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GEOLOGY, PETROLOGY AND RADIOACTIVITY OF THE OLDER GRANITOIDS AND YOUNGER GRANITES OF GABAL EL-UMRAH AREA, CENTRAL EASTERN DESERT, EGYPT

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ABSTRACT

Gabal El-Umrah area (about 93 km^2) is located between latitudes 25° 16' - 25° 21' N and longitudes 34° 15' - 34° 21' E in the Central Eastern Desert of Egypt. The older granitoids are characterized by their low to moderate topography, exfoliation and cavernous weathering. Their hand specimens are coarse-grained with light to dark grey colour. More than one type of the younger granites are easily noticed in the field because of the variability in grain size (from fine to coarse) and the difference in colour (greyish pink, pink, buff and light red), which reflect the variability in the type and intensity of mafic minerals as well as the plagioclase/K-feldspars ratios. The contact between these types is irregular and difficult to be traced.

The older granitoids (quartz diorites and granodiorites) originated from upper mantle materials. The younger granites are classified as monzogranites and syenogranites. Monzogranites originated from felsic crust material contaminated with upper mantle. Syenogranites originated from highly fractionated, K-rich, crust materials.

The older granitoids show eU/U ratios greater than one indicating U-loss. The monzogranites show ratios ranging between 0.92 and 1.10, suggesting restricted uranium mobilization or may suggest approximately similar uranium leaching and addition. The syenogranites show ratios lower than one, indicating uranium addition especially to fractured zircon and apatite as well as hematite. The petrographic, geochemical and radiometric data suggest that the studied syenogranites of Gabal El-Umrah are uraniferous granites. Along the northern peripheries of Gabal El-Umrah, some zoned pegmatite pockets possess abnormal values of uranium contents ranging between 67.4 and 92.3 ppm. The associated radioactive minerals occurred either as filling fractures of feldspars or as dissemination. They are represented by betafite, samarskite, euxenite and ashanite.

INTRODUCTION

Gabal El-Umrah area is located between latitudes 25° 16' - 25° 21' N and longitudes 34° 15' - 34° 21' E in the Central Eastern Desert of Egypt (Fig. 1). The area covers about 93 km^2 of the Precambrian shield rocks and could be easily accessed through two main roads. The eastern side of the area could be reached from Wadi Mubarak (30 km west of Quseir-Marsa Alam paved road). The southern periphery of the area could be attained from Wadi Um Nar (26 km north of Idfu-Marsa Alam paved road). The area of study is characterized by high and rugged topography. Gabal El-Umrah (787 m a.s.l.) represents the highest elevation point in the area.

The younger granites have usually rounded or oval outline with relatively small masses in comparison with the older granitoids. The older granitoids are classified as "Grey Granites" (El-Ramly and Akaad, 1960) and "GI-granites" (Hussein *et al.*, 1982). They are related to subduction setting and represent the plutonic equivalent of the mature volcanic rocks (Dokhan volcanics) originated during mature arc stage (Hussein et al., 1982 and Ragab, 1987). The younger granites are classified as "Younger Red and Pink Granites" (El-Ramly and Akaad, 1960) and "G II- and G III-granites" (Hussein *et al.*, 1982). GII-granites were formed by partial melting of the lower crust probably with some addition of mantle during collision (suturing) at plate boundaries (Ragab, 1987 and 1991). On the other hand, GIII-granites (e.g. G.Gharib and G.El Zeit) are intra-plate anorogenic, peralkaline, riebeckite granites (Hussein *et al.*, 1982 and Ragab and El-Kaliobi, 1992).

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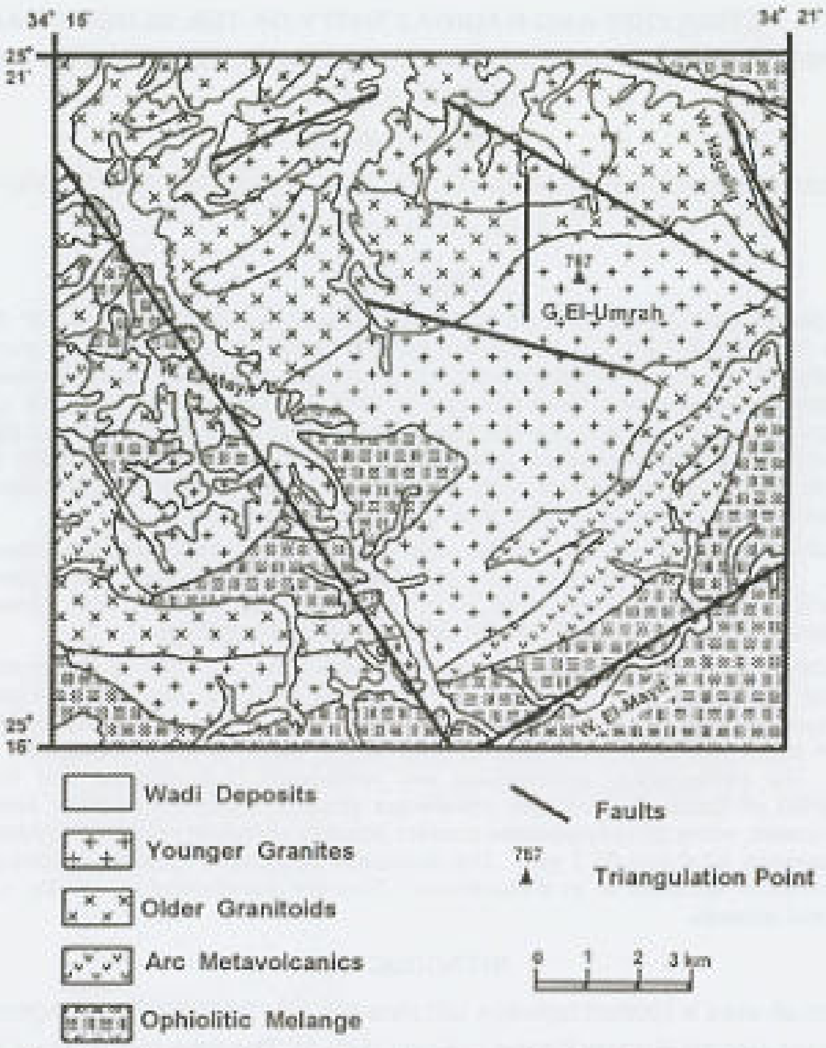

Fig. 1: Geologic map of Gabal El-Umrah area (modified after Takla et al., 2001)

GEOLOGIC OUTLINES

The older granitoids are characterized by their low to moderate topography, exfoliation and caverneous weathering (Fig. 2). They crop out intruding the metavolcanics and the ophiolitic melange and are intruded by the younger granites. The older granitoids occasionally enclose xenoliths of the metavolcanics (Fig. 3), especially along the eastern side of the mapped area. In hand specimens, the older granitoids are coarse-grained with light to dark grey colour. Near their contacts with the ophiolitic melange, they become highly weathered and foliated but along their contacts with the younger granites they appear massive with reddish grey colour due to the repeated offshoots of the younger granites and the irregular feldspar veinlets (Fig. 4). Sometimes, they are sheared and cataclased especially west of Wadi El-Mayit near the southwestern corner of the studied area.

The younger granites send offshoots of various sizes into the surrounding rocks. These offshoots sometimes cut the foliation of the metasediments but in some areas, especially at Wadi El-Mayit, they are conformable with the foliation planes. Also, the younger granites carry roof pendants of the ophiolitic melange and metavolcanics (Fig. 5); they are of different extension (from few square meters to several square kilometers) and thickness (between about 20 cm and 60 meters).

