Sci. J. Fac. Sci. Minufia Univ., 2009, Vol.XXIII(2).121 - 147

RADIOMETRIC AND MINERALOGICAL STUDIES ON THE MUSCOVITE GRANITES AT WADI EL GEMAL AREA, SOUTHEASTERN DESERT, EGYPT.

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ABSTRACT

This paper deals with the radiometry and mineralogy of six masses of muscovite granites at Wadi El Gemal area in the southeastern Desert. The investigated masses are exposed at Umm Seleimat, Sikait I, Sikait II, Umm El Kheran, Umm Baanib and Umm Addebaa. exposures. These masses occur as elongated bodies with N-S to NNW-SSE trends and show similar deformation. Petrographically, the muscovite granites are mainly composed of plagioclase, K-feldspars, quartz, muscovite and biotite. Garnet, fluorite, zircon, tourmaline and opaques are accessories. Moreover, these granites were affected by sericitization, greisenation, silicification and fluoritization.

The distribution of uranium and thorium in the investigated granites was carried out using GS-512 instrument in the field and by chemical analyses in the laboratories. The results reveal that most of these granites gained uranium from outer sources and reflect the amount of remobilization and migration that took place within the study area.

Mineralogical studies indicate the presence uranophane, pyrite, garnet, columbite, tantalite, tourmaline, wolframite and fluorite.

Key words: Wadi El Gemal, muscovite and radiometry

INRODUCTION

Wadi El Gemal is one of the most important Wadis in the southeastern Desert of Egypt. The outlet of Wadi El Gemal is located at about 52 km. south of Marsa Alam coastal city. Six masses of muscovite granites are exposed at Wadi El Gemal area. The masses are exposed at Umm Seleimat, Sikait I, Sikait II, Umm El Kheran, Umm Baanib and Umm Addebaa exposures. The main aim of this work is to study the radiometry and mineralogy of these masses.

Mohamed and Hassanen (1997) concluded that the Sikait leucogranites are strongly peraluminous and have the characteristics of S-type granites. Ibrahim et al. (2006) studied the leucogranites in the Nugrus-Wadi El Gemal area, and concluded that they have equigranular and pegmatitic types, strongly peraluminous and have nearly the similar geochemical characteristics. Saleh (2008) concluded that the Abu Rushied-Eir Arib leucogranites are strongly peraluminous associated with miarolitic cavites and pegmatitic patches indicating the role of the aquous fluids released from the downgoing slab during subduction. Ibrahim et al. (2008) concluded that those granites are strongly peraluminous, posses high content of LILE (Rb, Sr, Ba, Y, Zr & Nb) and have a moderate to high content of HFSE (Cu, Zn, Pb, Hg, Cd, As, Sb, Sn, Bi, Mo & W). They were crystallized from relatively soda rich magma, calc-alkaline in nature, belong to A-type and emplaced within plate tectonic setting.

The present study focuces on the geology, petrography, radiometry and mineralogy of the muscovite granites at W. El Gemal area.

GEOLOGIC SETTING

A general geologic map (Fig. 1) for the study area was constructed based on aerial photos, landsat images (scale 1:50,000) and field observations and structural relations.

The rocks exposed in the study area (Fig. 1) are ultramafics (oldest), metagabbros, ophiolitic mélange, metasediments, biotite granites, muscovite granites, pink granites and post granite dykes and veins (youngest). The ultramafic rocks are thrusted over the mafic and ophiolitic mélange by WNW-ESE faults and dipping in the NNE direction. Ultramafics, mafics, metagabbros, ophiolitic mélange and metasediments were studied by several workers (Hegazy, 1984; Eid, 1986; El Maghraby, 1994; Saleh, 1998; Ibrahim et. al., 2000, 2002, 2004 & 2007). The field relationships and description of the studied granites are listed in the following paragraphs,.

a) Biotite granites

Biotite granite is whitish grey, pale pink to reddish in color with visible biotite flakes. It is medium to coarse grained and composed essentially of K-feldspars, plagioclases, quartz and biotite flakes with hornblende in lesser abundance. Biotite granite is sheared, fractured, jointed, deformed, foliated and lineated. Mullion structures and ribbing are very well marked on the foliation surfaces. This rock is cut and crossed by a number of pegmatite veins and basic dikes striking 130° and dipping N 45° E/65°.

b) Muscovite granites

In the present study area, there are many small to large bosses of muscovite granites intruding the metasediments, ophiolitic mélange and granitic rock units.

The muscovite granites are generally sheared, white in color, fine to coarse grained with large crystals of feldspars and quartz, in addition to flakes of muscovite and crystals of garnet which are visible in hand specimens at some exposures. No chilled margins are observed at the contact between the muscovite granites and the surrounding roc units. Some of these granites exhibit exfoliated and weathered.

The muscovite granites crop out at many locations in the study area namely; at Umm Seleimat, Sikait (two locations), Umm El Kheran, Umm Baanib and Umm Addebaa.

At Umm Seleimat area, the muscovite granite intrudes the biotite granite and ophiolitic mélange which is located closed to the major Nugrus thrust. It is large in size (>1 km^2) and emplaced along NW-SE trend, reaching about 1-2km in length and 200-300m in width. This intrusion commonly possesses sharp contact truncating the foliation of the schists at high angle. The muscovite granite occurs either as small off-shoots of boss-like bodies or as dike-like bodies. They form huge semi circular mass (Fig. 2), which form domal shape around Wadi Umm Seleimat.

At Sikait area, the muscovite granites are represented by two exposures. The first intrudes the biotite granite and ophiolitic mélange with sharp contacts. It is small in size (<1.0 km^2) and emplaced along NW-SE trend, with 250-300m length and 50-100m width. At this exposure, muscovite granite occurs as masses or bosses with either rounded tops or elongated at western side of Wadi Sikait or even sharp peaks intruding the ophiolitic mélange and biotite granite at eastern side. Quartz veins are associated with muscovite granite with N-S trend cutting the country rocks. The second exposure intrudes the ophiolitic mélange. It occurs as low topographic masses or as bosses, very small in size (<1.0 km^2), and emplaced along NW-SE trend. Reddish, brecciated and highly deformed quartz veins are associated with the muscovite granite with N 40° E trend cutting the country rocks (Fig. 2).

At Umm El Kheran area, the muscovite granite intrudes the ophiolitic mélange. It occurs as a huge semi-circular mass forming rounded and domal-shape intruding a high topographic ridge of metagabbro rocks (Fig. 3). It is large in size (>1.0 km^2) and emplaced along NW-SE trend, with 1.5-2.5km in length and 300-500 m in width. Two conjugate faults dissected Umm El Kheran muscovite granite, NNWand WNW with opposite sense of movements (left and right hand, respectively). The NW trend which is parallel to the Najd shear system is responsible for this movement. Highly fractured quartz veins cut this muscovite granite and its surrounding rocks in different directions.

At Umm Baanib area, the muscovite granite intrudes the ophiolitic mélange. It is small in size (<1.0 km^2) emplaced along Lewiwi thrust and occurs as dike-like bodies as well as rounded masses; reaching 10-20 m in width and 10-100 m in length and striking NW-SE. These granites have no contact aureoles, and are low relief, highly deformed, stretched and elongated in NW-SE. The muscovite granite is intruded by the pink granite (Fig. 4); this reveals the relation that the pink granite of Wadi El Gemal is younger than the muscovite granite.

