Qatar Univ. Sci. Bull. (1986), 6 : 287 – 315

PETROGENESIS AND GEOCHRONOLOGY OF THE GRANITIC INTRUSIONS OF GABAL KULYIET AND SEIGA, SOUTH EASTERN DESERT, EGYPT

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Key words : Granitic rocks, Egypt, petrology, geochronology.

ABSTRACT

In the South Eastern Desert of Egypt tonalite. granodiorite and granite intruded intermediate to acidic metavolcanics and volcanogenic metasedimentary rocks of Precambrian age. The geological features of these granitic masses were investigated and a geological map (scale 1 : 40 000) was prepared. They have been classified into two groups : tonalite and granodiorite (syn to late–tectonic), and biotite and muscovite granites (younger granitoids). The two groups appear to be genetically related on the basis of their major and trace element contents. The chemical compositions of these tonalitic to granitic rocks indicate that these granitic rocks belong to calc–alkaline series. The magma, during crystallisation, was under 3–4 kb pressure. Radiometric age determination indicates that they have a Pan–African age of 589 to 603 Ma. It is believed that these granitic intrusions have been intruded directly after the tectonic modification of an island arc.

INTRODUCTION

No detailed geologic studies have hitherto been carried out on the granitic masses of Gabal Kulyiet and Gabal Seiga which lie in the southern part of the South Eastern Desert of Egypt about 300 Km south–east of Aswan.

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The area is located between latitudes 22° 32' 00" to 22° 38' 00" North and longitudes 34° 13' 00" to 34° 20' 00" East. It covers an area of about 120 Km^2 (Fig. 1).

The area is generally characterized by moderate relief except for Gabal Kulyiet, which is relatively high, being composed of granitic rocks. The country rocks consist mainly of volcanic and volcanogenic sedimentary rocks, metamorphosed and injected by granitic rocks which form the Kulyiet and Seiga plutonic rocks.

Structurally, the area is a part of a major fold with its axis trending in the direction NE–SW composed of volcanogenic metasediments and intercalated metavolcanics which are intruded, in some places, by metagabbro and diorite. The core of the fold is intruded by the granitic mass of Gabal Kulyiet. The area is crossed by sets of major and minor faults.

The first important contribution to the general geology of the area was presented by Hunting Geology and Geophysics Corporation Ltd. (1967) who undertook a systematic study of the geology and drawn a modern style photogeological map of scale 1 : 500,000. According to Hunting, the area under consideration consists mainly of the so called Seiga–Shianit Gneisses complex (psammitic gneisses, pinkish leucocratic granitic gneisses and amphibolites). These rock types are separated by a series of mica and amphibole–schists associated with granodioritic rocks. The main sequence was accompanied and closely followed by the syntectonic and late–tectonic granite–granodiorite complex which forms the main mass of Gabal Kulyiet.

GEOLOGIC SETTING

The general geology of the area was revealed through detailed geologic mapping (scale 1 : 40,000 – Fig. 1).

In general, the rocks of the area represent a segment of the basement complex and constitute a sequence of metamorphosed volcanogenic sediments, which are overlain, interfingered and interlayered with a sequence of intermediate to acidic metavolcanic assemblage. These metamorphics form a belt of folded sedimentary and volcanic rocks intruded by igneous intrusions mostly granitoids and the whole succession is cut by different types of dykes.

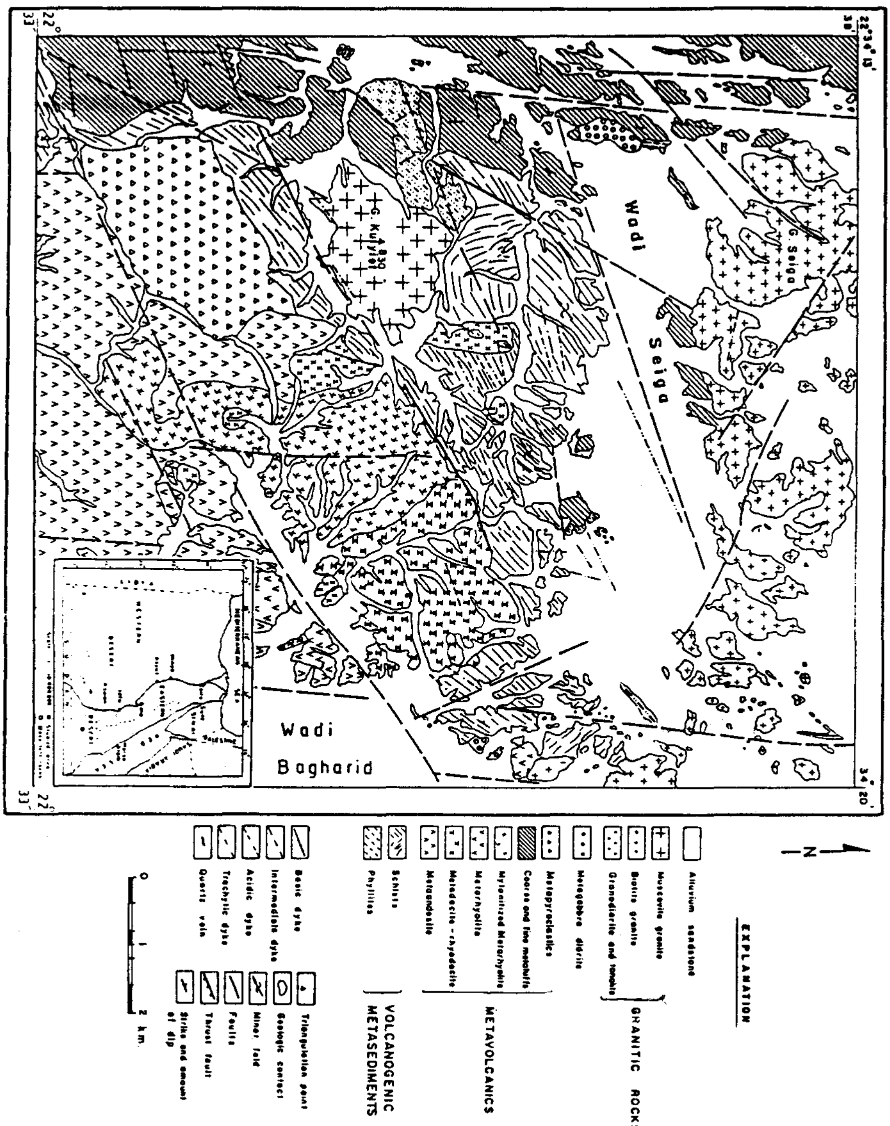

Fig. 1 Geologic map of the area around Gabal Kulyiet, south Eastern Desert, showing the investigated granitic rocks.

Morphologically, the northern part is bounded by Gabal Seiga about 600 m high and Wadi Seiga. The southern part is generally characterized by moderate relief with occasional high peaks. The most conspicuous topographic feature is Gabal Kulyiet with an elevation of about 830 m above sea level.

The southern boundary is characterized mostly by low to moderate hills, and consist mainly of volcanogenic metasediments and metavolcanics while granitic rocks are relatively rare.

Field study of the area as a whole reveals the presence of two discordant masses of tonalite and granodiorite, and granite (Syntectonic to late tectonic, younger granitiods) intruded into the metamorphic rocks.

The syntectonic plutonites form small masses and apophyses prevailing mainly in the southern part. This group include tonalite and granodiorite as the predominant phases. The rocks are medium to coarse–grained, relatively rich in mafic minerals, They are characterized by the presence of quartz accompanying plagioclase and amphibole.

The younger granites originally named Seiga granite and Kulyiet granite, cover the northern part where they form the main mass of Gabal Seiga and Gabal Kulyiet. Also they form isolated islands scattered in the sandy plains.

Two different rock varieties are recognized in the field namely biotite granite which is abundant in Gabal Seiga and muscovite granite restricted to Gabal Kulyiet. Normally both are entirely devoid of any internal parallel structures.

Gabal Seiga is composed of coarse–grained, rather leucocratic granitic rocks. They are rich in quartz. pink feldspar and some biotite as the only mafic mineral constituent. The contact between Gabal Seiga granite and the metarhyolite, in the east, is rather sharp.