More than one variety of younger granites are easily noticed in the field because of the diversity in grain size (from fine to coarse) and the difference in colour (greyish pink, pink, buff and light red), which reflect the variability in the type and intensity of mafic minerals as well as the plagioclase/K-feldspars ratios. The contact between these types is irregular and difficult to be traced. Also, the younger granites attain yellowish brown and brick red colours along their fractures (Fig. 6) due to staining with iron hydroxides and oxides respectively. Other fractures are usually stained with Mn-dendrites (Fig. 7).

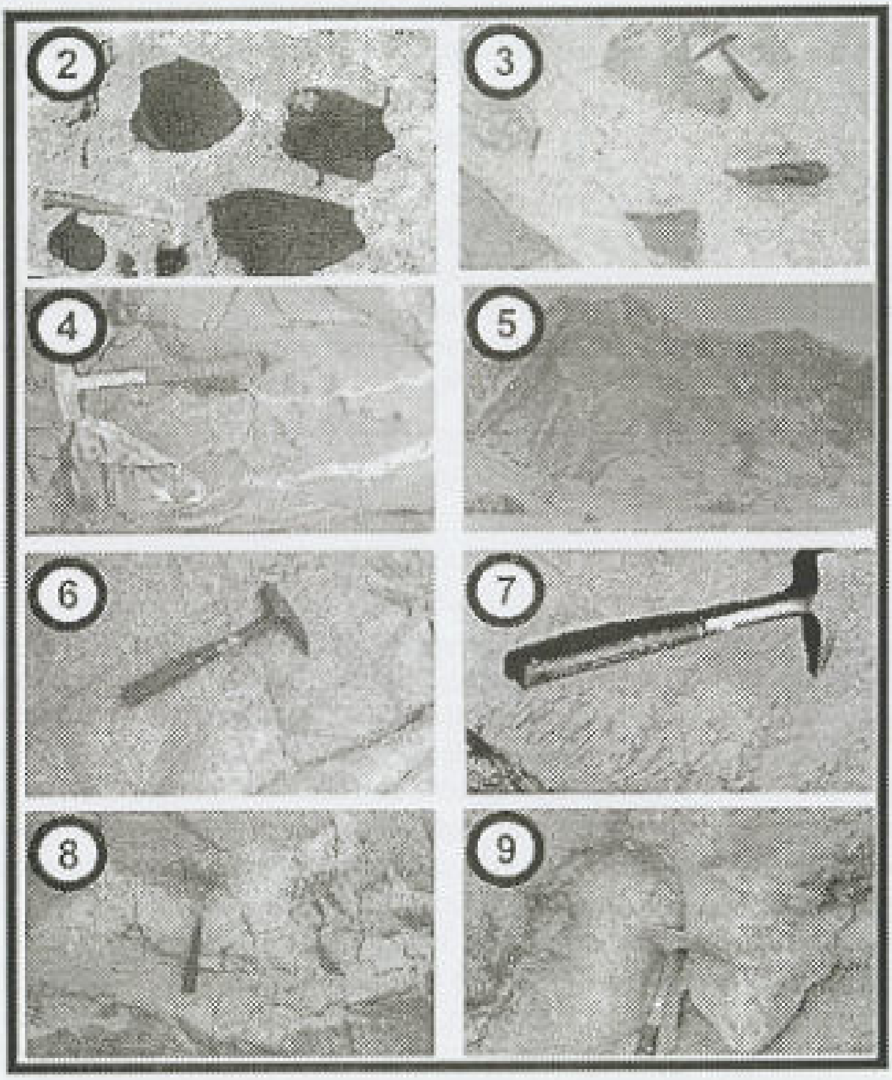

Fig.2: Cavernous weathering, older granitoids
Fig.3: Older granitoids enclosing oval-shaped and elongated xenoliths of metavolcanics
Fig.4: Parallel irregular feldspar veinlets in the older granitoids
Fig.5: Younger granites intruding the metavolcanics and carry them as roof pendants, looking southeast
Fig.6: Younger granites stained with iron oxyhydroxides along fracture planes
Fig.7: Well developed Mn dendrites along the joint surface of younger granites
Fig.8: Pegmatite pocket enclosing metallic black minerals
Fig.9: Close up view for the previous pegmatite pocket showing metallic black minerals associated with hematization

The area of study is dissected by several felsic and mafic dykes. Generally the felsic dykes are less dominant and of less extension (25 – 200 m) than the mafic ones (25 m –1 km). The main trend of felsic and mafic dykes is NW-SE, while other trends are less common. Pegmatite pockets are of different sizes but do not exceed 8 m across. Most of these pockets are of unzoned type, where quartz and alkali feldspars are the dominant minerals, while mica and plagioclase are rare or absent. Along the northern peripheries of Gabal El-Umrah, some pegmatite pockets show slight zonation; they possess visible mineralization of metallic black colour (Figs. 8 and 9) in addition to dissemination of violet fluorite. The presence of both zoned and unzoned pegmatites indicate that they were formed by different magmatic fluids; one of them is rich in economic elements.

Faults traversing the area have several trends (mainly NW-SE while NE-SW and N-S trends are less common) and variable lengths (0.5 – 11 km) with vertical or steep angle of dip. These faults are either concomitant with wadis and drainage lines or cutting through the country rocks.

PETROGRAPHY

Older granitoids

The older granitoids are classified as quartz diorites and granodiorites. Both types have the same textural and mineral composition, but the quartz diorites show lower biotite/hornblende ratios, K-feldspars/plagioclase ratios and quartz contents relative to the granodiorites (Table 1). Titanite, zircon, apatite and opaques are accessory minerals. Epidote, chlorite, sericite and kaolinite are secondary minerals. In some parts, the rocks show gneissose texture.

Table (1): Petrographic characteristics of the studied older granitoids

Rock type	Quartz diorites	Granodiorites
Biotite/hornblende ratio	0.5 – 2.0	> 4.0
K-feldspar/plagioclase ratio	0.01 – 0.1	0.2 – 0.4
Quartz contents	7.6 – 16.4 %	19.2 – 28.6 %

Plagioclase occurs as subhedral tabular crystals, cutting each other (Fig. 10 a). The fresh crystals show albite twining and some crystals are zoned with more altered core relative to rim. Quartz occurs as interstitial anhedral crystals filling the spaces between the early-formed minerals. They show corroded margins against plagioclase and hornblende. Sometimes, they exhibit wavy extinction and/or cracking (Fig. 10 b) as a result of high tectonics. The cracks are usually filled with fine quartz crystals, clay minerals and iron oxy-hydroxides. Hornblende, of green colour, occurs as subhedral prismatic crystals. They poikilitically enclose zircon and apatite prisms as well as irregular opaque patches of different size. Some crystals are simply twinned, but others are highly chloritized (Fig. 10c). Biotite occurs as irregular flakes, up to 2.6 mm long. Most of them are altered to chlorite (Fig. 10d) and iron oxides especially along the cleavage planes and margins. Sometimes, biotite flakes show kinking due to local deformation. Alkali feldspars are represented by simply twinned, string-type, orthoclase perthite (Fig. 10e). They are altered to kaolinite and sericite, which slightly mask the twinning. Titanite presents as irregular patches and sphenoid-shaped crystals. It is enclosed in hornblende, biotite and sometimes plagioclase (Fig. 10f). Apatite occurs as needle-like crystals enclosed in hornblende and biotite.

Younger granites

The younger granites are classified as monzogranites and syenogranites. Hand specimens of monzogranites are fine- to medium-grained with greyish to light pink colour, while the syenogranites are medium- to coarse-grained with buff to red colour. The variable colour and crystal size may suggest that the studied younger granites intruded in successive pulses and may reflect the variable concentrations of mineral constituents (Table 2).