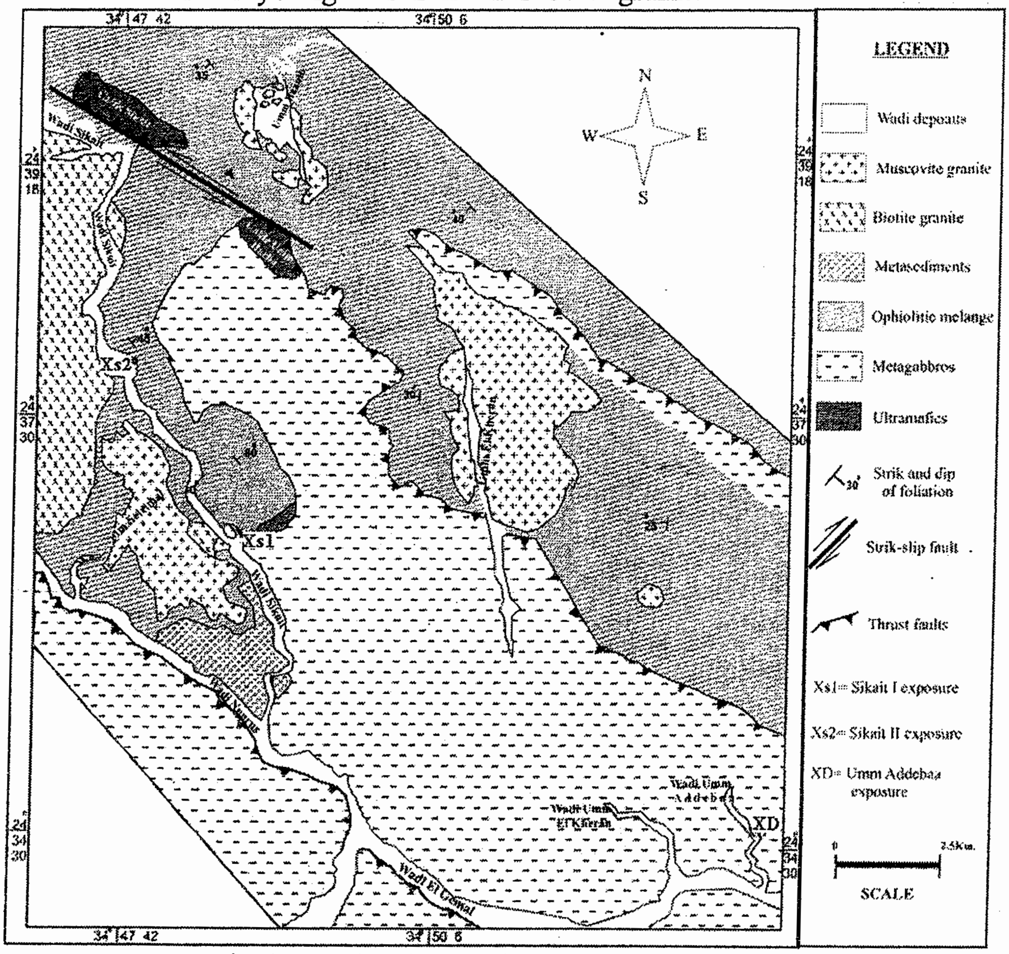


Fig. 1: Regional geologic map of the study area.

At Umm Addebaa area, the muscovite granite intrudes the ophiolitic mélange (Fig. 5) along N-S trend, about 100 m long and 50 m width. It occurrs as boss or dike–like body (<1.0 km2). Some quartz veins and basic dikes of different trends are cutting all the exposures of the studied muscovite granites.
Generally, the muscovite granites in the study area can be grouped into three exposures as; Umm Selemiat-Sikait exposure, Umm El Kheran-Umm Baanib exposure and Umm Addebaa exposure. Umm Selemiat-Sikait exposure and Umm Addebaa exposure are characterized by fine grained to pegmatitic with weak shearing and deformation, whereas Umm El Kheran-Umm Baanib exposures are characterized by fine-to coarse-grained and highly sheared rocks.

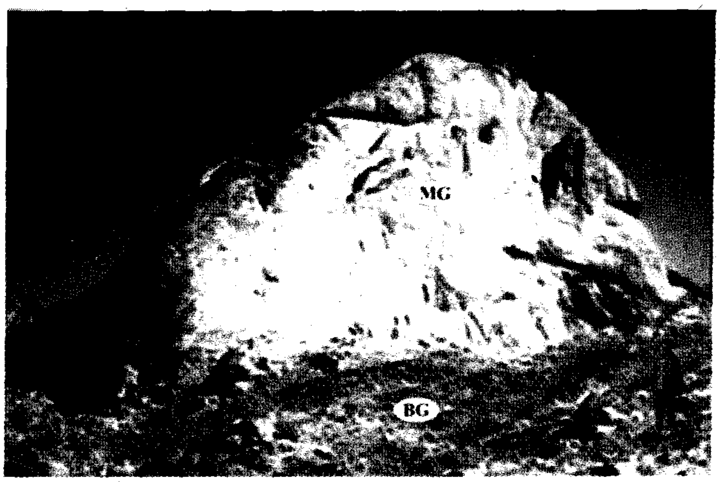


Fig. 2: A huge semi- circular mass of muscovite granite (MG) which form domal shape at Umm Seleimat area .Photo looking NW.

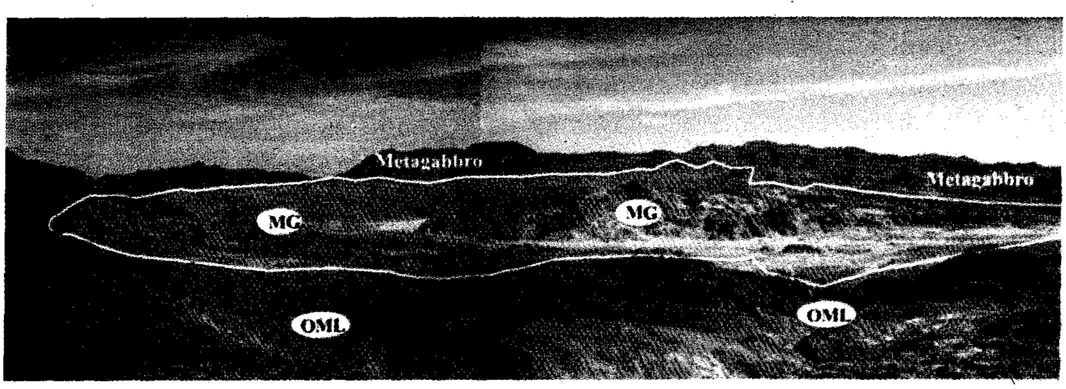


Fig.3: Panorama showing the muscovite granite (MG) and its surroundings at Umm El Kheran area. Photo looking NE.

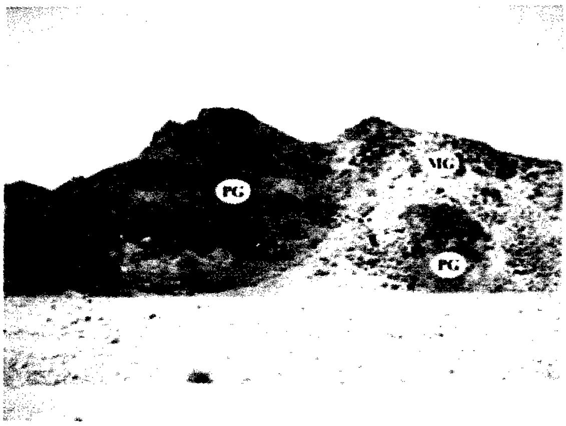


Plate 1: Some petrographic features of the studied muscovite granites at W. El Gemal area

Fig. 5: Dike-like body of the muscovite granite (MG) intrudes the ophiolitic mélange (OML) with sharp contact, at Umm Addebaa area. Photo looking NW.

c) Pink granite

The pink granite occupies the north side of the upper stream of W. Sikait (2km2). Moreover, the pink granite occurs either as offshoots in all area northeastern of Gabale Sikait, or intrudes the muscovite granite at Umm Baanib exposure (Fig. 4). This, for the first time, proves that the pink granite of Wadi El Gemal is younger than the muscovite granite of Wadi El Gemal. As compared to the biotite granite, it is richer in quartz and potash feldspars.

