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PETROCHEMISTRY, PETROGENESIS AND CLASSIFICATION OF UM HUQAB, GARF AND EL-MUEILHA GRANITIC MASSES, SOUTHEASTERN DESERT, EGYPT

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ABSTRACT

The granitic masses of Um Huqab, Garf and El-Mueilha Southeastern Desert, Egypt, and belonging to synorogenic, late- and post-orogenic cycles are examined. Petrochemical characters based on major elements data of 13 newly analysed samples are clarified. Behaviour of major elements is discussed and chemical and modal classifications are presented based on normative feldspars and modal composition. Petrographical and petrochemical data suggest a magmatic origin for the examined granitic rocks. El-Mueilha granitic mass suffered along the peripheral parts, as well as along faults leading to albitization.

INTRODUCTION

The present paper deals with the petrochemistry, petrogenesis and classification of the granitic masses of Um Huqab, Garf and El-Mueilha *(Fig. 1)*. The examined masses occur among the basement rocks in the Southeastern Desert, Red Sea Hills, Egypt. The examined granitic rocks are considered by EL RAMLY and AKAAD (1960), SABET, (1972) and EL RAMLY (1972) as belonging to the younger group of granitoids. These authors gathered the granites outcropping in the Central Eastern Desert, Egypt, into two major groups, vis., *a)* older grey granites and *b)* younger granites of pink and red colours. These two granite groups are equivalent to EL SHAZLY's (1964); *a)* synorogenic plutonites and *b)* late orogenic plutonites, respectively. Broadly speaking the granitic rocks of Egypt are distinguished into three groups (EL GABY, 1975 and HUSSEIN *et al.*, 1982), namely: *1)* synorogenic granitoids, comprising the Shaitian and grey granites, *2)* late-orogenic granitoids (younger granitoids) and, *3)* post-orogenic granitoids, comprising the alkaline granites. The late-orogenic granitoids are further subdivided into three phases, based on field relations and mineralogical composition, (SABET *et al.*, 1976 and AKAAD and NOWEIR, 1980).

However, a comprehensive classification of the granites of Egypt has been advanced by GREENBERG, (1981). According to this author, the younger granites are divided into three groups, based on field relations, mineralogy, textural and chemical characteristics. Um Huqab and Garf granitic rocks are classified as older granites (grey granites) while El-Mueilha granitic complex is presented in Group I (*op. cit.*, 1981).

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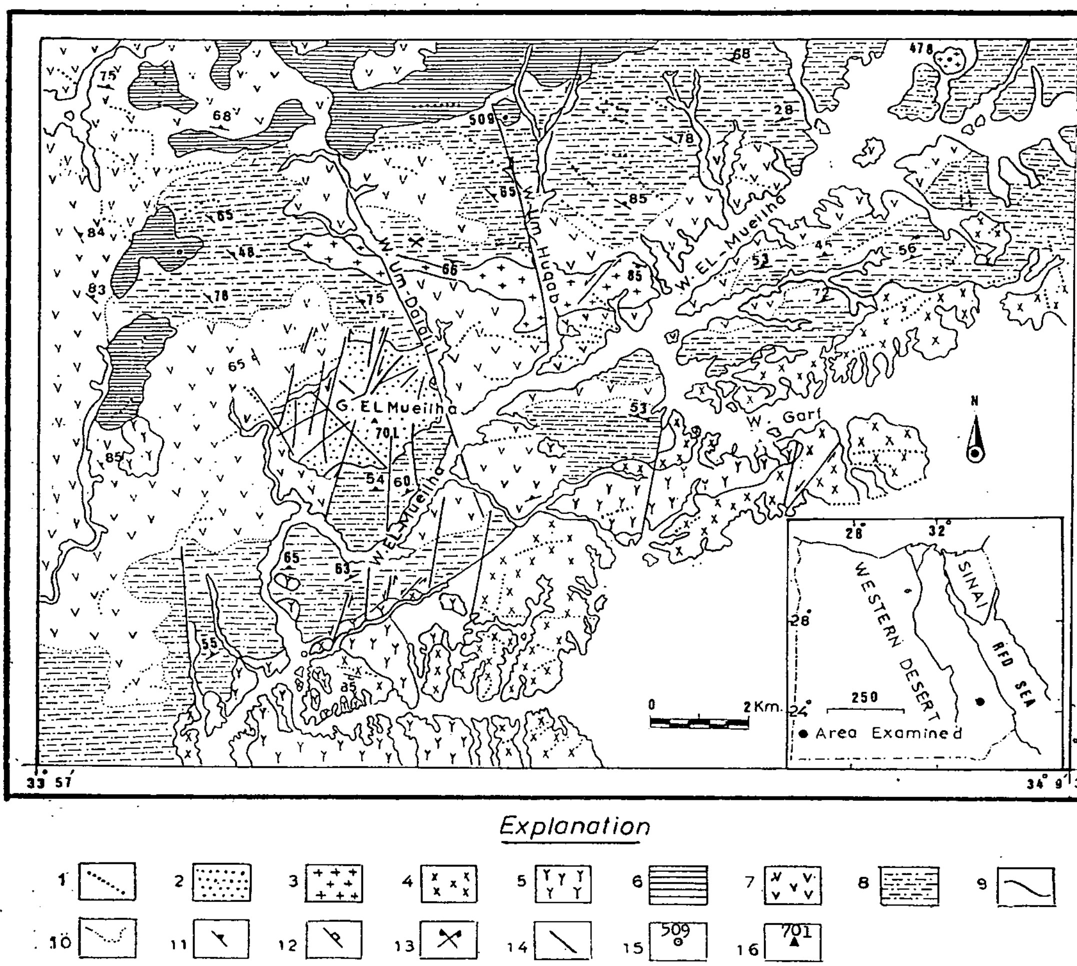