Table (2): Petrographic characteristics of the studied younger granites

Rock type	Monzogranites	Syenogranites
K-feldspar/plagioclase ratio	0.8 – 1.6	> 3.1
Muscovite/biotite ratio	0 – 0.4	0.3 – 1.2
Quartz contents	30.7 – 42.1 %	23.3 – 31.5 %

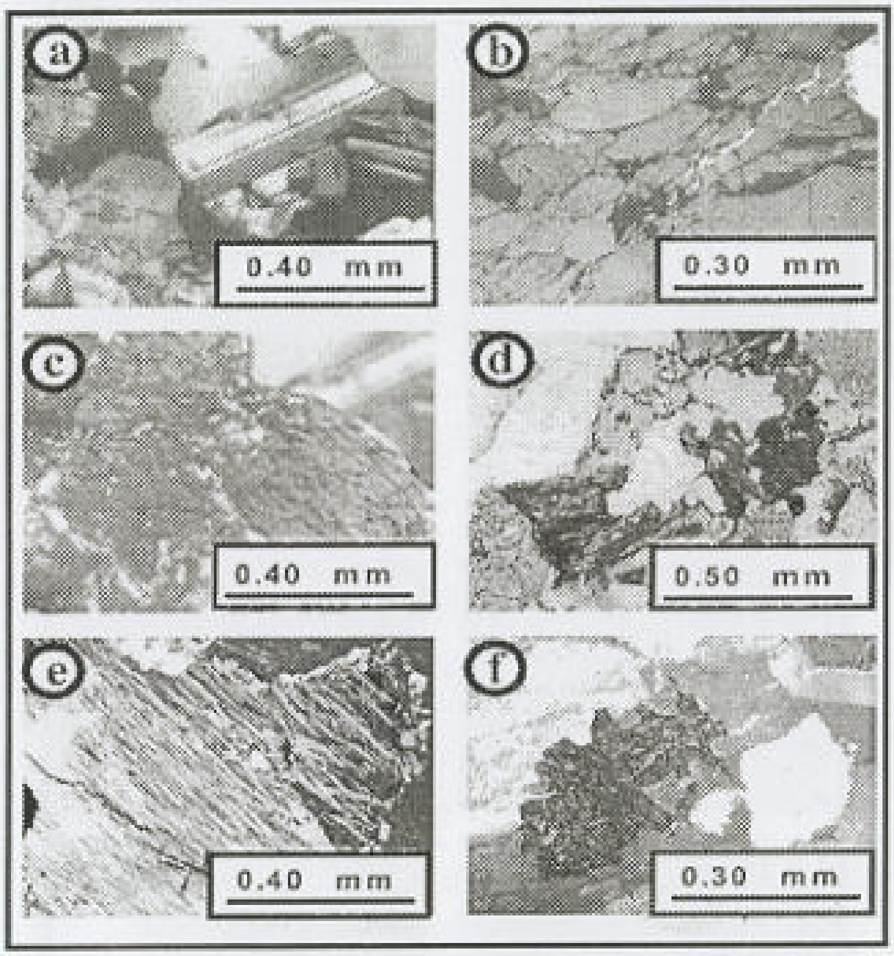

Fig: 10: Petrographic characteristics of the studied older granitoids
a: Plagioclase cutting each other and corroded by quartz, quartz diorites, C.N.
b: Highly cracked quartz, quartz diorites, C.N.
c: Chloritized hornblende corroded by plagioclase, quartz diorites, C.N.
d: Biotite flakes showing variable degrees of chloritization, granodiorites, C.N.
e: String type orthoclase perthite corroded by quartz, granodiorites, C.N.
f: Titanite showing irregular boundaries and enclosed in plagioclase, granodiorites, C.N.

Microcline and orthoclase show patchy and flame-like perthitic textures (Figs. 11a and b). The ratio of microcline/orthoclase increases from monzogranites to syenogranites, suggesting that monzogranites were crystallized at relatively higher temperature than syenogranites. They poikilitically enclose quartz and plagioclase (Fig. 11c) as well as minute crystals of zircon, apatite and fluorite. Their cracks and cleavage planes are usually filled with epidote, quartz and secondary muscovite. The kaolinitized and sericitized crystals are rare in the monzogranites and absent in the syenogranites. Quartz usually contains inclusions of zircon, fluorite and very minute undistinguishable scattered dark spots, while some crystals appear clear. On the other hand, small quartz crystals are secondary formed as fracture fillings. Crystals showing undulose extinction in the syenogranites are completely absent, indicating that these rocks are less affected by stresses than the monzogranites. Some quartz crystals show myrmikitic and graphic textures with feldspars, suggesting reaction during crystallization. The majority of plagioclase crystals show clear lamellar twinning with slight visible alteration. Some crystals represent an older phase corroded by other minerals, while others show overgrowth indicating local albitization. In the syenogranites, plagioclase is very rare or sometimes completely absent.