PERTOGRAPHIC FEATURES

The petrographic study was performed through choosing five samples from each of the six exposures of the studied peraluminous granites. This was carried out at the laboratories of Nuclear Materials Authority (NMA).

At Umm Seleimat exposure, the muscovite granite is composed mainly of Feldspars (plagioclase content = K-feldspars content), quartz, muscovite and biotite. Sericite and chlorite are secondary minerals, while garnet allanite, opaques, zircon, monazite are accessories. It is characterized by perthitic texture. Some muscovite flakes are oriented with shred of biotite flakes are present (Plate 1-a). Primary garnet crystals with euhedral edges in the muscovite granite are also present (plate 1-b). Occasionally, allanite occurred associated with albite crystals (Plate 1-c).

At Sikait I exposure, the muscovite granite is composed mainly of Feldspars (plagioclase content = K-feldspars content), quartz, muscovite and biotite. Sericite and chlorite are secondary minerals, while garnet, zircon, fluorite, monazite and opaques are accessories. It is characterized by perthitic texture. Some muscovite flakes are dislocated due to deformation (Plate 1-d).

At Sikait II exposure, the muscovite granite is composed mainly of Feldspars (plagioclase content > K-feldspars content), quartz, muscovite, biotite and phologobite. Sericite and chlorite are secondary minerals, while garnet, zircon, monazite and opaques are accessories. It is characterized by perthitic texture. Some plagioclase crystals are kinked due to deformation (Plate 1-e).Some garnet crystals are wrapped by muscovite flakes (Plate 1-f) and the other are wrapped by quartz grains (Plate 1-g).

At Um El Kheran exposure, the muscovite granite is composed mainly of Feldspars (plagioclase content = K-feldspars content), quartz, muscovite, biotite and phologobite. Sericite and chlorite are secondary minerals, while garnet, zircon, monazite and opaques are accessories. It is characterized by perthitic texture. Megacrysts of microcline perthite are observed (plate 1-h). Secondary quartz occurs as drop-like inclusions and the perthite is partially altered to kaolinite (plate 1-h). Some muscovite flakes are corroded by plagioclase crystals (Plate 1-i). Skeletal crystals of garnet are also observed (Plate 1-j).

At Um Baanib exposure, the muscovite granite is composed mainly of Feldspars (plagioclase content > K-feldspars content), quartz, muscovite and biotite. Sericite and chlorite are secondary minerals, while opaques, garnet, zircon, and monazite accessories. It is characterized by perthitic texture. Sometimes, veinlets of muscovite and biotite crystals are observed in the muscovite granite (Plate 1-k).

At Um Addebaa exposure, the muscovite granite is composed mainly of Feldspars (plagioclase content > K-feldspars content), quartz, muscovite and biotite. Sericite and chlorite are secondary minerals, while garnet, tourmaline, allanite, zircon and opaques are accessories. It is characterized by myrmekitic texture. Albite-twinned plagioclase with broken border is observed reflecting the deformation (Plate 1-l). Ghost myrmikite between K-feldspar and plagioclase are observed (Plate 1-m). Veinlet of chlorite cutting quartz grains in the muscovite granite was observed. Allanite crystal included zircon (Plate 1-n) and tourmaline crystals (Plate 1-o) are also observed.

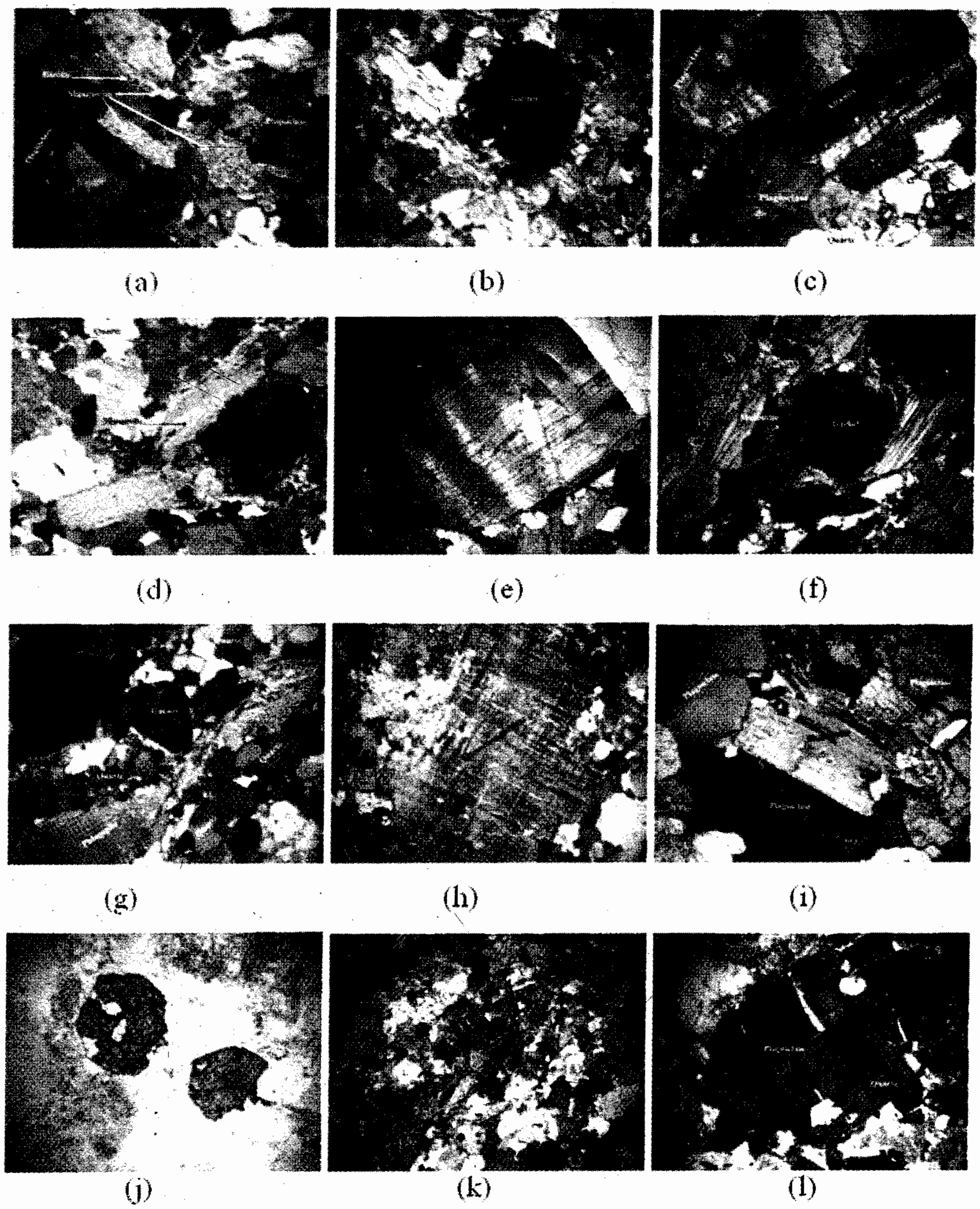
Generally, the muscovite granites are characterized by the scarcity of ferromagnesian minerals giving rise to a leucogranitic types. The presence of muscovite and garnet reflect the peraluminous nature of these granites.

