Petrological Analysis of the Granitoid Rocks from Pangon Area, Paung Township, Mon State

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Abstract

Pangon area is situated about 4.8 km southeast of Yinnyein and 10.4 km northwest of Paung Township. It covers about 36.86 km^2 and lies in one inch Topographic map No. 94 H/5 and H/6. Regionally, it is situated at the eastern margin of Central Granitoid Belt and partly on the western margin of Shan-Tanintharyi Region. The study area is mainly composed of igneous, metaigneous and metamorphic rocks. The igneous rocks (Late Cretaceous) are mainly occurred at central part and it is surrounded by metaigneous rocks and metamorphic rocks. The drainage shows rectangular pattern at western part and dendritic pattern at eastern part of the area. The igneous rocks are divided into two units; porphyritic biotite granite and muscovite granite. Biotitemicrogranite, tourmaline granite, pegmatite, aplite dykes and quartz veins are intruded into igneous and metamorphic rocks. The major oxide composition and trace elements of granite samples are analyzed by XRF analysis. Detailad petrochemical studies made by weight percent method in diagrams indicate that calc- alkaline series, peraluminous and the bulk composition of granitoid rocks falls in the granite range. According to the temperature-differentiation index diagram, the liquidous temperature for muscovite-biotite granite is 690˚C and biotitemicrogranite is 650˚C. In the depth-temperature relation diagram, muscovite- biotite granite has probably differentiated at the depth of 21 km and muscovite-biotitemicrogranite may be 23 km. On the basic of field occurrences, petrological, mineralogical, petrochemical criteria, these granitoid rocks are considered to be magmatic origin, S type and emplaced in mesozone during Late Cretaceous.

Key Words; Central Granitoid Belt, Shan Tanintharyi Region, Granitoid Rocks, Calc- alkaline Series, peraluminous, S type, Mesozone.

Introduction

Location, size, physiography and drainage pattern

The research area is situated about 4.8 km southeast of Yinnyein and 10.4 km northwest of Paung Township.It lies between latitude 16° 24' to 16° 46'N and longitude 97° 24' to 97° 28´ E, and is bounded by vertical grids 98 to 09 and horizontal grids 24 to 28 It covers about 36.86 km^2 and lies in one inch Topographic map no.94H/5 and H/6. In this area, the prominent peaks are Zingyaiktaung (830.3 m), Inbyangtaung(126.6 m) and Mintayatabataung (655 m), respectively Fig.(1,a,b,c).The eastern part of the study area has subparallel drainage pattern, the western part rectangular and the middle part dendritic pattern,Fig.(1,d).

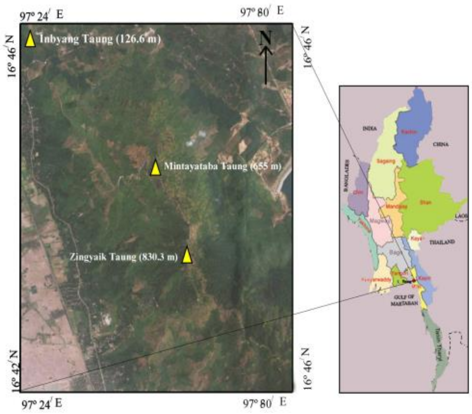

Fig.(1,a) Location map of the study area

Previous Works

J-CogginBrown(1924-25) andH.L.Chhibber (1934) reported that the suitable road stones were found for the construction of Bago-Mottama railway line in the Thaton district.KhinZaw (1990), ZawMyint Ni (1997), Min MinKhine (1999), Sanda Aye (2006), Hla Yin Min (2009), NawHtooKhuPhaw (2013) and May Thu Aung (2015) study the petrology, petro- chemistry and mineralization of the granitoid rocks of ZingyaikTaung and its environs.