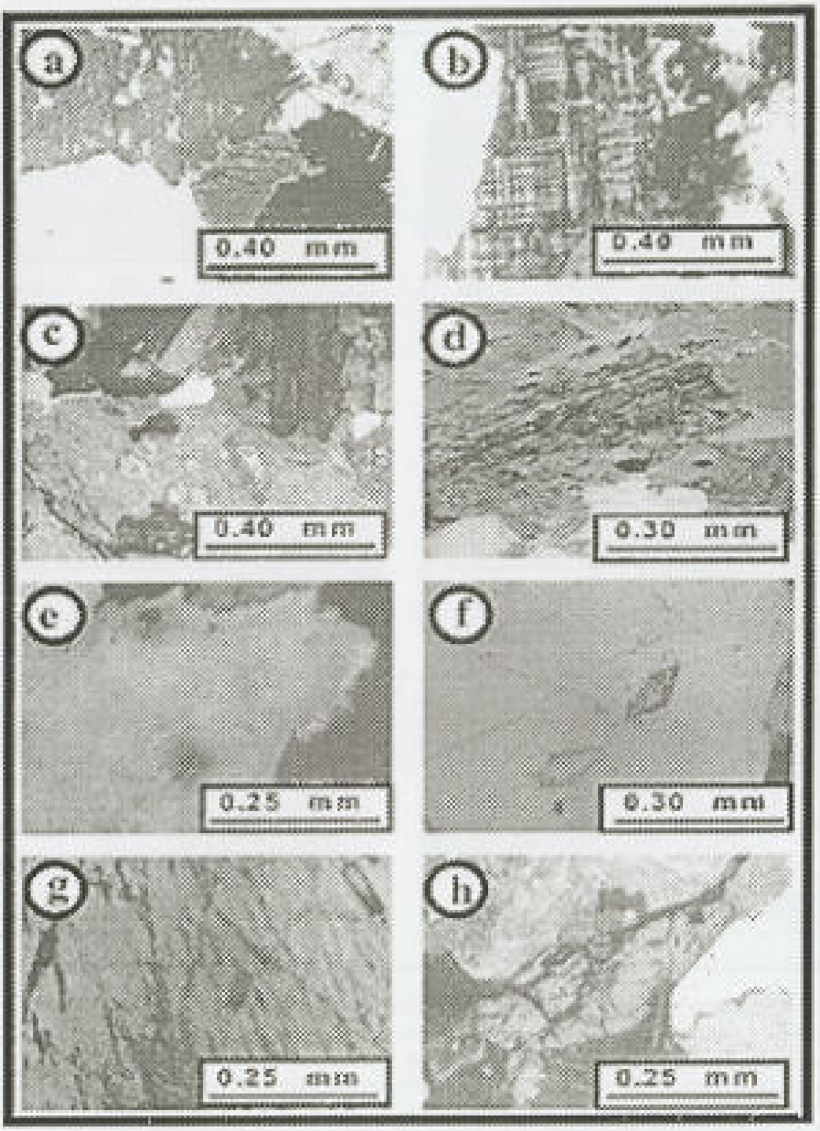

Fig. 11: Petrographic characteristics of the studied younger granites
a: Patchy-type orthoclase perthite corroded by quartz and corroding chloritized biotite, monzogranites, C.N.
b: Microcline perthite corroded by quartz, syenogranites, C.N.
c: Orthoclase perthite corroding plagioclase and enclosing quartz and plagioclase poikilitically, syenogranites, C.N.
d: Biotite flake corroded by quartz and feldspars, leaving isolated islands, monzogranites, C.N.
e: Biotite flake showing pleochroic haloes, syenogranites, C.N.
f: Primary muscovite flake enclosed in quartz, syenogranites, C.N.
g: Zircon and apatite enclosed in quartz, syenogranites, C.N.
h: Allanite corroding feldspars, syenogranites, C.N.

Biotite flakes of monzogranites are sometimes altered to chlorite with releasing iron oxides along peripheries and cleavage planes. On the other hand, biotite flakes of syenogranites are usually unaltered. Most biotite flakes of monzogranites are corroded by quartz and feldspars, leaving isolated islands (Fig. 11d). Biotite flakes of the syenogranites usually possess several pleochroic haloes (Fig. 11e) due to the presence of minute radioactive materials. Primary muscovite is found as irregular or oval-shaped, faint yellow flakes (Fig. 11f), especially in syenogranites, suggesting genesis from peraluminous magma. In some cases, muscovite appears of secondary origin filling the cracks. In some monzogranite samples, mica flakes are only represented by biotite. The accessory minerals in both younger granite varieties are apatite, zircon (Fig. 11g), allanite (Fig. 11h) and fluorite as well as iron oxy-hydroxides, while the secondary minerals are mainly epidote, chlorite, clays and muscovite.

GEOCHEMISTRY

Twenty samples representing the studied older granitoids and younger granites are chemically analyzed for major oxides by means of wet chemical techniques (Shapiro and Brannock, 1962). Trace elements were measured using X-ray fluorescence (Phillips PW 1410 together with a MO-target tube operated at 50 kv and 30 m A). The chemical analyses had been carried out in the laboratories of the Nuclear Materials Authority (NMA), Egypt.

K/Ba ratio of granitic rocks in the crust is 65 (Mason, 1966). The ratios higher than Mason's value reflect advanced degree of magma differentiation (Abdel Warith, 2000). K/Ba ratios of the studied younger granites range between 87.1 and 356.2 (Table 4), suggesting origin from highly fractionated magma.

Sr is depleted in the liquid magmas as a result of crystallization of calcic plagioclase, while Rb is enriched in the liquid phase (Imeokparia, 1981 and Hassan and Hashad, 1990). The higher Rb/Sr ratios (>1.5) suggest pre-existing felsic material in the source region, but ratios of low range (< 0.7) suggest derivation from upper mantle (Bucanan, 1982). Accordingly, the studied older granitoids were derived from the upper mantle (Rb/Sr ratio ranges from 0.02 to 0.13). The studied monzogranites show Rb/Sr ratios ranging between 1.21 and 1.81, suggesting derivation from felsic material contaminated with some upper mantle. On the other hand, the studied syenogranites show higher Rb/Sr ratios (2.62 – 3.98), suggesting derivation from pre-existing highly fractionated felsic material.

Ba/Rb ratio decreases with magmatic differentiation due to crystallization of feldspars (Moharem, 1999). The average Ba/Rb ratio of normal granites is 4.1 (Mason, 1966). Thus, the studied monzogranites are considered as normal granites (Ba/Rb ratio ranges from 2.02 to 7.92). On the other hand, the studied syenogranites are considered as highly fractionated granites (Ba/Rb ratio ranges from 0.69 to 2.45).

Cox *et al.* (1979) suggested that the Na_2O/K_2O ratio decreases during the main stage of crystallization. They also added that this ratio is less than one in the granitoids of crust origin but from 1 to 4.5 in the granitoids of mantle origin. The studied older granitoids show Na_2O/K_2O ratios ranging from 1.29 to 4.61 (Table 3), suggesting derivation from mantle materials. The studied monzogranites show Na_2O/K_2O ratios ranging from 0.93 to 1.12 (Table 4), suggesting derivation from crust materials contaminated with some mantle materials. The syenogranites show Na_2O/K_2O ratios ranging between 0.74 and 0.97 (Table 4), suggesting derivation from felsic, K-rich, crust materials.

Table (3): Major oxides (wt. %), trace elements (ppm) and some geochemical ratios of the studied older granitoids

Rock type	Quartz diorites					Granodiorites				
Sample No	1	2	3	4	5	6	7	8	9	10
Major oxides (wt %)										
SiO_2	63.80	62.58	61.78	62.34	63.99	66.85	66.72	65.61	67.31	69.02
TiO_2	0.58	0.49	0.32	0.35	0.41	0.16	0.13	0.52	0.12	0.29
Al_2O_3	13.83	14.05	13.75	14.12	13.76	14.21	13.59	14.39	12.51	14.02
Fe_2O_3	2.59	3.21	2.98	2.05	2.62	1.39	1.39	1.71	1.26	1.18
FeO	3.43	3.62	3.55	3.27	3.33	1.67	2.11	2.05	1.62	1.44
MnO	0.14	0.16	0.22	0.36	0.13	0.18	0.16	0.16	0.19	0.14
MgO	2.25	2.54	3.29	2.65	2.11	1.41	1.40	1.86	1.31	1.32
CaO	6.32	7.70	6.75	7.81	6.82	5.42	5.91	6.61	7.61	5.78
Na_2O	3.71	3.41	2.95	3.00	3.98	3.88	4.16	3.09	4.02	3.52
K_2O	1.12	0.74	1.04	1.22	0.98	2.01	1.91	2.39	2.67	1.87
P_2O_5	0.25	0.15	0.11	0.14	0.11	0.13	0.11	0.13	0.12	0.11
L.O.I.	1.59	1.11	2.93	2.64	1.55	2.65	2.35	1.09	1.18	1.15
Total	99.61	99.76	99.67	99.95	99.79	99.96	99.94	99.61	99.92	99.64
Trace elements (ppm)										
Rb	7	8	12	10	12	21	15	17	26	22
Sr	350	251	315	341	326	173	306	218	199	224
Zr	25	36	24	20	42	64	64	35	52	78
Nb	6	9	11	16	14	14	8	10	18	15
Ba	591	542	561	459	488	524	407	443	356	418
Geochemical ratios										
Na_2O/K_2O	3.31	4.61	2.84	2.46	4.06	1.93	2.18	1.29	1.51	1.88
Fe_2O_3/FeO	0.76	0.89	0.84	0.63	0.79	0.83	0.66	0.83	0.78	0.82
K/Rb	1328	768	719	1013	678	794	1056	1166	852	706
K/Ba	15.73	11.33	15.39	22.06	16.67	31.84	38.95	44.78	62.25	37.13
Rb/Sr	0.02	0.03	0.04	0.03	0.04	0.12	0.05	0.08	0.13	0.10
Ba/Rb	84.4	67.8	46.8	45.9	40.7	25.0	27.1	26.1	13.7	19.0
Zr/Sr	0.07	0.14	0.08	0.06	0.13	0.37	0.21	0.16	0.26	0.35
* A/CNK	1.24	1.19	1.28	1.17	1.17	1.26	1.13	1.19	0.87	1.26
** S/F	4.70	3.91	3.97	4.22	4.63	7.35	6.73	5.81	6.27	7.66

* A/CNK = Al_2O_3 / (Na_2O + K_2O + CaO) ** S/F = (SiO_2 + K_2O + Na_2O) / (FeO^* + MgO + CaO)

The ratio $Fe_2O_3/FeO>1$ suggests origin under oxidizing conditions (Shalaby, 1995 and Ali *et al.*, 1998). The studied syenogranites show ratios (1.26 – 3.64) higher than those of the monzogranites (0.74 – 2.13), suggesting that the syenogranites originated under higher oxidizing conditions.