1) Post-granit dykes; 2) El-Mueilha granite pluton (late- to post-orogenic granitoids); 3) Um Huqab granite body (synorogenic granitoids); 4) Garf granitic mass (synorogenic granitoids); 5) Metagabbro — diorite complex; 6) Serpentinites and related rocks; 7) Metavolcanics; 8) Geosynclinal metasediments; 9) Sharp contact; 10) Gradational contact; 11) Strike and dip of foliation and schistosity; 12) Inclined joints; 13) Fault (showing strike slip); 14) Fluorite quarry; 15) Elevation point; 16) Triangulation point

Fig. 1. Geological map of Um Huqab, Garf, and El-Mueilha granitic masses

GEOLOGICAL SETTING

The three examined granitic masses occur among the basement complex of Precambrian age. The basement rocks comprise a thick succession of geosynclinal metasediments alternating and partially overlain by metavolcanics. This succession is intruded by serpentinites, metagabbro-diorite complex and granitic massess of various types. The previous basement rocks are cut by post-granitic dykes. The lithostratigraphy of the various rock units is given below (GHAZALY, 1984).

Youngest: 7) Post granite dykes
6) Late to post-orogenic granitoids:
— El-Mueilha granite pluton
5) Synorogenic granitoids:
— Um Huqab granitic rocks.
— Garf granitic mass
4) Metagabbro-diorite complex
3) Serpentinites and related rocks
2) Metavolcanics
Oldest: 1) Geosynclinal metasediments

The granitic rocks form moderately elevated features (Garf and El-Mueilha) to highly elevated (Um Huqab) and comprise four major distinct field types; tonalite, microdiorite (Um Huqab and Garf), muscovite and albitized granite (El-Mueilha). Field observations suggest a younger age for these granitic rocks. This is confirmed by cross-cutting relations and the presence of included xenoliths of the country rocks within the host granites. It is argued that the emplacement of the granitic rocks was of intrusive nature according to the following field observations:

— The contacts dip gently or moderately away from the granitic masses.
— Angular to subrounded xenoliths of dark basic volcanics are recorded along the peripheral parts of El Mueilha granite pluton. These xenoliths show no sign of interaction with the granite, pointing to the rather 'cold' nature of the granite magma (SOLIMAN. 1971 and 1975) or else the emplacement of the granite at shallow depth.
— A thin hornfelsic metamorphic aureole has developed around El-Mueilha mass. The contacts are characterized by abundant shear zones affecting the surrounding rocks and occasionally at right angles to the contacts. Also schistose structures has been recorded among the rocks near the shear planes (GHAZALY, 1984).

PETROGRAPHY OF THE GRANITIC ROCKS

The petrographic description of the examined granitic rocks is given under the following categories:

1) Synorogenic granitoids; these rocks are represented by Um Huqab and Garf granitic masses.
2) Late- to post-orogenic granitoids; this group comprises El-Mueilha granitic pluton.

