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PETROGRAPHICAL AND PETROCHEMICAL ANALYSES OF IGNEOUS ROCKS OF LAUNGZIN AREA, MOGOK TOWNSHIP, MANDALAY REGION

Wathon Chit[1], Mi Paik[2], Min Min Khaing[3]

Abstract

The study area is situated in Mogok Township, Mandalay Region. It is bounded by latitude 22°42'00"N to 22°54'00"N and longitude 96°19'00"E to 96°27'00"E. The igneous rocks exposed in the study area consist of pegmatite and granite. The 16 granitoid samples were analyzed for major and trace elements by XRF method. Most of the peraluminous granitoids are plotted in felsic peraluminous field, one biotite microgranite falls in high-peraluminous field, one biotite microgranite and one tourmaline granite fall in moderate-peraluminous field and one hornblende granite fall in low-peraluminous field. According to the major and trace elements composition granitoids of the study area are both of S-type granite and I-type granite. Major elements analysis indicates that most of granitoids belong to the field of IAG, CAG and CCG and they correspond to syn-collision and late orogenic zone. Moreover, trace elements composition shows these granitoids belong to the field of VAG and syn-collision granite and they are tectonically located in the active continental margin. Economically important rare earth elements are discovered in the study area in granitoids and pegmatites.

Introduction

The study area is situated in Mogok Township, Mandalay Region. The study area lies between horizontal grids 300 to 400 and vertical grids 110 to 240 in one inch topographic map No. 93-B/5. The location map of the study area is shown in Fig. (1).

Purpose of Research

The study area has been investigated on the following objectives;

1. To describe the detailed petrography of igneous rock units observed in the study area
2. To study the petrochemical characteristics of the rocks of the study area
3. To investigate the economic possibility encountered in the study area

Methods of Investigation

The reconnaissance study included the topographic map analysis which was combined with satellite image to interpret the topography and drainage pattern. Landsat TM image was studied for possible distribution of rock unit by mean of band analysis and structure such as folds, faults and joints.

Field study was carried out for drawing detailed geological map. The Brunton Compass and GPS were using along the traverse. Representative samples were collected for references and investigation of mineralogical and petrological characteristics of rocks with the aid of GPS location. Measuring dip and strike of bedding, foliation, joints, structural information and major trends of dykes and veins were made by mean of Brunton Compass.

[1] Assistant lecturer, Department of Geology, Dagon University
[2] Lecturer, Department of Geology, Dagon University.
[3] Lecturer, Department of Geology, Dagon University.

As laboratory works, detailed petrographic study of representative samples of various rock units were studied with the aid of transmitted light polarizing microscope. Major oxides, minor andtrace elements were determined by applying XRF. The major oxides data were studied to calculate standard C.I.P.W norms and C.I.P.W norms with biotite and hornblende by using GCD kit 3.0 and microsoft excel. Moreover, rock classification, construction of variation diagram and comparison of rock composition with experimentally determined phase boundary for melt of similar composition were made by major oxides and trace elements composition. Trace elements such as Rb, Zr, Y, Nb, Ta, Yb, Th, Hf, Ce were used to determine the tectonic setting of granitoid rocks.

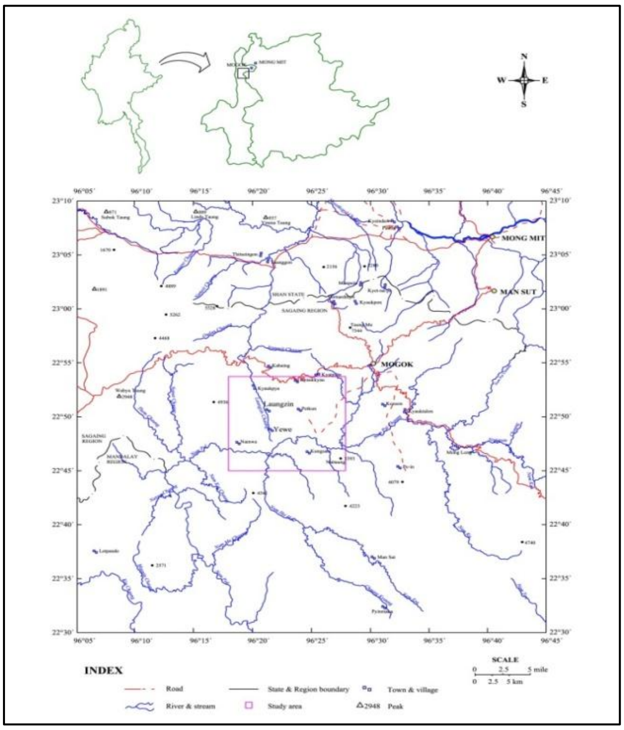

Figure 1 Location map of the study area.

Rock Sequence of the Research Area

Rock sequence of the research area is as shown in Table 1. Geological map of the research area is described in Fig. (2). The absolute age of igneous rocks is according to Kyaw Thu (2007).