Purpose of Study

A detailed geological map was prepared and petrological study of all rock units were carried out. There are four main factors in this study.They are to prepare a fairly detailed

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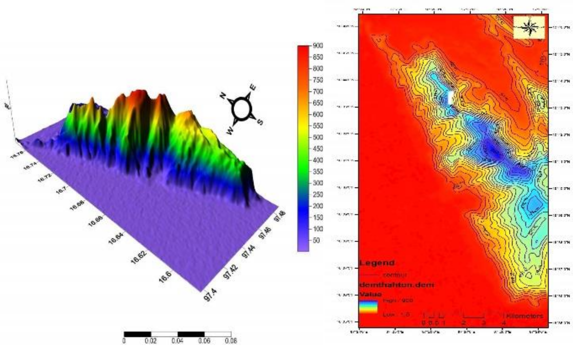

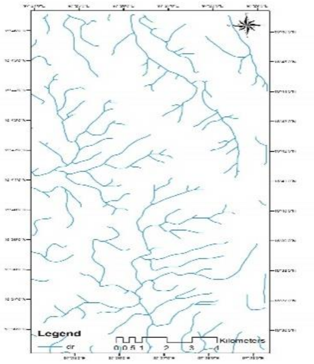

Fig. (1b,c)Three-dimensional view and Two-dimensional view.

Fig.(1,d) Drainage pattern

geological map of pangon area, to analyze the petrology and petrochemistry of each granitic unit, to interpret the petrogenesis of the igneous rock units by using modal compositionand geochemical data, to interpret the source of granitic rocks according to the tectonic setting by using modal composition and petrochemical methods.

Methods of Study

Using base map with the scale of four inches to one mile was used in the field work. Aerial photographs of satellite image were also used an aid to delineate the lithologic boundaries and the structures of the area.In the field works, outcrop mapping and located points were used with GPS, tape and compass traverse methods. Representative samples from each rock units were collected at all points where the rocks were considered to have changed in lithology for the study of petrographical and petrochemical data.Finally, recorded data on the base map were transferred onto the geological map on the scale of two inches to one mile.In laboratory works, (50) thin sections were studied microscopically. Modal analysis of thin sections of the granitic rocks was made by using the mechanical point counter in conjunction with the petrological microscope. Chemical composition and norm were determined by using CIPW norm and mode calculations which were programmed by U TheinSwe (1990), Released (1.0C), the composition of the plagioclase was determined by Michel-Levy's method, petrochemical analysis of the major oxides and trace elements on (10) representative specimens were made by XRF analysis in M.G.A petrochemical laboratory, Mandalay.

GENERAL GEOLOGY

Regional Geologic Setting

Regionally, the research area is situated at the eastern margin of Central Granitoid Belt and partly on the western margin of Shan-Tanintharyi region. Igneous rocks occurs along the Shan boundary fault system and Tenasserimgranitoids in the Sino-Burman Ranges are recently described by Bender (1983). The southern part of the study area, Zingyaik plutonic mass of Mesozoic age intruded into metasedimentary rocks. This intrusion may be the northern continuation of Tin-Tungsten mineralized granite of Tanintharyi Division.

Table. (1) Rock Sequences of the study area, Age Correlated by U Thein ,2014 and Su SuKhine ,2014.

Rock units	Age
- Alluvium	**Holocene**
- Older Alluvium and Lateritic soil	
Igneous Rocks - Dykes and veins - Muscovite-biotitegranite - Porphyritic biotite granite	**Late Cretaceous**
Metaigneous Rocks - Granite Gneiss	**Late Cretaceous**
Metamorphic Rocks - Black slate and quartzite interbedded with minor interclation of metagrewacke unit (C_1-P_1 t^5) -Quartz schist intercalated with quartzite unit (C_1-P_1t^1)	**Early Carboniferous-Early Permian**