Synorogenic granitoids:

Under the microscope, two types have been recognized among these granitic rocks namely tonalites and microdiorites. Generally, these rocks exhibit holocrystalline, hypidiomorphic granular texture. They are fine to coarse grained usually non-porphyritic and even-grained and occasionally porphyritic. The essential minerals are quartz, plagioclase, biotite, hornblende, muscovite and chlorite. Few micrographic intergrowths are observed. In Um Huqab granites many carlsbad twinning divide both normally and oscillatory zoned plagioclase megacrysts into two roughly equal parts, with the largest dimensions of these crystales parallel to the composition face. Accordingly the plagioclase twinning of Um Huqab granitic rocks is primary (SEIFERT, 1964). Plagioclase occurs as lath-shaped crystals 1.2×1.8 mm. The composition of plagioclase ranges from An_{32} to An_{36}. It is saussuritized to various degrees with epidote concentrated in the cores of normally zoned crystals. Oscillatory zoning is not uncommon. Hornblende occurs as long prismatic crystals ranging from 0.5 mm to 0.9 mm in length and from 0.2 mm to 0.4 mm in breadth. It has a deep green colour, pleochroic with X=green yellow Y=pale green and Z=deep green. Hornblende may show simple twinning and encloses iron granules, short prisms of zircon and sometimes quartz blebs. Hornblende is poikilitically sieved by small anhedral saussuritized plagioclase crystals. Sometimes, hornblende is chloritized and strongly pleochroic specially along peripheries and is usually cracked along cleavage perpendicular to the long dimensions of the crystals. Biotite occurs as stout, long flakes, 0.2 mm of deep brown, reddish brown and olive green colour. It is pleochroic from deep brown to straw yellow. The biotite flakes are usually clustered in patches, and slightly chloritized or charged with iron oxide rods and granules along cleavage planes. Muscovite forms fine interstitial aggregates, sometimes occurs as stout thick flakes 0.7 mm long, usually associated with biotite. Quartz occurs as anhedral crystals 1.2×0.8 mm, with sutured outlines. It is clear but may be undulosed and shows fine granulation along its peripheries. Quartz forms myrmekitic intergrowths with plagioclase, the latter is occasionally rimmed with quartz. Iron oxide, sphene, zircon and apatite are accessories.

Younger granitoids

Two phases could be distinguished among El-Mueilha granitic pluton: 1) muscovite granite and 2) albitized granite. Generally, these granites exhibit holocrystalline, hypidiomorphic granular texture. They are medium to coarse grained. The essential minerals are quartz, plagioclase, microcline, muscovite and lepidolite. Plagioclase occurs as subhedral crystals ranging from 1.7 mm to 2.0 mm in length and from 0.2 mm to 0.8 mm in breadth. Sometimes plagioclase forms aggregates of small subhedral albite crystals in the groundmass. It is slightly to moderately saussuritized and sericitized and corroded by quartz. Plagioclase is perthitically intergrown with microcline and twinned according to the albite law. Sometimes it shows intense undulose extinction. The alteration often begins in the interior which may be clouded or completely obscured while the margin remains clear. Microcline occurs either as subhedral to anhedral microcline-microperthite crystals, 5×3.5 mm, or as disseminated anhedral equal crystals, 1.5 mm across which are sieved and corroded by other constituents and display different degrees of alteration. In the microcline microperthite, the exsolved sodic plagioclase component occurs within the host microcline as microscopic lamellae which are frequently less altered than the host microcline. Drops of quartz inclusion are common within the microcline. Microcline is corroded by quartz, but itself replaces plagioclase and is sometimes intergrown with it forming perthite texture. It encloses minute prisms of zircon. Muscovite forms fine interstitial aggregates; sometimes occurs as short thick flakes 0.2×0.15 mm, usually associated with biotite and plagioclase of the groundmass or replacing them. Lepidolite occurs in fair amount, and possesses the same optical properties as muscovite, but the former has a large extinction angle (5°—7°). Lepidolite shows higher interference colour. It is recorded in El-Mueilha granites. Zircon, sphene, apatite and iron oxides are accessories. Rarely, cataclasis affects the different minerals of the examined granites. Due to deformation quartz shows wavy extinction, marginal granulation, fracturing and granulation along fractures. The deformation of plagioclase is manifested by undulose extinction and curved and displaced twinning lamellae.

MODAL COMPOSITION

The quantitative mineral composition for 18 representative samples from Um Huqab, Garf and El-Mueilha granitic rocks are given in Table 1. *Fig. 2* shows the classification suggested by IUGS Subcommission on the Systematics of Igneous Rocks, (1973)* which was further reviewed by STRECKEISEN (1976), based on modal quartz-alkali feldspars and plagioclase relative proportions. According to this classification Um Huqab and Garf granites plot in the fields of tonalite and quartz diorite while the granites of El-Mueilha fall within the fields of granite and granodiorite.