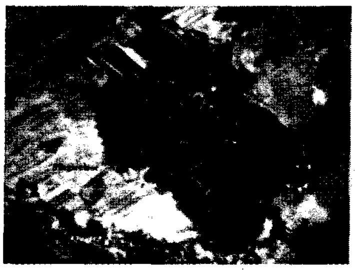
Perthite texture is coarser as secondary textural product formed as a result of unmixing mechanism in granitic rocks. In the muscovite granites, perthite was observed as perthite and microcline-perthite. The presence of coarse variety such as patchy perthite in the muscovite granites may be ascribed to deuteric alteration at temperature below 400°C (Parsons and Brown, 1984). This may be supported by the presence of partial alteration to kaolin in some perthitic crystals.

Myrmekite textures are observed at Umm Addebaa exposure. The presence of myrmekitic texture represents strong evidence for metasomatic origin, which are common in magmatic granite (Smith, 1974). Myrmekitic texture was formed due to the action of metasomatic processes with the exsolution around the margins of feldspar phenocrysts (Ashworth, 1979).

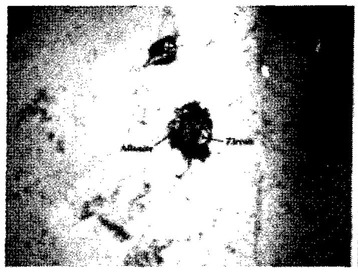
The petrographic study of the felsic minerals and biotite revealed that these minerals have been subjected to polyphase of deformation during a long span of time and a wide range of temperature conditions. Three phases could be determined as follows; the first phase took place at high temperature and it is indicated by the presence of quartz crystals with irregular shapes, most probably developed through crystal boundary migration during cooling at high temperature. The second phase probably took place at low temperature than the first phase. This phase is indicated by the presence of glide twining in plagioclase, and by the presence of flame-type perthite (Pryer, 1993). The third phase most probably took place at very low temperature conditions. This phase is evidenced by the presence of brittle fractures in grains, undulose extinction, and re-deposition of material in fractures and veins; in addition to intercrystalline deformation including faults and bent cleavage planes and twins.

Plate 1: Some petrographic features of the studied muscovite granites at W. El Gemal area

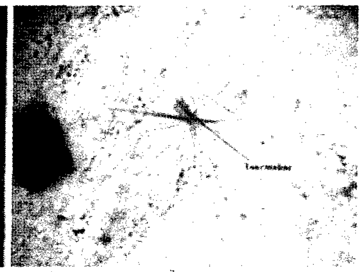




(m)



(n)



(o)

a) Oriented muscovite flakes with shred of biotite flakes in the muscovite granite of Umm Seleimat exposure. C.P., X 20.
b) Primary garnet crystal with euhedral edges in the muscovite granite of Umm Seleimat exposure. C.P.,X 20.
c) Allanite and plagioclase crystals (albite) in the muscovite granite of Umm Seleimat exposure. C.P., X40.
d) Dislocated muscovite flakes due to deformation in the muscovite granite of Sikait I exposure. C.P., X 10.
e) Kinked crystal of plagioclase in the muscovite granite at Sikait II exposure. C.P., X 20.
f) Garnet crystal wrapped by muscovite flakes in the muscovite granite of Sikait II exposure. C.P., X20.
g) Euhedral to subhedral muscovite flakes in the muscovite granite of Sikait II exposure. Notice the garnet crystal wrapped by quartz grains. C.P.,X 20.
h) Megacrysts of microcline perthite. Notice the secondary quartz as drop-like inclusions and the perthite is partially altered to kaolin in the muscovite granite of Umm El Kheran exposure. C.P., X10.
i) Muscovite flakes corroded by plagioclase in the muscovite granite of Umm El Kheran exposure. C.P., X20.
j) Skeletal crystals of garnet in the muscovite granite of Umm El Kheran exposure. P.PL., X20.
k) Veinlet of muscovite and biotite in the muscovite granite of Umm Baanib exposure. C.P., X10.
l) Albite-twinned plagioclase with broken border reflects the deformation in the muscovite granite of Umm Addebaa exposure. C.P., X10.
m) Ghost myrmikite between K-feldspar and plagioclase in the muscovite granite of Umm Addebaa exposure. C.P., X20.
n) Allanite crystal included zircon in the muscovite granite of Umm Addebaa exposure. P.PL, X40.
o) Tourmaline crystal in the muscovite granite of Umm Addebaa exposure. P.PL, X80.

RADIOMETRY

A) Spectrometric study

Gamma-ray spectrometry has been carried out on the muscovite granites using portable GS-512 spectrometer to recognize the uranium and thorium enrichment areas.

Detailed spectrometric measurements were carried out along profiles with interval 50m. The discontinuous measuring for the radiometry in these exposures has been carried out along the Wadis, fractures, as well as dikes.

The results of statistical analysis of the various radioelements and their ratios of muscovite granite at all the studied exposures are listed in table (1).

It is observed that there are two populations in the studied muscovite granites. The first is characterized by equivalent uranium content more than 5ppm and is represented by Umm Seleimat, SkaitII and Umm Addebaa exposures. The second is characterized by equivalent uranium content less than 5ppm and is represented by SikaitI, Umm El Kheran and Umm Baanib exposures.

Low eTh/eU ratios and high eU/K ratios in the granitic rocks of the study area as compared with reference granite mountains (Stuckless et al. 1983); indicate that the investigated muscovite granites of Umm Seleimat, SkaitII and Umm Addebaa exposures (Table 1) have been affected by processes that preferentially gain uranium from outer source (Stuckless et. al., 1983).

High eTh/eU ratios and low eU/K ratios in the granitic rocks compared with the granite mountains (Stuckless et al. 1983); indicate that muscovite granites of SikaitI, Umm El Kheran and Umm Baanib exposures (Table 1) have been affected by processes that preferentially remove uranium from these granites (Stuckless et. al., 1983).

Table 1: Some statistics of radiometric data and their ratios of the muscovite granites at the study area compared with some reference granites.

Umm Seleimat exposure (N = 40)						
	K%	eU	eTh	eU/eTh	eTh/eU	eTh/K
Range	1.3-7	1-19	2-20	0.14-2.4	0.1-7	1.1-7.1
Mean (X)	3.9	7.8	10.8	0.76	1.9	2.9
Sikait I exposure (N = 40)						
Range	1.4-8.6	1-11	4-27	0.06-0.86	1.17-16	1.1-11.7
Mean (X)	4.5	4.5	12.5	0.39	3.6	2.9
Sikait II exposure (N = 40)						
Range	1.2-6.3	2-33	5-17	0.2-1.7	0.36-4.67	1.3-7.1
Mean (X)	3.6	11.97	10.5	1.24	1.03	3.1
Umm El Kheran exposure (N = 40)						
Range	1-5.6	1-10	3-15	0.13-1.7	0.6-8	1.2-5.5
Mean (X)	3.1	3.9	7.3	0.58	2.3	2.5
Umm Baanib exposure (N = 40)						
Range	1.5-3.7	1-6	5-18	0.1-0.6	1.7-16	1.8-7.6
Mean (X)	2.7	2.1	10.3	0.22	6.6	3.9
Umm Addebaa exposure (N = 40)						
Range	0.3-5.9	4-20	3-13	0.55-3.75	0.27-1.8	1.3-14
Mean (X)	2.56	10.8	7.78	1.46	0.80	4
Crustal acidic igneous rocks (after IAEA, 1979 and Boyle, 1982)						
	K%	eU	eTh	eU/eTh	eTh/eU	eTh/K
Average	4	4.5	18	0.25	-	-
Range	-	1 -12	5-20	0.1-0.5	-	-
Adams et al, 1959 Clarke et.al, 1966						
	K%	eU	eTh	eU/eTh	eTh/eU	eTh/K
Average	-	4	19	0.25	-	-
Range	-	1-9	18-20	-	-	-
Granite Mountains in U.S.A (Stuckless et al., 1983)						
	K%	eU	eTh	eU/eTh	eTh/eU	eU/K
Average	3.27	3.54	16.67	-	4.37	1.05

N = number of measurements

The relation of the radioelements concentration in the muscovite granites at six exposures to those of the crustal igneous rocks after IAEA (1979), Boyle (1982), Adams et. al. (1959) and Clarke et. al. (1966) is listed in table (1).