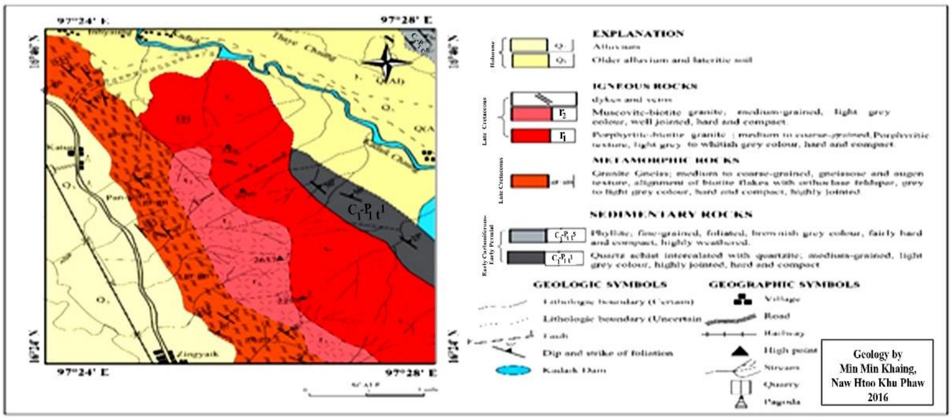

Fig. (2)Geological map of the Pangon area, Paung Township, Mon state.

Nyan Thin (1984) and MaungThein (1986) regarded that the Central Granitoid Belt of Myanmar is developed in the tectonic setting of subduction related magmatic arc.KhinZaw, (1990) stated that the Central Granitoid Belt emplaced during Continent-Arc Collision at the early stage of westward migrating, east-dipping subduction zone during the Upper Mesozoic and Lower Eocene.

Igneous rocks (Granitoid rocks)

Fig.(2) shows the geological map of Pangon area. In this area, the granitoid rocks can be divided into two units; porphyritic biotite granite and muscovite-biotite granite. These rocks are exposed in the central part of the study area. The modal composition of representative rock samples were determined by point counting analysis and the results are plotted on the I.U.G.S (2001) classification diagram, fig.(3).

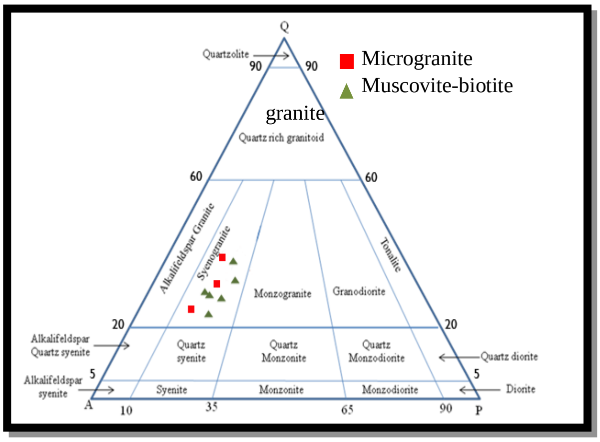

Fig. (3) Plotted data of the igneous rocks on the I.U.G.S classification diagram(2001, Le.Maitre)

Porphyritic biotitegranite

Megascopically, it is well exposed at the eastern flank of Zingyaik range. It is medium to coarse grained, hard, compact and highly jointed. It is intruded into granitoid body and it shows light grey colour on fresh surface and grey colour on weathered surface.Microscopically,it is medium-grained, hypidiomorphic granular to porphyritic texture and mainly composed of orthoclase, microcline, quartz, plagioclase,biotite. Tourmaline, muscovite, apatite, zircon and opaque minerals occur as accessory minerals.Orthoclase occurs as subhedral form showing contact twin and untwine. Microcline can be also found as subhedral form and shows distinct cross-hatched twin. Biotite, muscovite and zircon occur as inclusions in feldspar and quartz.Anhedralquartz crystals show wavy extinction and suture contact. Plagioclase shows subhedral to anhedral form and polysynthetic twin. Biotite occurs as subhedral prismatic crystals and shows strong pleochroism from brown to dark brown colour.

