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GEOCHEMICAL ASPECTS AND ORIGIN OF TIN-BEARING GRANITES IN THE EASTERN DESERT, EGYPT

M. A. HASSANEN*, N. A. SAAD*, O. M. KHALEFA*

Alexandria University, Geology Department

ABSTRACT

Three granitic plutons belonging to the younger granite province in the Eastern Desert of Egypt were selected for detailed petrological and geochemical studies. These granatic masses (Homr Akarem, Igla and Mueilha) are associated with Sn-W-Mo-F mineralization and selectively affected by post-magmatic albitization and greisenization processes. The granitic rocks of the three plutons have alkaline affinity with some metaluminous to moderately peraluminous character. They show pronounced enrichment in Sn, Nb, W, Rb, Y, Zr, Be, Zn and Ga coupled with moderate depletion in Ca, Mg, Fe, Ti, Sr, Ba, Eu and elemental ratios Ba/Sr and K/Rb. These chemical aspects are consistent with the metallogenetically specialized granites that elsewhere are often associated with deposits of Sn, W, Mo and rare metals. Despite the close similiarity of the studied granites with the intra-plate magmatism, yet the field occurence and many chemical features of post-collision granites are considered.

The origin of these granitic rocks is largely controlled by low-pressure crystal-melt fractionation from a source close to a within-plate magma. Although, the mineral fractionation could explain the rock chemistry, the abundances of HFS elements and HREE require the contribution of a fluorine-bearing fluid phase at a late stage of differentiation. These chemical features characterize the widespread metasomatic alteration and represent the potential economic source of Sn-W-Mo-F in the granitic rocks. The role of crustal contamination on such granites neither proved nor being exluded due to the lack of isotopic data.

Keywords: Eastern Desert, Egypt, Tin-bearing granites, Geochemistry

INTRODUCTION

During the past decade, intense geological and geochemical studies have been carried out on the main granitoid groups in the Egyptian Basement complex: the synorogenic granitoids (older granites) and the late to post-orogenic younger granites (AKAAD and EL-RAMLY 1960; EL-GABY 1975; AKAAD and NOWEIR 1980; EL-GABY et al. 1988; GREENBERG 1981). The older granites represent calc-alkaline, I-type mantle derived magmatism developed in subduction environment (HUSSEIN et al. 1982; STERN et al. 1984; DIXON 1981). Concerning the younger granites, it has been speculated that these rocks belong to the post collision granite group as a terminal phase of Pan-African orogeny. Other workers are biased to consider the younger granites as anorogenic rift-related magmatism (Stern et al. 1984). Some granitic plutons which belong to the younger granite group are commonly associated with Sn, Mo, W, F, Be and Nb-Ta mineralization (SABET and TSOGOEV 1973; SABET et al. 1973; HUSSEIN et al. 1982). They show many chemical characteristics of the specialized granites or correspond to the A-type granite (RENNO et al.

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* Alexandria, Egypt

1993; MOHAMED et al. 1994). Despite the interest, these mineralized granitic plutons have recieved little attention.

This paper presents a trial to reevaluate the gheochemical data of three Sn-bearing granitic plutons that crop out in the central part of the Eastern Desert (*Fig. 1*): the Mueilha, Igla and Homr Akarem plutons. These data are used to characterize the plutons, reevaluate their genesis, and finally to elucidate the geochemical aspects of the tin-bearing granites in Egypt.

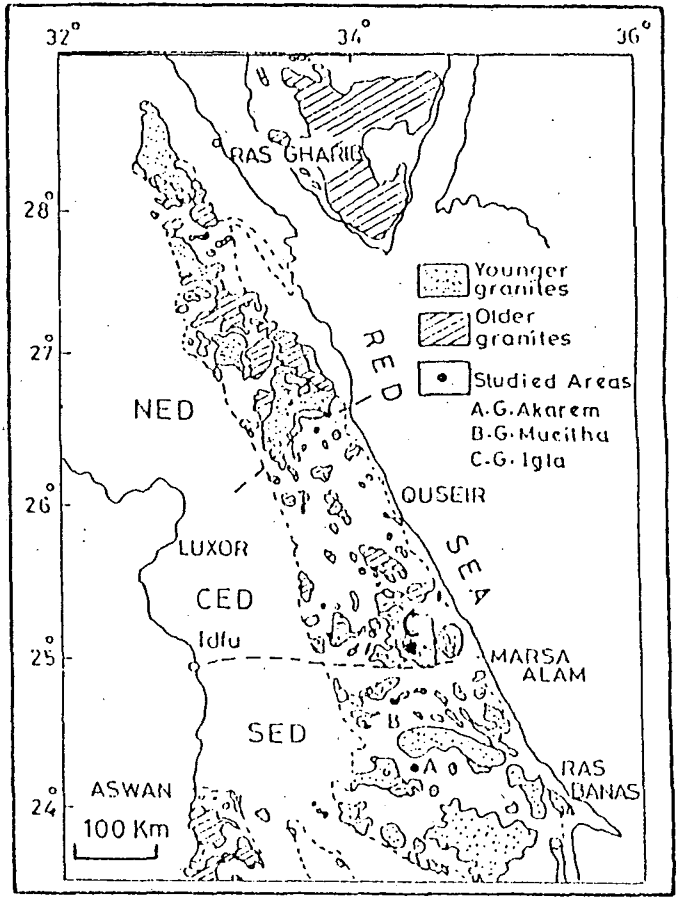

Fig. 1. Geologic map showing the distribution of older and younger granitoids in the Eastern Desert, Egypt. (After EL-RAMLY, 1972). Field circles indicate the location of (A) Homr Akarem; (B) Mueilha; (C) Igla plutons

GEOLOGICAL SETTING

Granitoid rocks constitute about 40% of the crystalline basement complex in Egypt (*Fig. 1.*). This granitic province include two major groups. The synorogenic calc alkaline intrustives (older granites) of wide compositional variation, range from quartz diorite, tonalite, granodiorite to granite. The second group comprises highly differentiated LIL-enriched alkaline granites forming shallow level intrustions of limited extension. Recent mapping activities by the Geological Survey of Egypt (EL-RAMLY 1972) have demonstrated the homogenity of this granitic group, although local variations in mineralogy and chemistry are commonly recorded. They are now referred to as younger granites or late- and post-orogenic granites. The younger granites have Rb-Srages ranging from 662 to 430 Ma (HASHAD et al. 1972; FULLAGAR and GREENBERG 1978; MENEISY and LENZ 1982; ROGERS and GREENBERG 1981; STERN and HEDGE 1985). Some of the granitic masses of this group are mineralized and commonly affected by post magmatic alterations (eg. albitization and greisenization) and have many chemical pecularities corresponding to specialized granites (MOHAMED et al. 1994).

