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GEOLOGY

GEOLOGY, RADIOACTIVE MINERALOGY AND GEOCHEMISTRY OF THE GRANITEIC ROCKS OF GABAL KHASHM EL-RISHA AREA, NORTH EASTERN DESERT, EGYPT.

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Abstrat: The rocks cropping out in the area are older granitoids (quartz diorites and granodiorites), Dokhan volcanics, younger granites (syenogranites and alkali feldspar granites) and dyke swarms of mafic and felsic composition trending mainly in the NE-SW and NW-SE directions. Radiometrically, the eU and eTh contents of the studied granitic rocks are systematically increase from the older granitoids passing through syenogranites to alkali feldspar granites. Alkali feldspar granites show wide range of eU contents if compared with syenogranites. The alkali feldspar granites have high eU contents (29.5-63ppm) and high eU/eTh ratios (0.44 – 1.25) and the associated pegmatite pockets have eU contents (23.7-112ppm) suggesting a good environment for uranium occurrence. The ferruginated alkali feldspar granites and the associated pegmatite pockets show visible mineralization of metallic black and brown colours as well as waxy yellow colour in addition to disseminations of green and violet fluorite. By means of scanning electron microscope (SEM) the following radioactive minerals were identified in the pegmatite pockets and the ferruginated alkali feldspar granites: ynchodite, euxinite, samarskite, betafite, ashanite and uranophane. The presence of these minerals suggests that the hydrothermal solutions or the residual magma from which these rocks originated are not only rich in uranium and thorium, but also rich in Nb, Ta and REEs. Geochemically, the older granitoids are metaluminous, calc alkaline. near the syn-collision field and have minimum melting point at moderate to high vapour pressure (> 3 kb) and crystallized at temperature between 850° to 1000° C. On the other hand, the younger granites are metaluminous to peraluminous and calc-alkaline to alkaline in characters with highly fractionated magma essentially with potassic affinities. They could be considered as post orogenic granites (POG), intruded under dry conditions in upper level of the earth crust at water vapour pressure between 1 and 3 kb and crystallized at temperatures range from 800° to 850° C.

Introduction

Gabal(G.) Khashm El-Risha area is a part of the north Eastern Desert of Egypt covering about 351 km^2 of crystalline basement rocks. It is located in the Red Sea mountain ranges at about 80 km west of Hurghada City. The area is bounded by latitudes 27° 04` & 27° 15`N and longitudes 33° 00` & 33° 10` E. The studied area lies along the western side of Wadi El Atrash which drains westwards to Wadi

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Qena. The area can be reached from Hurghada City, through Hurghada-Gharib paved road at about 19 km (north Hurghada City), turning to west through the Pharaohs Rally desert track to reach the eastern periphery of the mapped area.The area reveals a rugged topography with moderate to high mountaineous bodies including Gabal Um Guruf (1089 m), G. El-Hamra (908 m) and G. Khashm El-Risha (899 m). It possesses outcrops of older granitoids, Dokhan volcanics, younger granites and dyke swarms. Wadis(W.) traversing the mapped area have two major trends. The first is NE-SW to NNE-SSW (W.Abu Harba and W.El-Misdar). The second trend is N-S (W.El-Atrash and –W.Um Guruf). Structures observed in the area are almost of the secondary type such as faults, foliation and joints. Faults, traversing the area are limited in number. These faults are either concomitant with wadis and drainage lines or cutting through the country rocks. They are mainly of NE-SW, NNW-SSE, NNE-SSW, WNW-ESE and NW-SE directions, while the ENE-WSW, N-S and E-W directions are less common. The Dokhan volcanics and their granitic surroundings were previously studied by several authors (Dardir and Abu Zied, 1972; Basta *et al.*, 1980; Resseter and Monrad, 1983; Khalaf, 1986; Stern and Gottfried, 1986; Khalaf, 2000; and Khalaf and Ammar, 2000).

Field Geology

According to field studies, the crystalline basement rocks cropping out in the area are classified into three main rock types arranged from the youngest and represented by the younger granites (syenogranites and alkali feldspar granites), Dokhan volcanics and Older granitoids (granodiorites and quartz-diorites).

A detailed geologic map (scale 1:50,000) for G.Khashm El-Risha area is prepared (Fig.1). The constructed map shows some differences in contact locations and distribution of rock units if compared with the other previous geologic maps of EGSMA, 1978 and of Conoco, 1987. The present map shows great modifications in contacts and also in distribution of the various rock types. For example, the Hammamat clastics that appear in the EGSMA and Conoco maps does not actually encountered in the field. The study is concerned only with the granities, with special emphasis on mineralization.

1.The older granitoids are represent the oldest rock units in the studied area and occupying about 25% of it. They mainly dominate in the southern part of the map forming a huge belt trending E-W (Fig.1) and extending south and westwards beyond the limits. They usually form low-lying separate hills. The older granitoids are whitish grey to dark grey in colour and may attain pinkish to reddish grey colours near the contacts with the syenogranites. In hand specimens the rocks are medium-to coarse-grained, massive, non porphyritic and show numerous clusters of mafic minerals. Some varieties exhibit fine-grain size, especially near the peripheries of plutons and at contacts. Generally, In the Eastern Desert of Egypt, the older granitoids are of ages ranging from 930 to 850 Ma (Hashad, 1980).The studied older granitoids are intruded by the syenogranites (Fig.2a) with intrusive sharp contacts usually dip away from the younger. Several offshoots of syenogranites are recorded in the older granitoids. These offshoots are of different sizes that decrease away from the contact area. Also, the syenogranites contain numerous xenoliths as well as roof-pendants from the older granitoids. Along the southwestern corner of the map, they enclose xenoliths of metavolcanics that cropping out beyond the southern and western borders of the mapped area. These xenoliths are partially digested and assimilated (Fig. 2b). They are elongated or oval-shaped and vary in length from 10 cm up to more than 30 cm. The older granitoids are characterized by bouldery appearance, cavernous weathering and exfoliation (Fig. 2c) with well developed jointing structure. In some areas, their peripheral parts show gneissic texture due to their emplacement.

2.The younger granites cover about 50% of the mapped area (Fig. 1). Two varieties of younger granites are identified. They were intruded in successive pulses, starting with pink granites (syenogranites), which are intruded by the red granites (alkali feldspar granites), with sharp intrusive contacts (Fig. 2d). Syenogranites are more abundant than alkali feldspar granites. They send several offshoots into Um Guruf volcanics and carry them as roof pendants (Fig. 2e).

2.1.Syenogranites are emplaced at the northern and western parts of the area (Fig. 1) as well as along the contacts between the older granitoids and the Dokhan volcanics (south G. El-Hamra and south G. Um Guruf). These rocks are characterized by exfoliation, cavernous weathering, bouldery appearance and monumental shapes. Several blocky outcrops were recorded; they are suitable for economic quarries. Xenoliths, mainly of porphyritic andesites (Fig. 2f), are rare and highly digested, with sizes do not exceed 20 cm across. The pink granites are usually coarse, but sometimes show medium porphyritic texture. Sometimes, they show a whitish pink colour due to albitization processes.

2.2.Alkali feldspar granites are encountered in the eastern and northwestern parts of the mapped area (G. Khashm El-Risha). They extend southwestward adjacent to the volcanic rocks, forming high peaks and carrying the Dokhan volcanics as roof pendants. They are richer in K-feldspars and quartz and poorer in plagioclase and mafics relative to the pink granites. These rocks are medium- to fine- grained with equigranular texture. Xenoliths are rare and restricted to the contacts with Um Guruf volcanics (Fig. 2g).These rocks include most of the pegmatite pockets in the studied area.

Dykes recorded in the study area comprise mafic (dolerites, basalts and andesites), felsic (microgranites, felsites and aplites), and alkaline (trachytes and lamprophyres) dykes. They are mainly trend in NE-SW and NW-SE directions where ENE-WSW and WNW-ESE directions are less dominant. Most of them are vertical or subvertical (> 70o dip). The number of the mafic dykes highly exceeds that of the felsic ones and the alkaline dykes are rarely encountered.

Veins of different thickness and lengths are recorded in the study area. They comprise quartz and feldspars as well as several pegmatite pockets (Fig. 2h). They generally fill irregular fractures, and cut each other forming complicated net structures.

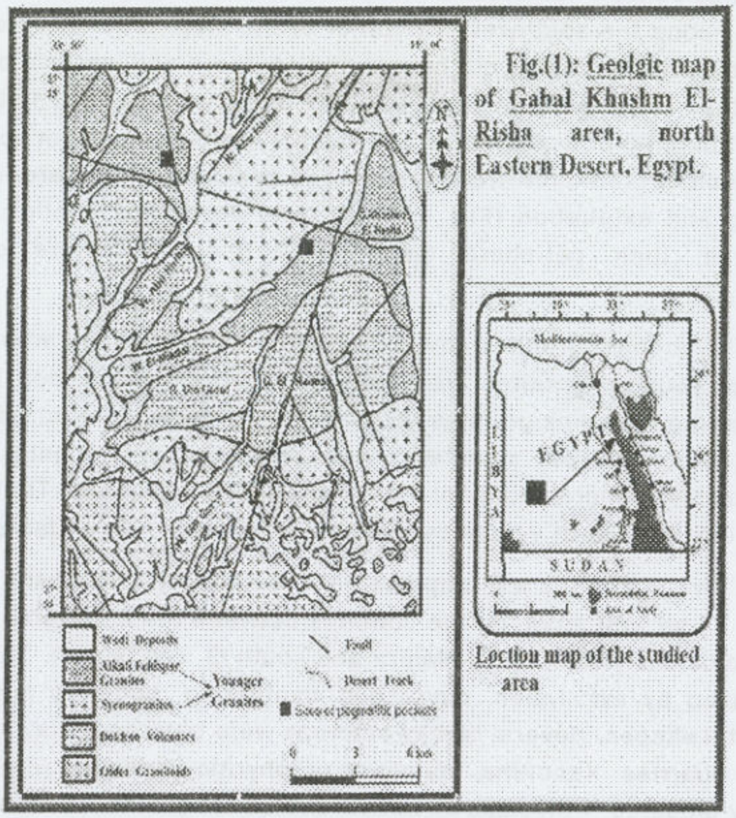


Fig.(1): Geolgic map of Gabal Khashm El-Risha area, north Eastern Desert, Egypt.