Muscovite-Biotite Granite

Megascopically, it is well exposed along the western part of Zingyaik range. It is medium to coarse-grained, whitish grey colour on fresh surface and dark grey colour on weathered surface. It is hard, compact, highly jointed and occurs as massive form and dome shaped. Tourmaline is also observed in this granite in some places, especially in the northern part of the area. Microscopically, it is medium to coarse-grained, hypidiomorphic granular texture. It is mainly composed of orthoclase, perthite, microcline, quartz, plagioclase,biotiteand muscovite.Tourmaline, sericite, apatite, sphene and zircon occur as accessory minerals. Orthoclase occurs as subhedral form and shows simple contact twin but some orthoclase shows cloudy appearance due to alteration. Some are fractured and altered to sericite. Microcline occurs as subhedral crystals and shows cross-hatched twinning. Perthitic texture occurs is predominance and occurred as patch perthite, vein perthite, microcline microperthite and string perthite. Plagioclase is found as subhedral crystals shows polysynthetic twinning and altered to sericite. Myrmekitic texture is present at the contact of orthoclase and quartz. The composition of plagioclase range determined by Michel-Levy's method, it is fall in An_{12-18} (Oligoclase range).

Quartz commonly occurs as anhedral crystals and shows wavy extinction. Biotite is mostly subhedral form and pleochroic from yellowish brown to dark brown in colour. Muscovite, zircon, apatite and sphene are present as accessory minerals.

Dykes and veins

Microgranite and tourmaline granite are mostly intruded into porphyritic biotite granite and mostly occurs at western part of the area. Quartzofeldspathic veins are intruded into muscovite biotite granite. Most of quartz veins are cut across the metamorphic rock units.

PETROCHEMISTRY

For petrochemical study the major oxide composition (wt%) and trace elements (ppm) of granite samples were determined by Wavelength Dispersive XRF Spectrometer in M.G.A Petrochemical Laboratory, Mandalay. Trace element concentrations were analyzed by XRF method. Standard CIPW norm and CIPW norm with biotite and hornblende are calculated according to the rules of Hutchison, (1974) and listed in Table.(2),(3). For Tectonic Discrimination Diagrams of Pearce et al. (1984) were used to interpret the possible tectonic setting of the assigned area. The major and trace element data were analyzed from the variation diagrams and triangular diagrams and were drawn by using Tridaw software, Microsoft Excel and Petrograph 2 Beter software.

Geochemical characteristics of igneous rocks of the study area

The granite rocks in the study area are muscovite-biotite granite and muscovite-biotitemicrogranite. According to the geochemical data, the range of the major oxide is SiO_2 from (57.76)to (78.4), Al_2O_3 from (10. 3) to (15.58), TiO_2 from (0.12) to (2.0), FeO from (0.23) to (3.68), MnO from (0.01) to (0.89), CaO from (0.2) to (2.48), MgO from (0.17) to (3.56), K_2O from (1.97) to (8.2), Na_2O from (1.4) to (3.3), P_2O_5 from (0.1) to (0.3), respectively. In the Harker variation diagram, major oxides (FeO, TiO_2, Al_2O_3, MnO, P_2O_5) have negative correlation with SiO_2 but K_2O has positive correlation. Based on the silica and alkali contents, igneous rocks have been classified into two major series; alkaline and subalkaline. In Na_2O + K_2O Vs SiO_2 diagram, all of the igneous rocks fall in the field of subalkaline, fig.(4a). The dividing line was chosen by Irvine and Baragar (1971).The subalkaline series was further subdivided as tholeiitic and calc-alkaline on the basis of their ion contents shown by AFM plot diagrams which indicate that all the subalkaline rocks fall in the field of calc-alkaline. According to the diagram, the granitic rocks in the study area belong to the calc-alkaline series and peraluminous, fig.(4b).