A similar contact phenomenon is recognized at the contact between Seiga granite and the metatuffs, west of Gabal Seiga. Gabal Seiga granites are cut by basic dykes trending N–S and acidic dykes trending E–W and NE–SW.

Gabal Kulyiet lies to the south of Wadi Seiga with conspicuous high peaked feature. If forms an oval shaped cone, covers an area of more than five square kilometer. It intrudes volcanogenic metasediments. It shows two high peaks,

Fig. 2 Tonalite consisting of plagioclase, hornblende and biotite with interstitial quartz.

(C.N. 2.5 × 6.3)

Fig. 3 Granodiorite consisting of plagioclase, alkali feldspar and deformed quartz with mafics.

(C.N. 2.5 × 6.3)

Fig. 4 Biotite granite showing deformed quartz and small crystals of kinked plagioclase enclosed in deformed alkali feldspar.

(C.N. 2.5 × 6.3)

Fig. 5 Muscovite granite showing perthitic texture and deformed quartz, muscovite is found in clusters between the light minerals.

(C.N. 2.5 × 63)

separated from each other by lower ones. The central mass shows enrichment of muscovite. The Kulyiet granite consists of medium to coarse grained, non–porphyritic, pinkish white muscovite granite being characterized by less weathered surface, rich in red alkali feldspar, quartz and clusters of muscovite. The rock is in most places fresh. Unlike Seiga granite, biotite is rare.

The contact between Kulyiet granite and volcanogenic metasediments is best shown in the northern side being characterized by hornfelsing in the metasediment. The intrusion of the granitic body has caused local folding, slight tilting and variation in the strike of the adjacent metasediments. Kulyiet granite is cut by small intermediate dykes trending NW–SW and guartz veins having the same direction.

PETROGRAPHY

Syntectonic plutonites (tonalite, granodiorite) are generally medium to coarse grained with hypidiomorphic and subophitic texture. The main rock forming minerals are quartz, calcic oligoclase, potash feldspar with mafics. They are characterized by the presence of high ratio of biotite percentage as slightly folded flakes associated with hornblende shown in Fig. 2. The alkali feldspar is subordinate. The mineral constituents are highly deformed and show incipient gneissosity. Accessory minerals are zircon and apatite. Secondary minerals include iron oxides, sphene, epidote, chlorite and saussurite.

Quartz is present poikilitically in these euhedral altered crystals of feldspar which are surrounded by calcite (alteration product). Andulatory quartz present in granodiorite as large crystals with corroded margins. It occurs also as irregular–shaped interstitial grains and contains biotite and iron oxide inclusions, it shows strain shadows (Fig. 3).

Plagioclase is the essential mineral. It is present in prismatic form; euhedral to subhedral. It exhibits complex twinning according to the albite and percline laws. The composition of plagioclase range from An_{35} to An_{48}. It displays varying degrees of saussuritization. Fresh crystals of quartz are found interstitial between feldspar crystals. Zoned plagioclase is occssionally found in granodiorite.

The alkali feldspars are partially altered, the altered crystals contain poikilitically inclusions of muscovite. It shows also perthitic intergrowth.

The ferromagnesians are represented, in tonalite, mainly by chlorite pseudomorphs after amphibole and relics of brown hornblende associated with biotite, making up about 15 % of the rock. Pyroxene is also present in small amounts as large crystals.

Biotite is the main mafic mineral in granodiorite. It accurs as brown to reddish brown subhedral flakes showing varying degrees of alteration to chlorite. Green hornblende occurs occasionally accompanying biotite as subhedral prisms. Accessory minerals are zircon, apatite, iron oxides and titanite.

The younger granitoids forming Gabal Seiga are composed of biotite granite while the main mass of Gabal Kulyiet is composed of muscovite granite.

The biotite granites are characterized by coarse grained hypidiomorphic texture. Mineral constituents include quartz, alkali feldspar, plagioclase and biotite. Quartz occurs in large deformed crystals; recrystallization of some deformed quartz crystals occur (Fig. 3).

Alkali feldspars are mainly microcline large crystals together with a small amount of slightly altered orthoclase.

The plagioclase form prismatic crystals up to 2 mm long. It is usually bent (Fig. 4). Some crystals show a distinct albite and percline twinning, complex albite–carlsbad twinning is occasionally found. The plagioclase is albite (An_8).

Euhedral crystals of biotite are common. In most cases it forms flakes which are twisted. Muscovite is rare and forms small platy crystals. The accessory minerals are zircon and iron oxides.

The muscovite granite is non–porphyritic, medium to coarse grained with hypidiomorphic texture. Perthitic texture is occasionally found (Fig. 5). It shows string and patchy type of intergrowth and usually encloses some quartz grains.

This type of granite is characterized by large crystals of quartz which commonly show deformation. It contains strings of bubbles and inclusions of muscovite.

Alkali feldspars are dominantly represented by microcline and orthoclase. They show perthitic intergrowth and include inclusions of small crystals of quartz and muscovite. The plagioclase occurs in well developed euhedral prismatic crystals of albite, and inculdes small platy crystals of muscovite along the twinning planes.

Muscovite is the most abundant mica mineral. It occurs in the form of flakes scattered between quartz and feldspars, as well as small inclusions in feldspar, biotite is rare. The accessory minerals are mainly zircon and iron oxides.

PETROCHEMISTRY

The geochemical characteristics of the investigated granites have been studied through the analyses of eight representative samples for major as well as some minor and trace elements. The chemical analyses were carried out at the Institute of Geological Sciences, Mainz University, West Germany, using inductively coupled plasma technique (ICP). Ten trace elements have been determined for each sample including Co, V, Ba, Sr, Rb, Y, Zr, Zn, Li and Nb. The results of the analyses are given in Tables 1 and 3. The data are compared with the corresponding geochemical data of Egyptian granites reported by Aly and Mostafa (1984) beside the world–wide average for granitic rocks of Le Maitre (1976). The CIPW norm minerals of the analysed granites are calculated and given in Table 2.

Table 1 shows that the tonalite and granodiorite are on the average more enriched in Fe, Ca, Mg, P and Ti and depleted in Si, Na and K relative to the biotite and muscovite granite. The granitiods possess the following geochemical characteristics:

a. The analysed rocks contain from 59 to 75 % SiO_2. The younger granites are characterised by high SiO_2 content ranging from 73 to 74 %, whereas the older tonalite and granodiorite are characterised by their relative low SiO_2 content.
b. The contents of MgO, CaO, Fe_2O_3 of younger granites are lower than the average Egyptian and world granites.
c. The FeO content is low compared to Egyptian and world granites. the total iron content decreases from 6.45 in tonalite to 0.92 in muscovite granite.
d. The percentage of Na_2O is significantly higher than the average Egyptian and world granites.
e. There are no marked differences in Al_2O_3. K_2O and TiO_2 content.
f. It is generally noticed that at Gabal Kulyiet, sodium content is generally higher than potassium which is not the case in the average Egyptian and world granites.

Comparing the contents of major oxides of the studied tonalites and granodiorites with those of the average Egyptian and world granodiorite and tonalite it was found that TiO_2 and Fe_2O_3 is slightly higher in the studied rocks reaching a maximum value in the tonalites. CaO is slightly higher in granodiorite, but shows marked increase in tonalite than the Egyptian and world tonalite. Al_2O_3, FeO, MgO, Na_2O is in accordance with the average Egyptian and world tonalite and granodiorite. Meanwhile, MgO and K_2O is in accordance with the Egyptian and world granodiorite and lower than the Egyptian and world tonalite.

It has been generally inferred that the principle factor controlling the configurations of oxide curves is some process of fractional crystallization. Thus, Larsen (1938) found that a better correlation of chemistry with the presumed order of magmatic evolution was given by plotting oxide percentage against $[(1/3SiO_2 + K_2O) - (CaO + MgO + FeO)]$. Nockolds and Allen (1953) modified this factor to demonstrate any absolute enrichment in iron and principally to show the variation of minor and trace elements in relation to the major componenet. The modified factor is $[(1/3Si\ 3Si + K) - (Ca + Mg)]$. The MDI shows a wide range of variation. It ranges from 2.95 up to 12.77 and reflect the wide compositional range of the studied granites.