PETROCHEMICAL CHARACTERS

The results of major oxide analyses for 13 samples, compared with reference high-calcium granites of TUREKIAN and WEDEPOHL (1961), and, in addition the average analysis of El-Mueilha (ZAGHLOUL *et al*, 1976) one analysis of leuco-granodiorite

TABLE 1

Modal analysis of the investigated granitic rocks

Granites and Sample No.	Mineral	Plagioclase	Quartz	Alk. feldspar	Hornblende	Biotite	Muscovite	Accessories	Total
Garf granitic mass	1•	60.43	22.73	0.00	13.23	0.00	0.00	3.61	100
	2	52.87	19.36	0.56	14.42	6.91	0.00	5.88	100
	3	66.49	12.39	0.62	12.09	6.98	0.00	0.89	100
	4	56.63	16.00	0.00	17.17	8.67	0.00	1.53	100
	5•	46.87	26.65	0.94	20.13	2.81	0.00	2.60	100
	6•	52.80	32.23	1.20	0.00	12.67	0.00	0.80	100
	7•	52.68	24.05	0.90	13.67	7.67	0.00	1.03	100
	8•	62.68	15.25	0.84	4.43	15.57	0.00	1.23	100
	9•	50.82	19.80	0.42	22.22	6.00	0.00	0.74	100
Um Huqab granite	10•	61.70	26.43	1.20	4.03	1.00	4.31	1.33	100
	11	64.56	14.03	0.74	12.03	8.10	0.00	0.54	100
	12•	56.93	36.83	0.00	0.00	4.83	0.00	1.41	100
	13•	65.07	20.46	1.92	0.00	11.39	0.00	1.16	100
El-Mueilha granite	14•	55.03	31.63	10.72	0.00	0.00	2.53	0.09	100
	15•	44.09	38.30	14.66	0.00	0.00	2.52	0.43	100
	16•	47.23	37.23	13.17	0.00	0.00	2.37	0.00	100
	17•	41.30	29.97	24.80	0.00	0.00	3.93	0.00	100
	18•	40.23	44.60	10.67	0.00	0.00	4.50	0.00	100

• These samples have been analysed.

* IUGS Subcomission on the Systematics of Igneous Rocks. Classification and nomenclature of plutonic rocks. Recommendations. Geotimes **18** (1973) 10,26—30.

of Wadi Beizah (DIAB, 1979), and the average analyses of granodiorite (LE MAITRE, 1976) are given in Table 2. From the chemical point of view, the granitic rocks of Garf, Um Huqab and El-Mueilha are considered as high-calcium granites.

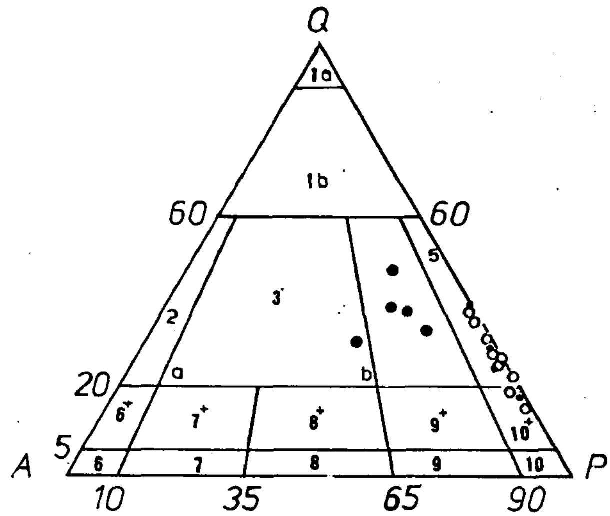

Fig. 2. Classification of the investigated granitic rocks on the basis of their quartz (Q), alkali feldspars (A), and plagioclase (P), (Diagram after the IUGS, 1973). *1a*: quartzolite (silexite), *1b:* quartz-rich granitoids, *2:* alkali-feldspar granite, *3:* granite, *4:* granodiorite, *5:* tonalite, *6:* alkali-feldspar quartz syenite (*6**: alkali-feldspar quartz syenite), *7:* syenite (*7**: quartz syenite), *8:* monzonite (*8**: quartz monzonite, *9:* monzodiorite, monzogabbro, (*9**: quartz monzodiorite, quartz monzogabbro), *10:* diorite, quartz gabbro), *10**: quartz diorite, quartz gabbro, quartz anorthosite. Symbols: ○ Um Huqab granitic mass; · Garf granitic rocks; ● El-Mueilha pluton

