspar and other crystals of feldspar began to shift from its center - next to the biotite Image under Nicole leaflet - Zoom 25.

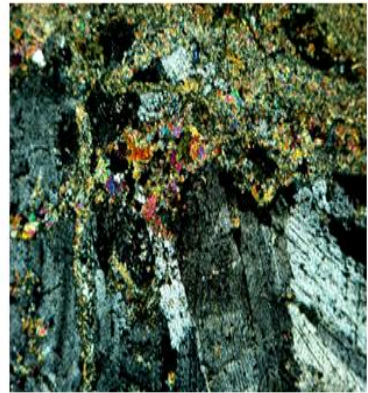


Figure (14) illustrates the plagioclase crystals converted to epidote.



Figure (15) Plagioclase covering most of the sector and is associated with the biotite, which contains condensates of iron oxides - under the polarizer - enlarge 25.



Figure (16) shows the biotite mineral and partially converted to chlorite - image under the polarizer - magnification 25.

3.9 Bulk geochemical analysis for major oxides

Bulk geochemical analysis for the collected samples were performed to detect the major oxides. The analysis were carried out by IRC laboratory.

To compare the current results (IRC, 2007), another data set of chemical analysis were used to represent granite samples from Morzidi Mountain this analysis were done by (IRC, 2000).

The chemical analysis of both areas (Eastern Alawinat & Morzidi Mountain) is shown in table 1.

3.9.1 Major elements

In order to come up with chemical properties and rock quality of the granite, the major elements were measured for: (SiO_2 , Al_2O_3 , Fe_2O_3 , MnO , MgO , CaO , Na_2O , K_2O , TiO_2 and P_2O_5), in both areas including eastern Al-Awainat & Morzidi Mountain (Table.1)

A comparative graph for the percentage of the major oxides of each sample for both data sets 2000 and 2007 are illustrated in figures (18 and 19) for Morzidi Mountain and eastern Alawinat.

TABLE 1. CHEMICAL ANALYSIS OF THE PERCENTAGES OF THE MAJOR OXIDES PREVAILING IN GRANITE ROCKS

Oxides	Morzidi area Industrial Research Center (2000)				Study area Industrial Research Center (2007)			
	1	2	3	4	1	2	3	4
SiO_2	70.8	67.6	64.55	71.4	66.08	71.49	69.66	72.44
Al_2O_3	15.08	15.18	16.72	14.16	15.08	14.66	15.39	14.85
Fe_2O_3	0.69	3.78	4.33	0.77	0.79	4	1.87	0.58
MnO	0.01	0.09	0.11	0.01	2.77	0.004	0.04	1.62
MgO	0.43	1.05	1.25	0.12	3.08	0.46	0.49	0.25
CaO	1.38	2.48	3.93	0.91	4.03	0.09	0.87	0.98
Na_2O	4.76	5.32	4.8	5.26	4.28	3.46	4.77	4.17
K_2O	5.59	3.42	3.01	5.17	3.21	4.51	5.91	5.08
TiO_2	0.02	0.2	0.48	0.03	0.39	0.31	0.18	0.18
P_2O_5	0.004	0.061	0.036	0.006	0.14	0.09	0.02	0.06

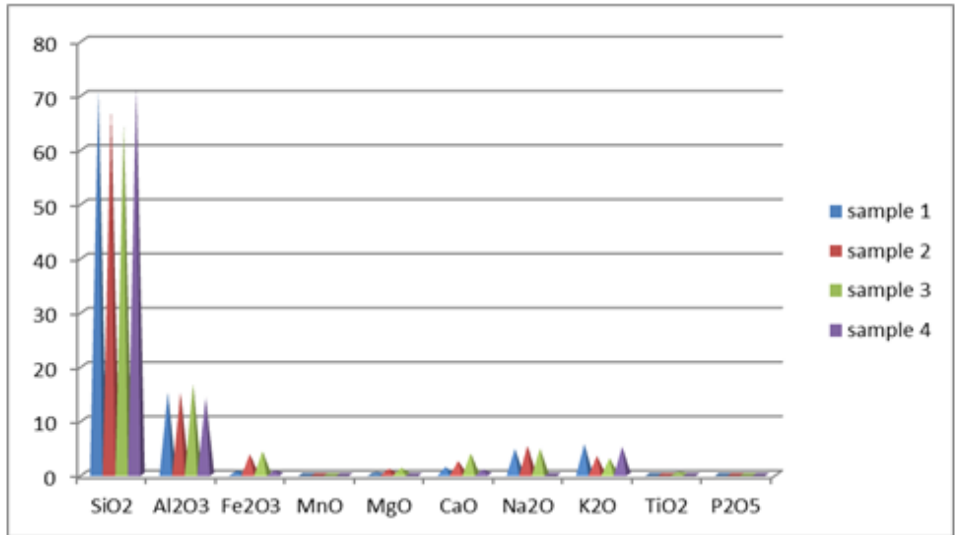


Figure (18) a comparative graph of the percentage of the dominant oxides obtained from the chemical analysis in Muzaridi Mountain (2000).