The studied granitoids have normal trends, consistant with the general trends of differentiating granitic magma: They show typical trend of calc–alkalic rocks (Nockolds and Allen, 1953, Smith, 1974, Müller and Saxena, 1977) with Al_2O_3, Tio_2, FeO, MgO, CaO and P_2O_5 showing negative correlation with modified Larsen's index (Fig. 6). SiO_2 and K_2O increase with increasing D.I. Na_2O does not appear to vary systematically with differentiation (Bateman & Dodge, 1970).

The petrochemical characteristics of the granitic rocks, were deduced from the study of the following variation diagrams, presented to evaluate the chemical behaviour of these granitic rocks using major elements content :

The Rittmann's (1957) suite indices for the granitic rocks of the area are given in Table 2. From the calculated values it follows that the petrochemical character of those granitic rocks range from strong pacific (syntectonic plutonites) to medium pacific for younger granitoids which correspond to calcic and calc–alkaline character. Rittmann (1962) constructed a diagram to exihibit this charácteristic by plotting total alkalies against SiO_2 (Fig. 7). The granitic rocks were found to range

Table : 1 Major element contents of the studied granites

Oxides	Syntectonic Plutonites 1	2	3	4	Egypt. Tona-lite	Egypt. Grano-diorite	World Toan-lite	World Grano-diorite	Younger Granitiods 5	6	7	8	Egypt Gra-nite	World Gra-nite
SiO_2	59.41	60.39	64.64	66.53	67.68	67.05	61.52	66.09	73.74	74.24	73.33	74.63	73.18	71.30
TiO_2	1.34	1.12	0.72	0.65	0.57	0.64	0.73	0.54	0.17	0.04	0.24	0.20	0.22	0.31
Al_2O_3	15.86	15.91	15.83	15.51	14.81	15.05	16.48	15.73	13.62	14.51	13.91	13.77	13.72	14.32
Fe_2O_3	3.05	3.41	3.54	2.82	2.13	1.81	1.83	1.38	0.79	0.60	0.97	0.83	1.10	1.21
FeO	3.10	3.39	2.65	2.13	2.18	2.87	3.82	2.73	0.94	0.38	0.20	0.68	0.97	1.64
MnO	0.11	0.11	0.12	0.10	0.07	0.10	0.08	0.08	0.06	0.08	0.05	0.03	0.05	0.05
MgO	3.36	2.36	1.63	1.66	1.21	1.59	2.80	1.74	0.15	0.11	0.32	0.29	0.46	0.71
CaO	6.78	6.93	3.96	3.64	3.42	3.03	5.42	3.83	0.92	0.75	0.90	0.84	1.19	1.84
Na_2O	3.69	3.97	3.11	3.35	4.17	3.88	3.63	3.75	4.60	4.27	4.47	3.66	3.84	3.68
K_2O	1.39	1.34	2.70	2.62	2.37	2.63	2.07	2.73	4.84	3.98	4.22	4.52	4.28	4.07
H_2O	0.31	0.24	1.03	0.91	–	–	1.24	1.04	0.21	0.54	0.83	0.37	–	0.77
P_2O_5	0.41	0.32	0.23	0.29	0.14	0.28	0.25	0.18	0.05	0.03	0.04	0.06	0.11	0.12
CO_2	1.37	1.00	–	0.10	–	–	0.14	0.08	0.09	–	–	–	–	0.05
Total	100.18	100.49	100.16	100.25	98.75	98.93	100.01	99.90	100.18	99.53	99.48	99.86	98.94	100.07
Na_2O/K_2O	2.65	2.96	1.15	1.28	–	–	–	–	0.95	1.07	1.05	0.81	–	–
Rittmann's	1.57	1.62	1.56	1.51	–	–	–	–	2.90	4.46	2.48	2.11	–	–
Index									2.90	2.46	2.48	2.11	–	–
Larsen's	2.95	3.59	7.37	7.83	–	–	–	–						
Index									12.77	12.59	12.33	12.71	–	–
Total	5.08	5.31	5.87	5.97	–	–	–	–						
alkalies									9.44	8.25	8.69	8.18	–	–
Alkalinity	1.29	1.61	1.83	1	–	–	–							
Ratio									4.70	3.35	3.84	3.54	–	–

Table : 2 CIPW normative minerals for the studied granites

Sample Number / Normative Mineral	Syntectonic Plutonites				Egypt Tona-lite	Egypt Grano-diorite	World Toan-lite	World Grano-diorite	Younger Granitoids				Egypt Gra-nite	World Gra-nite
	1	2	3	4					5	6	7	8		
Q	16.29	16.47	24.29	28.48	23.99	23.64	16.62	22.65	31.82	24.77	35.17	30.40	29.46	29.06
C	0.11	–	1.20	2.66	–	1.09	–	0.26	1.60	–	0.51	2.08	0.97	0.92
Or	8.25	7.80	16.25	10.50	14.12	15.85	12.24	16.11	27.10	28.65	25.35	23.95	25.72	24.50
Ab	33.20	35.75	28.55	30.70	38.24	35.53	30.67	31.73	33.30	41.20	32.60	38.85	35.07	31.13
An	22.40	21.80	18.85	15.95	15.10	13.47	22.58	17.34	3.85	2.23	4.25	3.40	5.27	8.04
Di	–	3.48	–	–	En 3.03	4.48	1.49	–	–	1.00	–	–	En 1.29	–
					Fs 1.10	2.50							Fs 0.52	
Hy	10.32	6.34	5.60	6.94	Di 1.04	–	9.68	7.40	1.06	0.72	1.00	0.52	Di –	3.37
Ap	0.88	0.67	0.45	0.53	0.30	0.60	0.58	0.48	0.13	0.13	0.08	0.08	0.23	0.28
Cc	3.46	2.56	–	0.34	–	–	–	0.19	–	0.22	–	–	–	0.12
Il	1.90	1.56	1.02	0.90	0.81	0.91	1.40	1.01	0.28	0.22	0.34	0.06	0.31	0.58
Mt	3.18	3.55	3.76	2.98	2.27	1.93	2.66	2.00	0.88	0.82	–	0.67	1.17	1.75
Hm	–	–	–	–	–	–	–	–	–	–	0.68	–	–	–
Total	99.99	99.98	99.97	99.98	–	–	–	–	100.02	99.97	99.98	100.01	–	–

Table : 3

Trace element contents of the analysed granites

Trace Element \ Sample Number	Syntectonic Plutonites				Younger Granitoids			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Co	36	66	38	40	80	98	163	122
V	164	193	150	127	14	32	28	40
Ba	814	794	442	558	398	537	414	737
Sr	644	706	352	304	156	167	260	198
Rb	76	77	83	92	135	112	102	129
Y	19	16	18	20	26	24	26	36
Zr	224	170	200	190	120	140	102	110
Zn	284	287	258	215	254	236	244	223
Li	18	20	12	11	17	18	47	32
Nb	18	22	24	21	9	12	16	18

from average pacific for syntectonic tonalites and granodiorites (suite index 1.5 to 1.62) to weak pacific (2.11 to 2.9) for younger granites corresponding to calc alkaline character.

The relationship between the alkalinity ratio (Wright, 1969) against silica is expressed in the SiO_2–Alkalinity ratio diagram (Fig. 8). On this diagram the tonalite and granodiorite are predominantly calc alkaline and grade to granite which show gradual increase in alkalinity ratio toward the alkaline field.

In Fig. 9 CaO, Na_2O and K_2O weight percentage were recalculated to 100 % and plotted on ternary diagram. Although there is a considerable scatter on this diagram, the rocks tend to fall in continuous field begin with Ca–rich tonalite and end at potash–soda rich granite. The samples show slight sodic affinities.

Fig. 10 shows that the younger granitoids are rather poor in Fe and Mg, and highly alkalic. Moreover, there is a general continuous trend of differentiation for the syntectonic granite from ($FeO + Fe_2O_3$), toward the ($Na_2O + K_2O$) corner for younger granitoids with decreasing contents of MgO and total iron. The synorogenic granitoids show magnesium–rich tonalite distinguished from iron–rich granodiorite.