Table 1 Rock Sequence of Laungzin Area, Mogok Township, Mandalay Region (Age of igneous rocks after Kyaw Thu, 2007)

Rock Type	Age
Alluvium	Quaternary
Igneous Rocks	
Pegmatite	Middle Miocene(15 Ma)
Tourmaline granite	Middle Miocene(15 Ma)
Biotite microgranite	Early Miocene(15.8±1.1 Ma)
Leucogranite	Early Oligocene(32±1 Ma)
Hornblende granite	Jurassic ?

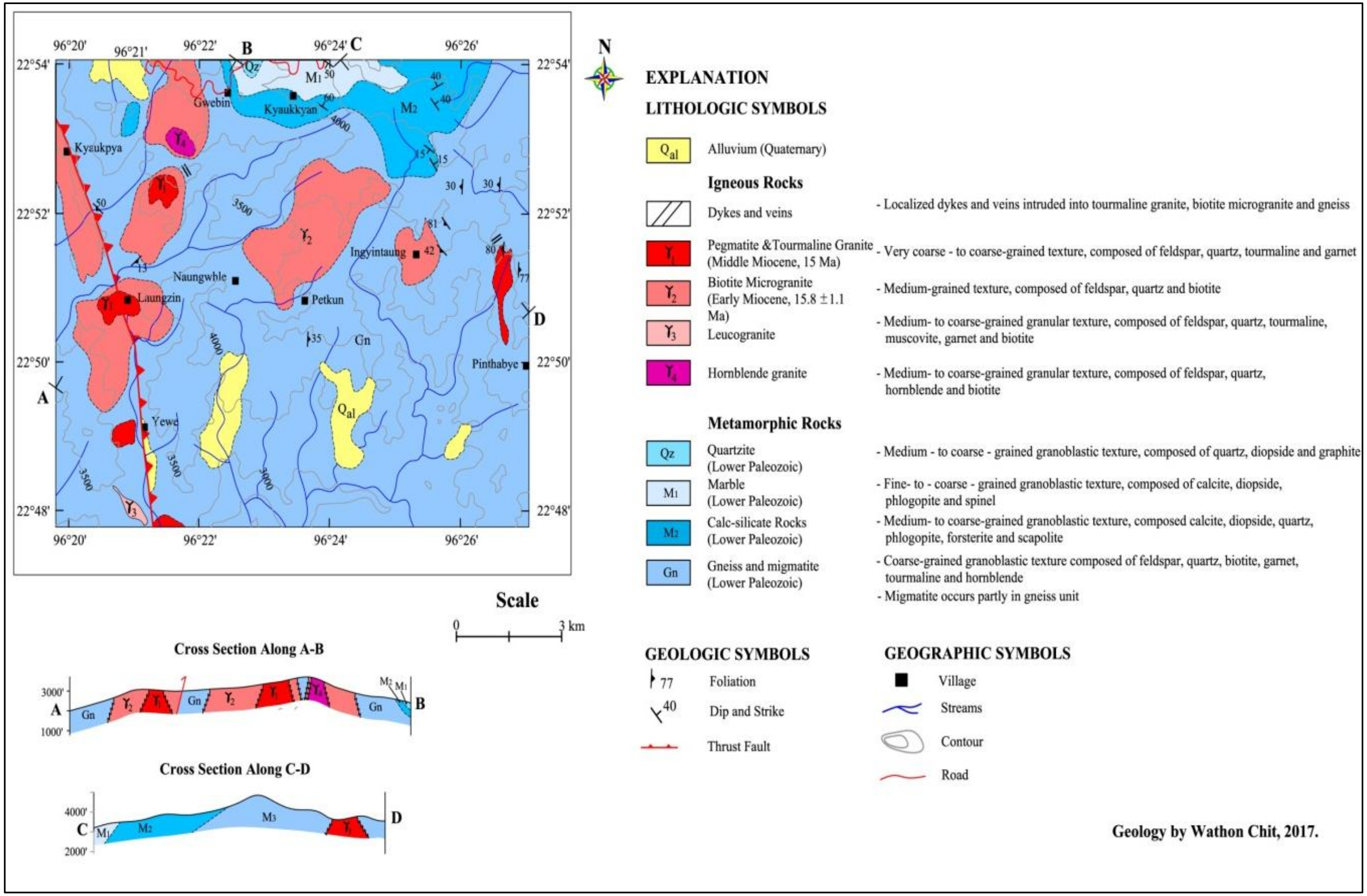

Figure 2 Geological Map of the Research Area

Petrography of Igneous Rocks

(i) Pegmatite

Megascopic study- Pegmatites are very prominent in the study area. Huge pegmatite bodies intruded into biotite microgranite and garnet-biotite gneiss at the vicinity of Laungzin Village and Pinthabye Village. Very coarse-grained quartz upto (1 inch diameter) is crystallized in pegmatite bodies. Weathered surface shows buff or dark grey colour and fresh colour is white. Kaolinization occurs on feldspars and chloritization occurs on biotite and garnet.