Loction map of the studied area

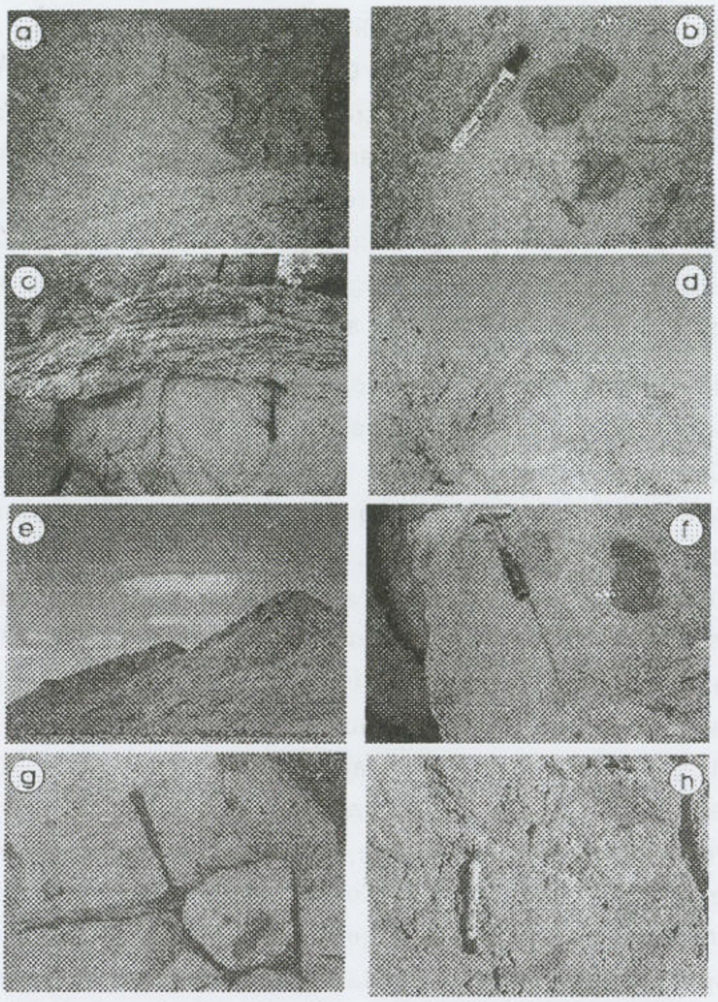
Pegmatite pockets are of different sizes but do not exceed 4 m across. Most of these pockets are of unzoned type, where some pockets show faint zoning; they possess visible mineralization of metallic black and waxy yellow colours in addition to disseminations of green and violet fluorite.

PETROGRAPHY

It is quite clear from the modal analyses (Tables1&2 and Fig. 3) of the studied rocks that the older granitoids range in composition from quartz diorites through tonalities to granodiorites where the younger granites can be classified into syenogranites and alkali feldspar granites.

1. Older Granitoids

Quartz Diorites are medium- to coarse-grained, essentially composed of plagioclase, quartz, biotite, hornblende and minor alkali feldspars. Titanite, zircon, apatite and opaques are accessory minerals. Epidote, chlorite, sericite and kaolinite are secondary minerals. In some sections, gneissose texture is observed. *Plagioclases* (An_{20}-An_{35}) occurs as euhedral to subhedral prismatic and tabular crystals exhibits various types of twinning as albite, pericline and combined albite-Carlsbad. Some plagioclase crystals display oscillatory zoning



(Fig.2a): Syenogranites intruding older granitoids, Wadi Um Guruf, looking southeast.

(Fig.2b): Close up view showing partially digested xenoliths of metabasalts in the older granitoids.

(Fig.2c): Close up view for older granitoids showing exfoliation.

(Fig.2d): Syenogranites intruded by alkali feld. granites with sharp intrusive contact, looking northwest.

(Fig.2e): Syenogranites carrying Dokhan volcanics as roof pendants, Wadi El-Misdar, looking south.

(Fig.2f): Close up view showing oval-shaped xenoliths of porphy. andesites in syenogranites.

(Fig.2g): Close up view showing oval-shaped xenolith of Dokhan volcanics in the alkali-feld. granites.

(Fig.2h): Close up view showing unzoned pegmatite pocket consisting of quartz and K-feldspar.

with an altered core and fresh rims. Others show kinking and deformation (Fig. 4a). Plagioclase is commonly enclosing apatite, quartz, smaller plagioclase crystals and sometimes opaques. Quartz occurs as interstitial anhedral crystals among the pre-existing minerals. They show corroded margins against plagioclase and hornblende. Sometimes, they exhibit wavy extinction and/or cracking. Alkali feldspars are very rare, mainly represented by flame and patchy-type orthoclase perthite. *Orthoclase* occurs as subhedral equant crystals. It usually exhibits simple twinning with slight alteration to sericite and kaolinite. Biotite occurs as irregular flakes, up to 0.6 mm long. Most of them are partially altered to chlorite and iron oxides especially along the cleavage planes and their margins (Fig. 4b). *Hornblende*, of green colour, occurs as subhedralprismatic crystals. They poikilitically enclose zircon and apatite prisms with opaques. Titanite presents as irregular patches and sphenoid-shaped crystals enclosed in hornblende, biotite and sometimes plagioclase. Apatite occurs as needle-like crystals enclosed in quartz, hornblende and biotite.

Granodiorites are coarse-grained, composed mainly of plagioclase and quartz together with subordinate amounts of alkali feldspars, biotite and hornblende. Opaques, zircon, apatite and titanite are accessory minerals. Chlorite, sericite and kaolinite are secondary minerals. Plagioclase (An_{15}-An_{25}) occurs as subhedral prismatic crystals, up to 2.0×3.8 mm. The fresh crystals show albite twining. They are commonly altered to sericite and kaolinite while the zoned crystals are characterized by more altered core relative to rim. *Quartz* occurs as anhedral interstitial crystals between the other mineral constituents. They show wavy extinction (Fig. 4c) and cracking; the cracks are usually filled with fine quartz crystals, clay minerals and iron oxy-hydroxides. *Alkali feldspars* are represented by simply twinned, flame-like type orthoclase perthites (Fig. 4d). They are altered to kaolinite and sericite, which slightly mask its twinning. Biotite occurs as irregular and elongated flakes of brown color occasionally enclose feldspars, iron oxides, epidote and quartz poikilitically. They are generally chloritized, especially along cleavage planes and peripheries. Hornblende, occurs as small green crystals, with simply twinned, and slightly altered to chlorite and iron oxides.

Table (1): Modal analyses of the studied older granitoids

Rock type	Quartz diorites						Granodiorites					
Sample No.	1	2	3	4	5	6	7	8	9	10	11	12
Quartz	13.7	17.2	15.3	14.5	16.4	18.2	28.3	25.6	29.2	20.8	22.3	29.2
Plagioclase	64.8	61.5	62.5	64.8	62.3	60.5	45.1	46.8	39.5	53.2	44.4	38.5
Alkali feldspars	3.5	4.8	6.0	3.3	5.0	3.8	12.6	15.8	18.0	13.2	18.1	16.0
Biotite	7.6	7.8	8.5	7.4	8.6	8.8	8.6	5.0	9.5	7.3	11.2	10.5
Hornblende	4.8	3.8	4.2	4.2	5.0	3.8	2.6	2.2	--	--	1.7	--
Accessories* and opaques	5.6	4.9	3.5	5.8	2.7	4.9	2.8	4.6	3.8	5.5	2.3	5.8

Table (2): Modal analyses of the studied younger granites

Rock type	Syenogranites						Alkali feldspar granites					
Sample No.	13	14	15	16	17	18	19	20	21	22	23	24
Quartz	34.5	46.2	42.0	39.2	39.1	32.6	22.1	23.3	26.0	24.3	22.1	26.7
Plagioclase	9.2	10.2	10.6	11.5	12.1	16.1	5.6	5.8	7.4	5.8	7.1	6.6
Alkali feldspars	48.0	39.1	44.4	46.1	46.8	48.5	70.6	67.2	64.1	66.2	69.4	63.0
Biotite	2.9	2.5	0.9	1.5	0.7	1.1	0.1	0.4	0.5	0.4	0.3	0.8
Muscovite	2.4	1.3	1.1	1.3	0.6	0.9	0.5	1.7	1.2	0.7	0.5	1.2
Accessories* and opaques	3.0	0.7	1.0	0.4	0.7	0.8	1.1	1.6	0.8	2.6	0.6	1.7