The chemical analyses of the examined rocks are plotted on the AFM variation diagram. *Fig. 3* reveals a small differentiation trend which is similar to the late differentiation trends of common calc-alkaline igneous rocks series given by NOCKOLDS and ALLEN (1953). These trends are characterized by decrease of Mg and ($Fe^{3+}+Fe^{2+}$) with increase of alkalies. Trends of variation of these elements follow those defined by EL-GABY (1975) and HUSSEIN *et al.*, (1982) for Egyptian granitoids. On the AFM diagram, the trends are nearly prependicular to the FM side. Duch a trend is characteristic for granites formed under compressional environment, (PETRO *et al.*, 1979).

Fig. 4 shows the alkalinity ratio variation diagram proposed by WRIGHT (1969). It is clear from the diagram that Um Huqab and Garf granitic rocks fall within the cal-alkaline field. This field is defined by HUSSEIN *et al.*, (1982) for synorogenic granitoids (Group I), while El-Mueilha granite show an alkaline tendency and plot within the field of late-orogenic granitoids. The enrichment in soda seems to be a general feature of the late-orogenic granitoids with alkaline affinity (SILLITOE, 1979). In addition, petrographic data reveals that El-Mueilha granites suffered greatly from alkali metasomatism.

The agpaitic coefficient from Zavaritski-parameters (*c.f.* BAILY and MACDONALD, 1970) is plotted *vs.* SiO_2 showing the peralkaline nature of Um Huqab, Garf and El-Mueilha granitic rocks *Fig. 5.* There are two main groups, the agpaitic and the

TABLE 2

Chemical analyses of the investigated granitic rocks and some chemical analyses for comparison

	El-Mueilha granite pluton						Garf granitic mass				Um Huqab granitic mass						
Sample No	1	2	3	4	5	6	7	8	9	10	11	12	13	A	B	C	D
SiO_2	72.71	70.60	75.34	72.73	72.18	74.97	66.11	68.07	59.69	62.37	66.95	66.88	70.22	67.23	76.96	66.09	66.40
Al_2O_3	13.32	15.79	13.26	14.54	14.79	12.29	17.34	15.60	16.97	14.90	16.31	17.22	14.94	15.50	13.22	15.73	15.07
Fe_2O_3	1.15	0.20	0.11	0.27	0.96	0.45	1.24	0.97	2.36	3.09	2.46	0.75	0.26	4.23	1.05	1.38	1.74
FeO	0.49	0.22	0.44	0.30	0.18	0.37	2.74	1.92	3.26	3.83	1.92	1.11	1.06	—	0.33	2.73	2.99
TiO_2	0.02	0.02	0.03	0.04	0.02	0.03	0.83	0.36	0.84	0.69	0.28	0.37	0.17	0.57	0.06	0.57	0.50
CaO	1.40	1.72	1.05	1.40	0.98	2.25	1.61	2.18	3.81	5.27	2.40	4.38	3.71	3.54	1.12	3.83	3.57
MgO	0.50	0.05	0.28	0.04	0.05	0.10	0.86	1.46	2.11	2.52	0.63	1.02	0.42	1.56	0.31	1.74	1.65
Na_2O	5.17	5.99	4.78	4.57	5.33	4.33	4.24	4.12	4.33	4.54	4.99	4.99	4.50	3.83	3.13	3.75	3.86
K_2O	3.88	3.65	3.81	4.33	3.82	3.55	1.86	1.90	1.78	1.43	2.04	2.05	2.47	3.04	3.29	2.73	3.07
MnO	—	0.02	0.06	0.05	0.09	—	0.09	0.06	0.05	—	0.09	0.04	0.08	0.07	0.03	0.07	0.07
P_2O_5	0.10	0.07	0.27	0.07	0.07	0.07	0.27	0.37	0.34	0.17	0.13	0.18	0.08	0.21	0.05	0.10	0.20
H_2O^-	—	0.10	—	0.02	—	—	0.07	0.07	0.02	0.52	0.20	0.11	0.23	—	0.04	0.19	—
H_2O^+	0.98	0.67	0.40	0.76	0.75	0.63	1.79	1.44	3.18	0.60	1.60	0.97	0.92	—	0.37	0.25	0.79
Total	99.72	99.10	99.83	99.12	99.22	99.04	99.05	98.72	98.74	99.93	100	100.07	99.06	99.36	99.96	99.90	99.89
Agpaitic coef.	0.95	0.87	0.90	0.84	0.87	0.89	0.52	0.58	0.53	0.60	0.64	0.61	0.67	0.62	0.65	0.58	0.64
Alkalinity ratio	4.19	3.45	4.00	3.53	3.76	3.37	1.95	2.08	1.83	1.84	2.20	1.97	2.19	2.13	2.70	1.99	2.18
Felsic/mafic ratio	21.64	33.90	42.10	38.34	35.02	24.77	10.54	10.72	5.33	4.34	9.31	9.49	13.34	7.53	29.61	6.93	7.17