The three granitic plutons which are selected for the present work represent the major tin-bearing granites in the Eastern Desert. Similar to many other mineralized granites, they are spatially related to major structure trends (MOHAMED, 1993). These granitic masses intruded thick succession of highly foliated metasediments (metasiltston, slate, phyllite metagreywacke and metatuffs) and basic metavolcanics. This volcano-sedimentary sequence contains minor serpentinite and is further intruded by metagabbro-diorite complex (*Fig. 2A,B*). The emplacement of these granitic masses was diapiric resulting in sharp contacts against the enclosing country rocks with development of thin hornfelsic aureoles (1–3 m) around Homr Akarem and Mueilha. Most of the mineralized granitic plutons in the Eastern Desert are of small sizes (1–10 km^2) with isometric outlines and have oval (Mueilha), subtriangular (Homr Akarem) or rarely irregular (Igla) shapes. They are commonly located along N30°W deep-seated fracture system and at or near its intersection with block faults striking N60°E (KRS et al. 1973; GARSON and KRS 1976).

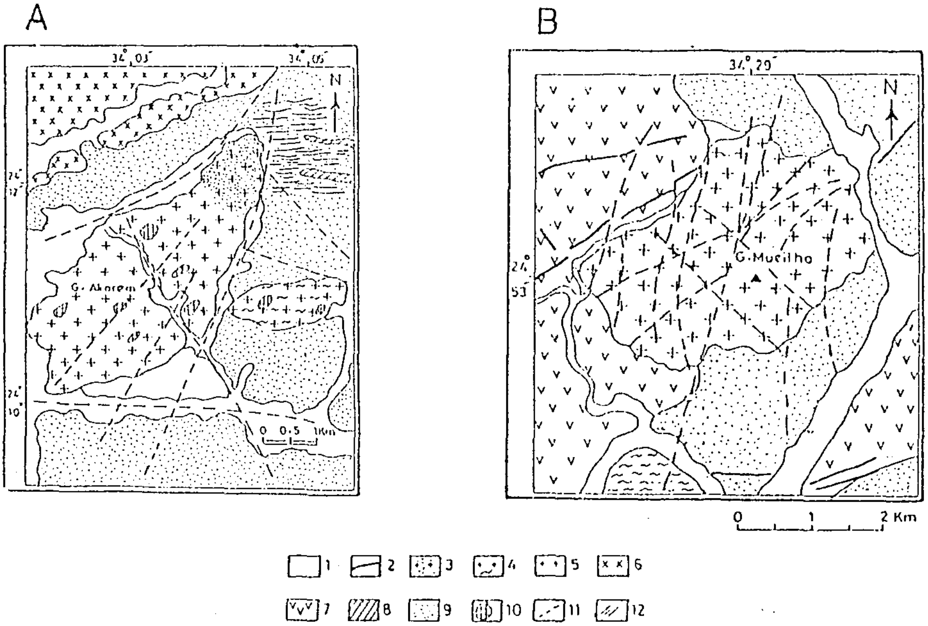

Fig. 2. Geologic maps of A, Homr Akarem and B, Mueilha granitic plutons
1. wadi deposits; 2. post-granatic dykes; 3. albitized granite; 4. greisenized granite; 5. medium-grained pink granite; 6. granodiorite; 7. basic metavolcanics; 8. metagabbro; 9. metasediments; 10. greisen pockets; 11. faults; 12. quartz veins

The studied granitic plutons are also dissected by two main sets of joints and faults trending NE-SW AND NW-SE which follow the major structure trends in the Eastern Desert of Egypt (MESHREF et al. 1980). The field relationships, such as sharp and mainly discordant intrusive contacts, and the internal isotropic fabrics, suggest that the granitic plutons were emplaced at high crustal level. The granitic rocks are locally affected by intense albitization and greisenization processes. The albitized rocks form the apical portion of the Homr Akarem pluton, the outer margin of Mueilha pluton and also occuras dykes and apophyses in Igla area. The rocks show bleached appearance, white colour with seriate to porphyritic textures. Greisens of pervasive and vein-types are erratically distributed in the granitic rocks. Greisen occurs as pockets, along fractures and often delineating the mineralized quartz veins. Some greisen pockets are mineralized and contain appreciable amounts of cassiterite as in Homr Akarem and Igla. The mineral transformation and geochemical aspects of all the metasomatic rocks associated with the mineralized granites in Egypt are treated in a further publication (HASSANEN et al. in prep.). Besides, the detailed mineralogical investigations of these area are carried out by SAAD et al. (1994).

PETROGRAPHY

The major granitoid phases and rock facies encountered in the investigated plutons include, 1) the older (synorogenic) granodiorite, 2) medium-grained pink (younger) granites and 3) metasomatites (albitized and greisenized rock facies). These rocks are briefly described as follows:

1. Granodiorite

This rock type is encountered in Homr Akarem and Igla Areas. The rock is medium grained with equigranular hypidiomorphic texture, often develop gneissose texture. The granodiorite consists of plagioclase, quartz, potash feldspar and biotite with minor hornblende. Apatite is the most common accessory besides zircon, titanite and irox oxides. Intensity of alteration is highly variable. Green chlorotized biotite, and different degrees of saussuritization are observed even within a single thin section. Plagioclase feldspar (An_{25}–An_{30}) constitutes about 38% of the rock mode. The crystals are medium-grained, polysynthetically twinned and strongly zoned with highly altered core. Potash feldspar (35% of the average rock mode) is mostly of microcline with rare perthite. Quartz usually forms anhedral interstitial crystals often display undulose extinction. Biotite occurs in subhedral fine grained pleochroic flakes (X=straw yellow; Y=brown; Z=reddish brown). Some large crystals represent a late-crystallized phase found to contain inclusions of quartz, feldspar, zircon and apatite.

2. Medium-grained pink granite

This granite type constitutes the main mass of Gabal Homr Akarem and Mueilha but has a restricted occurrence in Igla pluton. The granite outcrops are fairly uniform in appearance, consisting predominantly of medium-to coarse-grained pink biotite-(muscovite) granite. A porphyritic variety is recorded in Homr Akarem pluton with K-feldspar and quartz as common phenocrysts. The modal composition (*Fig. 3*) shows slight variation in the relative proportion of quartz and feldspar but with a higher variation in type and amount of mica. The rocks consist of K-feldspar (microline and perthite), plagioclase, quartz, biotite and muscovite. Accessory minerals are frequently abundant including zircon, apatite, fluorite, topaz, beryl, cassiterite and ilmenite.