(ii) Tourmaline granite

Megascopic study- Tourmaline granite forms as a series of intrusions into the Mogok gneiss. The rock intruded into the country gneisses near Laungzin Village, Shwedwingyi, Yewe Village and Ingyin Taung. It is mainly composed of feldspar and quartz. The composition of tourmaline and garnet are variable Fig. (4).

Microscopic study- It shows coarse-grained hypidiomorphic granular texture and mainly composed of orthoclase, quartz, tourmaline and plagioclase with garnet, sphene, minute apatite and zircon Fig. (3). Tourmaline shows idiomorphic porphyritic texture and strongly pleochroic from bluish grey to green.

(iii) Biotite microgranite

Megascopic study- Biotite microgranite mainly distributes at the northwestern and in the middle of the study area and intruded into gneiss unit. The rock shows medium-grained granular texture. The composition of this rock contains feldspar, quartz, biotite and graphite

Microscopic study- The rock exhibits medium-grained hypidiomorphic granular texture and is mainly composed of orthoclase, quartz, plagioclase and biotite with small amount of hornblende Fig. (4). Accessory minerals are sphene, zircon, apatite, graphite and magnetite.

(iv) Leucogranite

Megascopic study- Small body of medium- to coarse-grained leucogranite intruded into leucogneiss between Kyaukpya and Laungzin Village. This unit is poorly exposed and some exposures show exfoliation nature due to weathering. This unit composed of medium- to coarse-grained feldspar and quartz essentially. Grain size varies from place to place from <1 mm up to 2 cm. Minor amount of mafic minerals such as biotite, garnet and graphite are also present.

Microscopic study- It shows medium- to coarse-grained allotriomorphic to hypidiomorphic granular texture. It is mainly composed of orthoclase, plagioclase and quartz Fig. (5). Accessory minerals include biotite, garnet, sphene, apatite, zircon and graphite.

(v) Hornblende granite

Megascopic study- It is locally distributed rock unit and the intrusion of hornblende granite is found in the east of Kyaukpya Village. It also intruded into hornblende-biotite gneiss near Yewe Village. The rock shows coarse-grained granular texture with the composition of feldspar, quartz, hornblende and minor biotite. Some of them show faintly foliated nature.

Microscopic study- They show medium- to coarse-grained hypidiomorphic granular texture and foliated nature is observed in some section. It is dominated by orthoclase, plagioclase, quartz and hornblende Fig. (6) with minor biotite, sphene, zircon and apatite.