The variation of eU & eTh contents with their ratios in the studied muscovite granites (Table 1). The studied muscovite granites in each exposure have a positive correlation of eU vs eTh, positive correlation of eU vs eU\eTh and negative correlation of eTh vs eU\eTh (Fig.6), this indicates the uranium mobilization and post magmatic redistribution within or near the magmatic pluton (Charbonneau, 1982).

Mobilization

From Table (1), and depending on the concept that the muscovite granites are intruded in a closed system, we can calculate the uranium mobilization (eU_m) in the muscovite granite at all the studied exposures, the following equation was applied; $eU_m = eU - eTh/3.5$

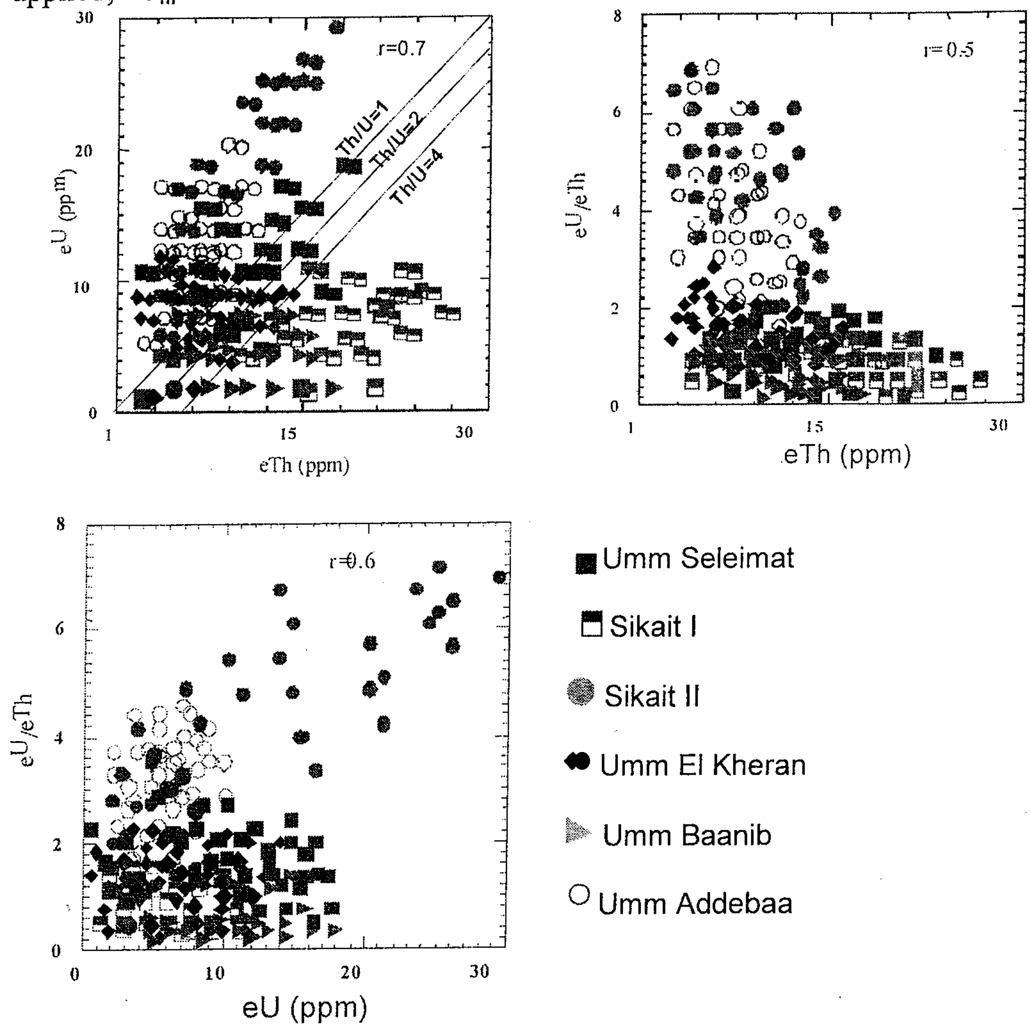


Fig. 6: Binary diagrams showing the correlation between eU, eTh and their ratios in the muscovite granites of W. El -Gemal area.

Positive value of (eU_m) indicates that the muscovite granite gain uranium from the surrounding rocks or outer source by mobilization, while negative value of (eU_m) indicates that the muscovite granite lost uranium by mobilization. The eU_m in the muscovite granite at Umm Seleimat = 4.7, at Sikait I = 0.9, at Sikait II = 8.97, at Umm El Kheran = 1.8, at Umm Baanib = - 0.8 and at Umm Addebaa = 8.6. Accordingly, the muscovite granite at Umm Baanib area is the only which lost uranium by mobilization, while the other exposures gain uranium from the surrounding rocks or outer source by mobilization

The muscovite granites are relatively normal case and have lesser values of uranium than the corresponding values in the crustal average. The prefix uraniferous should not be applied to this granite, which contain 3 ppm of eU lesser than the Clarke value. The prefix infertile should be applied according to Gangloff (1970), where the uranium content varies between 1-8 ppm.

The average value of the eTh/eU ratio is 4.5 in the muscovite granites as expected from 4 to 6 in the younger granites indicates that the muscovite granites loss uranium from these granites (Rogers et. al. 1978).

However, high eTh/eU ratios and low eU/K ratios in the muscovite granitic rocks of the study area as compared with the reference granites; indicate that the muscovite granitic rocks of the present area have been affected by processes of removing uranium from these granites (Stuckless et. al., 1983).

b) Geochemical distribution of uranium and thorium

The geochemical distribution of U & Th in the present study was carried out based on thirty samples collected from the six exposures of the studied muscovite granites. The U & Th elements were determined by used a Rigaka X-ray Fluorescence spectrometer (3100), at the department of Earth Resources Engineering, Kyushu University, Fukuoka, Japan.

The geochemical distribution data of Uranium (U) and Thorium (Th) contents in the muscovite granites at the study area are listed in table 2.

Table 2: Chemical analysis of U, Th, and their ratios and their some statistic parameters of the muscovite granites at the study area.