Table. (2) Standard CIPW norm

Code No.	A-1	A-2	A-4	A-5	A-6	E-1	E-2	E-3	E-4	E-5
Quartz	32.183	28.855	17.859	39.174	25.666	39.027	41.127	26.030	34.467	34.820
Albite	29.469	24.245	23.316	15.137	31.994	11.857	13.551	14.413	16.141	15.261
Corundum	6.610	3.714	0.441	4.057	5.176	0.000	0.079	0.000	1.436	1.377
Diopside	0.000	0.000	0.000	0.000	0.000	0.206	0.000	0.673	0.000	0.000
Illite	0.110	0.081	0.028	0.022	0.217	3.802	0.951	2.093	2.479	0.761
Orthoclase	29.288	21.048	36.260	38.801	13.299	37.265	39.039	48.552	38.564	43.443
Anorthite	5.036	8.091	9.812	1.530	10.821	3.217	1.490	3.631	2.490	0.994
Apatite	3.268	0.681	0.514	0.506	0.782	0.000	0.000	0.000	0.000	0.000
Hypersthene	0.847	8.821	8.853	0.430	8.421	4.481	3.618	4.463	4.278	3.419
Hematite	0.886	3.840	2.238	0.234	3.055	-	-	-	-	-
Rutile	0.303	0.620	0.676	0.111	0.569	-	-	-	-	-
Magnetite	0.000	0.000	0.000	0.000	0.000	0.145	0.145	0.145	0.146	0.145

DI	92.550	77.865	77.877	97.168	76.135	88.149	93.796	88.995	99.007	94.680
CI	5.629	14.274	16.017	1.832	16.723	5.954	3.761	6.620	5.119	3.258

DI – Differentiation Index of Thornton and Tuttle (1960)
CI – Crystallization Index of Poldervaart and Parker (1965)

Table.(3) CIPW norm with Biotite and Hornblende

Code No.	A-1	A-2	A-4	A-5	A-6	E-1	E-2	E-3	E-4	E-5
Quartz	33.123	34.941	24.069	35.574	31.535	42.771	43.741	79.947	73.824	37.190
Albite	29.372	24.114	23.192	15.121	31.794	11.769	13.508	14.140	16.054	15.228
Corundum	2.063	4.539	1.317	4.208	6.010	1.170	0.623	1.077	2.336	1.737
Ilmenite	0.110	0.000	0.028	0.022	0.216	0.892	0.138	2.054	1.115	0.218
Orthoclase	28.412	12.826	27.929	38.364	5.48	31.821	0.000	43.520	33.715	39.685
Anorthite	3.768	5.753	7.365	1.104	8.389	0.000	0.000	0.624	0.000	0.000
Apatite	0.268	0.677	0.512	0.505	0.777	0.000	0.000	0.000	0.000	0.000
Hypersthene	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Olivine	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Sphene	0.882	1.617	1.688	0.299	1.666	2.431	1.047	2.653	1.746	0.699
Hematite	0.883	3.820	2.226	0.234	3.036	0.000	0.000	0.000	0.000	0.000
Biotite	1.119	11.631	11.674	0.590	11.094	8.001	5.631	6.143	7.066	5.097
Magnetite	0.000	0.000	0.000	0.000	0.000	0.144	0.145	0.143	0.145	0.145
Honeblende	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Spinel	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

According to ACF and A/CNK Vs SiO_2 diagrams, fig.(4c), the granitic rocks from the assigned area fall within the S-type field. In the normative Ab-Or-An diagram, muscovite-biotite granite and muscovite-biotitemicrogranite fall in the field of granite. In geochemical classification of the granitic rocks, the SiO_2Vs Total Alkali (TAS) diagram, fig.(4d), (Cox et.al, 1979) is shown as similar as Ab-Or-An diagram.

Condition during the crystallization of the granite

The bulk composition of igneous rocks falls in the granite range. According to the temperature-differentiation index diagram,fig.(4e) the liquidous temperature for muscovite-biotite granite is 690˚C and muscovite-biotitemicrogranite is 650˚C.According to the depth-temperature relation diagram, fig.(4f), muscovite- biotite granite has probably differentiated at the depth of 21 km and muscovite-biotitemicrogranite may be 23 km.

Suggested Origin of Granitic Rocks

Based on the field evidences and petrological identification, the following characteristics were investigated in the granitic rocks of the study area, presence of the alkalifeldsparphenocrysts, presence of the perthite, presence of the myrmekitictexture, lack of the ghost structure within the granite body. Thus, the granitic rocks of the study area are magmatic origin.