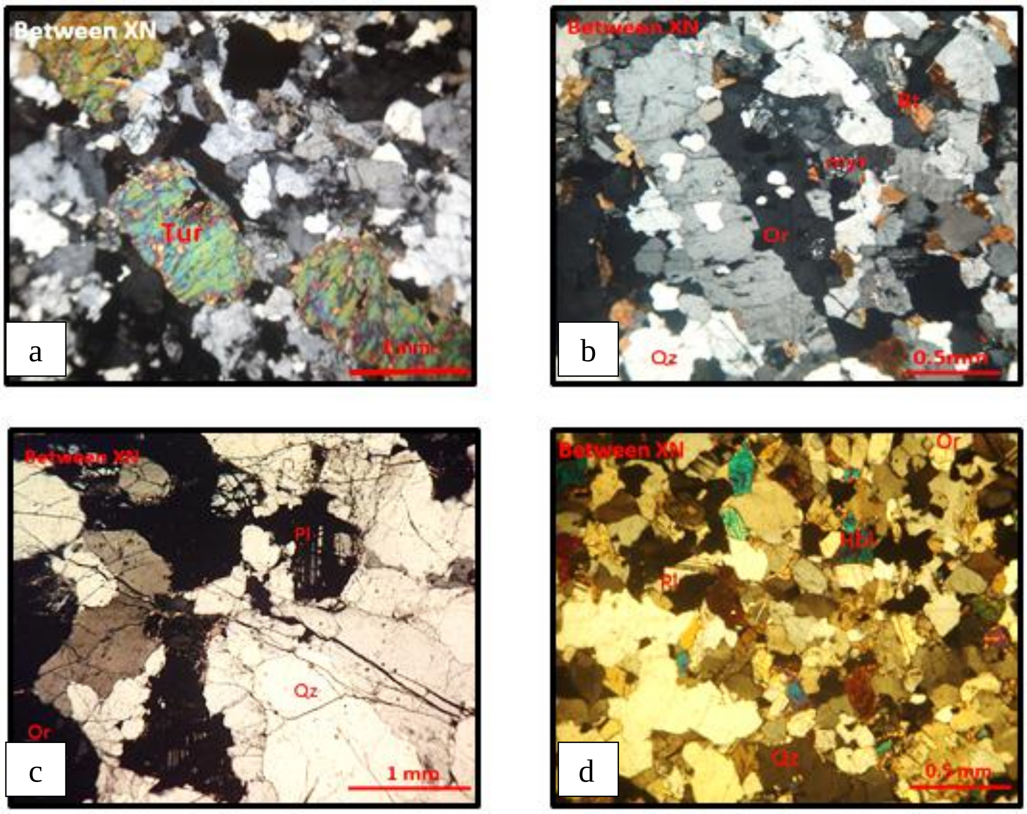

Figure 3 (a) Photomicrographs showing tourmaline phenocrysts in groundmass of alkali feldspar, quartz in tourmaline granite (sample- 29/17), (b) Photomicrographs showing mineral assemblages of orthoclase, quartz, biotite and plagioclase in biotite microgranite (sample- S-63), (c) Photomicrographs showing mineral assemblages of alkali feldspar, quartz and plagioclase in leucogranite (sample- S-50), (d) Photomicrographs showing mineral composition of hornblende granite from Yewe Village (sample- S-76)

Petrochemistry of Igneous Rocks of the Research area

The representative igneous rock samples (including 2 tourmaline granite, 6 biotite microgranites, 3 hornblende granites, 3 leucogranites and 2 pegmatites) from the study area were selected for analysis. All these samples were analysed by XRF method. The rock types and symbol used in diagrams of the selected samples are stated in Table 2. The weight percent oxide method, molar-percent and cation-percent methods in some diagrams were drawn by using GCD kit 3.0 software for the present study.

Table 2 Analysed samples, symbols and rock types of igneous rocks of the study area

Sample	Symbol	Rock Type	Sample	Symbol	Rock Type
wc-4	● (red)	Tourmaline Granite	**JGs-5**	▲ (blue)	Biotite Microgranite
wc-5	● (green)	Tourmaline Granite	**JGs-69**	▲ (light blue)	Biotite Microgranite
GS-55	■ (red)	Hornblende Granite	**JGs-81-a**	▲ (yellow)	Biotite Microgranite
JGs-6	▲ (black)	Biotite Microgranite	**JLgs-32**	◆ (light blue)	Leucogranite
JGs-50	▲ (red)	Biotite Microgranite	**JLgs-43**	◆ (green)	Leucogranite
JGs-87	▲ (green)	Biotite Microgranite	**JLgs-55**	◆ (red)	Leucogranite
JGs-76	■ (green)	Hornblende Granite	**JPs-28-a**	✡ (green)	Pegmatite
JGs-109	■ (blue)	Hornblende Granite	**JPs-81-b**	✡ (blue)	Pegmatite

According to the QAPF diagram (Si oversaturated), the igneous rocks of the study area are plotted in quartz-rich granitoids, Fig. (7). The SiO_2 vs Na_2O+K_2O diagram of Middlemost (1985) indicates that the igneous rocks of the study area fall in granite field, Fig. (8). According to Irvine and Baragar (1971), the samples are classified in magmatic series of subalkaline and belong to calc-alkaline magmatic series, plotted in Fig. (9). Based on the SiO_2 vs K_2O diagram for classification of magmatic series proposed by Peccerillo and Taylor (1976), most of granites belong to high potassium calc-alkaline series Fig. (10).

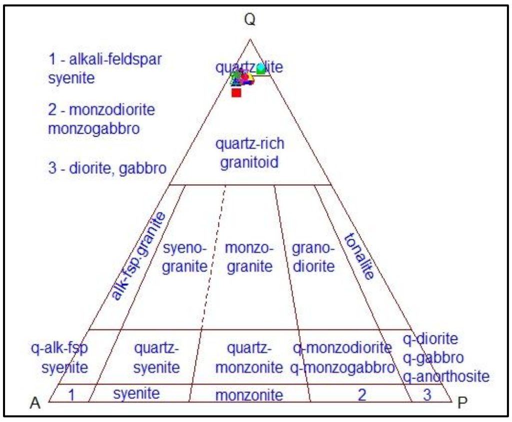

Figure 7 The QAPF diagram with plotted data of igneous rocks of the study area (**Source:** IUGS classification, 2006).

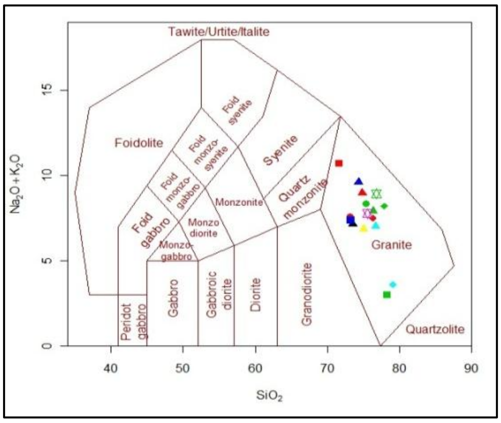

Figure 8 Classification of igneous rocks by Middlemost(1985) showing igneous rocks of the study area.