* Accessories*: Fluorite, titanite, zircon and apatite

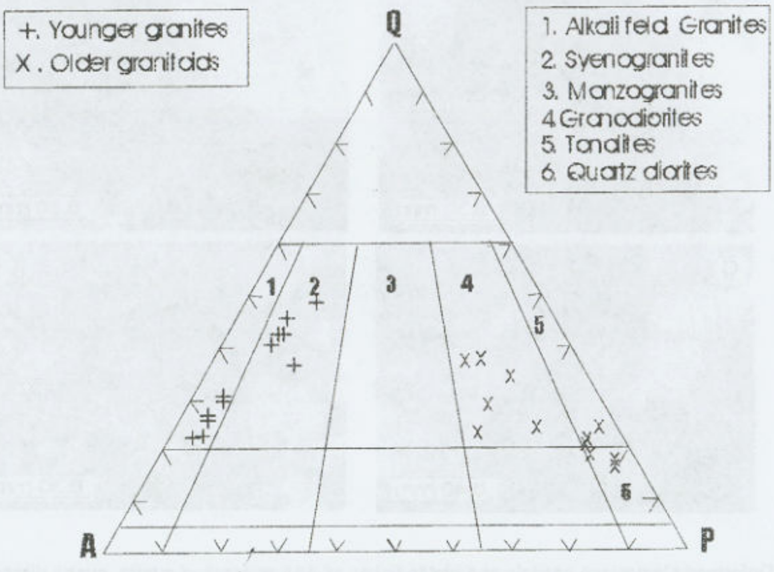
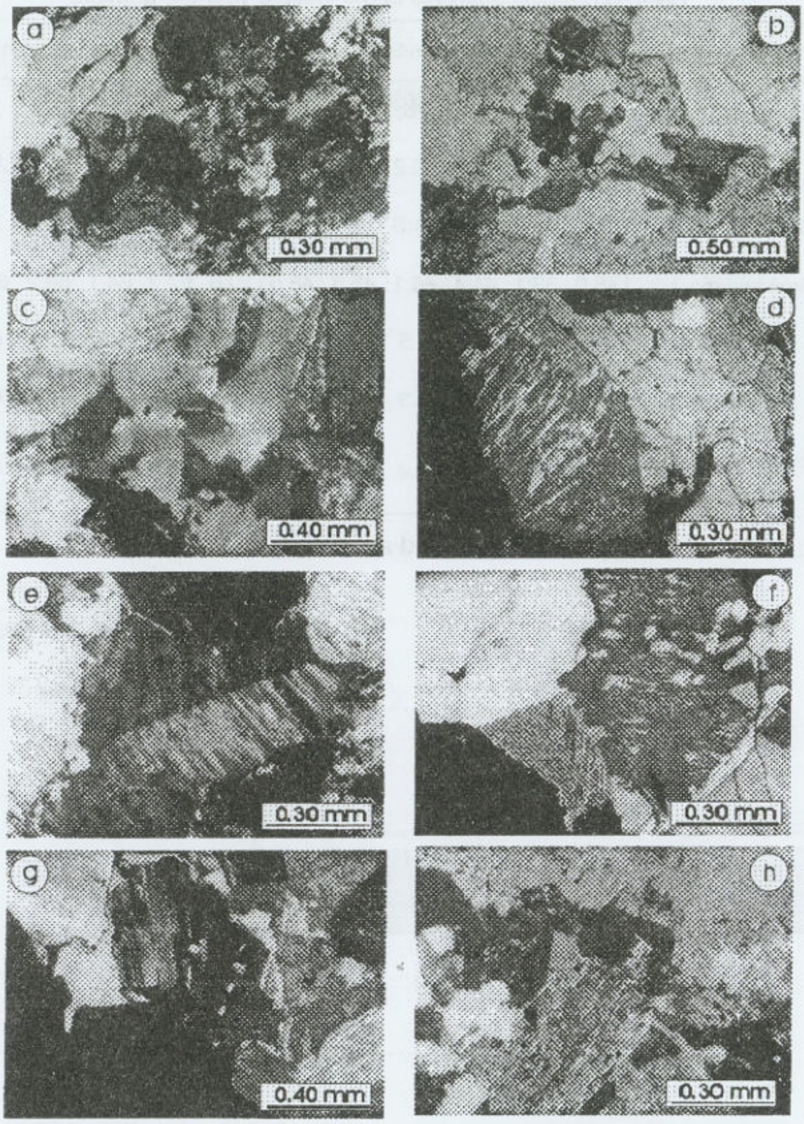


Fig. (3): Q-A-P ternary diagram (Streckeisen, 1976) for the studied older granitoids and the younger granites

2. Younger Granites

The studied younger granites comprise syenogranites and alkali feldspar granites. They are fine, medium to coarse grained, ranging in color from pink to reddish colour and consist mainly of various ratios of alkali feldspars, quartz, plagioclase and biotite in addition to muscovite. The accessory minerals are, epidote, barite, zircon, and fluorite as well as iron oxy-hydroxides.

Alkali feldspars increase in abundance from syenogranites (about 45.5%) to alkali feldspar granites (about 66.8%). The ratios of microcline/orthoclase and orthoclase/plagioclase also increase in the same trend. The former ratio suggests that syenogranites were crystallized at relatively higher temperature than alkali feldspar granites. Microcline perthite and orthoclase perthite of patchy and flame types are found as anhedral crystals up to 2.1 mm across They are usually corroded by quartz, small plagioclase crystals and fluorite. In the same time, they enclose minute crystals



(Fig. 4a): Deformed plagioclase crystals and biotite flakes as well as cracked quartz, quartz diorites, C.N.
(Fig. 4b): Biotite flakes showing different degrees of chloritization, quartz diorites, C.N.
(Fig. 4c): Quartz showing andulose extinction, granodiorites, C.N.
(Fig. 4d): Flame-like type orthoclase perthite with cracked quartz and plagioclase, granodiorites, C.N.
(Fig. 4e): Fresh simply twinned orthoclase perthite corroding other altered perthites, alkali feld. granites, C.N.
(Fig. 4f): Quartz enclosing primary muscovite and corroding biotite and feldspars, syenogranite, C.N.
(Fig. 4g): Slightely altered plagioclase crystals showing lamellar twinning, syenogranite, C.N.
(Fig. 4h): Fresh biotite flakes, alkali feldspar granites, C.N.

of zircon, barite and fluorite. Their cracks are usually filled with epidote, quartz and secondary muscovite . They are mainly unaltered with conspicuous simple twinning (Fig. 4e), while the kaolinized and sericitized crystals are rare in the syenogranites and absent in the alkali feldspar granites.

Quartz decreases in abundance from syenogranites (about 38.9 %) to alkali feldspar granites (about 24.1 %). Generally, three forms of quartz can be identified. The first one is common in syenogranites. It is coarse, interstitial anhedral crystals, appears to be developed due to overgrowth of the early-crystallized quartz due to process of silicification. They contain fine inclusions of clay minerals, barite, zircon, fluorite and iron oxides, especially along peripheries and are characterized by irregular or sutured boundaries and sometimes they enclose secondary muscovite flakes (Fig. 4f). This quartz corrodes feldspars and biotite and sometimes shows undulose extinction and cracking due to deformation. The second form is fine-grained undeformed and clear crystals that may represent a second crystallization stage. The third form is found as inclusions of variable sizes and shapes within other minerals. This form is probable to be the early crystallized phase. On the other hand, secondary quartz occurs as fine crystals filling fractures and cracks. Crystals showing undulose extinction in the alkali feldspar granites are completely absent, indicating that this rock is less deformed than the syenogranites. Some quartz crystals show myrmikitic and graphic textures with feldspars, revealing reaction during crystallization.

Plagioclase decreases in abundance from syenogranites (about 11.6 %) to alkali feldspar granites (about 6.4 %). In addition, the calcium contents and alteration as well as deformation decrease in the same trend. The majority of crystals show clear lamellar twinning without or with slight visible alteration (Fig. 4.g). Some crystals represent an older plagioclase phase corroded by other minerals while others show zoning, indicating local albitization.

Biotite occurs as medium to large irregular flakes usually corroded by the other essential minerals and sometimes charged with opaques, zircon and epidote. Biotite flakes of syenogranites are more fresh than that of alkali feldspar granites (Fig. 4h).*secondary muscovite* flakes are found as irregular, yellow, elongated, fan-shaped or leaf-like flakes. The presence of conspicuous amounts of muscovite suggests genesis from peraluminous magma. Some muscovite flakes show pleochroic haloes. In some cases, muscovite appears secondary filling the cracks.

Zircon occurs in a very minor amount as subhedral to euhedral prismatic crystals found as inclusions in feldspars and quartz. Zircon crystals are usually cloudy and rimmed by iron oxides. *Fluorite* is found as anhedral fine crystals, usually associated with iron oxides, enclosed in quartz and/or corroding micas and feldspars. They are usually colourless, but faint green and violet varieties are also present. *Iron oxides* are scattered as dissemination in the rock and/or as tiny inclusions in mica, quartz and feldspars

Radioactivity

The study area was radiometrically surveyed using gamma-ray spectrometer (model UG-130), in which, certain ranges of energy or windows are selected and gamma-rays in each energy range per second were counted. The prevailing topographic conditions prevented carrying out field gamma-ray radiometric survey according to a regular pattern traverses. During the study, almost all lithologic units exposed in the area of study were radiometrically surveyed. Particular attention was paid to all structural features such as contacts and faults as well as hydrothermally altered zones.The obtained data of U and Th in cps are recalculated to eU (equivalent uranium) and eTh (equivalent thorium) contents in ppm. This data in addition to eU/eTh and eTh/eU ratios are summarized in Table (3). These data are represented as bar histograms (Fig. 5) for comparison between the radioactivities of the rock units cropping out in the area.Uraniferous rocks are defined according to Darnley (1982) as any rock containing uranium at least twice the Clarke value (4 ppm). Assaf *et al.* (1997) concluded that uraniferous granites contain more than 18 ppm uranium. The studied younger granites show average eU contents greater than 19 ppm. Also, the previously mentioned rocks show high eTh contents suggesting that they originated from magma rich in radioelements. The alkali feldspar granites show wide range of eU contents if compared with syenogranites; the wide range of eU contents may attribute to secondary (post magmatic) processes which caused the redistribution (enrichment and/or depletion) of uranium.The rocks of eU/eTh average ratios greater than 0.4 are considered to be favourable environment for uranium deposits (Cambon, 1994). In Gabal Khashm El-Risha area, syenogranites and alkali feldspar granites show eU/eTh average ratios greater than 0.4.Normally, thorium is three times as abundant as uranium in rocks (Rogers and Adams, 1969). When this ratio is disturbed, it indicates a depletion or enrichment of uranium. In this work, the younger granites show eTh/eU average ratios lower than 3 suggesting addition of uranium to these rocks during secondary processes. High eU contents (29.5-63ppm) and high eU/eTh ratios (0.44-1.25) may suggest that alkali feldspar granites represent a good environment for uranium mineralization. This conclusion is confirmed in the field by the presence of several anomalous values of uranium contents (23.7-112 ppm) following some zoned and unzoned oval-shaped pegmatite pockets and ferruginated spots in the alkali feldspar granites. They sometimes show visible mineralization of metallic black and brown colours as well as waxy yellow colour in addition to disseminations of green and violet fluorite.

MINERALOGY

Mineralizations in the pegmatite pockets and ferruginated spots in the alkali feldspar granites were identified by means of EDAX-SEM technique (Philips XL30 attached with accelerating voltage of 30 kV.). To identify feldspars of pegmatites associated with radioactive minerals, it is noticed that they are mainly represented by perthites. The exsolved plagioclase phase is mainly of albite-oligoclase composition. The associated radioactive minerals occurred either as veinlets cutting and/or filling the fractures in perthites or as disseminations. They are represented by betafite, samarskite, lyndochite and euxinite (Figs.6a,b,c,d,e&f). Composite grains of ashanite and betafite are also encountered (Figs. 7a &b).