Possible Age of Granite

Absolute ages of these igneous rocks are still unknown due to the lack of radiometric dating of the rocks. But the radiometric dating of the granite samples which are collected from Thaton and Kyaikhto area by the G.I.A.C field trip (1996) and moattama area (After Su SuKhine, 2014), are described below;

Kyaikhto area	Porphyritic granite (K.Ar method)	My.96. 211 Bio.31 ± 0.9Ma
Thaton area	Porphyritic granite (K.Ar method)	My. 96.222 Bio. 29.2± 0.7Ma
Thaton area	Foliated granite (K.Ar method)	My. 96.217 Bio.25.9± 0.5Ma
Moattamaarea (U-Pb method)	Porphyriticbiotite granite	72.07± 0.78 Ma
Moattamaarea	Foliated porphyritic biotite granite (U-Pb method)	73.1 ± 1.4 Ma

These evidences for relative age and radiometric dating of the granitic rocks of the adjacent areas are used to assign the age of the igneous rocks of the study area. Therefore, it is regarded that the granitic rocks of the study area were intruded during Late Cretaceous(72.07-73.1 Ma).

Genetic type of Granite

The granitic rocks of the study area are considered as S-type granite, based on field character, petrographical analysis and petrochemical data. The following important points are supported this conclusion; common minerals are biotite, muscovite, zircon and apatite, biotite is principal mafic mineral, hornblende is absent, absence of hornblende-bearing xenoliths, mol A/CNK>1.1, normative corundum is more than 1%, most variation diagrams are irregular, plotting on A/CNK Vs SiO_2 diagram of Chappell and White (2001) shows that these granitic rocks fall in S-type field.The granitic rocks of the study area may be considered to have emplaced in the depth of mesozone, on the basis of the field and petrographic evidences of contact migmatite is absent, xenoliths are not observed, there is no relationship of volcanic rocks and intrusions are more alkalic and siliceous.The liquidous temperature of granitic rocks is estimated 670°C and the depth of crystallization of granitic rocks about 22 km.