A) High-calcium granites of TUREKIAN and WEDEPOHL, (1961), B) Average analysis of El-Mueilha (ZAGHLOUL ET AL., 1976), C) Leuco-granodiorite of Wadi Beizah (DIAB, 1979). D) Average analysis of granodiorite (LE MAITRE, 1976).

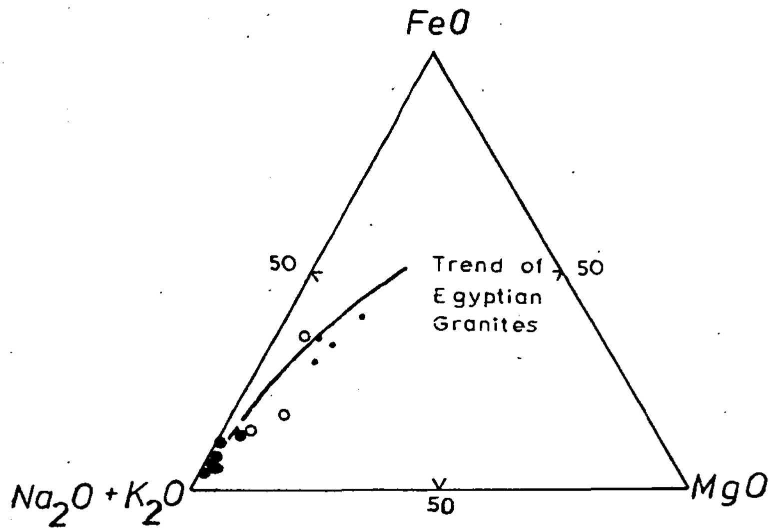

Fig. 3. AFM diagram for the studied granites. The trend of Egyptian granites is defined after HUSSEIN *et al.*, (1982), $A = K_2O + Na_2O$, $F = FeO + 0.9\ Fe_2O_3$, $M = MgO$. Symbols as in *Fig. 2.*

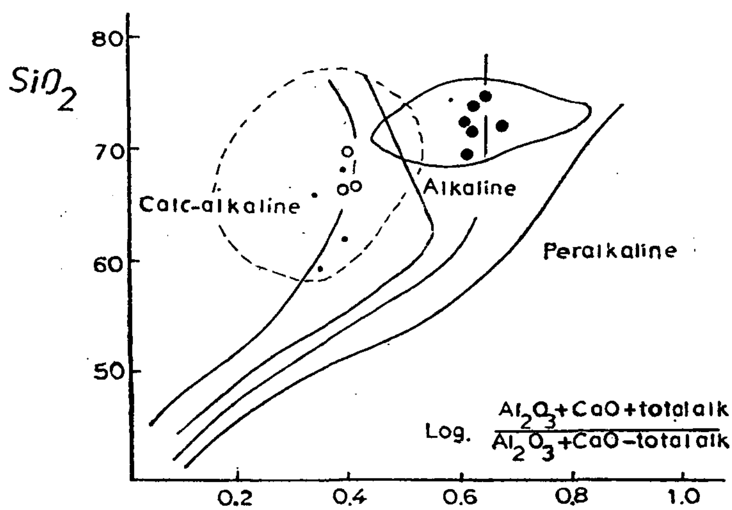

Fig. 4. Alkalinity ratio variation diagram of WRIGHT (1969) for the investigated granites. Fields of synorogenic granitoids (dashed) and late-orogenic granitoids (solid) are defined after HUSSEIN *et al.*, (1982). Symbols as in *Fig. 2.*

miaskitic types with agpaitic coefficient more or less than 1, respectively. It is evident that the investigated samples plot within the field of miaskitic nature i.e. mol. ratio of $Na_2O + K_2O/Al_2O_3$ is less than unite (hyperalkaline granites).