Table (3): eU and eTh contents (in ppm) and their ratios of the studied rocks

Contents	Rock type	Older granitoids (N = 285)	Younger granites: Seyenogranites (N = 315)	Younger granites: Alkali feldspar granites (N =159)
eU (ppm)	Minimum	2.5	17.4	29.5
	Maximum	8.1	31.5	63.0
	Average	3.9	21.4	41.0
eTh (ppm)	Minimum	11.2	34.1	29.4
	Maximum	25.7	82.1	98.1
	Average	13.8	50.0	67.2
eU/ eTh	Minimum	0.21	0.38	0.44
	Maximum	0.34	0.82	1.25
	Average	0.27	0.50	0.67
eTh/ eU	Minimum	2.88	1.22	0.80
	Maximum	4.76	3.63	2.26
	Average	3.69	2.01	1.52

N = number of readings measured I each rock variety

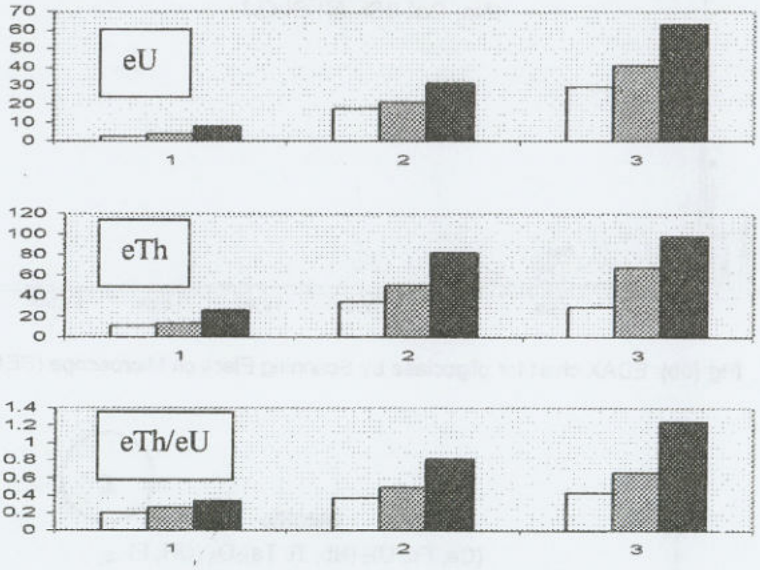


Fig. (5): Equivalent uranium (eU) and thorium distributions (eTh) and eTh/eU ratios in the studied rock

1. Older granitoids 2. Syenogranites 3. Alkali feldspar granites

Minimum Average Maximum

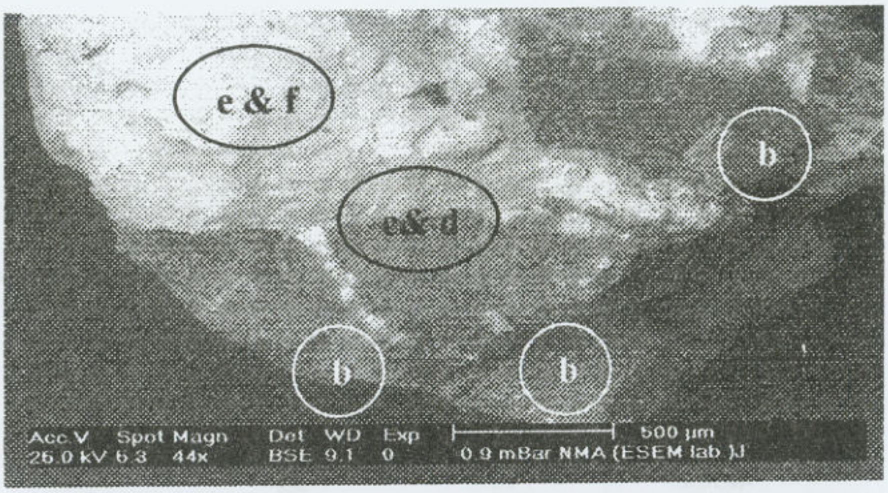


Fig (6a): Microphotograph by Scanning Electron Microscope (SEM) for oligoclase (b) associated with betafite and samarskite (c&d), lyndochite and oxinite (e&f)

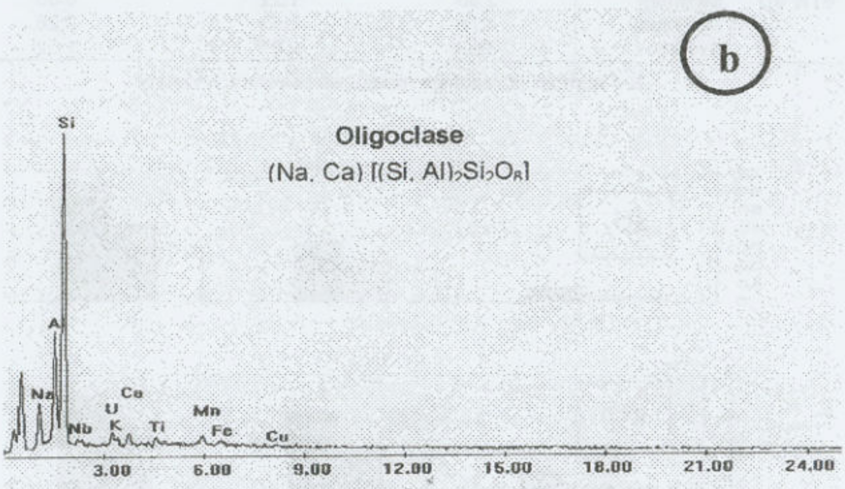


Fig (6b): EDAX chart for oligoclase by Scanning Electron Microscope (SEM)

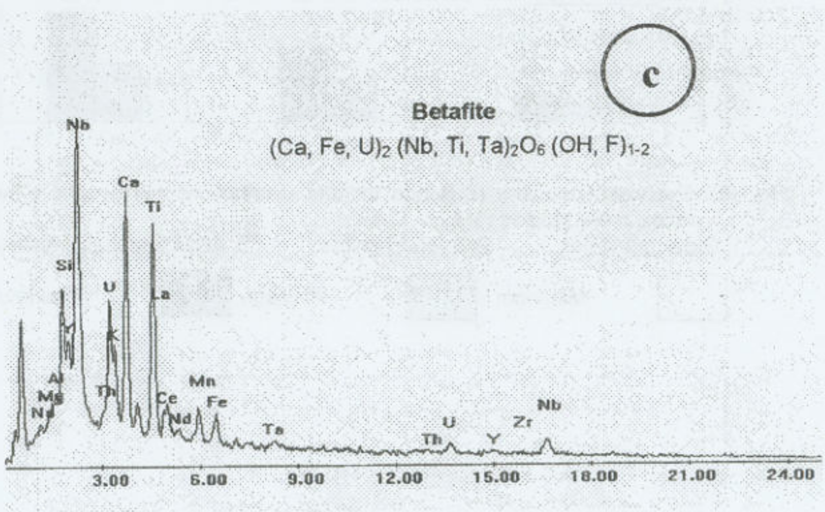


Fig (6 c): EDAX chart for betafite by Scanning Electron Microscope (SEM)

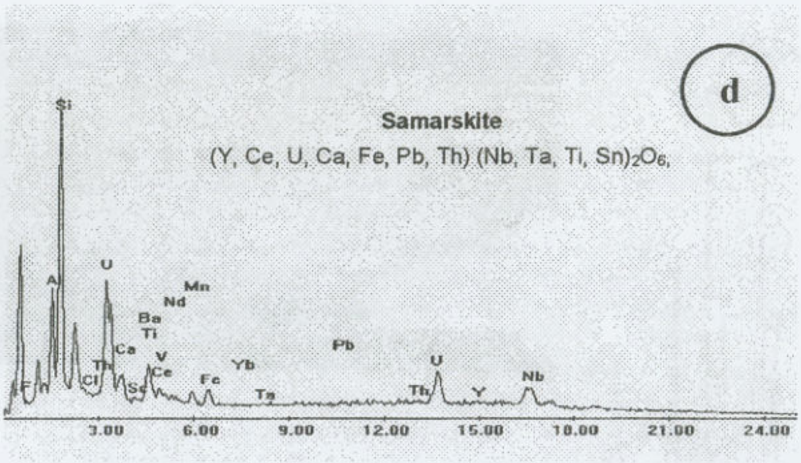


Fig (6 d): EDAX chart for samarskite by Scanning Electron Microscope (SEM)

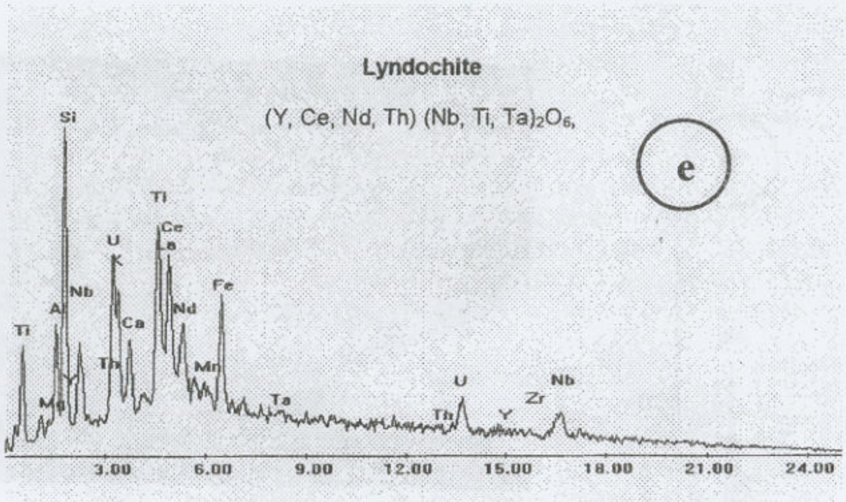


Fig (6 e): EDAX chart for lyndochite by Scanning Electron Microscope (SEM)

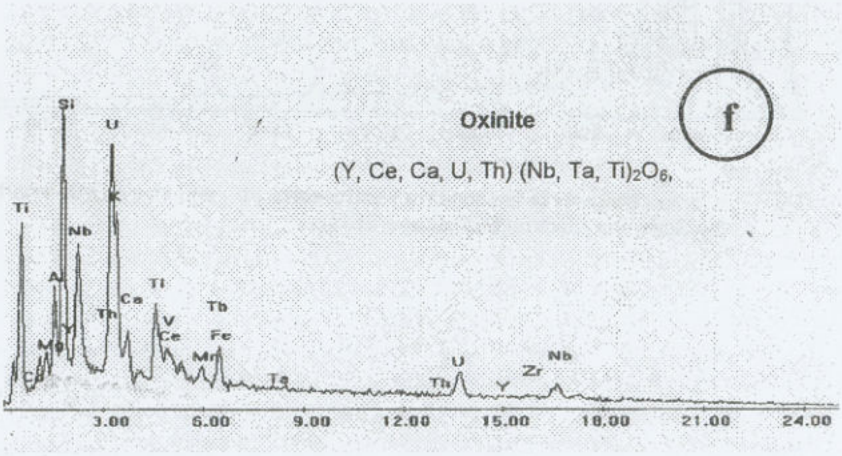


Fig (6 f): EDAX chart for oxinite by Scanning Electron Microscope (SEM)