Rock Unit		exposure	Statistical parameter	U (ppm)	Th (ppm)	U/Th	Th/U
THE MUSCOVITE GRANITES	Umm Seleimat-Sikait exposure	Umm Seleimat (N = 5)	Minimum	1	2	0.4	1
			Maximum	6	13	1	2.3
			Mean (X)	4	7.4	0.58	1.9
		Sikait I (N = 5)	Minimum	3	9	0.3	1.4
			Maximum	8	15	0.7	3.8
			Mean (X)	5.4	12.2	0.5	2.5
		Sikait II (N = 5)	Minimum	3	2	1.3	0.3
			Maximum	9	5	3	0.8
			Mean (X)	6	3.2	1.9	0.6
	Umm El Kheran -Umm Baanib exposure	Umm El Kheran (N = 5)	Minimum	2	4	0.4	1.3
			Maximum	6	13	0.8	2.8
			Mean (X)	4	8.60	0.54	2.1
		Umm Baanib (N = 5)	Minimum	1	4	0.1	2
			Maximum	4	8	0.5	7
			Mean (X)	2	6	0.3	3.8
	Umm Addebaa exposure (N = 5)		Minimum	4	4	1	0.6
			Maximum	13	9	1.8	1
			Mean (X)	9	6	1.5	0.7

N = number of analyzed samples

Table (2) can show the followings:

The muscovite granites at Umm Seleimat-Sikait exposure show considerable average variation in U/Th ratios ranging from 0.3 at Sikait I, to 1.4 and 1.5 at Sikait II and Umm Addebaa exposures respectively (Table 2), which is higher than the range commonly recorded (0.08-0.5) for granites (e.g.,Taylor,1965, Rogers and Adams,1969a and Stuckless et. al., 1977). The high U/Th ratio of the muscovite granites may be due to their enrichment in radioactive accessory minerals such as zircon and monazite.

The muscovite granites at Umm El Kheran-Umm Bannib exposures show considerable average variation in the U/Th ratios ranging from 0.3 at Umm

Baanib exposure to 0.5 at Umm El Kheran exposure (Table 2) which is nearly equal to the range commonly recorded (0.08-0.5) for granites (e.g., Taylor, 1965, Rogers and Adams, 1969a and stuckless et. al., 1977). This reflects normal distribution of the radioelement contents.

The correlations between U, Th and their ratios in the studied muscovite granites (Fig. 7) reveal thatare shown in Figure 7 the studied granites have a positive correlation between U vs. Th, a positive correlation between U/Th vs. U and a negative correlation between U/Th vs Th.

If the U/Th ratios increase strongly with U but not with Th, post magmtic redistribution of U is suggested and if U/Th ratios are inversely correlated with Th, the radioelement distribution is, at least in part, governed by magmatic process (Charbonneau, 1982).

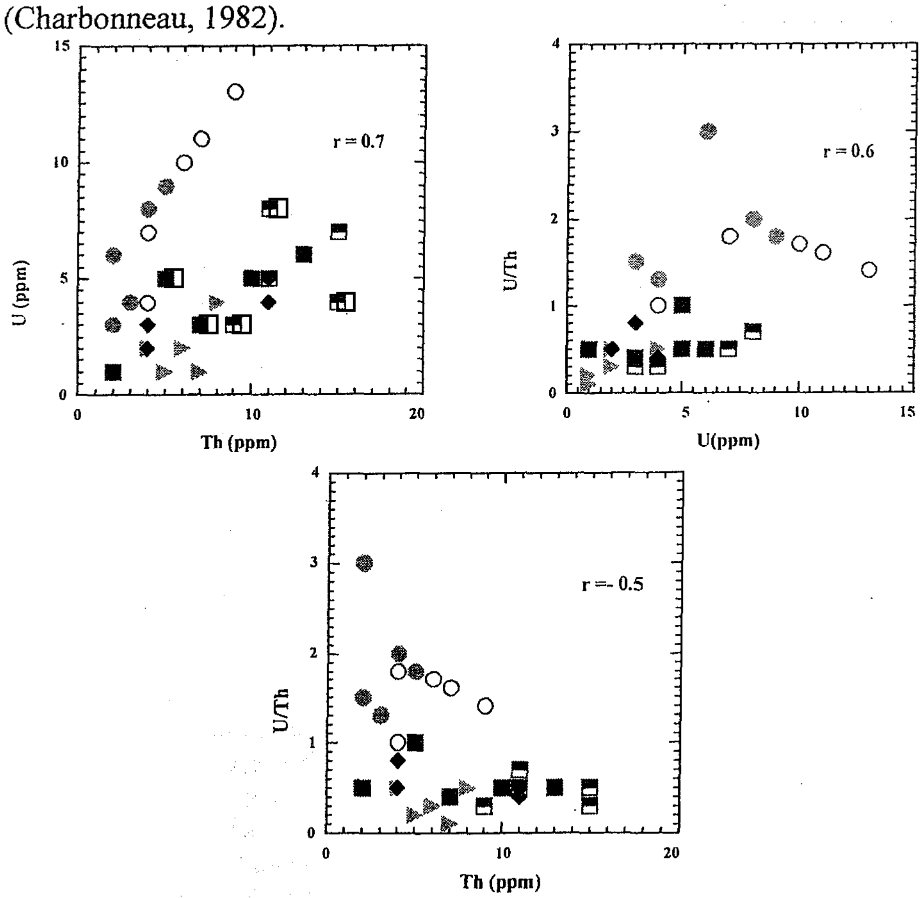


Fig.7: Binary diagrams showing the correlation between U, Th and their ratios in the muscovite granites at the study area.

■ Umm Seleimat ⬒ Sikait I ● Sikait II

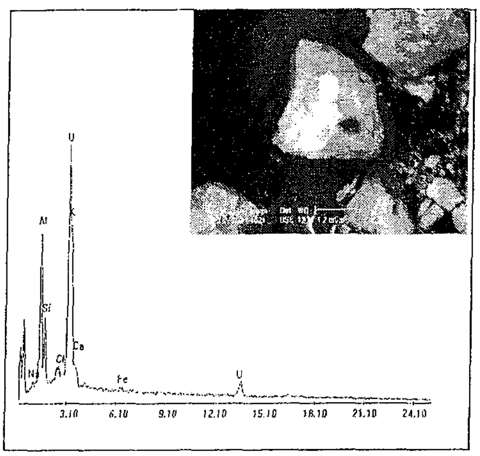
◆ Umm El Kheran ▶ Umm Baanib ○ Umm Addebaa

MINERALOGY

The mineralogical study was performed through choosing one sample from each exposure of the six exposures of the studied muscovite granites. These samples were crushed to 0.23--0.5mm. in size. The heavy minerals were concentrated employing a shaking table, bromoform (sp. gr. 2.8) and magnetic separation. The heavy fractions were further purified by hand picking under the binocular microscope. Then the mineral identification was confirmed by Scan Electron Microscope (SEM) techniques at Nuclear Materials Authority laboratories (NMA). There are most common minerals in the studied muscovite granites as:

1. Uranophane ($CaO.2UO_3.2SiO_2.6H_2O$)

Uranophane occurrs in Umm Seleimat exposure in some spots. Under binocular microscope, the uranophane grains (Fig.8) characterized by a massive radiated and tufted aggregates as well as dense microcrystalline masses. The grains are very soft with different grades of yellow to brownish yellow color. The luster is waxy or greasy and the streak is pale brown or brownish yellow.

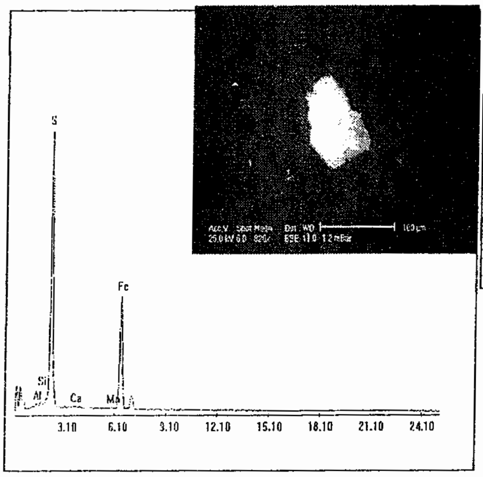


Element	Wt%	Element	Wt%
Na	0.06	Ca	2.31
Al	7.54	Fe	0.84
Si	3.99	U	79.88
Cl	0.92	Total	100.0
K	4.47		

Fig. 8: Photomicrograph showing semi-quantitative analysis for uranophane using the EDAX-SEM at the study area.