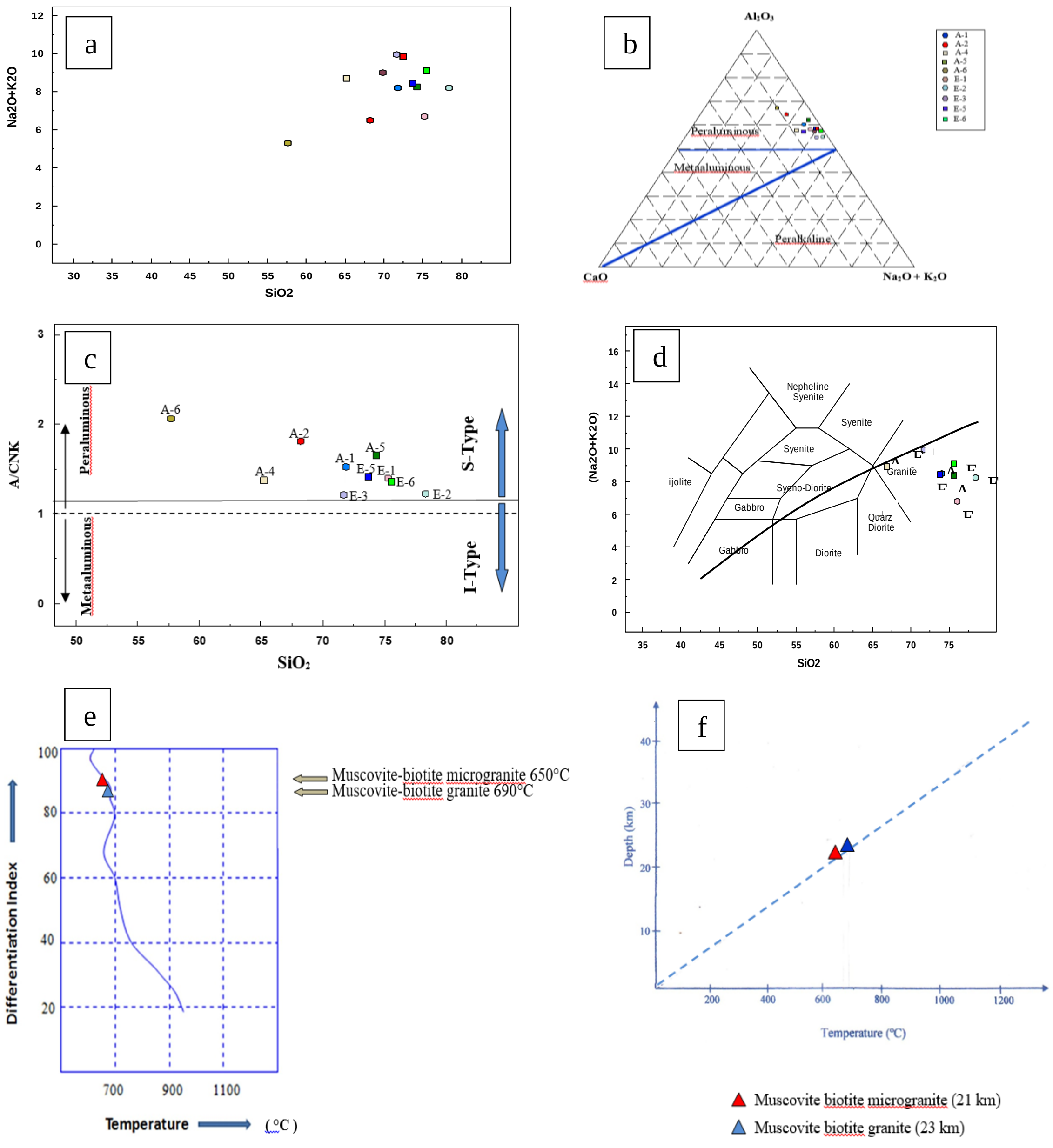

Fig.(4) (a) Alkali Vs Silica diagram, showing the distinction between the alkaline and subalkaline series (After Irvine and Baragar,1971), (b) Al_2O_3-CaO-(Na_2O+K_2O) plot of the granitic rocks of the area (After Hyndman, 1985), (c) A/CNK Vs SiO2 diagram for classification of I-type and S-type granitic rocks from the study area. (After Chappel and White, 2001). Line at A/CNK = 1 divided between peraluminous and metaluminous and line at A/CNK = 1.1 divided between I and S-type granite, (d) Chemical classifications of plutonic igneous rock according to total Alkali Vs Silica (TAS) diagram of Cox et.al. (1979).The dividing line between alkali and subalkali magma is from Miyashio (1978), (e) Temperature-Differentiation Index Diagram for the Igneous Rocks of the Study Area, at 2 Kb Water Pressure (After Piwinskii and Wyllie, 1970) and (f) Schematic depth-temperature relation diagram (After Marmo, 1969).

Summary and Conclusion

Muscovite-biotite granite and porphyritic biotite granite are the common granitoid rocks and mainly composed of alkali feldspar, quartz, plagioclase, biotite and muscovite. The accessory minerals are sphene, apatite, zircon, tourmaline and opaque minerals. The plagioclase is commonly oligoclase range (An_{12} to An_{18}). The plots of the modal composition of these granitic rocks, in the I.U.G.S classification indicate that these rocks fall in syenogranite field. The major oxide composition (wt %) and trace elements (ppm) of granite samples were analyzed by XRF analysis. The variation diagrams of major oxides Vs SiO_2 show the variation is irregular. AFM diagram shows these granites fall in the calc-alkaline suite and Al_2O_3-Na_2O+K_2O-CaO diagram shows strongly peraluminous. SiO_2Vs A/CNK plot of these granitic rocks clearly falls in the S-type granite field.The granitic rocks of the study area are considered to be magmatic origin, emplaced in the mesozone and were intruded during Late Cretaceous.

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