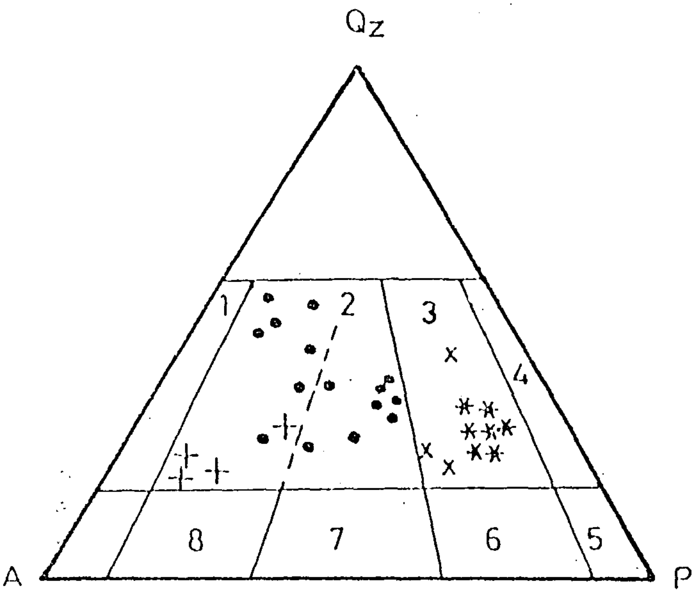

Fig. 3. Modal analysis of younger granites and metasomatized rocks plotted on the classification diagram recommended by Streckeisen (1976). Alkali feldspar granite (1); Granite (2); Granodiorite (3) and Tonalite (4)

Alkali feldspar is medium-grained represented by microline, patch and flame perthites. The crystals are clouded and turbid due to argillic-type alteration. Quartz (30.3% on the average mode) occurs in two distinct forms and sizes. The first is coarse grained (up to 2.5×1.8 mm) anhedral and display undulose extinction. The second is less abundant and occur as fine grained, undeformed crystals that paragenetically represent post-deformation recrystallization during subsolidus rock-fluid interaction. The latter process is rather effective at the apical part of the plutons particularly in Homr Akarem pluton. Plagioclase (An_{10}–An_{15}) occurs as subhedral polysynthetically twinned crystals forming on average about 24.7% of the rock mode. Some crystals are zoned and show patchy, irregular and selectively sericitized core with fresh albite rim. Biotite and minor hornblende are common mafic phases in Igla granite, while Homr Akarem granite contains biotite and muscovite. The latter is the only mica type found in Mueilha granite. The biotite crystals are subhedral, pleochroic from X, pale yellow to Y and Z reddish brown. The muscovite is also subhedral and displayserratic abundance and distribution in the different samples. Most of the muscovite crystals are secondary formed at the expense of biotite and feldspar, but few are of primary magmatic nature.

3. Albite-rich granite

Albite rich granite (albitized granite) occurs as small outcrops randomly distributed at the outer margin of the plutons (Mueilha), as apophyses (Igla) and forming the apical portion of Homr Akarem pluton. This rock facies is fine-grained, white in colour with inequigranular to seriate texture. It is similar to their parent medium grained pink granite but with minor amounts of biotite and larger amounts of plagioclase and muscovite. The latter is mostly developed at the expense of biotite. Plagioclase is of albite composition (An_5–An_{10}) representing the most abundant constituent of the rock (57% of the average mode). The albite crystals are fine grained with subhedral prismatic form and rarely show zoning. Few crystals of anhedral form are formed as reaction rim around K-feldspar. The abundant secondary muscovite, fluorite and bleached appearance of this granitic type indicate the high rock-fluid interaction during the alteration process.

GEOCHEMISTRY

Analytical Techniques

Thirty two samples were chosen for whole-rock major and trace element analyses by full automatic energy dispersive X-ray fluorecence spectrometer. Two representative samples from Mueilha granite pluton were analysed for REE and Hf by inductively coupled plasma emission spectrometer (ICP). The analyses were performed at the Technical University of Berlin, Germany. Precisions for major elements (except REE) range from 5–10%. Sn, Be and Mo were measured by optical emission spectroscopy using d.c. are emission source. FeO and H_2O (as LOI) in the rocks were determined by the classical wet method with a precision of ±2%.

Major element characteristics

The post magmatic alteration and metasomatic processes that probably have disturbed the primary igneous signature of the rocks put some constraints when we attempt to interpret the chemistry of these rocks and their possible derivation. These processes such as albitization, greisenization and extraction of residual pegmatitic fluids will be considered in relation to mineralization process is subsequent sections. Chemical analyses of typical samples from the three granitic plutons and associated metasomatites are presented in Table 1. The samples have been classified in *Fig. 4* using the Q-P diagram of DEBON and LEFORT (1982). Most of the studied samples range from K-rich granites to adamellite while the older grey granite fall in the granodiorite field. This diagram is sensitive to feldspar alteration (e.g., alkali metasomatism) and therefore the albitized rocks are shifted to lower Q and P values. The major element chemistry of the less altered samples from the investigated granitic pluton display a restricted major element variations (SiO_2 68.32 to 76.05%) with a relatively high Al_2O_3 and total alkali contents but with a marked depletion of CaO, TiO_2, MgO and P_2O_5 (*Fig. 6., 7*). The pink granitic rocks are collectively of alkaline character (*Fig. 5A*) and comparable to the Group II alkaline. Younger granites (*Fig. 5B*) defined by ROGER and GREENBERG (1981). The albitized rocks show a noticeable enrichment in Na_2O, Al_2O_3 and SiO_2 and slight impovershment in K_2O, CaO and Fe_2O_3. The granitic rocks from Homr Akarem, Igla and Mueilha plutons are metaluminous to weakly peraluminous (*Fig. 5C*) with percent normative corundum between 0.16 and 4.58. On the variation diagrams (*Fig. 6*) the three granitic plutons have defined chemically specific compositional areas, with no direct chemical link.