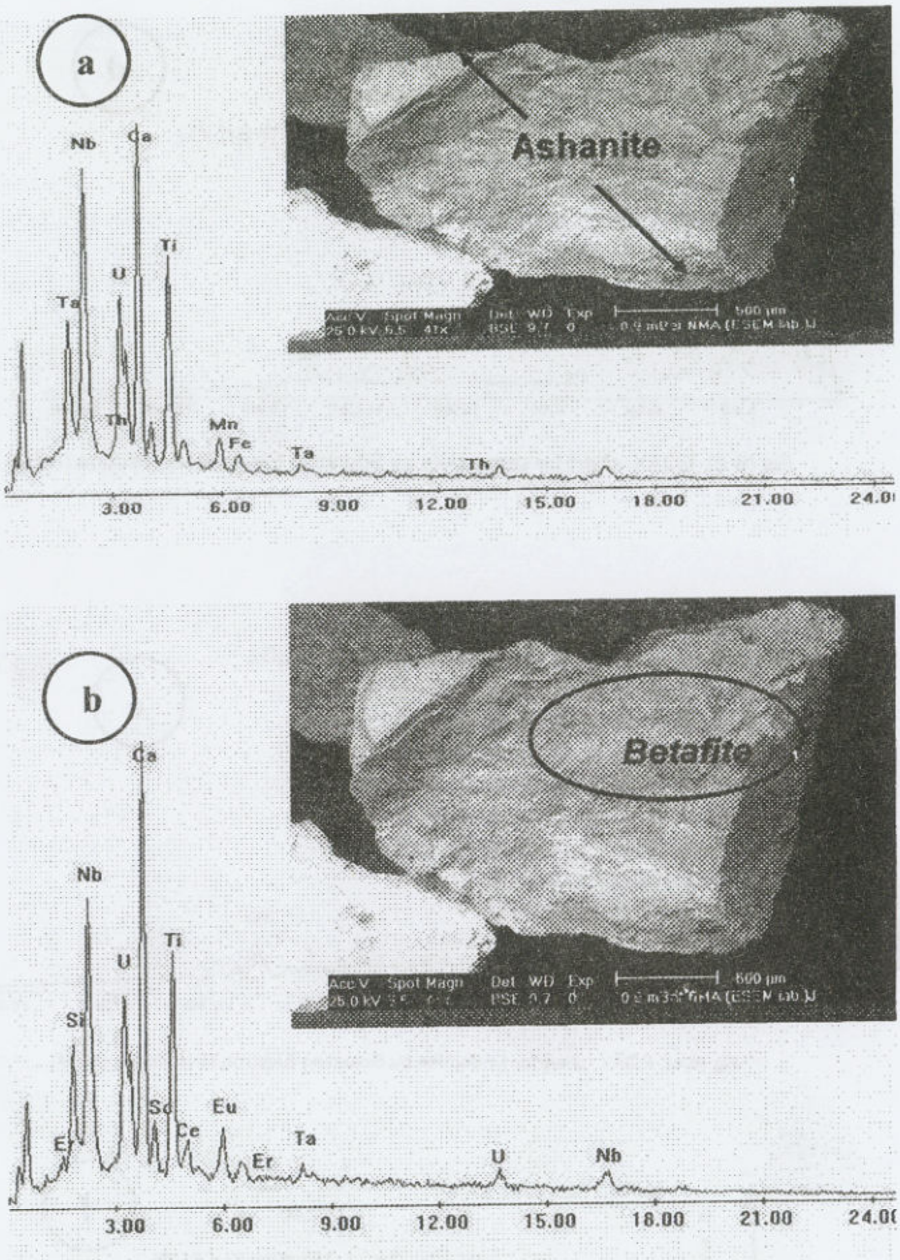
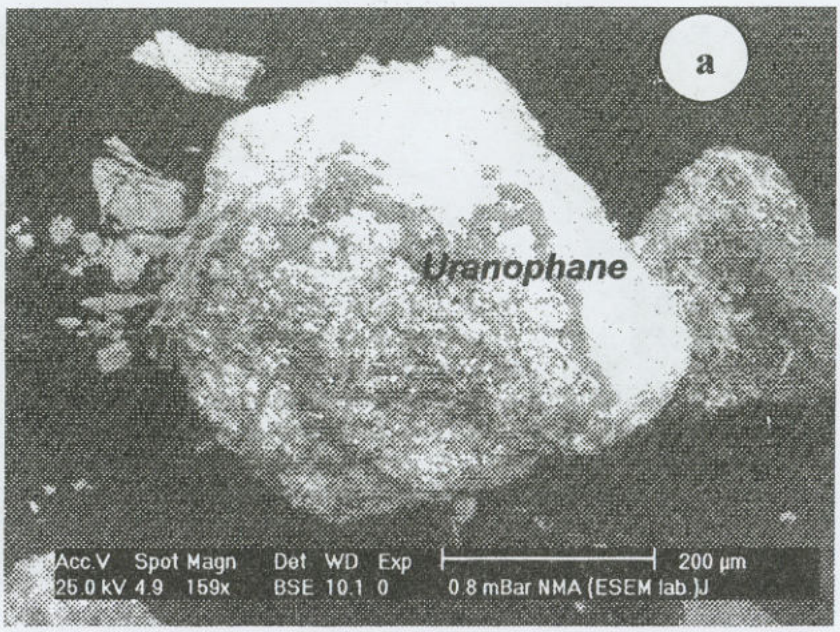


Fig. (7): Composite grain of ashanite (a) and betafite (b) and their EDAX charts by Scanning Electron Microscope(SEM)



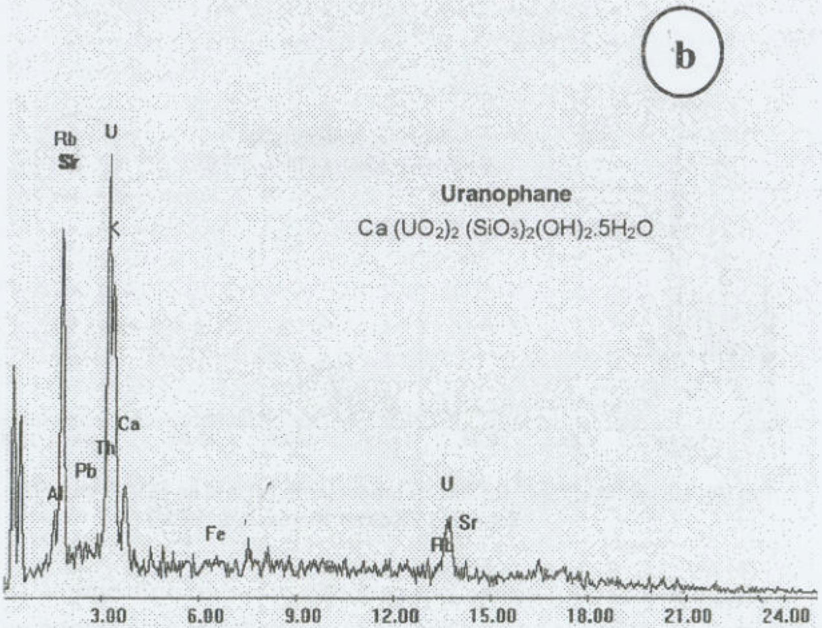


Fig (8): Microphotograph for uranophane (a) and its EDAX chart (b) by Scanning Electron Microscope (SEM)

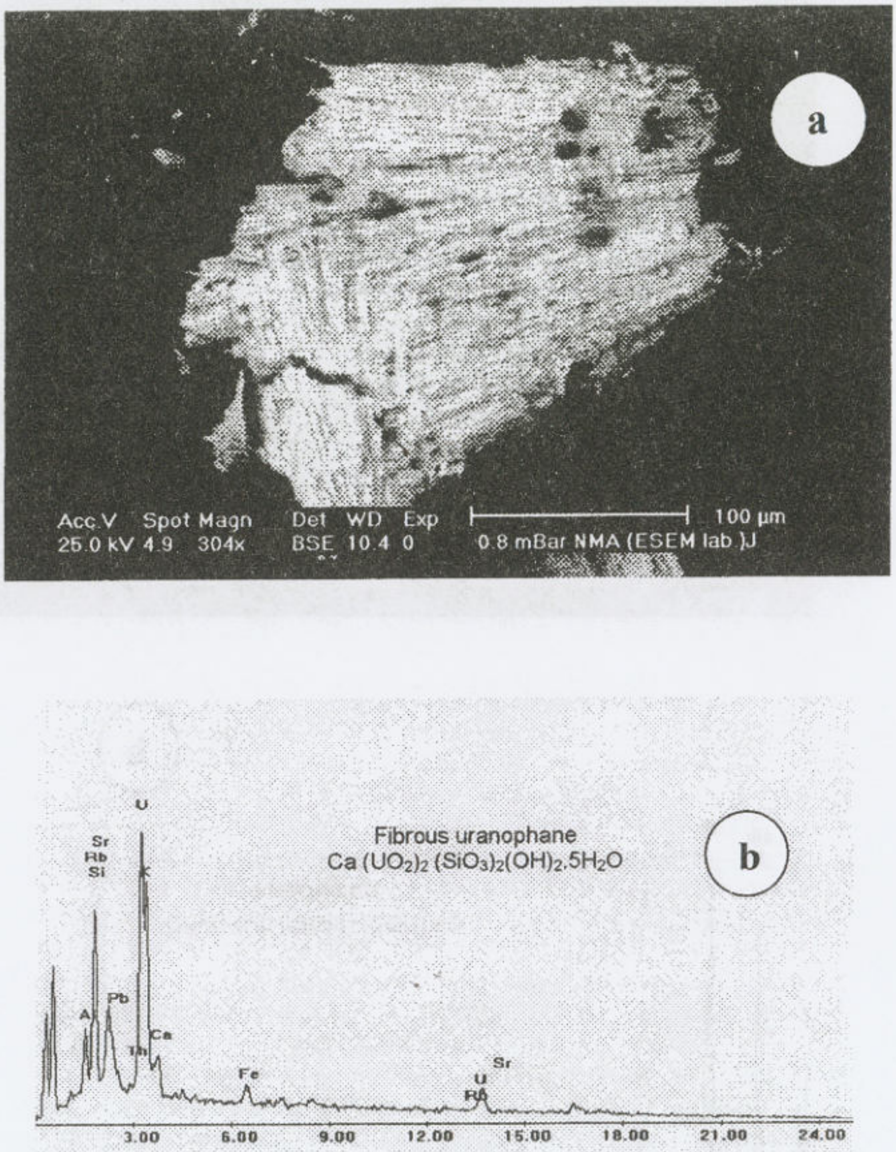


Fig (9): Microphotograph for fibrous uranophane (a) and its EDAX chart (b) by Scanning Electron Microscope (SEM)

Uranophane occurs either as randomly oriented aggregates (Fig.8a&b) or as fibrous radiate acicular ones (Fig.9a&b). All of them are stained with iron oxy-hydroxides. The presence of these minerals suggests that the hydrothermal solutions or the residual magma from which these pegmatites originated are not only rich in uranium and thorium, but also rich in Nb, Ta and REEs.