Petro *et al.,* (1979) used the AFM diagram to differentiate between compressional and extensional suites. The trend of extensional suites tends to be closer to and more nearly parallel to the AF–side at a composition approaching the Alkali apex. On the other hand, trends of compressional suite tend to be more nearly perpendicular to FM–side for the entire trend. The trend of the studied granitoids is nearly perpendicular to the FM–side indicating a possible compressional environment.

The granitic rocks of the area are characterised by high normative Q–Ab–Or. The sum normatives of albite, orthoclase, quartz changes from 58 in tonalite to 93 in muscovite granite. Three feldspars exist in the norms of syntectonic tonalites and granodiorites, and post tectonic granitoids from the area with normative Ab–An–Or and normative Ab–Or–An respectively.

Fig. 11 shows the relation of normative quartz plotted against normative anorthite (after Brandock, 1969). From the diagram, it is evident that the examined granitic rocks fall within the calc–alkaline series.

The normative albite, orthoclase and quartz proportions of the analysed granitic rocks are recalculated to 100 % and plotted on the normative Q–Or–Ab ternary diagram (Fig. 12) where the minimum melting field of granitic rocks and isobaric minimum (after Tuttle and Bowen, 1958) are also shown on the diagram. It appears from this diagram that most of the granitic rocks plot near a maimum P_{H_2O} of about 3–4Kb. The plots for the granitic rocks of the area show some scatter, but fall in a rather limited region suggesting a genetic relationship. The synorogenic granitoids are plotted close to the Q–Ab jointing line whereas the younger granitoids are close to the Q–Or line.

The studied granites were classified on the basis of their normative mineral content. The classification of syntectonic tonalite and granodiorite as well as Kulyiet and Seiga granites is presented on their Or–Ab–An relative proportion using the classifications proposed by Heitanen (1963). According to this scheme, the samples of Gabal Kulyiet and Seiga fall within the field of granite whereas syntectonic plutonites fall within the field of tonalite and granodiorite (Fig. 13).

Fig. 14 shows the classification suggested by Streckeisen (1976), based on the relative normative quartz, alkali feldspar and plagioclase relative proportions. According to this classification, Gabal Kulyiet and Seiga granitic rocks plot in the field of granite, whereas the syntectonic plutonites plot in the field of tonalite and granodiorite.

Concentrations and ratios of the trace element in the studied granitoids are plotted against the modified Larsen's Index (Fig. 15). Ba, Zr, Sr, Nb, Zn and V show a progressive decrease towards the younger granitoids, while Rb and Co contents increase gradually in the same direction. However, Y shows a slight increase towards the younger granitoids and Li remains approximaterly constant with fractionation. The tonalite and granodiorite have higher Sr and Ca contents reflecting the enrichment of plagioclase minerals, otherwise the oposite realtion is observed in the younger granites.

The Ti/Zr ratio decreases and the Rb/Sr, Ba/Sr and K/Ba ratios increase with increasing MDI (Fig. 16) suggesting a progressive differentiation within tonalite, granodiorite, biotite granite and muscovite granite, and reflects highly differentiated calc–alkali magma characterised by a great chemical variation in their element content (Nockolds, 1966).

Pearce *et al.*, (1984) classified granitic rocks using trace elements Rb, Nb and Y into four major groups; ocean ridge granites (ORG), volcanic arc granites (VAG), within plate granites, (WPG) and collision granites (COLG). He constructed variation diagrams to illustrate these major groups using Rb and Y, plotted in the ordinate against absissa of silica in weight percentage (Fig. 17).

The granitic rocks are plotted in the field of volcanic arc granite. This fact is confirmed using the diagrams of Nb against Y and the Rb against Y + Nb (Figs. 18 & 19) which indicate clearly the distinct volcanic arc setting of the group.

GEOCHRONOLOGY OF KULYIET GRANITE

Isotopic age determination were carried out on four selected samples from the main granitic mass of Gabal Kulyiet. No isotopic ages data have hitherto been done, and dating of these granites was always based on the field relations.

In this work potassium/argon age determinations were carried out on muscovite separates from the Kulyiet granite. Age dating was carried out at "Bundesanstalt für Geowissenschaften und Rohstoff", Hannover, Federal Republic of Germany. Potassium content was measured by automatized and digitized corning–455–double channel flame photometer with lithium as internal standard. Two sets of measurments were carried out for sample No. 1. The average standard deviation percentage of the replicate analysis is 1 %. Argon was obtained by single conventional total fusion static mass spectrometer. The results obtained are presented in Table 4.

Table : 4 K/Ar ages of Gabal Kulyiet granitic rocks

Rock type	**Fraction**	**K_2O wt. %**	**Radio. Ar ml / C^3**	**Atm. Ar (ml / g)**	**Apparent age (Ma)**
Pink muscovite granite	Muscovite	8.70	242	1.71	603 ± 7
" " "	"	8.61	233	2.17	589 ± 8
" " "	"	8.75	243	2.31	601 ± 7
" " "	"	8.66	237	2.31	594 ± 2

Though few as they are, yet the results obtained in this work help to throw further light on the age of these granitic rocks. The apparent ages obtained (603 to 589 Ma.) confirm a late Precambrian age. This is in accordance with the geologic set up regarding the emplacement of the plutonic rocks in the Eastern Desert.

CONCLUSIONS

Two granitic masses occur in the area of Gabal Kulyiet and Gabal Seiga. Petrographically they are divided into two main rock types : tonalite and granodiorite which is composed of quartz, biotite, hornblende, predominant sodic plagioclase of oligoclase composition and smaller amount of alkali feldspar. The second rock type is the granite which has been divided into two classes. The first granite class is biotite granite, occurs only in Gabal Seiga. The second granite class is the muscovite granite, occurs mainly in Gabal Kulyiet.

The major elements of the granites show that the tonalite and granodiorite are on the average more enriched in Fe, Ca, Mg, P and Ti and depleted in Si, Na and K relative to the biotite and muscovite granite.

The trace elements of the granitic rocks show high concentrations of Ba, Sr, V, Nb, Zr and Zn at the early stage of crystallisation of the magma, while Rb and Co are concentrated at the late crystallisation stage of magma.

Chemically, the different granitic rocks have the parameters of calc–alkaline series developed in volcanic arc setting. They merge into each other suggesting a genetic relationship.

K/Ar dating of the muscovite granite gives a late precambrian age of 589 to 603 Ma generally accepted for the Pan–African tectonothermal event.

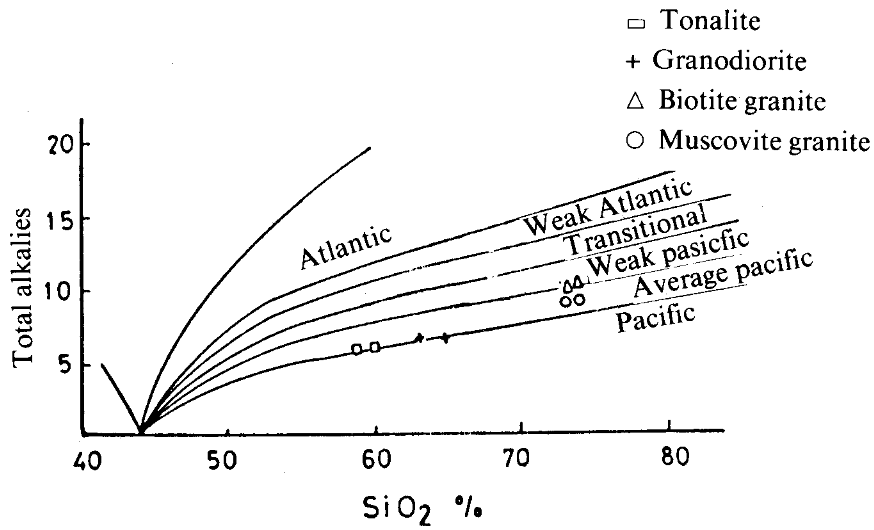

Fig. 7 Rittmann suite index for the studied granitic rocks.