Bucanan (1982) suggested that (SiO_2 + Na_2O + K_2O)/(CaO + MgO + FeO^*) ratio in the granitic rocks, resulted from crust materials, is more than 18.5. In the present study, this ratio ranges from 18.26 to 37.76 (Table 4) for the younger granites suggesting derivation from crust material. The ratios of syenogranites are slightly higher than those of monzogranites suggesting advanced degree of magmatic differentiation.

Al_2O_3/(Na_2O + K_2O + CaO) ratio discriminates between crust type (C-type) and mantle type (M-type) granitic rocks. Ratios greater than 1.3 suggest C-type granites, while those less than 1.3 suggest M-type granites (Didier et al. 1982). The studied younger granites show ratios greater than 1.53 (Table 4) suggesting origin from crust material, while the ratios of older granitoids range between 0.87 and 1.28 (Table 3) suggesting origin from mantle materials.

Table (4): Major oxides (wt. %), trace elements (ppm) and some geochemical ratios of the studied younger granites

Rock type	Monzogranites					Syenogranites				
Sample No	11	12	13	14	15	16	17	18	19	20
Major oxides (wt %)										
SiO_2	74.08	72.62	73.49	72.45	73.87	74.21	73.59	73.74	74.05	73.15
TiO_2	0.55	0.61	0.25	0.54	0.24	0.10	0.14	0.22	0.11	0.17
Al_2O_3	14.65	14.42	13.62	14.49	14.42	14.09	14.56	14.57	14.01	13.91
Fe_2O_3	0.67	0.84	1.75	1.85	1.49	0.91	0.83	1.05	1.0	1.64
FeO	0.68	1.14	1.01	0.87	0.89	0.35	0.66	0.54	0.48	0.45
MnO	0.19	0.05	0.06	0.04	0.15	0.03	0.26	0.02	0.03	0.41
MgO	0.35	0.47	0.39	0.36	0.31	0.31	0.40	0.33	0.31	0.23
CaO	0.91	1.74	0.84	1.25	0.98	0.61	0.33	0.52	0.67	0.82
Na_2O	3.51	3.38	3.67	3.12	3.26	3.99	3.41	3.68	4.13	3.92
K_2O	3.14	3.24	3.85	3.36	3.16	4.12	4.62	3.94	4.24	4.33
P_2O_5	0.29	0.06	0.17	0.37	0.12	0.09	0.04	0.15	0.1	0.19
L.O.I.	0.91	1.26	0.84	1.15	0.92	0.93	0.97	0.96	0.84	0.71
Total	99.93	99.83	99.94	99.85	99.81	99.74	99.81	99.72	99.97	99.93
Trace elements (ppm)										
Rb	41	36	56	40	38	76	104	95	195	62
Sr	34	20	31	26	23	29	32	36	49	23
Zr	44	42	68	53	36	67	61	95	152	119
Nb	8	12	23	15	11	19	24	16	31	18
Ba	276	165	113	142	301	96	116	121	135	152
Geochemical ratios										
Na_2O/K_2O	1.12	1.04	0.95	0.93	1.03	0.97	0.74	0.93	0.97	0.91
Fe_2O_3/FeO	0.99	0.74	1.73	2.13	1.67	2.60	1.26	1.94	2.08	3.64
K/Rb	636	747	571	697	690	450	369	344	180	580
K/Ba	94.4	163.0	262.8	196.4	87.1	356.2	330.6	270.3	260.7	236.4
Rb/Sr	1.21	1.80	1.81	1.54	1.65	2.62	3.25	2.64	3.98	2.70
Ba/Rb	6.73	4.58	2.02	3.55	7.92	1.26	1.12	1.27	0.69	2.45
Zr/Sr	1.29	2.10	2.19	2.04	1.57	2.31	1.91	2.64	3.10	5.17
* A/CNK	1.94	1.72	1.63	1.87	1.95	1.62	1.74	1.79	1.55	1.53
** S/F	30.96	18.96	20.41	18.26	21.91	37.76	36.72	34.55	33.58	25.92

* A/CNK = Al_2O_3 / (Na_2O + K_2O + CaO) ** S/F = (SiO_2 + K_2O + Na_2O) / (FeO^* + MgO + CaO)

RADIOACTIVITY

Field radiometric survey was carried out using a calibrated portable gamma ray spectrometer (model UG-130). This instrument detects gamma radiation of wide energies (from 0.0 to 3.0 M eV). In fact U and Th are not gamma emitters. Accordingly, they were measured depending on the gamma rays emitted from their daughters. Equivalent uranium (eU) is detected by the decay of ^{214}Bi (1.76 M eV), while equivalent thorium (eTh) is detected by the decay of ^{208}Tl (2.62 M eV). Also, uranium was chemically measured using uranium-laser analyzer technique. In this work, chemically measured uranium (U) as well as radiometrically measured uranium (eU) and thorium (eTh) exhibit systematic increase from quartz diorites to syenogranites (Table 5).

U, Th, Nb, Rb, and Zr behave incompatibly in granitic melt, so that where uranium concentration is controlled by magmatic processes, these elements would be expected to increase (Briqueu et al., 1984). The older granitoids and monzogranites show positive relationships for U versus Zr, Rb and Nb (Fig. 12), indicating uranium enrichment due to magmatic processes. The syenogranites show poor sympathetic relationship when uranium is plotted versus Rb and Nb, indicating uranium enrichment due to post magmatic (secondary) processes. Uranium shows positive correlation with Zr, Fe_2O_3/FeO, P_2O_5 and CaO in the syenogranites, suggesting that uranium enrichment has occurred in the crystal lattice of zircon, hematite and apatite respectively.