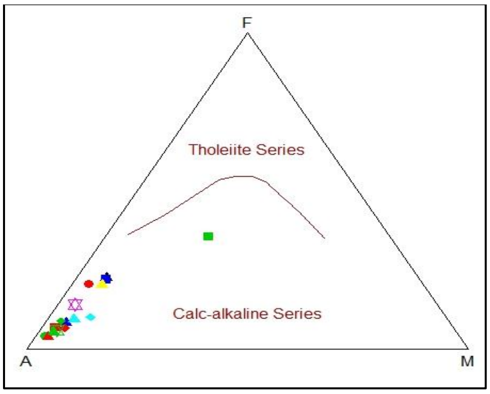

Figure 9 ($Na_2O + K_2O$)- FeO_t- MgO(AFM) diagram distinguishing tholeiite series andcalc-alkaline series (Irvine and Baragar, 1971).

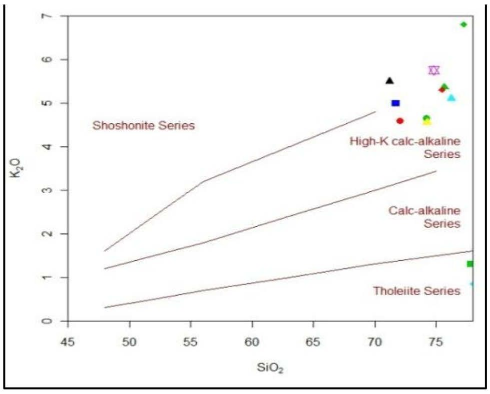

Figure 10 SiO_2 vs K_2O diagram distinguishing the tholeiite, calc-alkaline, high-K calc-alkaline and shoshonite series (Peccerillo and Taylor, 1976)

According to CaO- Al_2O_3- (Na_2O+K_2O) ternary diagram Fig. (11), igneous rocks of the study area fall in the peraluminous field. According to ASI (aluminum saturation index) vs A/NK (AL_2O_3/ (Na_2O+K_2O) mol) plot by Frost et al.(2001) Fig. (12), the tourmaline granites, leucogranites and biotite microgranites are predominantly peraluminous with high aluminum saturation indexes. Hornblende granites display a low alumina saturation index belonging to metaluminous field. Granite types discrimination is also plotted in Fig. (12). The most granitoids of the study are S-types granite and some are I-type granite according to Chappell and White, (2001). By means of Villaseca et al. (1998) outlined in B-A ((Fe+ Mg+ Ti) vs Al- (K+ Na+ 2Ca)) binary diagram, most of the peraluminous granitoids are plotted in felsic peraluminous, one biotite microgranite falls in high-peraluminous, one biotite microgranite and one tourmaline fall in moderate-peraluminous and one hornblende granite fall in low-peraluminous Fig. (13).

The ternary diagram Ba-Rb-Sr, Fig. (14) shows that one tourmaline granite and and one biotite microgranite fitted in strongly differentiated granite. Two biotite microgranites, one tourmaline granite and one leucogranite fitted in high calcium granite. One hornblende granite and one leucogranite fitted in granodiorite and the rest samples fall in the normal granite with low calcium composition (Bouseily and Sokkary, 1975).

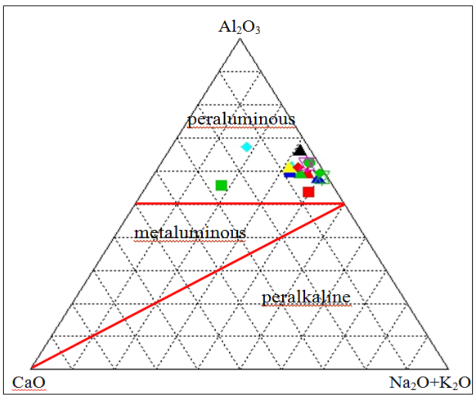

Figure 11 CaO- Al_2O_3- (Na_2O+K_2O) diagram distinguishing peraluminous from metaluminous and peralkaline igneous rocks of the study area.

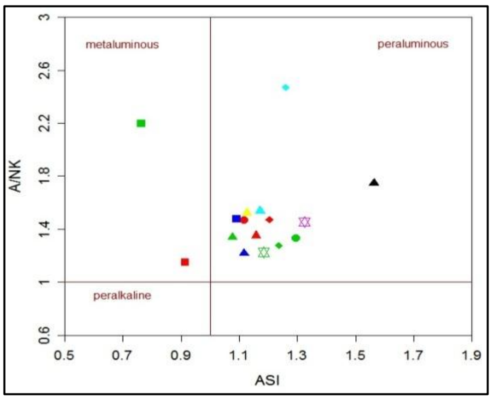

Figure 12 Binary diagram of aluminium saturation index and A/CNK to discriminate metaluminous/ peraluminous rocks from peralkaline rocks (Frost et al., 2001)

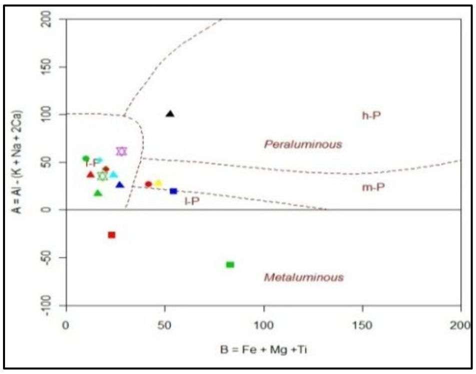

Figure 13 B-A plot of Al-saturation index todistinguish felsic, low, moderate and high peraluminous divisions of peraluminous rocks (using millications, after Villaseca et al., 1998).