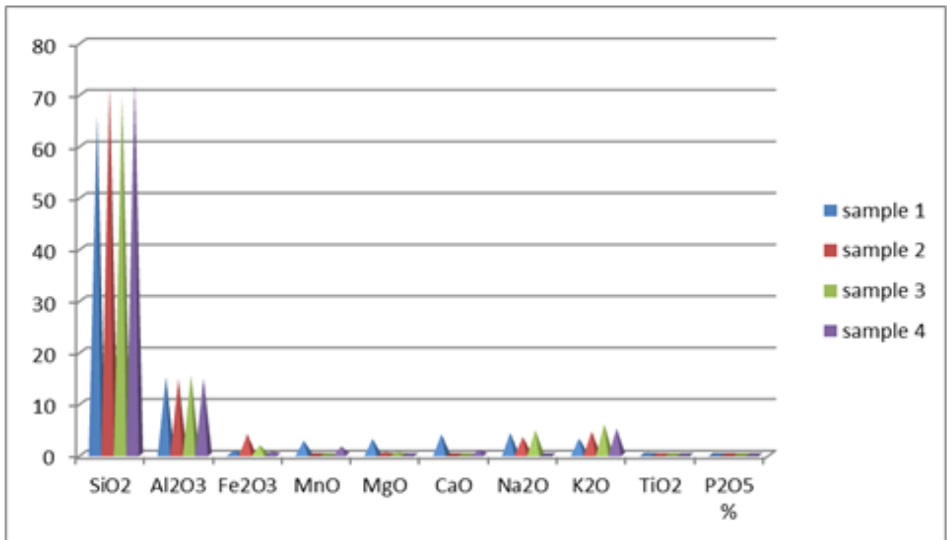


Figure (19) a comparative graph of the percentage of the dominant oxides obtained from the chemical analysis in the study area (2007).

3.9.2 Major Oxides Comparison

Based on the results shown in table.1, the comparison is as following:

-Silicon oxide SiO_2 in the samples of the study area with an average of 69.91% and this percentage up to 68.59% in the area of Morzidi, which means that this percentage is very close, that means the granite type in the region is mainly Granodiorite

- Aluminum oxide Al_2O_3 is about 14.99% in the study area and up to 15.28% in Morzidi, these ratios are very close.

- Ferric oxide Fe_2O_3 percentage in the study is about 1.81% while in Morzidi region is up to 2.39% which is higher than in the study area.

- Manganese oxide MnO is very low in the Morzidi region and slightly higher in the study area.

- Magnesium oxide MgO in the study area is 1.07%, while this ratio is 0.71% in the Morzidi region.

- Calcium oxide (CaO) in the study area is 1.5% and its percentage in Morzidi is 2.17%, indicating Morzidi region tends to have more calcareous than the study area.

- Sodium oxide Na_2O ratio in the study area is about 4.67% and about 5% in Morzidi region, both ratios are very similar.

- Potassium oxide K_2O is 4.67% in the study area and about 4.29% in Morzidi area, both values are very close.

- Titanium dioxide TiO_2 was 0.26% in the study area, while the average was 0.18% in the Morzidi region, seems very similar.

- Phosphorus oxide P_2O_5 has a very low average in both regions.

To illustrate relationships between the dominant elements and silica ratio, correlations between these oxides and silicon oxide were made, the relationship were as following:

-There is an inverse relationship between silicon oxide and the other oxides: aluminum, titanium, phosphorus, magnesium ferric and calcium oxide, (Figures 21,22, 23, 24 and 25), the higher the percentage of silica, the lower the percentage of previous oxides.

-There is a direct proportion between the silicon oxide and the other oxides: sodium oxide, potassium, and manganese oxide, (Figures 26, 27 and 28), as silica ratio increase, the oxide ratios of NaO , K_2O , and MgO will increase.