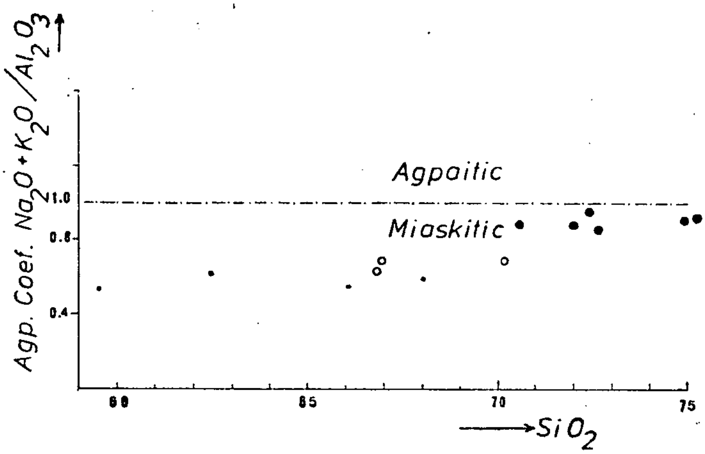

Fig. 5. Agpaitic index *versus* SiO_2 diagram. Symbols as in *Fig. 2.*

NIGGLI *values*

The calculated NIGGLI-values of the examined granitic rocks are given in Table 1. The values of *al* plotted *vs. alk* are given in *Fig. 6.* It is obvious from the figure that all samples of Um Huqab and Garf fall within the inermediate with the exception of one sample falling in the field relatively rich, (*alk*=2/3 *al*).

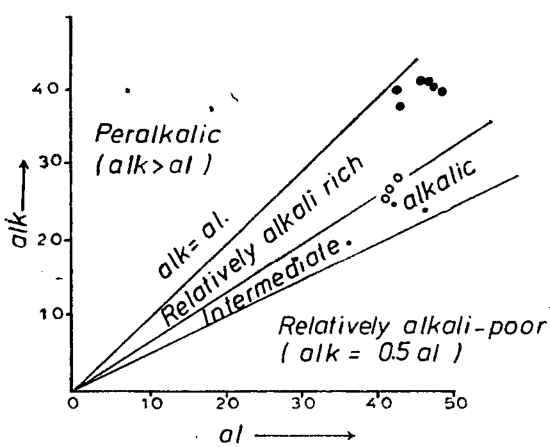

Fig. 6. Relationships of *al* and *alk* in the granitic rocks (after BURRI and NIGGLI, 1945). Symbols as in *Fig. 2.*

Norm values

The calculated norm values for the investigated granitic rocks are given in Table 2. The normative Or, Ab and An proportions of the granitic rocks are plotted in a ternary diagram *Fig. 7.* It is clear from the diagram that most of the granites of El-Mueilha fall close the field of sodic series, thus indicating their enrichment in sodium content while few samples of the examined rocks fall nearer to the field of the average

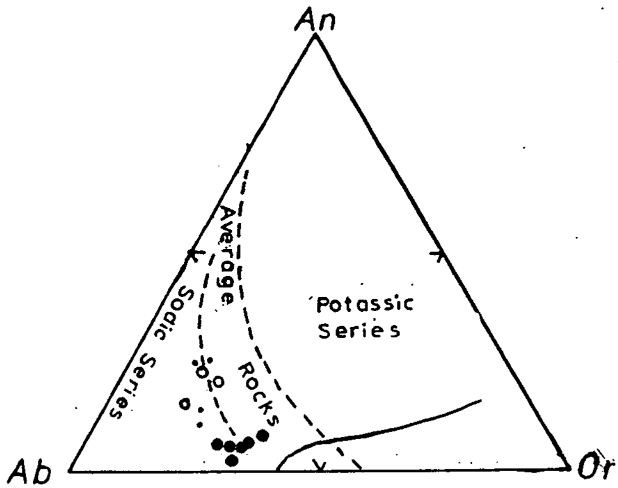

Fig. 7. An, Ab and Or normative proportions in the investigated granites. The solid line represents the two feldspar boundary curve for the quartz saturated ternary feldspar system at 1000 bars water-vapour pressure (after JAMES and HAMILTON, 1969). Sodic and potassic zones from IRVINE and BARAGAR, (1971). Symbols as in *Fig. 2*.

rocks, all plots of the examined granites follow the isobaric univariant curve, indicating that crystal-liquid equilibrium was the dominant mechanism involved in the genesis of these granites (JAMES and HAMILTON, 1969).