Table (5): Equivalent uranium (eU) and thorium (eTh) measured radiometrically as well as U measured chemically for the studied older granitoids and younger granites

Rock type		Sample No.	U (ppm)	eU (ppm)	eTh (ppm)	eU/U	eTh/U
Older Granitoids	Quartz-diorites	1	1.5	2.1	7.9	1.40	5.27
		2	1.7	1.9	6.4	1.12	3.76
		3	2.6	3.1	17.0	1.19	6.54
		4	2.2	2.8	9.6	1.27	4.36
		5	2.8	3.4	8.8	1.21	3.14
	Grano-diorites	6	4.7	6.1	16.3	1.30	3.47
		7	3.4	7.3	17.1	2.15	5.03
		8	3.8	5.9	16.2	1.55	4.26
		9	6.1	8.1	24.9	1.33	4.08
		10	5.3	8.0	28.1	1.51	5.30
Younger Granites	Monzo-granites	11	7.8	8.6	23.9	1.10	3.06
		12	7.2	7.5	22.5	1.04	3.13
		13	12.1	12.0	36.7	0.99	3.03
		14	11.0	10.1	33.8	0.92	3.07
		15	10.3	10.5	31.1	1.02	3.02
	Syeno-granites	16	28.2	24.3	54.6	0.86	1.94
		17	22.6	21.7	47.3	0.96	2.02
		18	29.9	24.4	59.4	0.82	1.99
		19	30.9	19.6	45.2	0.63	1.46
		20	33.1	18.5	72.4	0.56	2.19

To get accurate measurements for U concentrations, the decay series of U^{238} must be in equilibrium, but any recent loss or gain of U gives incorrect values. Recent loss or gain of U in rocks can be indicated by plotting gamma spectrometry determined U (based on its daughters) against chemically determined U (Fig. 12). Ratios of $U_{equivalent}$ / $U_{chemically}$ (eU/U) greater than one indicate recent U loss (while daughter products from the radioactive decay of U remain). The eU/U ratios less than one indicate recent U addition (the daughters which emit gamma-ray are not produced yet or at least the decay series does not reach the equilibrium state). In this work, the older granitoids show ratios greater than one (Table 5 and Fig. 12) indicating U loss, while the monzogranites show ratios ranging between 0.92 and 1.10 suggesting limited uranium mobilization. The syenogranites show ratios lower than one indicating U addition. According to Reeves and Brooks (1978), U attains equilibrium in about 1.5 m.y. Therefore, the latest mobilization of U in the studied rocks took place within the last 1.5 m.y. as there was not enough time to restore equilibrium. Th is an immobile element (chemically stable). So, decay series of ^{232}Th is usually in equilibrium state because mobilization (gain or loss) of Th is very restricted. Accordingly, eTh could be considered as Th measured chemically (Dardier, 1997 and Moharem, 1999). Normally, Th is three times as abundant as U in granitic rocks (Rogers and Adams, 1969). The studied syenogranites show eTh/U ratios ranging between 1.46 and 2.19 (Table 5 and Fig.12). Thus, uranium was post magmatically added to syenogranites. Monzogranites show eTh/U ratios ranging between 3.02 and 3.13 (Table 5), suggesting very restricted mobilization of uranium or may suggest approximately similar uranium leaching and addition. On the other hand, older granitoids show eTh/U ratios ranging between 3.14 and 6.54 (Table 5), suggesting uranium leaching.

The uraniferous granites are defined and discussed by several authors (Rogers and Adams, 1969; Hall and Walsh, 1969; Darnley, 1982; Cuney, 1984; Cambon, 1994; Shalaby, 1995; Assaf et al., 1997, Breiter et al., 1998 and Ahmed and Dardier, 1999). They defined the following characteristics for uraniferous granites:

1) Presence of two mica, 2) Pleochroic haloes in mica and feldspars,
3) CaO < 0.98 wt%, 4) Al_2O_3 > 13.38 wt%,
5) U > 18.22 ppm, 6) Rb > 184.8 ppm,
7) Ba < 298 ppm, 8) Sr < 98.98 ppm,
9) L.O.I. < 1.5, 10) Zr/Sr > 1.65,
11) Rb/Sr > 2.4 and 12) Na_2O/K_2O <1.

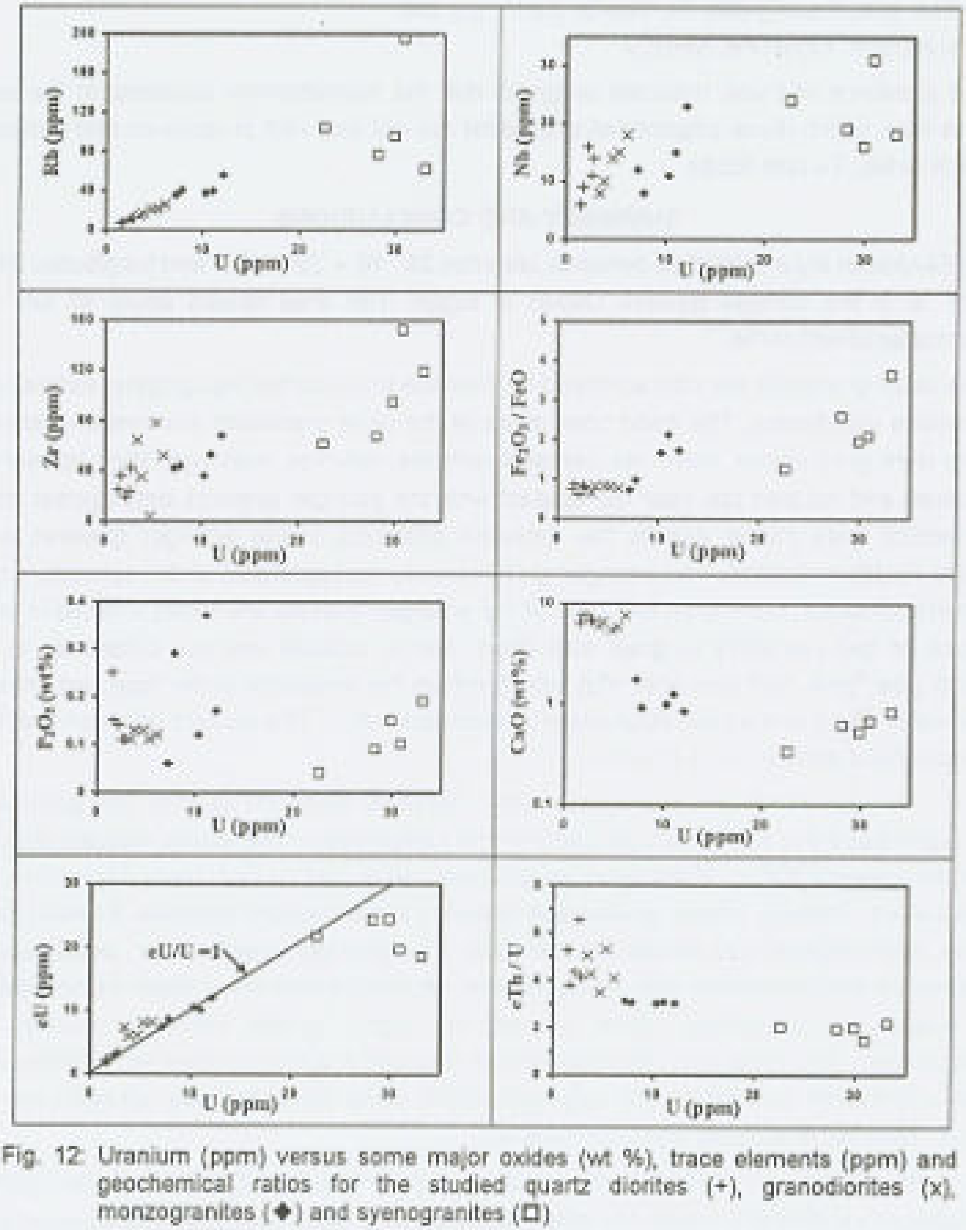

Fig. 12: Uranium (ppm) versus some major oxides (wt %), trace elements (ppm) and geochemical ratios for the studied quartz diorites (+), granodiorites (x), monzogranites (◆) and syenogranites (□)

The petrographic, geochemical (Tables 3 and 4) and radiometric (Table 5) data of the studied syenogranites are completely concordant with the previously mentioned parameters, suggesting that the syenogranites of Gabal El-Umrah are uraniferous granites.