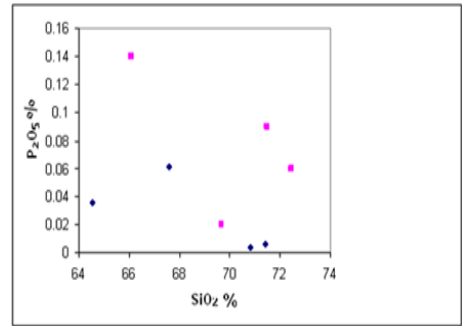
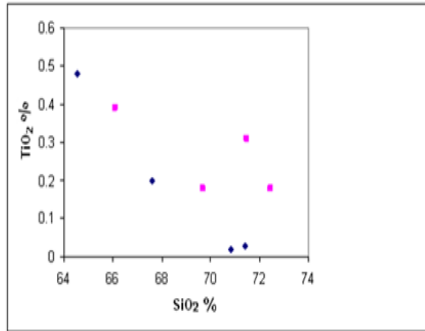


Figure (21) the relationship between Silicon oxide and Titanium oxide. Figure (22) the relationship between Silicon oxide and Phosphorus pentoxide.

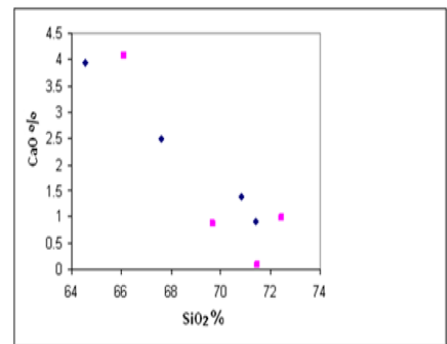
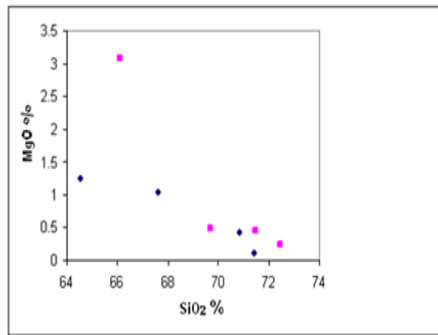


Figure (23) the relationship between Silicon oxide and Magnesium oxide. Figure (24) the relationship between Silicon oxide and Calcium oxide.

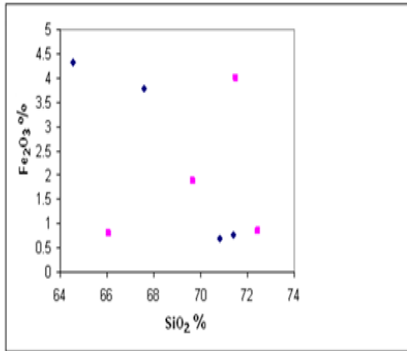


Figure (25) the relationship between Silicon oxide and Ferric oxide.

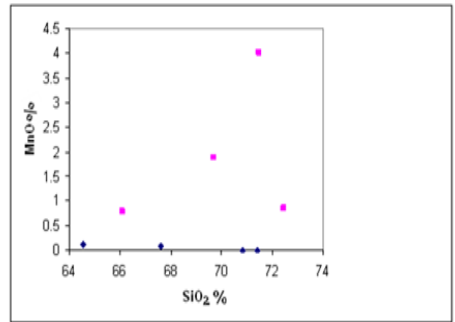


Figure (26) the relationship between Silicon oxide and Manganese oxide.

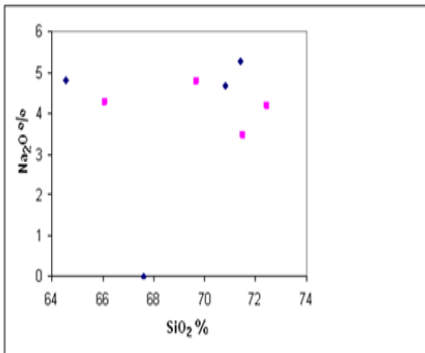


Figure (27) the relationship between Silicon oxide and Sodium oxide.

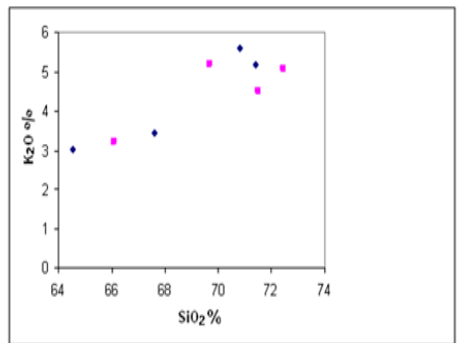


Figure (28) the relationship between Silicon oxide and Potassium oxide.

3.9.3 Magma type

To set the magma type, we used the geometric form A F M It is a trilateral relationship based on the flowing:

A=Na₂O% +K₂O% which indicate felsic oxides.

F=FeO % + Fe₂O₃% which indicate mafic oxides.

M= MgO which indicate mafic oxides.