The $K_2O/(Na_2O+K_2O)$ ratio of the granitic samples range from 0.38 to 0.72. This wide variation in K_2O and Na_2O concentrations within the granitic instrusions resulted from the

TABLE 1

Representative major and trace element analyses of Tin-bearing granitic plutons, Eastern Desert, Egypt

	Granodiorite		Medium grained pink granite							Albitized granite			Greisens	
Sample#	A–1	A–2	M–5	M–6	M–7	A–15	A–16	I–20	I–21	M–23	A–28	A–29	M–30	A–32
SiO_2	69.50	69.55	76.05	74.25	73.86	75.03	75.02	75.53	73.50	71.84	74.90	75.07	73.10	75.65
TiO_2	0.80	0.85	0.12	0.01	0.05	Bd	0.16	0.01	0.15	Bd	0.02	0.08	0.09	0.09
Al_2O_3	14.95	14.48	13.64	13.74	13.45	14.31	12.91	11.84	14.41	15.39	14.43	12.68	14.18	14.05
Fe_2O_3	1.23	0.83	0.93	0.74	4.61	0.69	0.41	1.54	1.39	0.30	0.38	1.29	0.29	0.19
FeO	1.90	2.93	0.51	0.58	0.12	0.13	0.13	1.76	1.44	0.23	0.59	1.08	1.36	1.25
MnO	0.08	0.05	0.05	0.03	0.04	0.30	0.08	0.04	0.03	0.01	0.07	0.01	0.07	0.07
MgO	0.90	0.91	0.23	0.10	0.10	0.72	0.63	0.10	0.20	0.51	0.20	0.13	0.23	0.24
CaO	2.85	2.79	1.35	0.89	0.71	0.79	0.99	0.79	0.79	0.56	0.12	0.79	1.00	0.11
Na_2O	3.61	3.43	2.10	2.88	4.43	2.51	4.04	4.32	4.31	6.67	5.56	4.97	2.10	2.54
K_2O	2.51	1.89	3.32	5.29	4.77	3.82	3.95	2.65	2.65	3.66	1.05	4.22	5.53	5.22
P_2O_5	0.33	0.09	0.01	0.02	Bd	0.01	0.02	0.01	0.05	0.03	0.01	0.01	0.13	0.17
LOL	2.20	2.21	0.91	1.01	0.81	1.41	0.56	0.94	1.07	0.46	0.53	0.52	0.80	1.03
Total	100.86	100.01	99.22	99.54	102.95	99.72	98.90	99.53	99.99	99.66	97.86	100.85	98.88	100.61
K/K+Na*	4.61	4.43	3.10	3.88	5.43	3.51	5.04	5.32	5.31	7.67	6.56	5.97	3.10	3.54
Ba/Sr	1.82	1.40	1.44	1.20	1.41	2.25	1.63	1.32	2.08	6.00	1.31	0.73	–	–
Rb/Sr	0.29	0.30	8.78	5.70	14.19	1.88	2.46	1.17	–	9.17	3.10	1.40	–	–
K/Rb	417	201	70	154	103	151	102	149	13.47	276	40	263	–	–
Ba/Rb	6.20	4.60	0.20	0.20	0.10	1.20	0.70	1.10		0.70	0.40	0.50		
Trace elements (ppm)														
Rb	50	78	395	285	383	210	320	148	–	110	220	133	–	–
Ba	309	360	65	60	38	252	212	165	256	72	93	69	–	–
Sr	170	258	45	50	27	112	130	126	123	12	71	95	68	850
Ga	20	14	50	30	32	27	29	21	19	17	21	18	–	–
Nb	4	5	39	50	30	65	70	46	42	27	54	49	35	29
Zr	95	119	66	39	80	259	250	325	320	343	106	390	50	60
Y	11	22	29	32	156	50	45	40	39	33	12	11	75	80
Th	12	11	28	Bd	32	Bd	Bd	21	20	Bd	37	27	–	–
U	Bd	2	8	Bd	9	Bd	Bd	–	4	Bd	9	6	–	–
Sn	5	Bd	750	105	130	540	390	–	1348	780	199	74	–	–
Co	Bd	Bd	Bd	Bd	Bd	8	8	2	Bd	38	11	4	7	7
Sc	17	14	5	9	18	7	5	4	5	12	8	4	7	8
V	15	Bd	4	Bd	6	27	Bd	24	22	8	12	11	–	–
Cu	110	27	600	1100	32	168	224	28	25	343	–	112	60	110
Pb	17	16	38	2	57	15	29	7	8	42	–	66	530	120
Zn	32	50	65	50	104	–	–	78	76	430	–	35	50	50
La	50	45	33	–	39	–	–	62	59	–	46	65	–	–
Ce	40	32	19	–	18	–	–	52	48	–	34	51	–	–
Pr	4	4	2	–	3	–	–	6	7	–	6	7	–	–
Nd	16	14	12	–	14	–	–	22	20	–	25	18	–	–
Sm	5	4	5	–	4	–	–	5	6	–	4	5	–	–

Complete set of Chemical analyses is available from the authors upon request

* $K_2O/(K_2O+Na_2O)$

\# M = Mueilha A = Homr Akarem and I = Igla

– Not determined Bd: Below detection limit amount of feldspar fractionation defined by the pronounced modal variation in potash feldspar and plagioclase. Alternatively, variable intensity of albitization, greisenization and subsolidus reequilibration of feldsparat at the late stage of consolidation could induce considerable variation in both Na_2O and K_2O contents (*Fig. 7*).

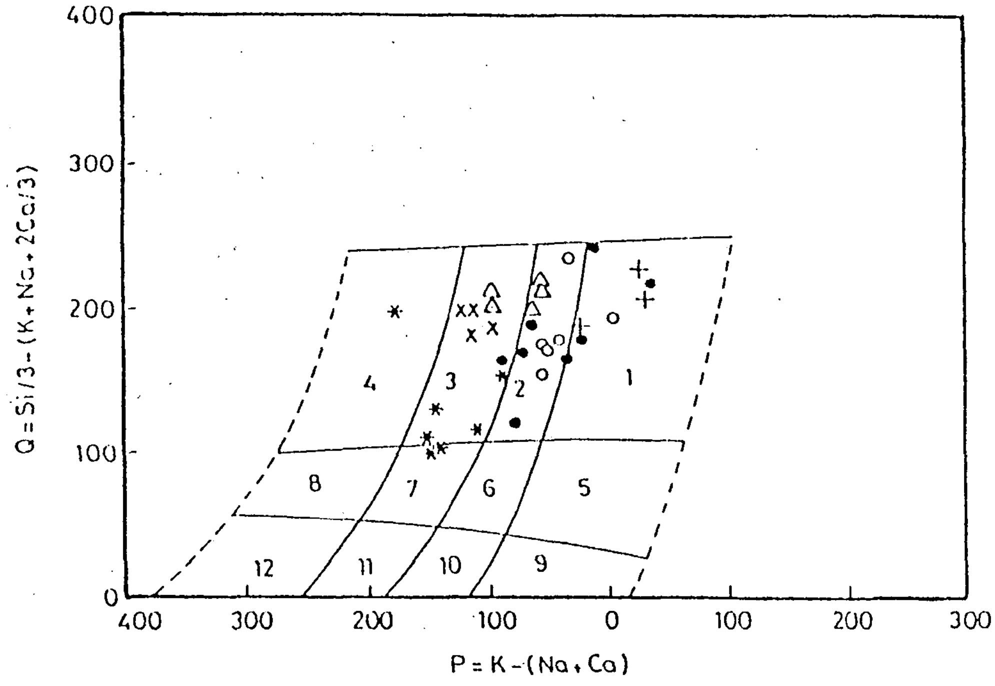

Fig. 4. Q-P diagram of DEBON and LEFORT (1986). Rock symbols are as follows
x = granodiorite; medium grained pink granite, ● = Homr Akarem; O = Mueilha; Δ = Igla; ✱ = albitized granite; + = greisenized granite.
1. granite; 2. adamellite; 3. granodiorite; 4. tonalite; 5. quartz syenite; 6. quartz monzonite; 7. quartz monzodiorite; 8. quartz diorite