Geochemistry

Seventeen samples of the studied granitic rocks are chemically analyzed for major oxids and trace elements by means of wet chemical techniques (Shapiro and Brannock, 1962) and X-ray fluorescence (Phillips PW 1410 together with a

MO-target tube operated at 50 kV and 30 mA) respectively. These analyses were carried out in the laboratories of Nuclear Materials Authority (NMA), Egypt. Tables (4 and 5) present the geochemical analyses, some geochemical ratios and parameters of the studied rocks as well as symbols used for plotting.These analyses revealed that the older granitoids are higher in FeOT, Al_2O_3, MnO, MgO, K_2O and CaO but lower in SiO_2, TiO_2 and Na_2O than those of the average older granitoids recorded by El-Gaby (1975) and higher in CaO, MnO, MgO, Na_2O and K_2O and lower in SiO_2, TiO_2, Al_2O_3, and P_2O_5 as well as relatively similar in the other major oxides with those of average world granodiorites of Le Maitre (1976). Regarding the trace elements, the studied older granitoids have low Rb, Sr, Zr and Y contents and highe Ba contents compared with those of granodiorites of Takla *et al.* (1991).The studied younger granites are high in SiO_2 and low in CaO and can be correlated with younger granites of El-Gaby (1975). The syenogranites have high contents of SiO_2, TiO_2, Ba and Sr and low contents of FeOT, Na_2O, Rb, Y and Nb. They have an average CaO content equal to 0. 99 %. The potash contents are more than the soda contents and their ratios are more than 1.13. On the other hand, the alkali feldspar granites have high SiO_2, Na_2O, Nb and Pb and low Al_2O_3, CaO, Ba Y, Zr and Sr contents relative to syenogranites. The potash contents are slightly exceeding soda contents. They are considered as low calcium granites with an average value of 0.64 % CaO. They have FeOT, MgO and TiO_2 contents with average values of 1.17 %, 0.29 % and 0.09 %.respectively. These results reveal that the alkali feldspar granite is more differentiated than the syenogranites.

The petrochemical characteristics of the studied granitic rocks are identified by certain parameters as differentiation index (D.I.), solidification index (S.I.) and geochemical ratios tables (4&5). The solidification index (S.I.) decreases gradually with the increase of acidity (i.e. from older granitoids [14-16] to younger granites [2.20-3.10]. The older granitoids are the relatively basic rock units while the younger granites are distinctly acidic. The differentiation index (D.I.) values of the older granitoids(Tables 4&5) are relatively low (from 70.14 to 75.03) compared with those of the younger granites (ranging between 91.64 and 93.99). These high values of the younger granites indicate a highly differentiated magma, but the very narrow range within each rock type reflects a high degree of homogeneity. K/Rb has been used as an index of differentiation to separate granitic rocks of similar mineral composition and major element contents (Buttler *et al.*, 1962). K/Rb ratio in igneous rocks, resulted from lower crustal or upper mantle materials, range from 700 to 1500 (Heier, 1973). Taylor (1968) suggested that the average K/Rb ratio for granite is 240. Generally K/Rb ratio decreases with fractionation (Heier, 1970). In the studied granitic rocks, K/Rb ratio shows wide range (535-1350) in older granitoids and (129-464) in younger granites. This is attributed to the wide modal variation of biotite which is more tolerant for the large Rb ions (El-Gaby, 1975). The ratio of Rb/Sr increases with magmatic differentiation due to Sr depletion in liquid magmas as a result of crystallization of feldspars, while Rb is enriched in the liquid phase. In the present study, the studied older granitoids have Rb/Sr range from 0.03 to 0.20 reflecting low differentiation. The studied younger granites have a high range of Rb/Sr ratios (from 0.5 to 14) suggesting that they originated from highly differentiated magma. Gast (1965) and Heier (1973) have shown that, high K/Rb ratios and low Rb/Sr ratios are characteristic features for rocks formed from lower crust or upper mantle. On the contrary, the younger granites have low K/Rb ratio, and high Rb/Sr ratio indicating their formations from the sialic crust. The K/Ba ratio of granitic rocks in the crust suggested by Mason (1966) is 65. In the studied granitic rocks, the K/Ba ratios range from 30 to 43 for older granitoids and from 98 to 341 for younger granites (Tables 4&5). The ratios higher than Mason's value reflect depletion of Ba in source magma and /or advanced degree of magma differentiation and contribution of sialic crustal materials. The ratio of Ba/Rb decreases with magmatic differentiation due to crystallization of the feldspars. The average crustal ratio of Ba/Rb for granites, as given by Mason (1966), is 4.1. In the older granitoids, the Ba/Rb ratio ranges between 10 and 38, suggesting mantle origin but in the younger granites, the Ba/Rb ratio ranges between 0.56 and 4.2 with an average 2.21 (lower than Mason's value), suggesting crustal origin.

The major oxides as well as the normative values are used to classify the studied granitic geochemically. On the Or-Ab-An ternary diagram (O'Connor, 1965 and Barker, 1979), the studied older granitoids plot in trondhjemite (quartz diorite) and granodiorite fields but the studied younger granites plot in the granite field (Fig. 10a). On the R_1-R_2 diagram (De La Roche *et al.* 1980), the older granitoids spread over the field of granodiorite, and the younger granites plot in the syeno-granite and alkali granite fields (Fig.10b). From the previous discussion and diagrams, the older granitoids are classified as trondhjemite (quartz diorite) and granodiorite but the younger granites are classified as alkali feldspar syeno-granites. The magma type of the studied granitic rocks can be identified using the following relationships. On the $(Al_2O_3 + CaO)/(FeO_t + Na_2O + K_2O)$ versus 100 $(MgO + FeO_t + TiO_2)/SiO_2$ (Sylvester, 1989), the older granitoids plot in the calc-alkaline granite field (Fig. 10c), while the younger granites plot in the highly fractionated calc-alkaline granite field. The same author suggested that the highly fractionated calc-alkaline granite has chemical composition similar to a great extent to the alkali granites due to the high total alkali contents and depletion in the CaO content. The A/CNK versus A/NK (molar Al_2O_3/Na_2O+K_2O) diagram (Maniar and Piccoli, 1989) is used to discriminate between the peraluminous, metaluminous and peralkaline nature. This diagram shows that, the older granitoids plot in metaluminous field whereas the younger granites plot between the metaluminous-peraluminous fields (Fig.10d). Also, all rocks are I- type in nature. The plotting of older granitoids in metaluminous field indicates magma generation within a mature thickened crust typical for magmatic suites of igneous sources whereas the magmatic suites of sedimentary sources tend to start from highly peraluminous positions (Debon and Le Fort, 1983). The previous diagrams suggest that, the studied older granitoids are considered as granitoids, originated from metaluminous calc- alkaline magma, but the younger granites are considered granites, originated from metaluminous-peraluminous calc- alkaline magma. Both older granitoids and younger granites are I- type in nature. The tectonic setting of the studied granitic rocks can be interpreted using the following relationships. The R_1 - R_2 variation diagram of Batchelor and Bowden (1985) discriminates between the different tectonic settings of granitic rocks using the multicationic parameters R_1 and R_2 of De la Roche *et al.* (1980), (Fig. 11a). This figure reflects that the studied older granitoids plot near the syn-collision field and formed under compressional regime whereas the studied younger granites plot near the post-orogenic field Also, most of the studied younger granites plot in late-collision alkali-feldspar granites field of Ragab and El-Gharabawi (1989), (see Fig 11a), this suggests that the studied younger granites have originated from the remelting of crustal materials and were intruded in the late collision stage. On the Maniar and Piccoli (1989) variation diagrams, the older granitoids plot in continental arc granitoids (CAG), island arc granitoids (IAG) and continental collision granitoids (CCG) whereas the younger granites mainly plot in the post collision granites (POG) field (Fig. 11b). Post-orogenic granitoids are rocks intruded during the last phase of an orogeny, generally after the deformation in the region has ceased. The origin and petrogenesis, of the studied rocks, can be deduced from the following relationships.On the normative Ab-Q-Or diagram (Tuttle and Bowen, 1958) (Fig. 11c), the older granitoids have minimum melting point at moderately to high vapour pressure (>3 kb), whereas the younger granites originated at relatively lower vapour pressure (1-3 kb). This suggests that, the older granitoids are emplaced at a moderate depth in the earth crust, while the younger granites are formed at shallow depth. The high pressure (>3kb) of older granitoids favours the entry of Ba, Sr and Rb isomorphously into K-feldspars (Shamkin, 1971 and 1979). Regarding the temperature of crystallization, the present data are plotted on the Ab-An-Or ternary diagram of Yoder *et al.* (1957), (Fig. 11d). This figure shows that, the older granitoids crystallized at temperature ranging from 850 to 1000o C and the younger granites are crystallized at temperature ranging from 800 to 850° C.

Table 4: Major oxides (w%), trace elements (ppm), CIPW norms and geochemical ratios of the studied older granitoids.