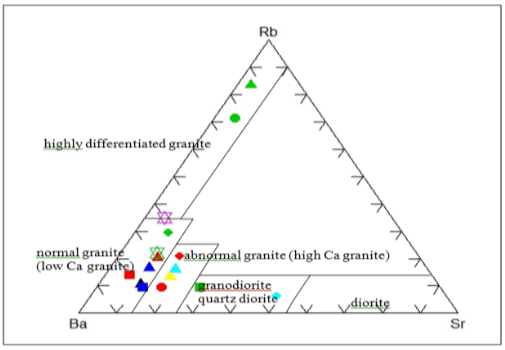

Figure 14 Ba- Rb- Sr ternary diagram used fordistinguishing different fields of granitoids (Bouseily and Sokkary, 1975)

Normative quartz, albite and orthoclase ratios are plotted in the Ab-Q-Or ternary diagram with water pressure of 2 kbar to 10 kbar, after Tuttle and Bowen, 1958, Fig. (15). Two biotite microgranites, two leucogranites and one hornblende granite lies below P_{H2O} 2 kb, two biotite microgranites lie between P_{H2O} 2 kb to 10 kb and one hornblende granite lies above 10 kb. All tourmaline granites, one hornblende granite and the other biotite microgranites lie in the 5kb curve of Wiebe (1974).

According to anorthite- quartz- orthoclase ternary diagram Fig. (16), most of the granitoids were formed below 0.5kb, two biotite microgranites were formed between 0.5 kb to 5 kb and one hornblende granite was formed above 5 kb of water vapour pressure, after Tuttle and Bowen (1958).

If the rocks have crystallized at minimum pressure of 2kb, their liquids temperatures can be estimated from the diagram showing the relationship between differentiation index and temperature at 2kb water pressure, Fig. (17). According to the diagram, biotite microgranites were formed at the liquidus temperature between 660° C and 700° C, and hornblende granite was formed at the liquidus temperature between (690° C and 710° C).

Depth of the crystallization of the igneous rocks can be stated from the schematic depth-temperature diagram after Marmo (1956), Fig. (18). According to the diagram, leucogranites probably crystallized at the depth of 21 km, tourmaline granites crystallized at 22 km, biotite microgranite at 23 km and hornblende granite at 24 km.

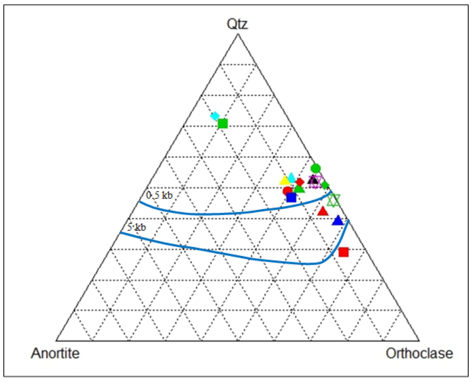

Figure 15 Albite- Quartz- Orthoclase ternary diagram showing water saturated liquidus field boundaries and isobaric temperature inthe system (after Tuttle and Bowen, 1958).

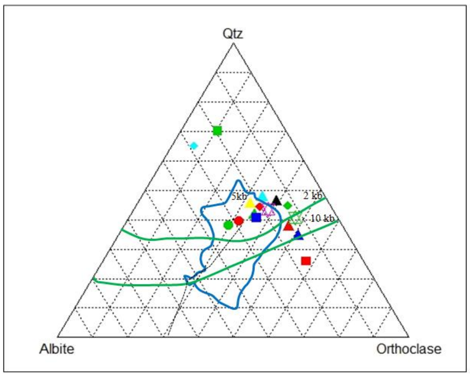

Figure 16 Normative ternary plot of anorthite-quartz- orthoclase diagram with dividing curves of water vapour pressure in the formation of igneous rocks (after Tuttle and Bowen, 1958).

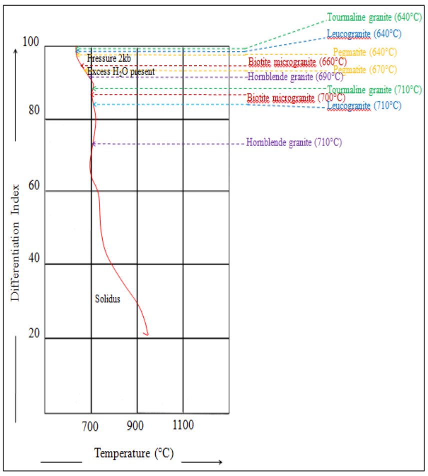

Figure 17 Temperature- differentiation index diagram for the igneous rocks of the study area at 2 kb water pressure (after Piwinskii and Wyllie, 1970).