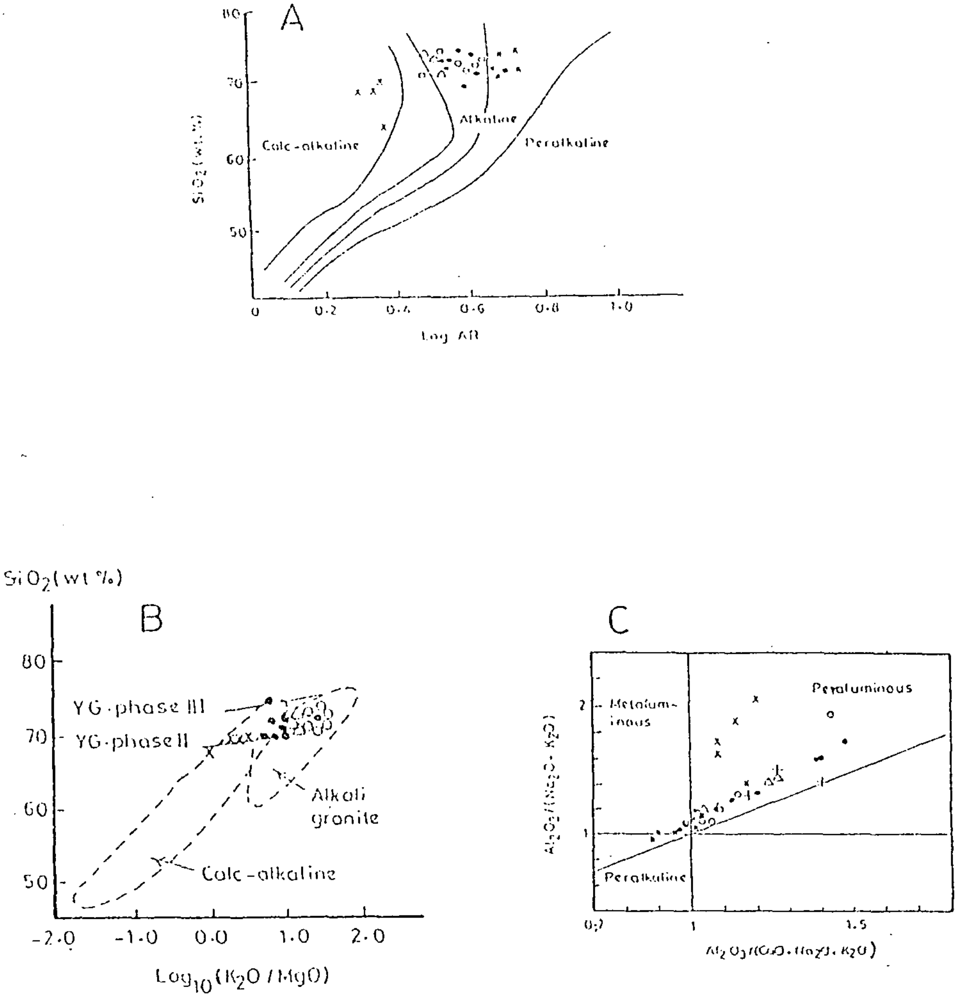

Fig. 5. Compositional variation of the granitic plutons in the SiO_2–LogAR (alkalinity ratio) (A), SiO_2–Log (K_2O/MgO) (B) and in the $Al_2O_3/(Na_2O+K_2O)$–$Al_2O_3/(CaO+Na_2O+K_2O)$. Symbols as in *Fig. 4.*