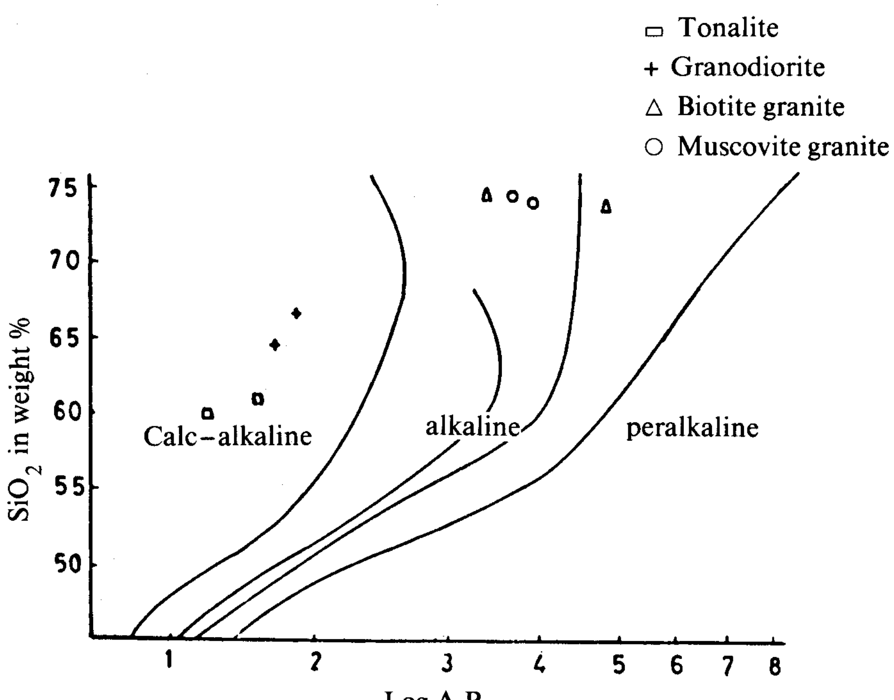

Fig. 8 Alkalinity ratio versus SiO_2 diagram for the studied granitic rocks.

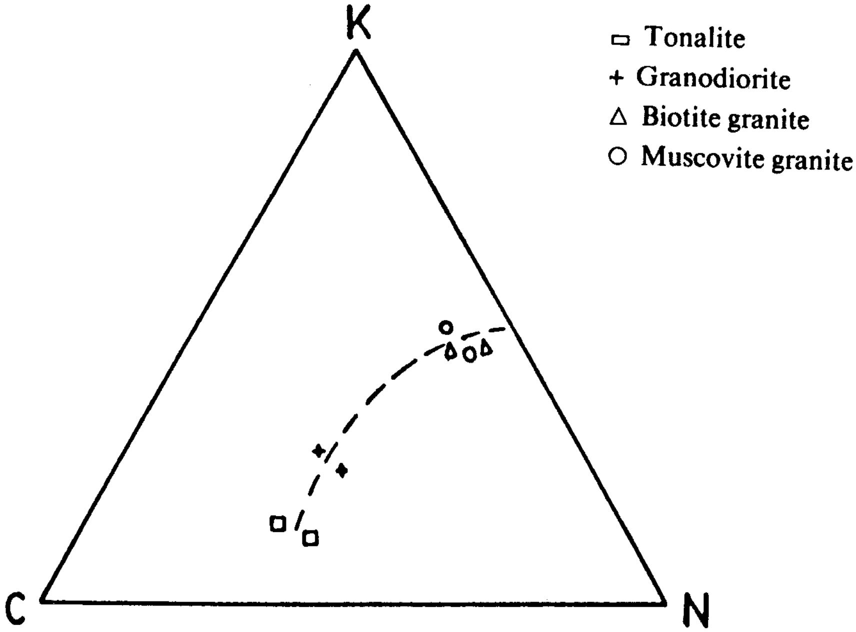

Fig. 9 Relation between K_2O and CaO contents of the examined granitic rocks.

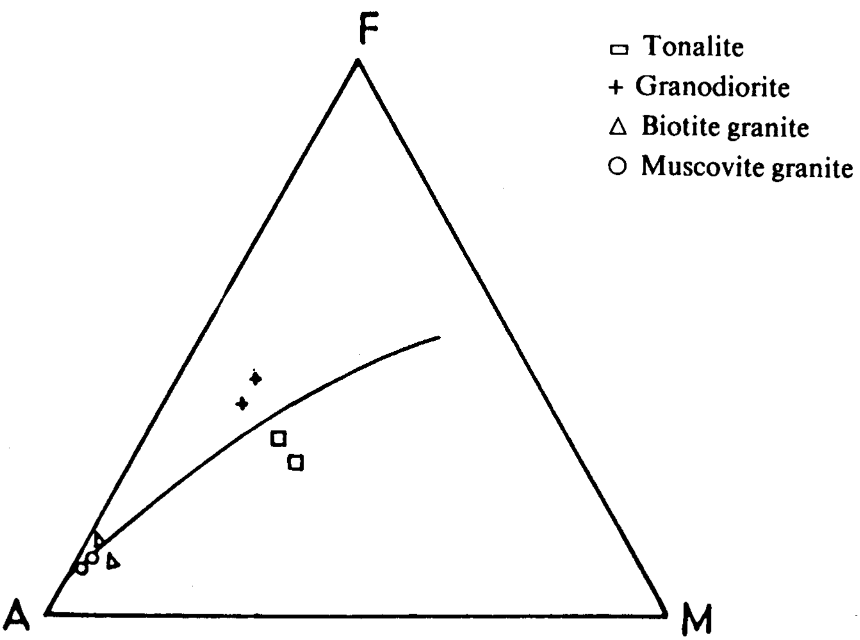

Fig. 10 Relation between MgO, [(FeO + Fe_2O_3) and (Na_2O + K_2)] for the examined granitic rocks. The curve shows the trend proposed by Petro *et al.*, (1979) for compressional suites.

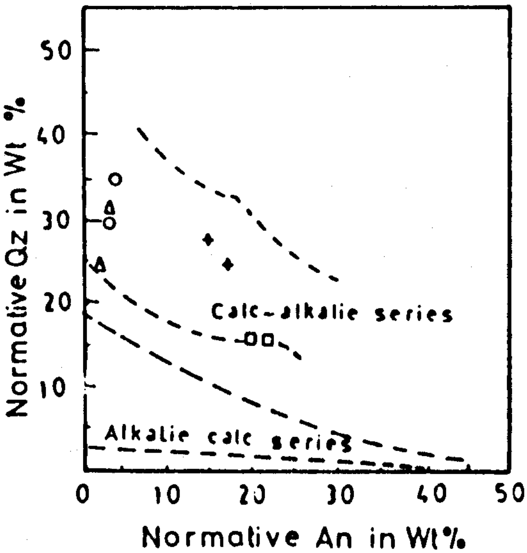

Fig. 11 Normative Qz–An relation for the investigated granites (after Brandock, 1969).

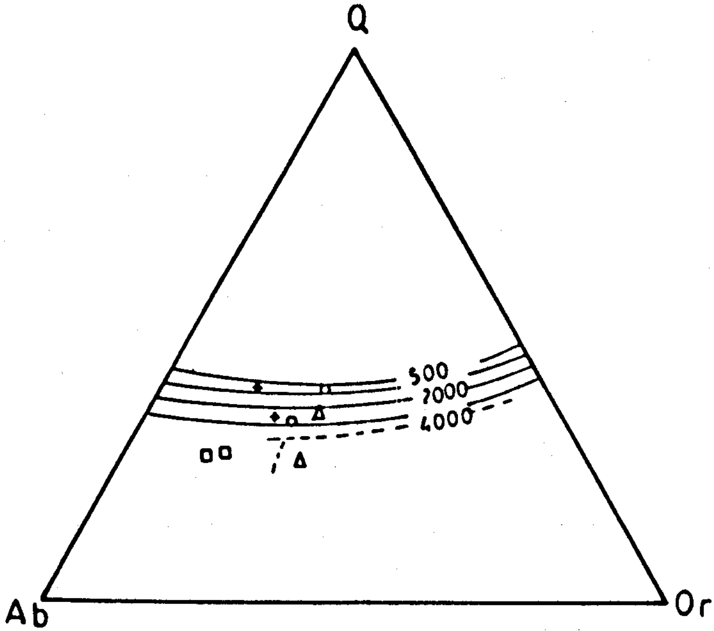

Fig. 12 Plots of the normative proportions of Q–Ab–Or for the studied granites on the Q–Ab–Or plane of the system An–Or–Q–H_2O from 500 to 4000 bars (after Tuttle and Bowen, 1986).