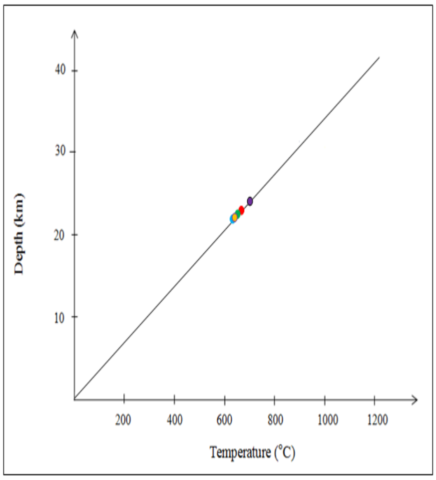

Figure 18 Schematic depth- temperature relation diagram for igneous rocks of the study area (after Marmo, 1956).

Tectonic Discrimination of Granitoid Rocks

Discrimination of a possible tectonic setting of the study area is particularly important for the purpose of characterization of granitoids. According to major elements analysis by C/ACF (CaO/Al_2O_3 + CaO + FeO) vs F/ACF (FeO/Al_2O_3 + CaO + FeO) variation diagram Fig. (19), all granitoids in the study area are mostly confined to the IAG, CAG and CCG field. It can be considered that the granitoids were formed on the continent owing to the subduction of an oceanic plate beneath the continent.

According to Ta/Hf- Th/Hf binary plots of Schandl and Gorton (2002), tourmaline granite of the study area is tectonically located in the active continental margin Fig. (20). By using (Y+Nb)- Rb, Y- Nb, (Ta+ Yb)- Rb and Yb- Ta binary diagrams proposed by Pearce et.al, the tourmaline granites are plotted in VAG (Volcanic Arc Granite) and syn-collision granite Fig. (21). Therefore, according to trace elements analysis, the tourmaline granites of the study area fall in the field of syn-COLG and VAG.

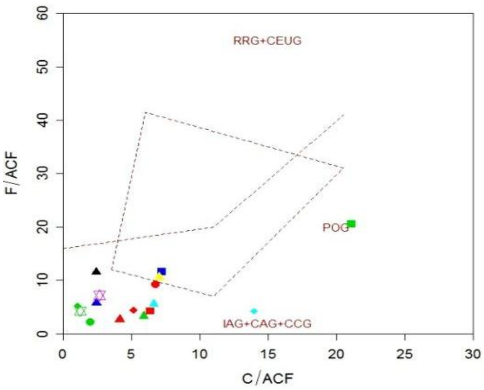

Figure 19 C/ACF vs F/ACF binary diagram showing the tectonic discrimination of granitoids of the study area (Maniar and Piccoli, 1989).

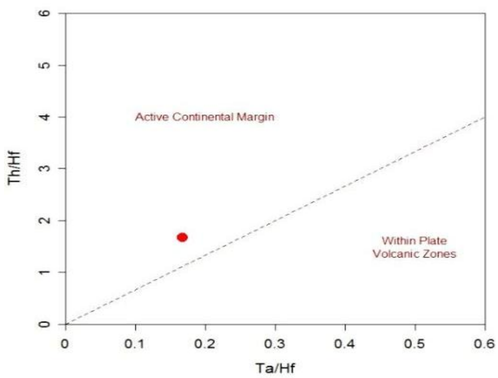

Figure 20 Ta/Hf- Th/Hf binary diagram classifying geotectonic environment of felsic rocks (after Schandl and Gorton, 2002).