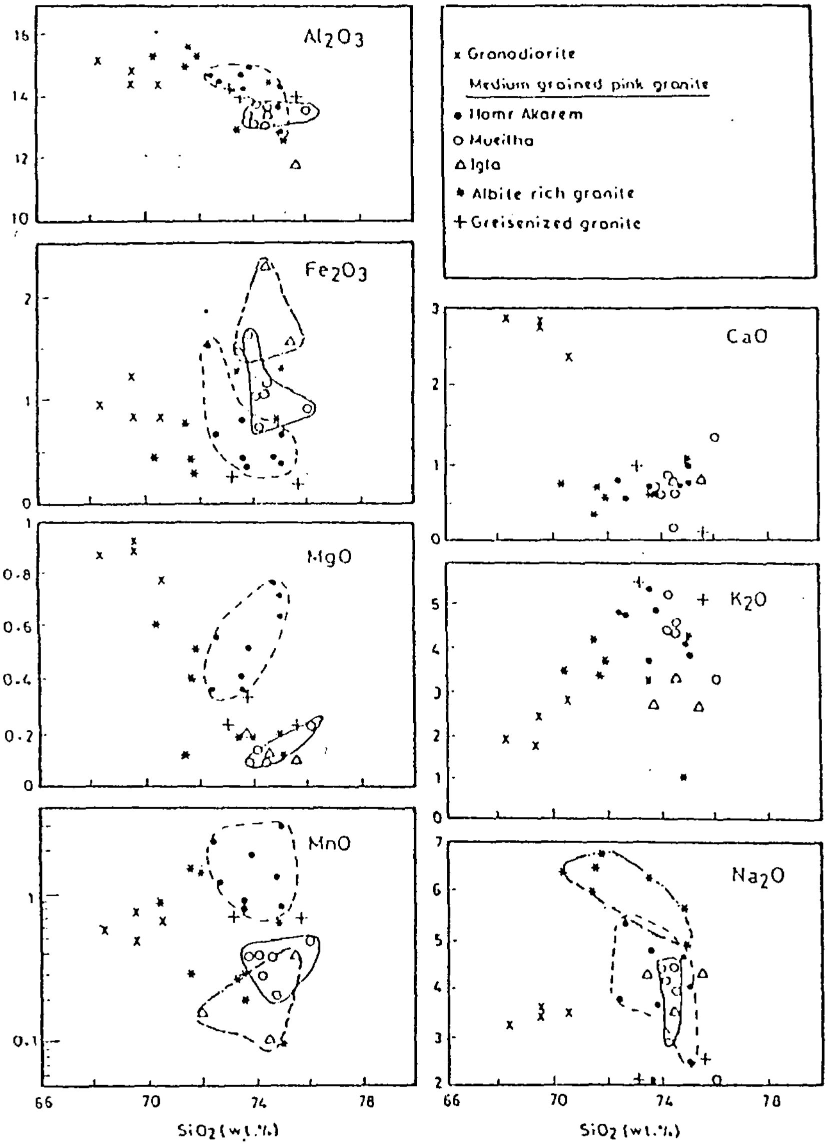

Fig. 6. Major elements versus Silica variation diagrams. Symbols as in *Fig. 4.*

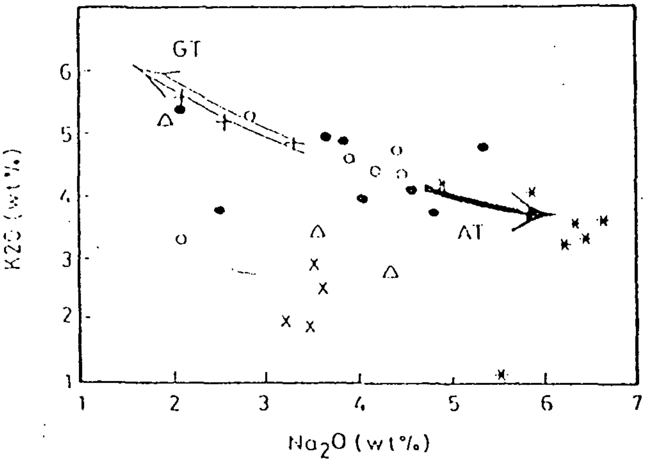

Fig. 7. Binary variation diagram of Na_2O vs. K_2O; the arrows are the optimum trends of albitization (AT) and greisenization (GT)

Trace Element variations

The granitic rocks of the studied plutons show marked and wide variations in their trace element abundances. They show noticeable enrichment in HFS elements (Zr, Y, Zn, Nb, Ga) and HREE (*Fig. 8*), as well as low contents of LIL elements. The albitized rocks are

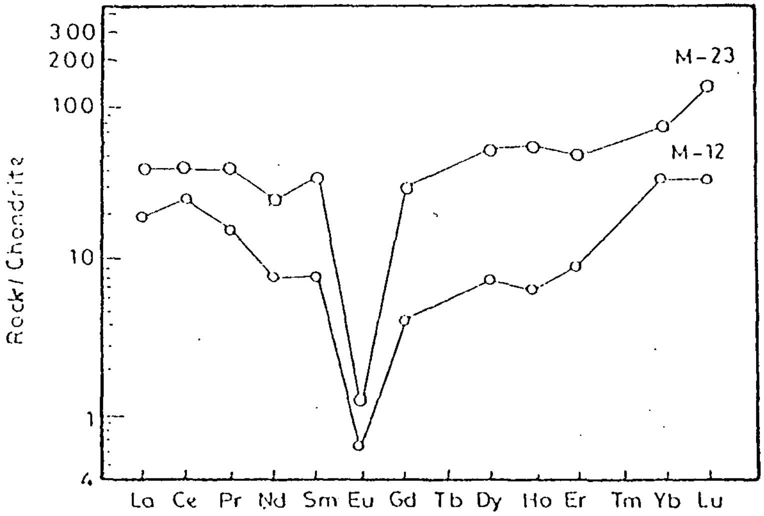

Fig. 8. Chondrite-normalized REE patterns for Mueilha medium-grained pink granite (normalized values of SUN, 1982).

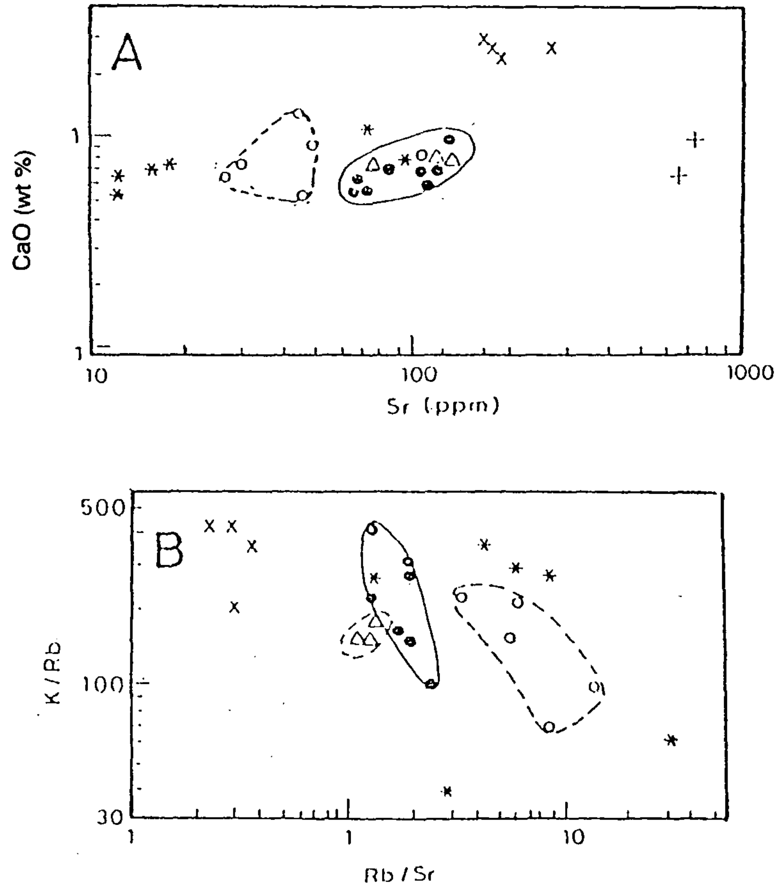

Fig. 9. Binary scatter diagram of (A) Ca vs. Sr, (B) K/Rb vs. Rb/Sr in the three granitic plutons. Symbols as in *Fig. 4.* In A and B, the pink granites of Homr Akarem, Mueilha and Igla are shown as fields outline marked by the rock symbol

still more depletion in Ba, Sr and Rb. The relatively distinct chemical characteristics of the different granitic plutons are illustrated on CaO–Sr and K/Rb–Rb/Sr plots (*Fig. 9A and B*). Each granatic pluton define a distinctive area on most diagrams with little or no evidence of common link between them.