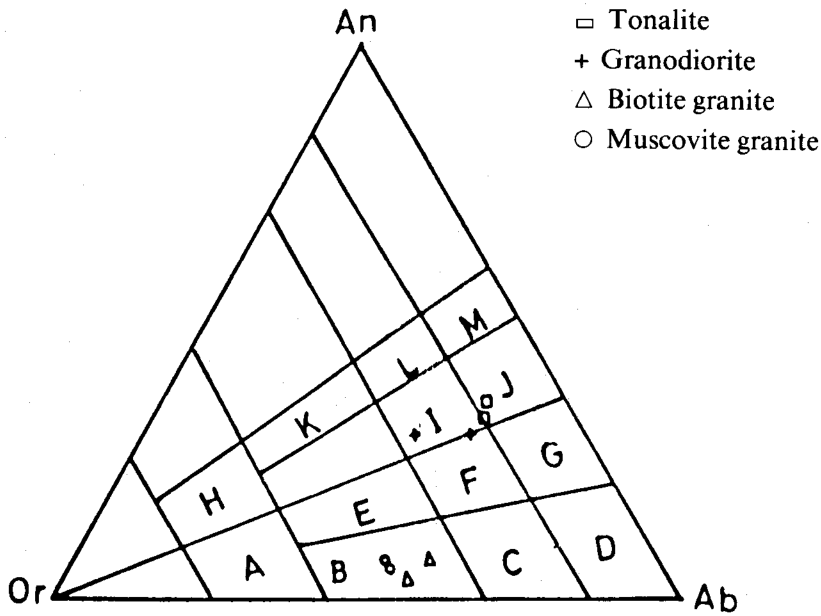

Fig. 13 Petrochemical classification of the studied granitic rocks based on their normative feldspar content (after Hietanen, 1963).

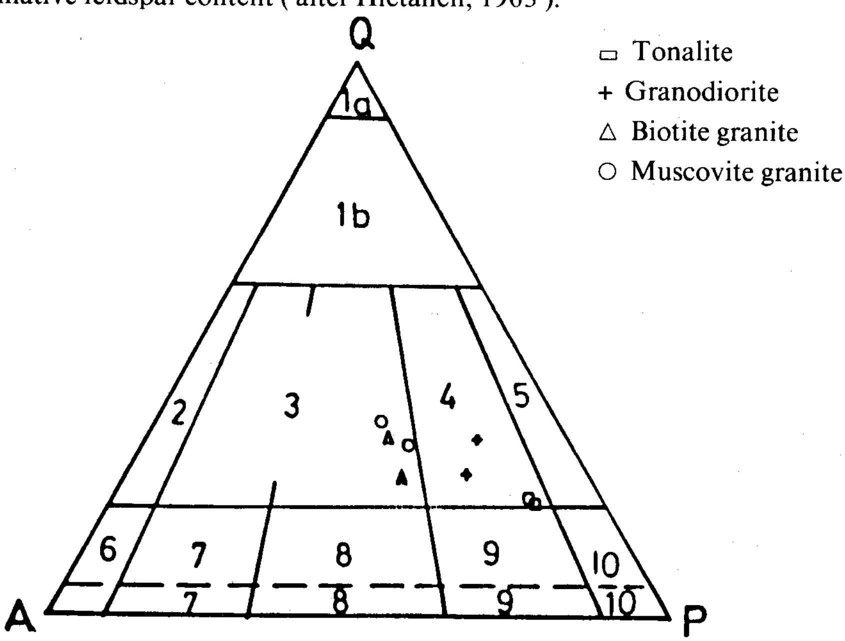

Fig. 14 Normative classification of the studied granitic rocks on the basis of their normative quartz (Q), alkali feldspar (A), and plagioclase (P) content.

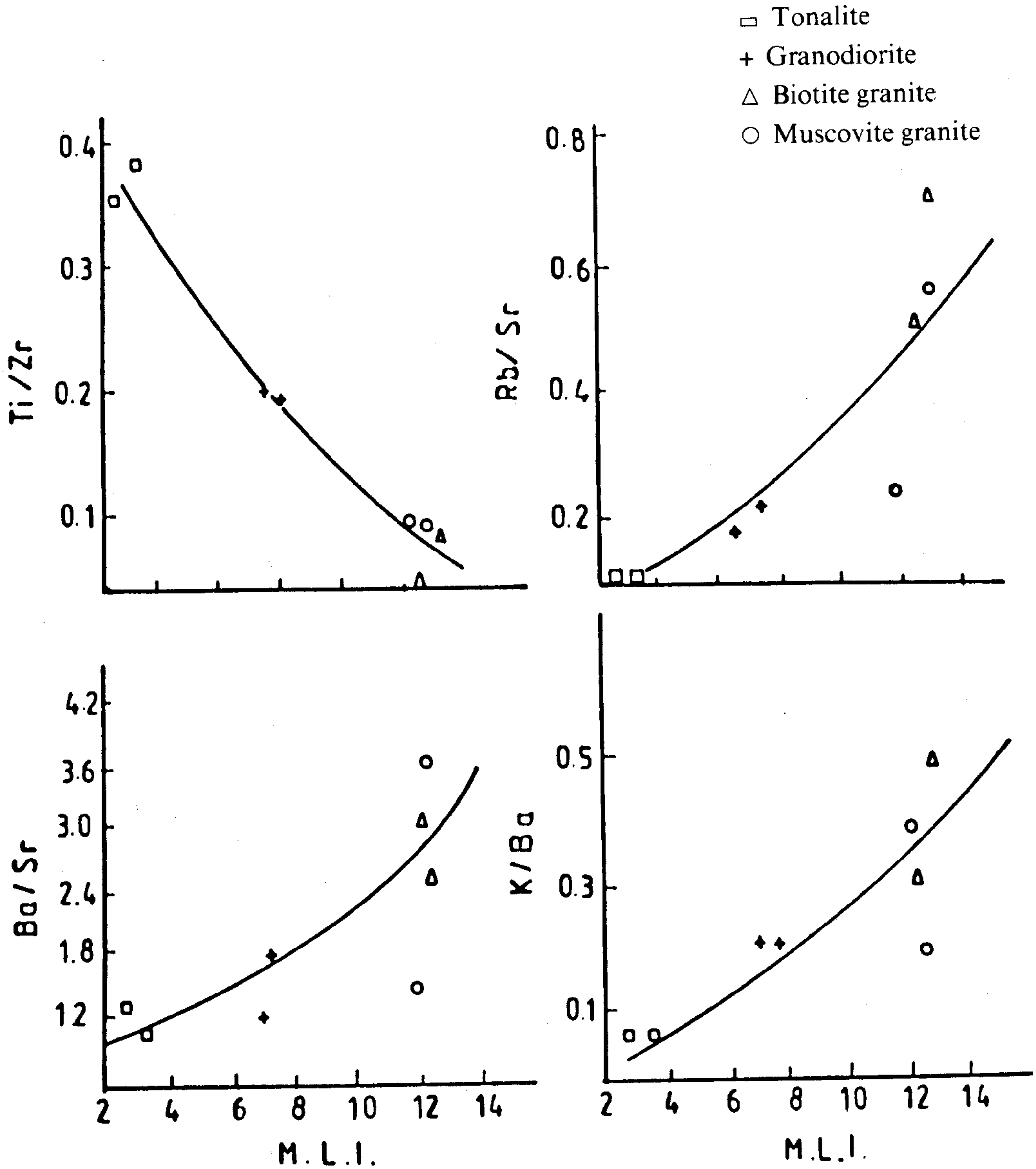

Fig. 16 Variation diagrams Ti/Zr, Rb/Sr, Ba/Sr and K/Ba with the modified Larsen's Index.