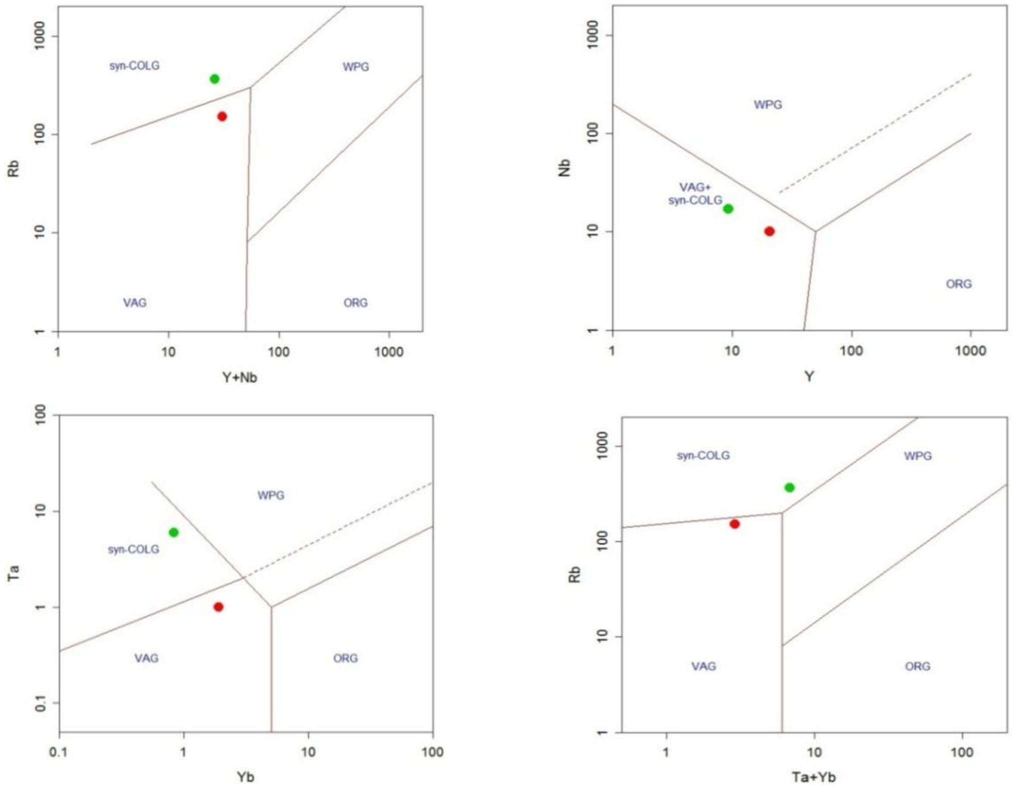

Figure 21 Granite tectonic discrimination diagram using trace elements by Pearce et al. (1984).

According to cations analysis, Batchelor and Bowden (1985) used to discriminate the tectonic setting of granites according to R1-R2 binary (using millications) diagram. By means of major element ratios of granitoids, the granites of the study area correspond to syn-collision and late orogenic zone Fig. (22).

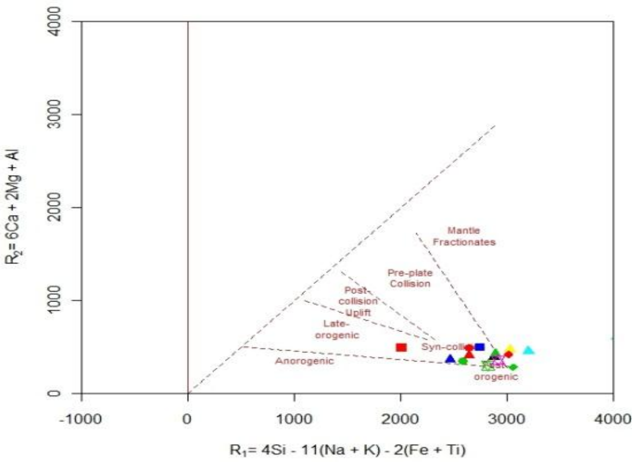

Figure 22 R1-R2 binary (in millications) diagram showing tectonic setting of granitoids correspond to syn-collision to late orogenic zone (after Batchelor and Bowden, 1985).

Economic Possibility of the Research Area

According to the investigation with XRF analysis, the granitoids and pegmatites of the study area associated with rare earth elements and antinides (uranium and thorium). Therefore, the study area can be expected for rare earth elements production in the future, although there has not been economically mined for rare earth elements.

Summary and Conclusions

The igneous rocks exposed in the study area consist of pegmatite and granite 16 granitoid samples were analyzed for content of major and trace elements by XRF method. According to the QAPF diagram (Si oversaturated), the igneous rocks of the study area are plotted in quartz-rich granitoids. The SiO_2 vs Na_2O+K_2O diagram by Middlemost (1985) indicates that the igneous rocks of the study area fall in granite field. According to Irvine and Baragar (1971), the samples are classified in calc-alkaline magmatic series. The SiO_2 vs K_2O diagram proposed by Peccerillo and Taylor (1976), most of granites belong to high potassium calc-alkaline series. According to CaO- Al_2O_3- (Na_2O+K_2O) ternary diagram, igneous rocks of the study area fall in the peraluminous field. According to B-A binary diagram outlined by Villaseca et al. (1998), most of the peraluminous granitoids are plotted in felsic peraluminous, one biotite microgranite falls in high-peraluminous, one biotite microgranite and one tourmaline fall in moderate-peraluminous and one hornblende granite fall in low-peraluminous. According to granite types discrimination diagrams of ASI vs A/NK described the most granitoids of the study are S-types granite and some are I-type granite. By using major elements, all granitoids in the study area are mostly confined to the IAG, CAG and CCG field. By using trace elements, tourmaline granite of the study area is tectonically located in the active continental margin in the field of syn-COLG and VAG granite. By using cations of major element ratios of granitoids, the granites of the research area correspond to syn-collision and late orogenic zone. The study area can be expected for rare earth elements production in the future, although there has not been economically mined for them.

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