Normalized geochemical patterns for some representative samples from each granitic pluton are shown in *Fig. 10 A–C.* The normalized factor is the hypothetical ocean ridge granite (**ORG**) of PEARCE et al. (1984). The patterns of the granitic rocks have significant enrichment in Rb and Th relative to Nb. According to PEARCE et al. (1984) such patterns can be considered crust-dominated. The patterns of Homr Akarem, Igla and Mueilha granites (*Fig. 10A–C*) resemble the collision granitic rocks (*Fig. 10D*), while on the Nb–Y and Rb–(Y+Nb) discrimination diagrams (PEARCE et al. op. cit.), most of the granitic rocks

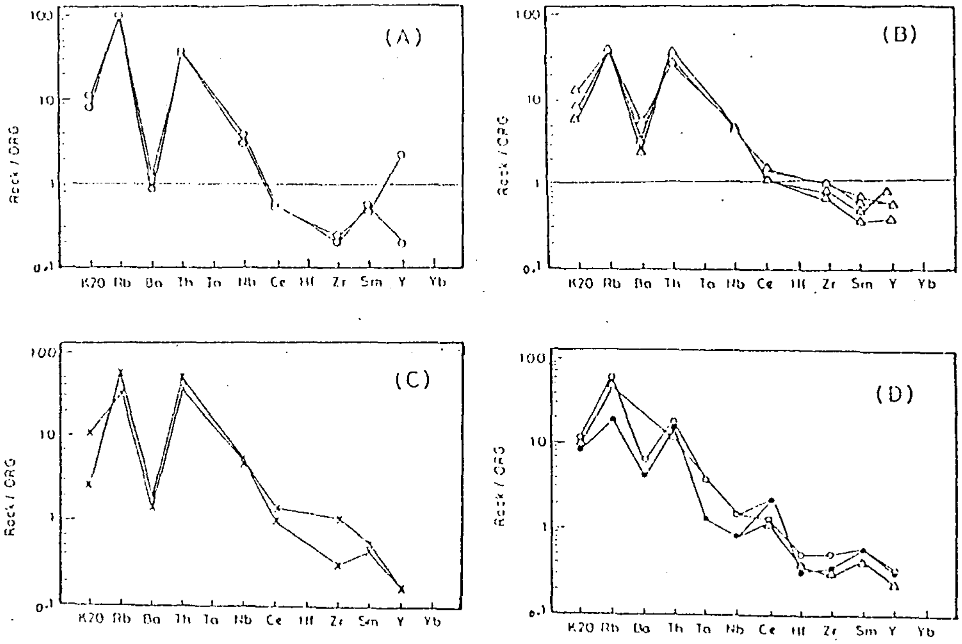

Fig. 10. Geochemical patterns for some representative samples from each granitic pluton, normalized to the oceanic ridge granite (ORG) of PEARCE et al. 1984.
A) Homr Akarem; B) Mueilha and C) Igla granites. D) granites from well-known tectonic setting (from PEARCE et al. 1984). D: ● = Sabaoka, Sudan; O = Skaergaard; Δ = Querigate (Pyrenees), based on data given in PEARCE et al. 1984.

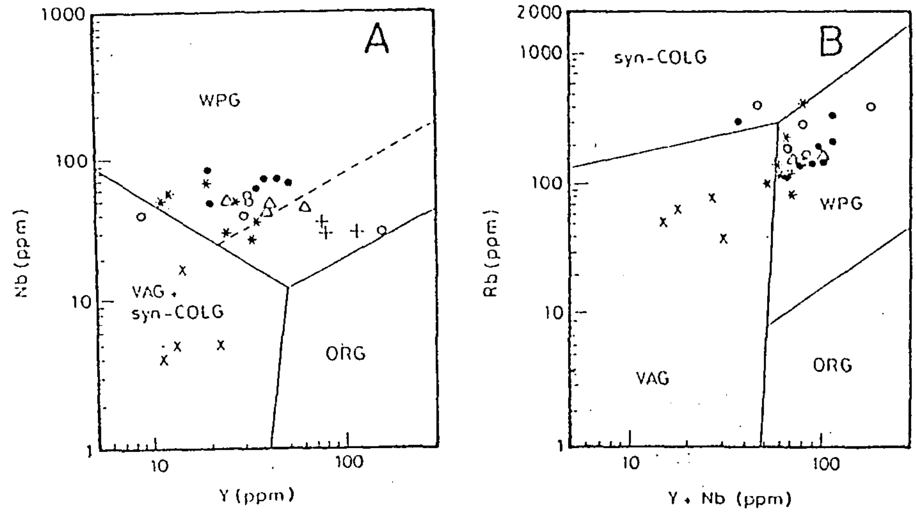

Fig. 11. (A) Nb vs. Y and (B) Rb vs. (Y+N) diagrams for tectonic interpretation of Egyptian younger granites (Field boundaries from PEARCE et al. 1984). Syn-collision granites (Syn-COLG); volcanic are granites (VAG); within-plate granites (WPG) and ocean-ridge granites (ORG). Symbols as in *Fig. 4*.

fall in the field of within-plate (**WP**) granitic rocks (*Fig. 11*). Some post-collision granites commonly plot in the **WP** field (SYLVESTER 1989) and therefore it is difficult to distinguish both post collision and syncollision from the within plate granites on these diagrams.

Lithophile element ratios and fractionation

The abundance of large ion lithophile elements (LIL) (K, Ba, Sr and Rb) in a granitic melt is largely controlled by the major phases such as plagioclase, alkali feldspar and biotite, since they have moderate to high Kd values (>1, ARTH 1976). Hence, the behaviour of these elements give qualitative assessment on the nature of the fractionating

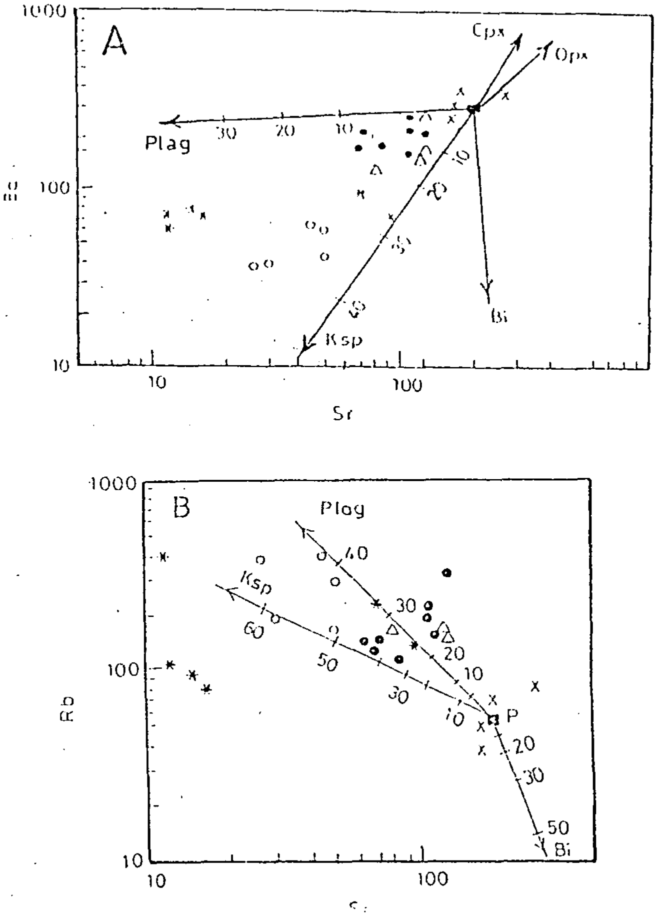

Fig. 12. Logarithmic binary scatter diagrams of (A) Ba vs. Sr and (B) Rb vs. Sr for younger granites. Symbols as in Fig. 4. Vectors denote change in melt composition due to fractional crystallization of named phases. The amount of separating phases (F) is annotated on each vector.