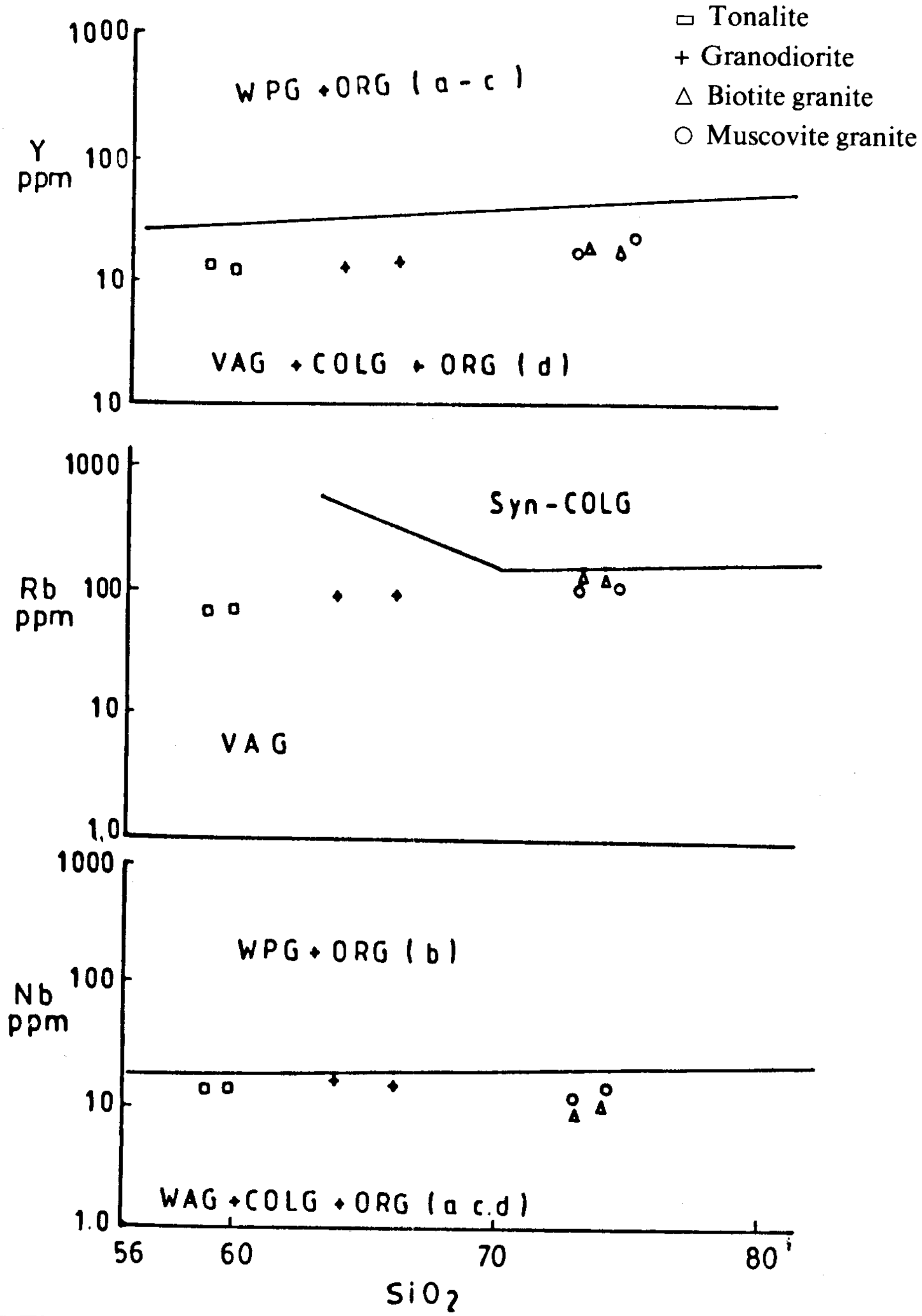

Fig. 17 The studied granitoids ploted on SiO_2 variation diagrams for Y, Rb and Nb (boundaries after Pearce et al., 1975).

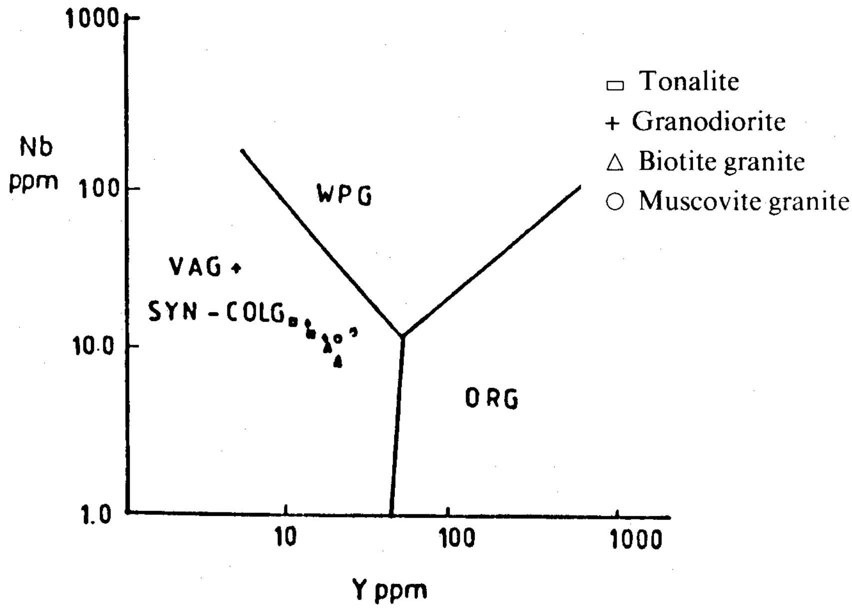

Fig. 18 Nb–Y diagram for syn–collision granites (SYN–GOLG), volcanic arc granites (VAG), within plate granites (WPG) and Ocean ridge granites (ORG), (boundary after Pearce *et al.*, 1984).

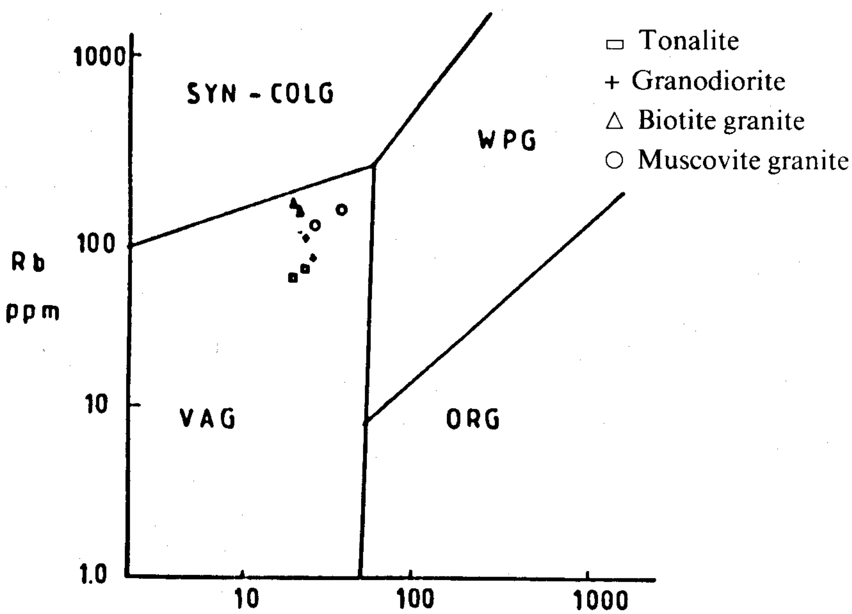

Fig. 19 Rb–(Y+Nb) diagram for syn–collision (SYN–COLD), volcanic arc (VA), within plate (WP) and ocean ridge (OR) granites (boundaries after Pearce *et al.*, 1984).