During fractionation, uranium may become enriched in the final fractions of magma, and the residual hydrothermal solutions may form U-rich pegmatites and veins (Goldschmidt, 1954). In Gabal El-Umrah, two types of pegmatite pockets were recorded. The first type is unzoned; it shows uranium contents less than the syenogranites but higher than monzogranites (13.8 – 19.2 ppm). The second type is zoned, hematized and possesses higher uranium contents ranging between 67.4 and 92.3 ppm. The associated radioactive minerals occurred either as filling fractures of feldspars or as dissemination. Using EDAX-SEM technique, they are identified as betafite, samarskite, euxenite and ashanite (Figs. 13 and 14).

1-Euxenite (Y, Ce, Ca, U, Th) $(Nb, Ta, Ti)_2O_5$,

2-Samarskite (Y, Ce, U, Ca, Fe, Pb, Th) $(Nb, Ta, Ti, Sn)_2O_6$.

3-Betafite $(Ca, Fe, U)_2$ $(Nb, Ti, Ta)_2O_6$ $(OH, F)_{1-2}$ and

4-Ashanite $(Nb, Ta, U, Fe, Mn)_4O_8$

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.

SUMMARY AND CONCLUSIONS

Gabal El-Umrah area is located between latitudes 25° 16` - 25° 21` N and longitudes 34° 15` - 34° 21` E in the Central Eastern Desert of Egypt. The area covers about 93 km^2 of the Precambrian shield rocks.

The older granitoids are characterized by their low to moderate topography, exfoliation and caverneous weathering. The hand specimens of the older granitoids are coarse-grained with light to dark grey colour. Near the contacts with the ophiolitic melange, they appear highly weathered and foliated but near the contact with the younger granites they appear massive with reddish grey colour due to the repeated offshoots of the younger granites and the irregular feldspar veinlets. The younger granites carry roof pendants of the ophiolitic melange and metavolcanics. More than one type of the younger granites are easily noticed in the field because of the variability in grain size (from fine to coarse) and the difference in colour (greyish pink, pink, buff and light red), which reflect the variability in the type and intensity of mafic minerals as well as the plagioclase/K-feldspars ratios. The contact between these types is irregular and difficult to be traced.

The older granitoids are, petrographically, classified as quartz diorites and granodiorites. Both types have the same textural and mineral composition. The quartz diorites show lower biotite/hornblende ratios, K-feldspars/plagioclase ratios and quartz contents relative to the granodiorites. Titanite, zircon, apatite and opaques are accessory minerals. Epidote, chlorite, sericite and kaolinite are secondary minerals. The younger granites are, petrographically, classified as monzogranites and syenogranites. Monzogranites show lower muscovite/biotite and K-feldspars/plagioclase ratios as well as higher quartz contents relative to the syenogranites. The accessory minerals in both younger granite varieties are allanite, apatite, zircon and fluorite as well as iron oxy-hydroxides, while the secondary minerals are mainly epidote, chlorite, muscovite and clay minerals.

On the basis of K/Rb, Rb/Sr, Ba/Rb, $(SiO_2+Na_2O+K_2O)/(CaO+MgO+FeO^*)$ and $Al_2O_3/(Na_2O+K_2O+CaO)$ ratios, the origin of the studied older granitoids and younger granites could be deduced. Older granitoids (quartz diorites and granodiorites) originated from upper mantle materials. Monzogranites originated from felsic crust material, but with some contamination with upper mantle. Syenogranites originated from highly fractionated, K-rich, crust materials.

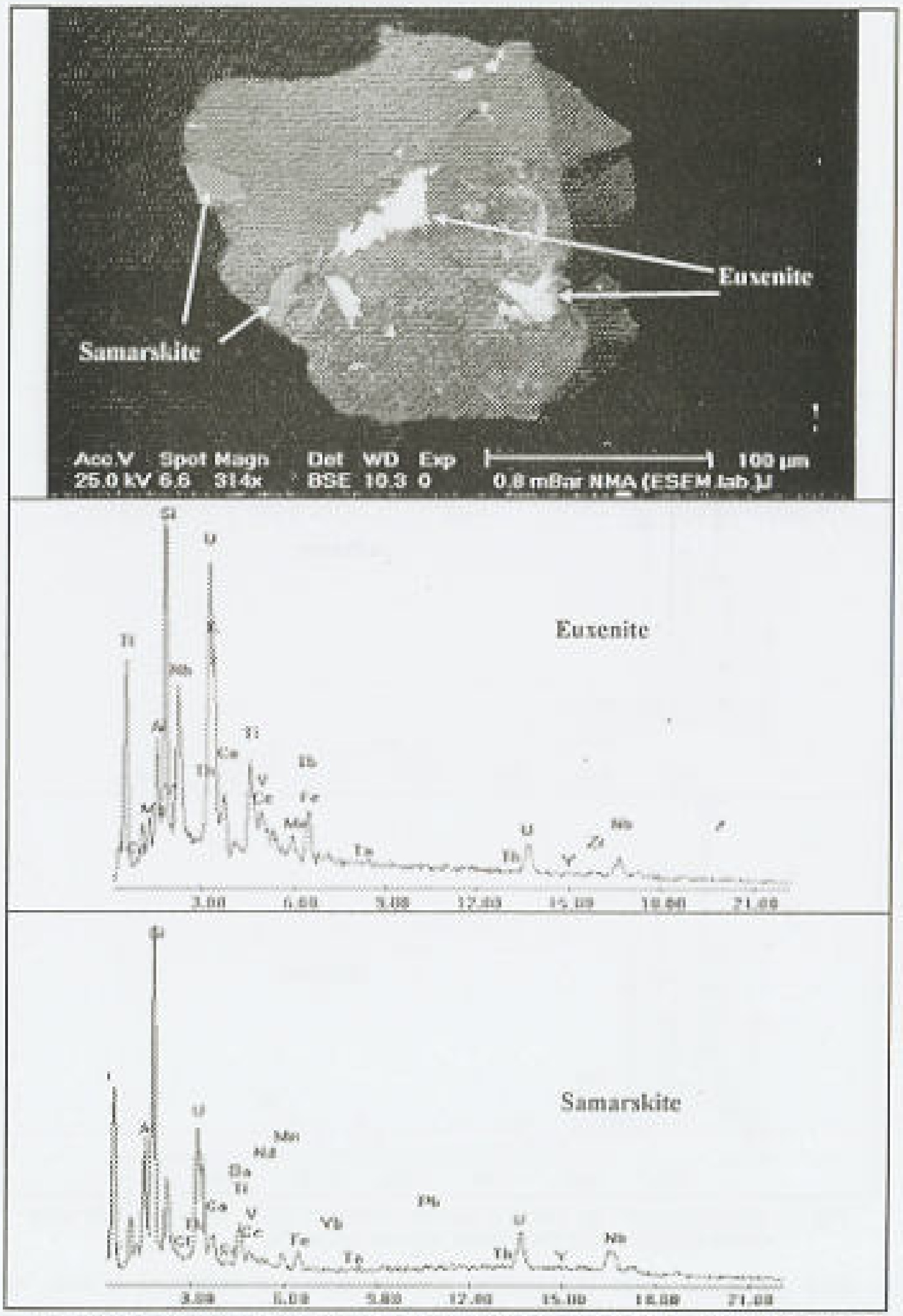

Fig. 13: Microphotograph by Scanning Electron Microscope (SEM) for a K-feldspar grain and the EDAX charts for the enclosed euxenite and samarskite