Rock type	Quartz diorites			Granodiorites		
Symbol	∇	∇	∇	×	×	X
Sampl No.	2	3	5	8	9	12
SiO_2	64.46	64.44	65.37	66.47	67.64	67.11
TiO_2	0.51	0.63	0.48	0.26	0.22	0.27
Al_2O_3	14.44	14.33	14.40	13.67	13.75	13.61
Fe_2O_3	2.79	2.91	2.55	2.17	2.31	2.39
FeO	2.23	2.59	2.34	2.50	2.30	2.65
MnO	0.16	0.15	0.13	0.15	0.19	0.18
MgO	2.26	2.27	2.09	2.11	2.19	2.00
CaO	4.20	4.36	3.94	3.81	3.61	3.66
Na_2O	3.96	4.06	3.99	4.11	4.27	4.01
K_2O	3.02	3.00	3.39	3.26	3.35	3.16
P_2O_2	0.15	0.16	0.17	0.11	0.13	0.12
L.O.I	1.72	1.05	1.11	1.30	1.82	0.75
Total	99.90	99.95	99.96	99.92	99.59	99.91
			CIPW norms			
Q	18.77	18.09	18.67	19.73	19.08	21.50
C					-	
Z	0.02	0.02	20.04	0.02	0.02	0.01
Or	17.86	17.74	33.76	19.28	19.82	18.70
Ab	33.51	34.35	11.97	34.77	36.13	33.93
An	12.77	12.06	5.52	9.26	8.48	9.83
Di	6.07	7.17	4.25	7.51	7.16	6.35
Hy	4.04	3.87	3.70	4.29	4.34	4.71
Mt	4.04	4.22	-	3.15	3.35	3.46
Hm			0.91	-	-	-
H	0.97	1.20	0.41	0.49	0.42	0.51
Ap	0.36	0.38	72.47	0.26	0.31	0.29
			Trace elements			
Rb	40	33	19	41	52	49
Ba	1006	736	728	693	649	611
Sr	734	656	583	416	326	271
Nb	3	3	2	13	5	3
Zr	99	87	73	123	97	58
Y	2	2	2	12	8	6
Pb	12	9	13	25	28	24
Hf	12	12	12	13	14	14
Ga	10	16	22	19	21	5
			Geochemical ratios and parameters			
S.I.	16.00	16.00	15.00	15.00	5.00	14.00
K/Rb	627	755	13.50	660	535	535
Rb/Sr	0.05	0.05	0.03	0.10	0.20	0.20
K/Ba	30	34	35	34	43	43
Ba/Rb	25	22	38	10	12	13
D.I.	70.14	70.18	72.47	73.78	75.03	74.13

Table 5: Major oxides (w %), trace elements (ppm), CIPW norms and geochemical ratios of the studied younger granites.

Rock type	Syenogranites						Alkali feldspar granites				
Symbol	O	O	O	O	O	O	Δ	Δ	Δ	Δ	Δ
Sampl.No.	13	14	15	16	17	18	20	21	22	23	24
SiO_2	74.71	74.67	74.73	74.63	74.66	74.63	74.53	75.24	75.20	75.25	74.32
TiO_2	0.11	0.11	0.10	0.10	0.11	00.12	0.08	0.07	0.08	0.10	0.11
Al_2O_3	13.67	13.40	13.65	13.98	13.52	13.74	13.35	13.05	12.99	12.97	13.03
Fe_2O_3	0.88	0.65	0.76	0.70	0.79	00.60	1.01	1.10	1.12	0.81	1.07
FeO	0.19	0.20	0.21	0.26	0.37	00.39	0.28	0.34	0.19	0.24	0.18
MnO	0.03	0.03	0.04	0.02	0.04	00.06	0.02	0.03	0.03	0.03	0.02
MgO	0.25	0.26	0.23	0.29	0.25	00.29	0.30	0.36	0.27	0.23	0.31
CaO	0.81	1.01	1.10	1.06	0.94	1.00	0.71	0.50	0.67	0.69	0.61
Na_2O	3.93	4.01	3.83	3.88	3.92	03.79	4.15	4.15	4.13	4.15	4.22
K_2O	4.51	4.53	4.61	4.43	4.52	04.45	4.60	4.37	4.45	4.34	4.61
P_2O_2	0.09	0.08	0.07	0.08	0.09	00.14	0.10	0.09	0.11	0.10	0.10
L.O.I	0.62	0.77	0.53	0.48	0.56	00.71	0.80	0.58	0.52	0.71	0.37
Total	99.80	99.72	99.86	99.91	99.77	99.92	99.93	99.88	99.76	99.62	99.95
					CIPW norm						
Q	32.63	31.60	32.24	32.75	32.32	33.23	31.01	32.94	32.56	32.91	30.58
C	1.01	0.21	0.49	1.03	0.63	1.16	0.46	0.77	0.40	0.41	0.21
Z	0.04	0.03	0.01	0.02	0.04	0.04	0.04	0.02	0.01	0.01	0.02
Or	26.70	26.81	27.29	26.23	26.75	26.34	27.27	25.94	26.37	25.72	27.31
Ab	33.25	33.93	32.41	32.83	33.17	32.07	35.11	35.11	34.94	35.11	35.70
An	3.60	4.63	5.12	4.86	4.26	4.20	2..95	1.93	2.65	2.80	2.42
Di	-	-	-	-	-	-	-	-	-	-	-
Hy	0.62	0.65	0.57	0.72	0.62	0.85	0.75	0.90	0.67	0.57	0.77
Mt	0.38	0.40	0.35	0.59	0.99	0.87	0.72	0.98	0.46	0.57	0.31
Hm	0.62	0.37	0.52	0.29	0.10	-	0.51	0.43	0.80	0.42	0.86
H	0.21	0.21	0.19	0.19	0.21	0.23	0.15	0.17	0.15	0.19	0.21
Ap	0.22	0.19	0.17	0.19	0.22	0.34	0.24	0.22	0.26	0.24	0.24
					Trace elements						
Rb	113	81	115	134	102	97	213	281	182	193	173
Ba	361	341	310	321	384	320	230	118	161	108	155
Sr	211	142	89	92	226	180	71	12	22	14	19
Nb	8	17	10	3	10	4	53	32	12	24	2
Zr	219	153	31	81	213	187	181	77	64	32	101
Y	7	8	3	3	8	9	4	2	3	2	2
Pb	10	10	12	11	8	10	8	13	11	11	11
Hf	12	11	13	10	12	13	11	12	12	11	13
Ga	12	11	11	10	11	13	11	11	11	11	13
					Geochemical ratios and parameters						
S.I.	2.56	2.20	2.39	3.03	2.54	3.05	2.9	2.49	2.27	2.40	3.10
K/Rb	331	464	333	279	368	381	179	129	203	187	221
Rb/Sr	0.5	0.6	1.30	1.50	0.5	0.5	3	14	9	6	8
K/Ba	104	110	123	115	98	115	166	307	232	341	247
Ba/Rb	3.2	4.2	2.7	2.4	3.8	3.3	1.1	0.56	0.89	1.37	0.88
D.I.	92.58	92.34	91.94	91.81	91.24	91.64	93.39	93.99	93.87	93.74	93.59

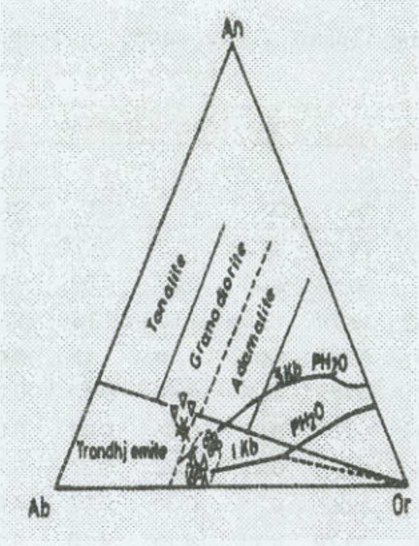


Fig. (10a): Ab-An-Or ternary diagram (O'Connor, 1965 and Barkar, 1979). The curved lines represent the low feldspar boundary at PH_2O 1 and 5 Kb (James and Hamilton, 1969). The dotted lines are after Ragab and El Gharabawi, (1989).

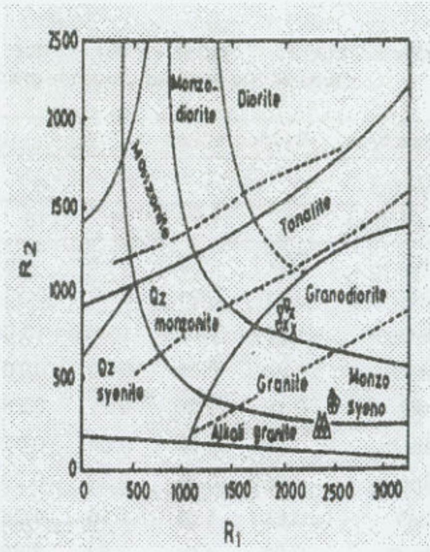


Fig. (10b): R1-R2 variation diagram (De La Roche *et al.*, 1980).

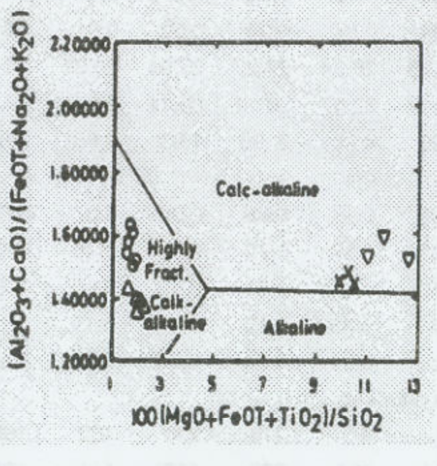


Fig. (10c): Al_2O_3+CaO/ FeOT+Na_2O+K_2O vs. 100 (MgO+FeOT+TiO_2)/SiO_2 (Sylvester, 1989).

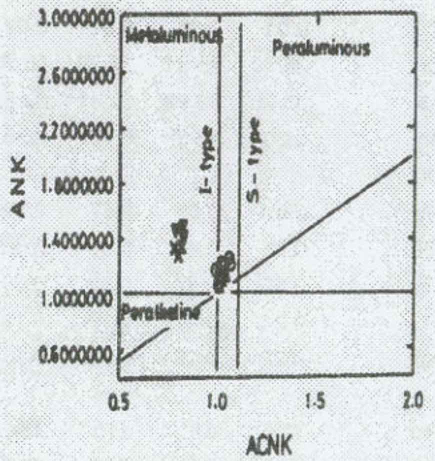


Fig. (10d): A/CNK vs. A/NK variation diagram (Maniar and Piccoli 1989).