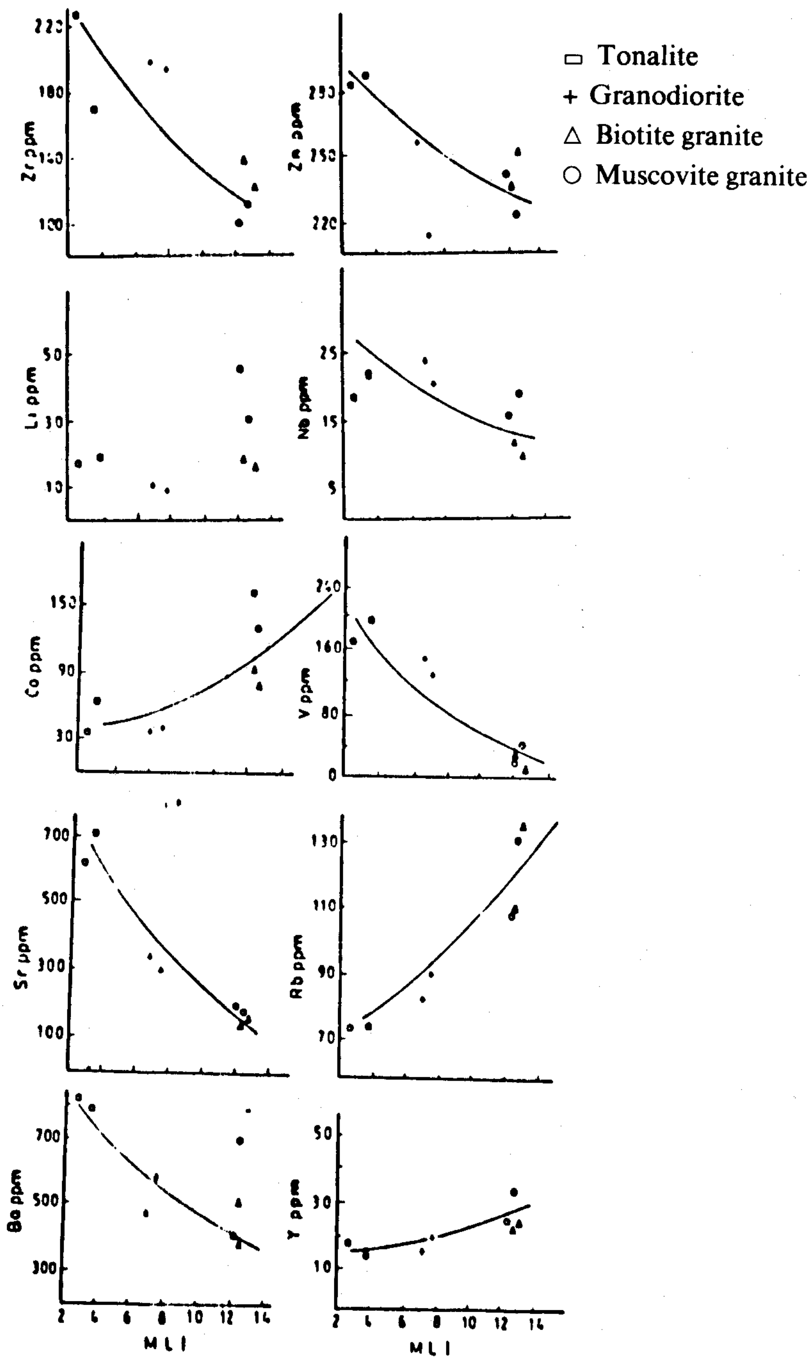

Fig. 15 Variation of trace element contents with the modified Larsen's Index.

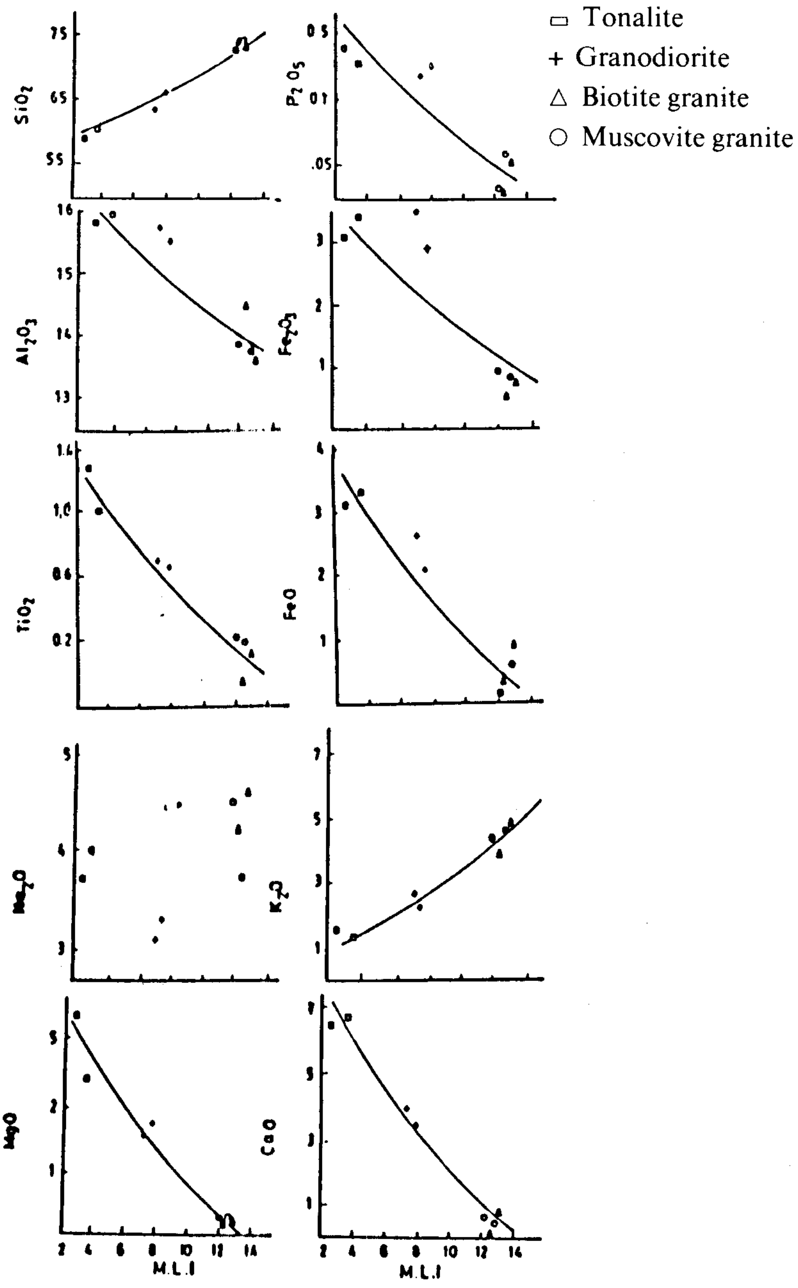

Fig. 6 Variation of major element contents with the modified Larsen's Index.

ACKNOWLEDGEMENT

The chemical analyses were carried out at "Mineralogische Petrologische Institut der Universitat Mainz" which is greatly appreciated. K/Ar Age dating was carried out at "Bundesanstalt für Geowissenschaften", Hannover, by the first author during an 'Alexander Von Humboldt' scholarship which is gratefully acknowledged.

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نشـأة وعمـر الصـخور الجرانيتيـة المتداخلـة
بجبـل كوليـت وسـيجه
جنـوب الصـحراء الشـرقية بمصـر

محمـد يسـري منيسـي و باهـر عبد الحميـد القليوبي

و

زينهـــم الألفـــي

يقع جبل سيجه وجبل كوليت في جنوب الصحراء الشرقية بمصر ، وهما يمثلان بكتل جرانيتية يتراوح تركيبها من صخور التونـاليت إلى صخور الجرانيت متـداخلـة في صخور بركانيـة متوسطـة وحمضية .

تم رسم خريطـة چيولوچيـة للمنطقـة مقيـاس ١ : ٤٠,٠٠٠ وقسّمت هـذه الصخور إلى مجموعتين الأولى صخور التونـاليت والجرانوديوريت ، والثـانيـة صخور الجرانيت الممثلـة بـالبيوتيت جرانيت والمسكوفيت جرانيت .

وقد إتضح من الدراسة البتروجرافية والكيميائيـة وجود علاقـة بين المجموعتين من حيث النشأة والتطور الصهيري وأنهم يتبعون مجموعـة الصخور الكلس قلويـة ، وقـد تبلورت هـذه الصخور تحت ضغط متوسط أثناء تكوّن أقواس الجُزر .

ومن تقـدير عمر صخور المسكوفيت جرانيت بطريقـة البوتـاسيوم / أرجون ، إتضح أن عمرهـا يتراوح بين ٥٨٩ و ٦٠٣ مليون سنة .