2. Pyrite (FeS_2)

It occurrs in Umm Seleimat, Sikait I, Sikait II and Umm Addebaa exposures. Pyrite (FeS_2) is widely oxidized, thus imparting some parts of the outcrops a reddish color. Pyrite (Fig.9) is found as euhedral to subhedral crystals characterized by pale brass yellow color.



Element	Wt%	Element	Wt%
Al	0.51	Mn	0.62
Si	0.79	Fe	48.63
S	49.19	Total	100.00
Ca	0.27		

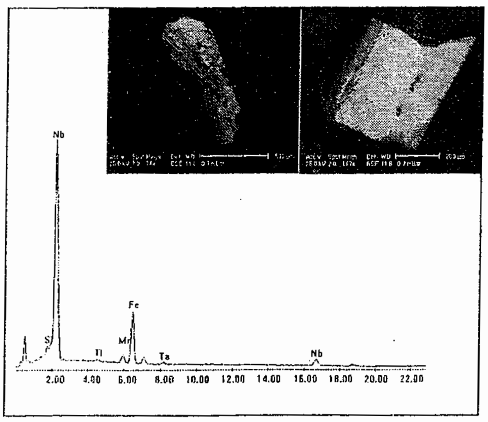
Fig. 9: Photomicrograph showing semi-quantitative analysis for pyrite using theEDAX-SEM at the study area.

3. Niobium - Tantalum Minerals

Niobium - Tantalum Minerals are recorded in all exposures especially in Sikait II

3.1. Columbite [(Fe,Mn)(Nb,Ta)$_2$O$_6$]

Columbite (Fig.10) occurs as black, flattened, prismatic and euhedral to subhedral crystals.

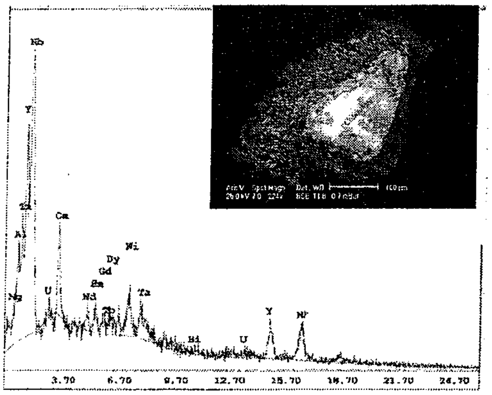


Element	Wt%
Si	7.12
Ti	1.25
Mn	4.24
Fe	36.71
Ta	4.36
Nb	46.32
Total	100.00

Fig. 10: Photomicrograph showing semi-quantitative analysis for columbite using the EDAX-SEM at the study area.

3.2. Pyrochlore (Nb, Y, Ta, U, Al, Mg, REE)

Pyrochlore (Fig. 11) is present in the form of a tabular prismatic shape. Nearly all the grains are coated by a dark brown film produced by the metamict decay. Pyrochlore contains up to 8% uranium content.

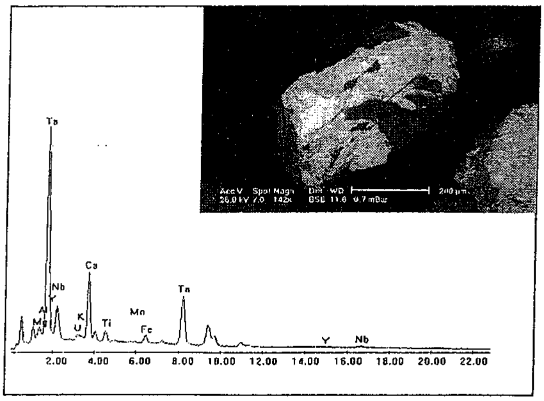


Element	Wt%	Element	Wt%
Mg	4.11	Fe	10.41
Al	8.59	Ta	1.60
U	7.94	Y	10.92
K	1.54	Nb	50.29
Ca	3.37	Total	100.0
Mn	1.23		

Fig. 11: Photomicrograph showing semi-quantitative analysis for pyrochlore using the EDAX-SEM at the study area.

3.3. Tantalite [$(Fe,Mn)(Nb,Ta)_2O_6$]

Tantalite occurs as black to deep brown with metallic appearance, flattened, prismatic and euhedral to subhedral crystals as in (Fig. 12). Most crystals are stained with iron oxide which are partially or fully coats the surface of the grains. Few grains form massive aggregates.



Element	Wt%	Element	Wt%
Mg	2.85	Mn	0.46
Al	2.04	Fe	2.22
U	3.97	Ta	61.76
K	0.42	Y	2.15
Ca	13.26	Nb	8.32
Ti	2.55	Total	100.0

Fig. 12: Photomicrograph showing semi-quantitative analysis for tantalite using the EDAX-SEM at the study area.

4. Accessory minerals

They are represented by garnet, wolframite, fluorite, beryl and iron oxides. Garnet minerals occur in all the studied exposures of muscovite granite. The most common garnet minerals are:

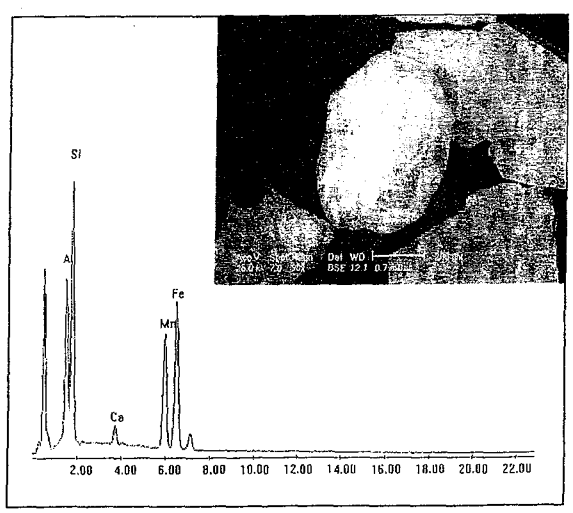
4.1. Garnet group

4.1.a. Almandine-spessartine garnet

Almandine-spessartine garnet (Fig.13) is a widespread occurrence in the muscovite granites. The spessartine molecules commonly occur in almandine, thus Fe and Mn metals are present together, indicating an inter-mixing between almandine and spessartine. This type of garnet is commonly deep red to brownish black in colors.

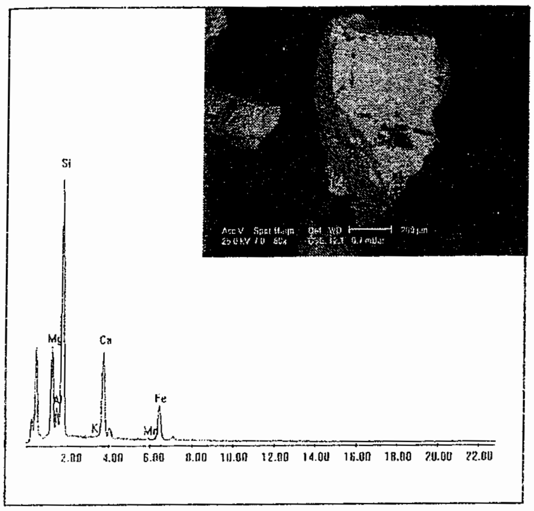
4.1.b. Pyrope- andradite garnet

The andradite molecules commonly occurring in pyrope, thus Mg and Ca metals are present together, indicating an inter-mixing between the pyralspite and ugrandite series. Pyrope-andradite garnet (Fig.14) is commonly pinkish red to purplish color.