phases during the evolution of their parent magma. On the binary variation diagrams Ba and Rb versus Sr (*Fig. 12A and B*) and K/Rb versus Rb (*Fig. 13*), the granitic rocks show a limited variation in Ba–Sr and Rb–Sr but with vide variation in K/Rb and Rb/Sr. On these binary diagrams sets of fractionation vectors of major minerals are calculated using Ralyeigh fractionation equation ($C^1/C^0=F^{D-1}$). The average composition of granodiorite is used as a parent melt (C^0) while the distribution coefficients (Kds) are taken from published work (ARTH, 1976; HANSON 1978). The composition of the melts (C^1) at different degrees of fractionation (F) for each mineral phase are annotated as percentage on each vector (*Fig. 12A and B*). Comparing the analytical data of the studied granites with these vectors reveal that 20% and 40% separation of plagioclase and alkali feldspar respectively are required for fractionation of Homr Akarem and Igla granites. The Mueilha granite on the other hand is more fractionated (F=40–60%) than the other two granitic plutons (*Fig. 12*).

Granity type and Chemical Specialization

Some isometric granitic plutons of the younger granite province are characterised by a marked enrichment in HFS elements (Zn, Y, Nb, F, Sn, W, Mo, Rb and HREE) (RENNO et al. 1993, MOHAMED et al. 1994). Most of these granitic plutons are often associated with Sn, Mo, W, Be or Nb–Ta mineralization. The investigated granites (Homr Akarem, Igla and Mueilha) belong to this group. The trace elements characteristics of this granitic group correspond to those defined as specialized granites and follow the specialization trend in the Arabaian Shield defined by LE BEL and LAVAL (1986) (*Fig. 13*). The noticeable enrichment in HFS elements, low K/Rb and Ba/Rb are also consistent with their specialization character (TISCHENDORF 1977; MATHEIS et al. 1982; MOHAMED et al. 1994). They are also chemically equivalent to the A-type granite in the sense of WHITE and CHAPELL (1983) and COLLINS et al. (1982). The calculated Ba/Rb ratios for most of the granitic samples are generally less than 0.5. The low Ba/Rb ratio has been used by OLADE (1980) to characterize Sn-bearing from barren granites (Ba/Rb > 0.5) of Northern

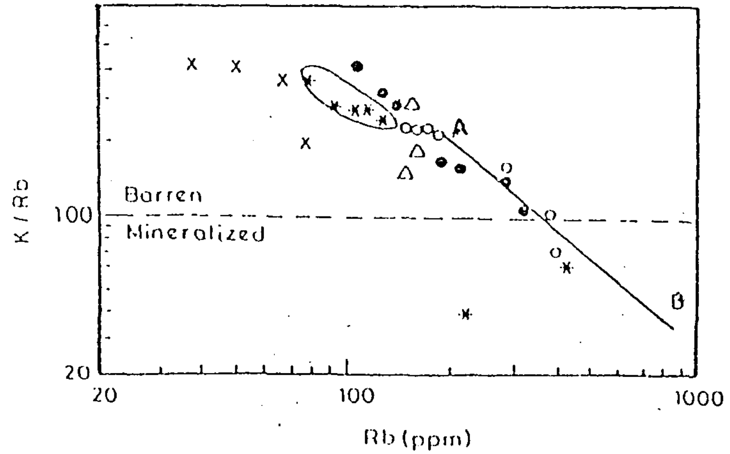

Fig. 13. K/Rb vs. Rb diagram. Heavy line AB represents the trend of specialized granites in Saudi Arabia (LEBEL and LAVAL 1986). Symbols as in *Fig. 4*.

Nigeria. The low Ba/Rb and K/Rb ratios (Table 1) of Homr Akarem and Mueilha granites confirm their chemical specialization (TISCHENDORF 1977) and are also consistent with being Sn-bearing granites. On the contrary, the high Ba/Rb (> 0.5) and K/Rb (> 100) ratios of Igla tin-bearing granite can be attributed either to the mobilization and depletion of Rb by intense post magmatic albitization or to strong fractionation of alkali feldspar and biotite. Rb is commonly accomodated in K-feldspar ($\mathrm{Kd}^{\mathrm{Rb}}_{\mathrm{k\text{-}feldspar}}=0.65$) and biotite ($\mathrm{Kd}^{\mathrm{Rb}}_{\mathrm{biotite}}=3.26$) which are readily altered to albite and muscovite respectively causinga low and wide Rb/Sr range (1.17–14.19), and high Ba/Rb (0.1–1.2) and K/Rb (70–154) ratios.

SUMMARY AND CONCLUSIONS

Tin-bearing granitic plutons were included among the younger granite province in the Egyptian basement complex. The granitic rocks of Homr Akarem, Igla and Mueilha plutons are coarse-grained two mica granites. These granitic masses are associated with Sn, W, Mo, Be and F mineralizations and selectively affected by post-magmatic albitization and greisenization processes. The mineralization occurs in quartz veins, stockworks, greisens and less commonly as dissemination in the host granite. The less altered samples show slight variations in petrography, mineralogy and major elements geochemistry. The altered samples have marked increase in the abundance of quartz, albite and muscovite beside the metallogenetically related minerals such as fluorite, topaz, cassiterite, molybdenite, wolframite and beryl. Unlike, the other younger granites (barren granites) the mineralized ones (Homr Akarem, Igla and Mueilha) show marked chemical pecularities such as high Rb, Zr, Y, Nb, Zn, Ga, Sn, W, Be, HREE, Ba/Rb and Rb/Sr coupled with depletion in Ca, Mg, Fe, Ti, Sr, Ba, Eu, Ba/Sr and K/Rb. These chemical aspects represent late-phase magmatic differentiation and also consistent with metallogenetically specialized granites which elsewhere are oftenly associated with deposits of Sn, Mo, W and rare metals. Greisenization and albitization are the most common alteration processes in the studied granites which can be considered as strong field evidence accompaning these types of mineralizations. Low pressure crystal-melt fractionation of plagioclase, K-feldspar and mica play significant role during the evolution of these granitic rocks. The abnormal enrichment of HFS and HREE elements require the contribution of fluorine-bearing fluid phase at the late stage of magma differentiation.

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