All the samples were plotted on the geometric form; most of them occurred in the calc-alkaline field and may confirm that the granite rocks in the study area were formed in a continental environment (Figure 29)

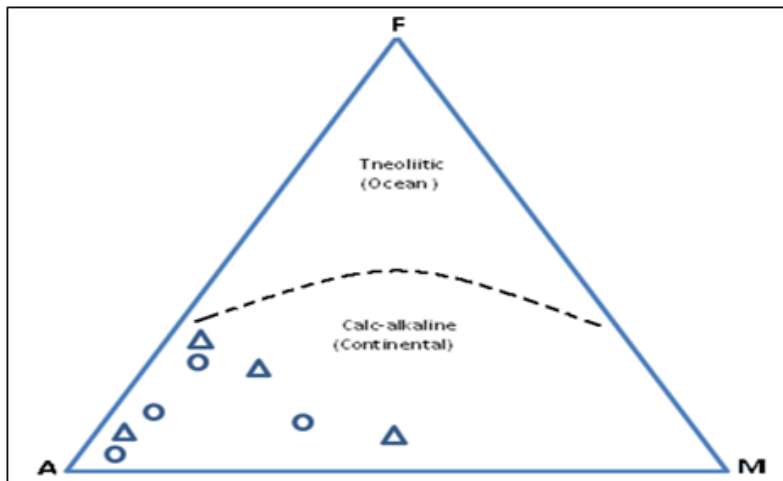


Figure (29) this is a triple relationship showing magma environment based on the value of the three components of A F M. (Petro etal 1979)

4. THE ECONOMIC IMPORTANCE OF THE GRANITE

The rocks are exposed in the northwestern part of the ring complex of Jabal Alawainat and are found in the form of prominent blocks above the ground in the eastern part of the study area.

Granite is a multi-colored rock resulting from the difference in mineral content, with red, gray and pink granite. The granite rocks have important physical properties such as durability, tensile strength and resistance to acids that make it suitable for the production of decorative stones.

The problem with the invest of this granite is that the site currently is very far from areas of consumption and difficulty of transportation makes it of no economic value.

As a result of the process of weathering the granite rocks consist of a thick layer of kaolin and it is possible to exploit this material in some different ceramic industries

As a result of the weathering process of the granite, a thick bed of kaolin deposits were formed and which can be exploited for some different ceramic industries.

5. CONCLUSION

Granite rocks in Jabal Al-Awainat is characterized by coarse texture, some granite types characterized by porphyritic texture which indicate that it crystallizes in two phases of temperature, the granite is chemically classified as acid rock because it consists of metals with a silica content of more than 66%. Two types of granite rocks were found, calcium-alkaline granite and alkaline to alkaline granite.

Based on the geochemical analysis results of the major elements: (SiO₂, Al₂O₃, Fe₂O₃, MnO, MgO, CaO, Na₂O, K₂O, TiO₂ and P₂O₅), a comparison between both areas was made and revealed that Silicon oxide SiO₂ in the samples of the study area with an average of 69.91% and up to 68.59% in of Morzidi area, which which are very close, that means the granite type in the region is mainly Granodiorit. For the rest of the oxides the comparison showed a similar percentages with very minor differences.

A trilateral relationship based on the felsic oxides and the mafic oxides, the data was plotted and it revealed that the granite was formed in a continental environment.

The investment of this granite in the site currently is very far from areas of consumption and difficulty of transportation makes it of no economic value.

REFERENCES

- [1] مشروع التخریط الجيولوجي المشترك 2000 (لوحة جبل أركنو) مقياس رسم 1:250,000 . مركز البحوث الصناعية والهيئة المصرية للثروة المعدنية .
- [2] مشروع التخریط الجيولوجي المشترك 2007 (لوحة جبل العوينات) مقياس رسم 1:250,000 مركز البحوث الصناعية والهيئة المصرية للثروة المعدنية
- [3] AL ALFY ,Z.1996 ;Geological history of Precambrian rocks at AL Uwaynat area and its reflection on the mineral exploration . symposium on mineral resources of Jamahiriya and their development (17-18 jumel) IRC ,TRIPOLI .
- [4] EGSMa and IRC . 2007 ; Geological map of shet jabal AL Uw aynat (NF 35-9) ,On scale 1;250,000.
- [5] EL – Ramly ,M.F.1972 ; Anew geological map for the basement rocks in the Eastem desert and south westesn deserts of Egypt scale 1;1000;000 Arm Geol .surv . Egypt , v2,pp 1-18-
- [6] FULL agar ,P,D .,1980; pan-African age granite of north eastesn Africa ;NEW Or reworked silica materials in ; salem ,m, J . AND m. t. Busrewil (eds) the geology of Libya , v.III pp 1051-1058 .