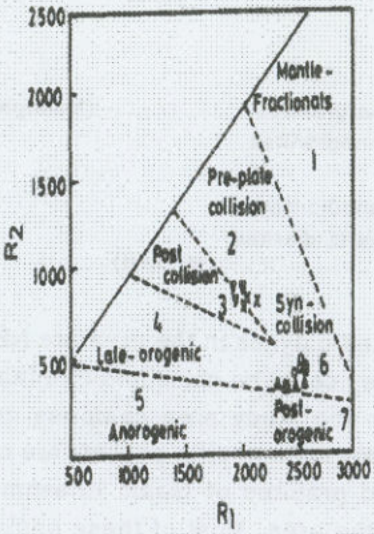


Fig. (11a): R1-R2 variation diagram (Batchelor and Bowden)

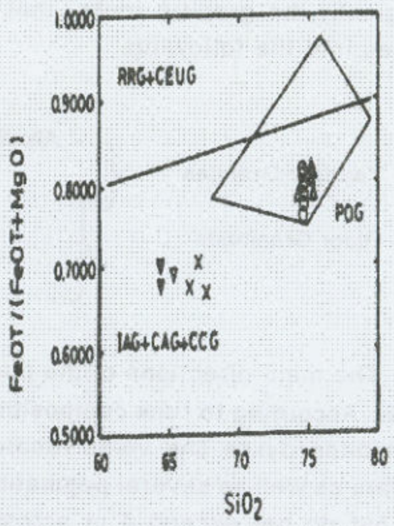


Fig. (11b): SiO2 vs. FeOT/ (FeOT+MgO) variation diagram (Maniar and Piccoli, 1989).

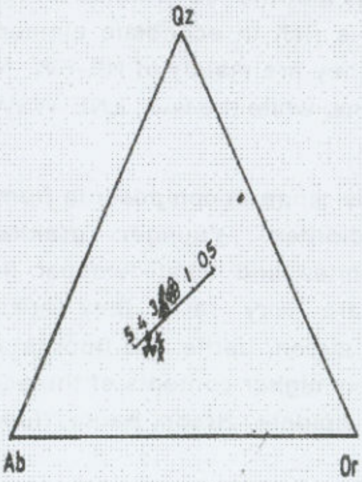


Fig. (11c):Ab-Q-Or ternary diagram (Tuttle and Bowen, 1958)

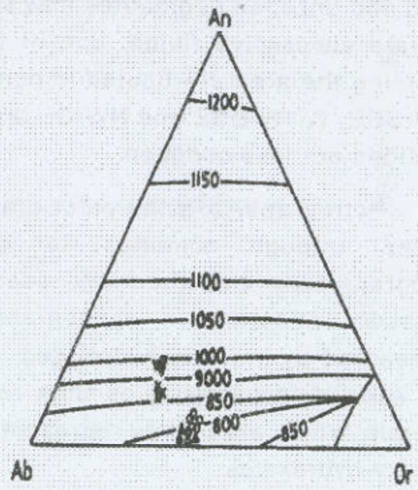


Fig. (11d): Ab- An-Or ternary diagram (Yoder et al., 1957)

Summary and Conclusions

Geologically,the granitic rocks. that cropping out in Gabal Um Guruf area are arranged into the following:

- Younger Granites	- Alkalifeldspargranites..................(Youngest) - Syenogranites
- Older Granitoids	- Granodiorites - Quartz-diorites ....(Oldest)

The main directions of the post-granitic dykes in the area are NE-SW and NW-SE. According to rock composition, they could be classified into felsic, mafic and alkaline dykes.The veins recorded in the study area comprise quartz and feldspars as well as several pegmatite pockets. Pegmatite pockets are of different sizes but do not exceed 4 m across. Red granites of Gabal Khashm El-Risha include most of the pegmatite pockets in the area. Most of these pockets are of unzoned type where quartz and alkali feldspar are the dominant minerals, while mica and plagioclase are absent or rare. Some pockets show faint zoning, possessing visible mineralization of metallic black and waxy yellow colours in addition to disseminations of green and violet fluorite. The presence of both zoned and unzoned pegmatites may suggest that the red granites affected by two separate successive fluids; one of them is rich in economic elements.Faults, traversing the area are limited in numberThey are mainly of NE-SW, NNE-SSW, NNW-SSE, WNW-ESE and NW-SE directions, while the N-S, ENE-WSW and E-W directions are less common.

Petrographically,the older granitoids range in composition from quartz diorites through tonalites to granodiorites. Younger granites are petrographically classified into syenogranites and alkali-feldspar granites. Accessory minerals in syenogranites are very rare; they are mainly represented by iron oxy-hydroxides, while zircon, barite and fluorite are very rare. Alkali feldspar granites show relatively higher contents of the accessory minerals, which are mainly represented by epidote, zircon, barite, fluorite and iron oxy-hydroxides.

Radiometrically, the radioactivity values reflect a systematic increase from the older granitoids passing through syenogranites to alkali feldspar granites. High eU contents (29.5 63 ppm) and high eU/eTh ratios (0.44-1.25) may suggest that alkali feldspar granites represent a good environment for uranium occurrence. This conclusion is confirmed in the field by the presence of several anomalous values of uranium contents (23.7-112 ppm) following some oval-shaped pegmatite pockets (diameter ranges between 1 and 4 m) and ferruginated spots (0.5 – 3.0 m across) in the alkali feldspar granites. They sometimes show visible mineralization of metallic black and brown colours as well as waxy yellow colour in addition to disseminations of green and violet fluorite. Scanning Electron Microscope (SEM) studies revealed that these minerals are lyndochite, oxinite, samarskite, betafite,ashanite and uranophane. The presence of these minerals suggests that the hydrothermal solutions or the residual magma from which these pegmatites originated are not only rich in uranium and thorium, but also rich in Nb, Ta and REEs.

Geochemically, The older granitoids are metaluminous, The older granitoids are also restricted to syn-collision field and formed under compressional regime. They have minimum melting point at moderate to high vapour pressure (> 3 kb) and crystallized at temperature between 850 to 1000 °C. On the other hand, the younger granites are metaluminous-peraluminous natures, calc-alkaline to alkaline highly fractionated magma essentially with potassic affinities. This magma is rich in Rb indicating that this granite has originated under low-pressure extensional conditions. They could be considered as post orogenic granites (POG), intruded under dry conditions in upper level of the earth crust at water vapour pressure between 1 and 3 kb and crystallized at temperatures ranging from 800 to 850 °C

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جيولوجية,تمعدنيه اشعاعيه و جيوكيميائية الصخور الجرانيتيه لمنطقة جبل خشم الريشه , شمال الصحراء الشرقيه – مصر

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تقع منطقة جبل خشم الريشه بين خطى عرض 4 27-15 27 شمالا و خطى طول 00 33-10 33 شرقا و تغطى مساحة حوالى 351كم2 بشمال الصحراء الشرقيه بمصر. تغطى هذه المنطقة صخور الجرانيتويدات القديمة (كوارتز ديوريت و جرانوديوريت)، وصخور بركانيات الدخان وصخور الجرانيتات الحديثة (السيانوجرانيت والجرانيت ذو الفلسبار القلوى) علاوة على حشود من الجدد والقواطع الفلسية والمافية السائدة فى اتجاهات شمال شرق – جنوب غرب و شمال غرب – جنوب شرق. الصخور الجرانيتيه المختلفة تغطى حوالى 75% من منطقة الدراسة. الفوالق القاطعة لصخور المنطقة محدودة العدد و تضرب اساسا فى اتجاهات شمال شرق-جنوب غرب , شمال شمال شرق – جنوب جنوب غرب, شمال شمال غرب- جنوب جنوب شرق, غرب شمال غرب- شرق جنوب شرق و شمال غرب-جنوب – شرق .

إشعاعيا, تعكس معدلات محتوى كل من اليورانيوم والثوريوم بالوحدات الصخرية المختلفة زيادة منتظمة بداية من الجرانيتويدات القديمة ثم السيانوجرانيت ثم الجرانيت ذو الفلسبار القلوى. تعرض صخورالجرانيت ذو الفلسبار القلوى مدى واسع من محتوى اليورانيوم مقارنة بالسيانوجرانيت مما يدل على أهمية العوامل الثانوية -البعد مجماتية- فى إعادة توزيع اليورانيوم. يبلغ محتوى اليورانيوم فى الجرانيت ذو الفلسبار القلوى(29,5-63 جزء فى المليون) و كذلك نسب اليورانيوم على الثوريوم من44, إلى1,25 دلالة على أنه بيئة مناسبة لتواجدات اليورانيوم ومما يدعم ذلك فى الحقل تواجد بعض الشاذات الإشعاعية (تصل الى 112جزء فى المليون من اليورانيوم)فى الجيوب البجماتيتية المصاحبة للجرانيت الحديث وتظهر بها بعض التمعدنات ذات بريق معدنى ولون أسود وبريق شمعى ولون أصفر علاوة على الفلوريت الأخضر والبنفسجى. وبدراسة هذه التمعدنات اتضح تواجد معادن فلوريت،ليندوكيت، أوكسينيت، سمارسكيت، بيتافيت،أشانيت و يورانوفين. ويدل تواجد هذه المعادن على أن المحاليل المائية الحارة التى كونت البجماتيت ليست غنية فقط فى اليورانيوم والثوريوم ولكن أيضاً فى النيوبيوم والتانتالوم والعناصر الأرضية النادرة.

جيوكيميائيا, اتضح ان الجرانيتيدات القديمة نشأت عن صهير قلوي كلسي ميتاالوميني قادم من الوشاح عند ضغط بخاري مائي أكثر من 3 كيلوبار ودرجة حرارة تتراوح مابين 850 –1000 م اثناء تكوين الأقواس البركانية بينما الجرانيتات الحديثة نشأت عن صهير قلوي كلسي إلى قلوي متوسط بالالومينا شديد التمايز قادم من منطقة السيال في القشرة الأرضية عند ضغط يتراوح ما بين 1و 3 كيلوبار ودرجة حراره تتراوح ما بين 800 – 850 م في المرحلة اللاحقة للحركات التكتونية البانية للجبال.