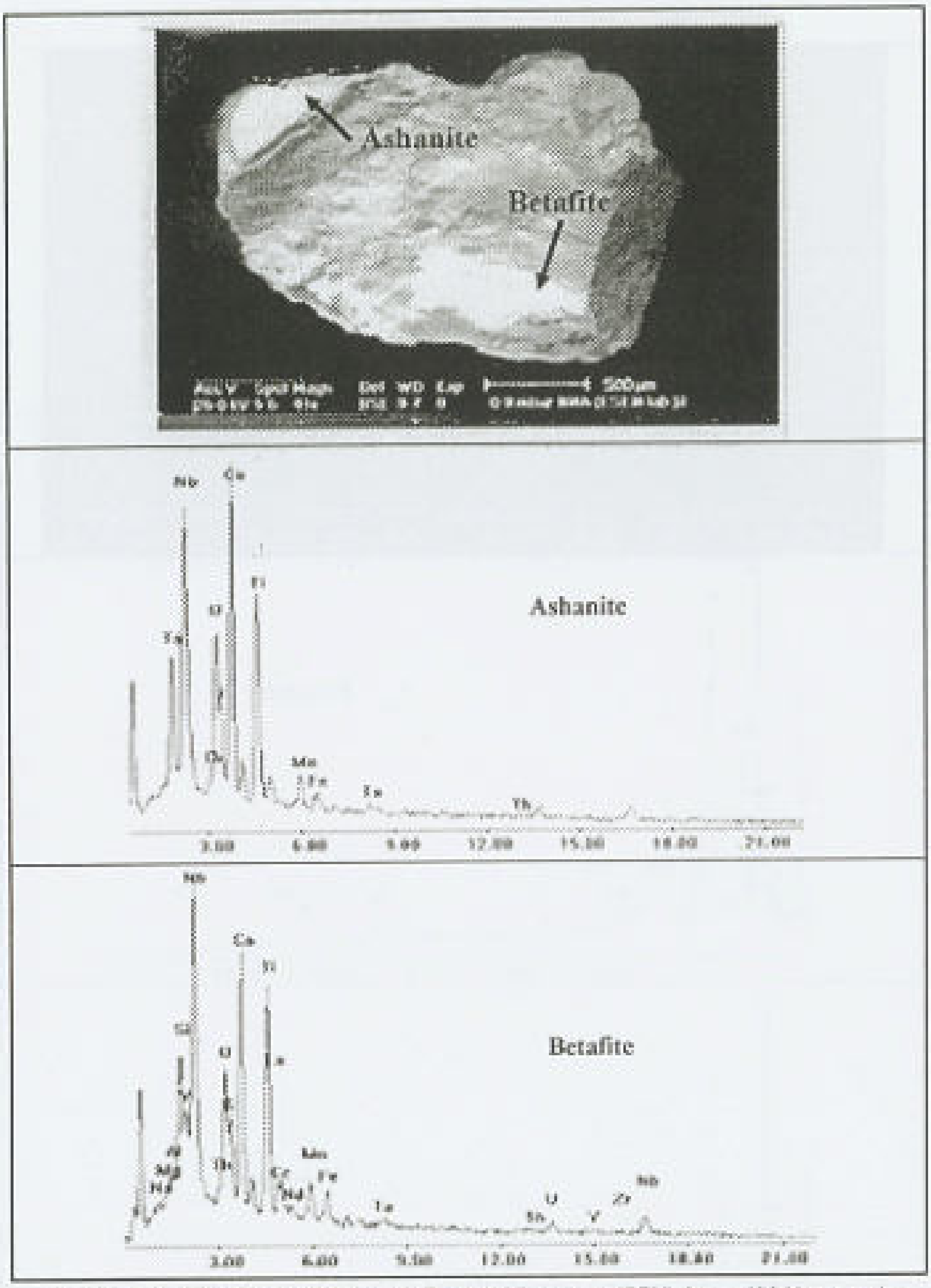

Fig. 14: Microphotograph by Scanning Electron Microscope (SEM) for a K-feldspar grain and the EDAX charts for the enclosed ashanite and betafite

The older granitoids show eU/U ratios greater than one indicating U loss, while the monzogranites show ratios ranging between 0.92 and 1.10 suggesting restricted uranium mobilization or may suggest approximately similar uranium leaching and addition. The syenogranites show ratios lower than one indicating U addition. This conclusion is confirmed by the eTh/U ratios. The petrographic, geochemical and radiometric data suggest that the syenogranites of Gabal El-Umrah are uraniferous granites. Uranium shows positive correlation with Zr, Fe_2O_3/FeO, P_2O_5 and CaO in the syenogranites, suggesting that uranium enrichment in zircon, hematite and apatite respectively.

In Gabal El-Umrah, two types of pegmatite pockets were recorded. The first type is unzoned; it shows uranium contents less than the syenogranites but higher than monzogranites (13.6 – 19.2 ppm). The second type is zoned, hematized and possesses higher uranium contents ranging between 67.4 and 92.3 ppm. The associated radioactive minerals occurred either as veinlets filling the fractures of feldspars or as dissemination. Using EDAX-SEM technique, they are identified as betafite, samarskite, euxenite and ashanite. 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.

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جيولوجية و بترولوجية و إشعاعية الجرانيتويدات القديمة والجرانيتات الحديثة بمنطقة جبل العمرة بوسط الصحراء الشرقية، مصر

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تقع منطقة جبل العمرة بين خطى عرض ١٦ ´ ٢٥° و ٣١ ´ ٢٥° شمالاً و خطى طول ١٥ ´ ٣٤° و ٢١ ´ ٣٤° شرقاً فى وسط الصحراء الشرقية، مصر. تغطى المنطقة مساحة ٩٢ كم٢ من صخور البريكامبرى. تتميز الجرانيتويدات القديمة بارتفاعات منخفضة إلى متوسطة و تعرية التورق والتجاويف و تتميز العينة اليدوية بحبيباتها الخشنة و لونها الرمادى الفاتح. يوجد عدة أنواع من الجرانيتات الحديثة تتميز بتباين فى حجم الحبيبات من الدقيق للخشن و يتباين اللون من الوردى إلى الأحمر و التى تعكس تباين نوعية و تركيز المعادن المافية و كذلك نسبة البلاجيوكليز/الفلسبار البوتاسى. الحدود الفاصلة بين هذه الأنواع يصعب تتبعها فى الحقل.

الجرانيتويدات القديمة (كوارتز دايورايت و جرانودايورايت) نشأت من مواد الوشاح العلوى. تم تقسيم الجرانيتات الحديثة إلى مونزوجرانيت وسيانوجرانيت. نشأ المونزوجرانيت من مواد القشرة الفاتحة الملوثة بالوشاح العلوى بينما نشأ السيانوجرانيت من مواد القشرة غنية بالبوتاسيوم عالية التباين.

الدراسات البتروجرافية و الجيوكيميائية و الإشعاعية تقترح أن صخور السيانوجرانيت المدروسة بجبل العمرة تعتبر جرانيتات يورانيومية. الجرانيتويدات القديمة توضح نسبة eU/U أكبر من الوحدة مما يدل على فقد اليورانيوم. المونزوجرانيت توضح نسب تتراوح بين ٠,٩٢ و ١,١٠ مما يدل على نقل محدود لليورانيوم أو درجات متساوية من الإضافة و الفقد. السيانوجرانيت يوضح نسب أقل من الوحدة مما يدل على إضافة اليورانيوم للصخور و خصوصاً فى الزيركون المشروخ و الأباتايت و كذلك الهيماتايت. تحتوى جيوب البجماتايت النطاقى على كميات عالية من اليورانيوم تتراوح بين ٦٧,٤ و ٩٢,٣ جزء بالمليون. المعادن المصاحبة تتواجد منتشرة أو مالئة للشروخ بالفلسبار و هى تتمثل بالبيتافايت و السمارسكايت و الإيوكسينايت و الأشانايت.