Element	Wt%
Al	19.11
Si	34.65
Ca	1.81
Mn	19.14
Fe	25.28
Total	100. 00

Fig. 13: Photomicrograph showing semi-quantitative analysis for almandine-spessartine garnet using the EDAX-SEM at the study area.

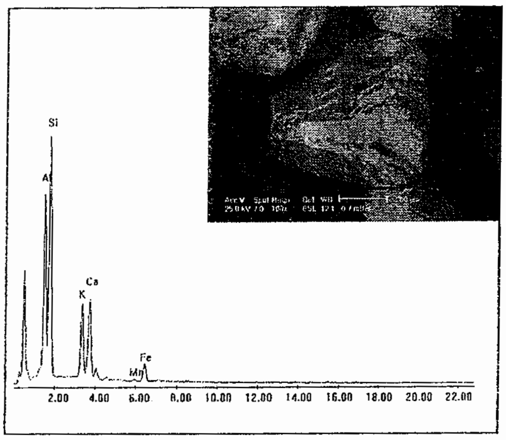


Element	Wt%
Mg	16.56
Al	6.03
Si	48.83
K	0.22
Ca	16.13
Mn	0.50
Fe	11.72
Total	100. 0

Fig. 14: Photomicrograph showing semi-quantitative analysis for pyrope-andradite garnet using the EDAX-SEM at the study area.

4.1.c. Grossularite garnet

Grossularite garnet (Fig.15) is present in the studied muscovite granites. Grossularite is a very close to the end-member in composition of ugrandite series. The color of grossularite is determined largely by the amount of iron and manganese present (Lee, 1962).

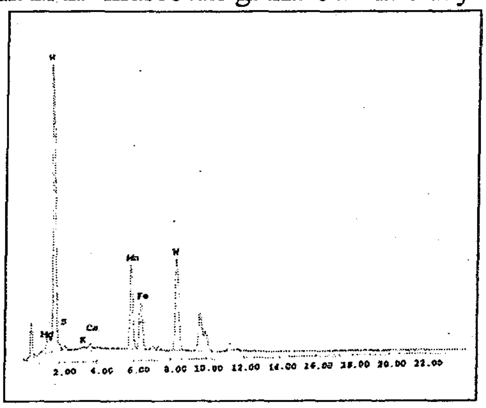


Element	Wt%
Al	23.32
Si	42.97
K	12.98
Ca	14.72
Mn	0.45
Fe	5.56
Total	100. 00

Fig.15: Photomicrograph showing semi-quantitative analysis for grossularite garnet using the EDAX-SEM at the study area.

4.2. Wolframite (Fe, Mn) WO_4

Wolframite belongs to opaque minerals and is displayed by glasses and most non-metallic minerals. Wolframite occurs as thin laminate producing a lamellar structure. It occurs in high-temperature hydrothermal veins, in greisen, granitic rocks and pegmatites (Short, Max N.,1940). Wolframite (Fig.16) is present in the muscovite granites at the study area speacially in Umm Baanib exposure.

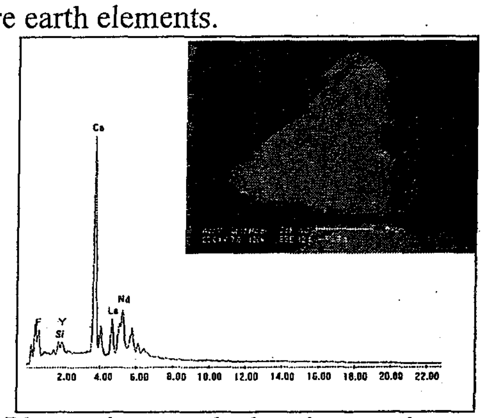


Elements	Wt%
Mg	1.64
S	0.00
K	0.25
Ca	0.70
Mn	15.32
Fe	[illegible] 13
W	7[illegible]96 Total
100.0	

Fig. 16: Photomicrograph showing semi-quantitative analysis for wallfrmite using the EDAX-SEM at the study area.

4.3. Fluorite (CaF_2)

Green fluorite is recorded in the muscovite granite at the study area, especially in Umm Seleimat-Sikait intrusion. Fluorite occurs either as disseminated subhedral grains or as veinlets, which reflects its secondary origin. Fluorite (Fig.17) exhibits colorless to pale green associated with iron oxides and contains rare earth elements.



Element	Wt%
F	45.27
Ca	54.73
Total	100.0

Fig. 17: Photomicrograph showing semi-quantitative analysis for using the EDAX-SEM at the study area.

4.4. Beryl [$Be_3 Al_2 (Si_6O_{18})$]

Beryl (Fig.18) occurs within the quartz and pegmatite veins that cut across the muscovite granite in Umm Addebaa exposure.

4.5. Iron Oxides Minerals

4.5.1. Ilmenite ($FeO-TiO_2$)

Ilmenite occurs in the muscovite granites at the study area associated with hematite and magnetite. Ilmenite has an iron black or asphaltic color as well as it is metallic and dull luster with black streak.

Fig. 18: Overview showing well developed beryl crystal enclosed in quartz at Umm Addebaa area.

4.5.2. Magnetite (Fe_3O_4)

Magnetite in the studied muscovite granites is well common of black hexahedral or octahedral in form. It has metallic to submetallic luster.

Generally, the occurrences of the above recorded minerals in the different exposures are illustrated in table (3).

Table (3): Lateral distribution of the recorded minerals in muscovite granite, Wadi El Gemal area, Southeastern Desert, Egypt.

Samples / Minerals	Um Seleimat	Sikait I	Sikait II	Um El Kheran	Um Baanib	Um Addebaa
Uranophane ($CaO.2UO_3.2SiO_2.6H_2O$)	√					
Pyrite (FeS_2)	√	√	√			√
Columbite [$(Fe,Mn)(Nb,Ta)_2O_6$]	√	√			√	
Pyrochlore (Nb, Y, Ta, U, Al, Mg, REE)	√		√			√
Tantalite [$(Fe,Mn)(Nb,Ta)_2O_6$]	√		√	√		√
Almandine-spessartine garnet	√	√	√	√	√	√
Pyrope- andradite garnet	√	√	√	√	√	√
Grossularite garnet	√	√	√	√	√	√
Wolframite (Fe, Mn) WO_4			√		√	
Fluorite (CaF_2)	√	√	√			
Beryl [$Be_3Al_2(Si_6O_{18})$]	√	√	√			√
Ilmenite ($FeO\text{-}TiO_2$)	√		√	√	√	
Magnetite (Fe_3O_4)	√					√

CONCLUSIONS

- The exposed rocks which in the study area are ultramafics, metagabbros, ophiolitic mélange, metasediments, biotite granite, muscovite granite, pink granite and post granite dykes and veins.

- The distribution of uranium, thorium and their ratios in the muscovite granites reveal that most of these granites gained uranium from outer sources and reflect the amount of remobilization and migration that took place within these granites.

- The muscovite granites were affected by numerous alteration processes which are represented by sericitization, greisenation, silicification and fluoritization. Due to these alterations processes and hydrothermal solutions, a lot of mineralizations

- The muscovite granites were affected by numerous alteration processes which are represented by sericitization, greisenation, silicification and fluoritization. Due to these alterations processes and hydrothermal solutions, a lot of mineralizations have been formed. These mineralizations include uranophane, pyrite, columbite, tantalite, beryl, tourmaline and fluorite.

- The presence of the different mineral paragnesis with the various alterations in the study area, indicates that these rocks were subjected to the effect of mineralizing acidic and alkaline solutions.

- It is believed that the various mineralizations such as uranium, beryl, Nb-Ta-minerals and tourmaline, which occurring in Wadi El Gemal and Abu Rushied area is somehow related to the muscovite granites.

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