Chemical classification

A chemical classification of the granitic rocks of Um Huqab, Garf and El-Mueilha is attempted on the basis of their normative feldspars. *Fig. 8* shows the normative classification suggested by O'CONNOR (1965). According to this normative classification, Um Huqab and Garf granites fall within the field of granite-trondhjemite with the exception of two samples falling within the field of tonalite. All the granitic samples of El-Mueilha fall within the field of granite, with two sample falling within the field of trondhjemite.

SEGERSTROM *and* YOUNG'*s classification*

For purpose of classifying igneous rocks SEGERSTROM and YOUNG (1972) using data of average chemical composition of NOCKOLDS (1954), introduced a felsic-mafic ratio, later slightly modified by YOUNG. This ratio is expressed by SiO_2+ $+K_2O/Fe_2O_3+FeO+MgO+CaO$; values of felsic-mafic ratio are as follows:

Rock type	*Felsic-mafic ratio*
Extreme alkali granite	>50
Alkali granite (alkali rhyolite)	25—50
Granite (rhyolite)	15—25
Quartz monzonite (quartz latite)	10—15
Granodiorite (dacite)	7—10

Quartz diorite (quartz andesite)	5—7
Monzonite (latite)	3—5
Diorite (andesite)	2.1—3
Gabbro (basalt)	1.4—2.1
Ultramafics	<1.4

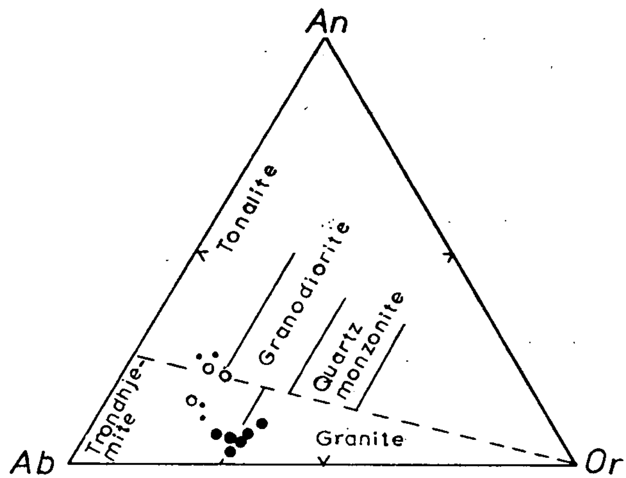

Fig. 8. Normative feldspar ratios (after O'CONNOR, 1965). Symbols as in *Fig. 2.*

In the present work felsic-mafic ratios of El-Mueilha range from 21.64—42.10 (Table 2) indicating alkaline granite and granite while Um Huqab range from 9.31—13.34 (Table 3). Accordingly the examined granitic rocks of Um Huqab are classified as granodiorite and quartz monzonite. Garf granites range from 4.34 to 10.54 indicating that Garf granites are classified as alkali granite and monzonite.

STRECKEISEN's *classification (1976)*

The normative Or, Ab and An proportions of the studied rocks are plotted in a ternary diagram introduced by STRECKEISEN (1976). It appears from the *Fig. 9.* that the granitic rocks of Um Huqab and Garf fall within the fields of granodiorites *(4)* with one sample falling in field of trondhjemite *(5)* and the other samples of El-Mueilha falling in field of syeno-granite and monzo-granite (*3a*, *3b* respectively).

Petrogenesis

The normative Or, Ab and An proportions of the examined granites are plotted in a ternary diagram *Fig. 10* and the results are compared with experimental data of TUTTLE and BOWEN (1958). It is observed from this figure that the examined granitic rocks fall around the minimum melting curve of the granite system at water—vapour pressure from 500 to 10,000 bars. Most of the samples are located nearer to the high water-vapour pressure end of minimum the melting curve. This suggests that the emplacement of the examined granitic rocks was at moderate to higher water-vapour pressure (10,000 bars and in turn, at moderate to deeper depths in the crust. Also, it is observed from *Fig. 10* that the plots for Um Huqab, Garf and El-Mueilha show some scatter along the minimum melting curve at moderate to high

TABLE 3

Niggli values of the investigated granitic rocks

Granite masses	El-Mueilha Granitic Pluton						Garf Granitic Mass			Um Huqab Granitic Body			
Sample No	1	2	3	4	5	6	7	8	9	10	11	12	13
al	42.61	47.21	46.18	48.09	47.39	42.83	46.82	42.78	36.90	30.25	42.17	42.23	42.96
fm	8.62	2.16	5.43	3.12	5.57	4.71	21.00	21.23	28.37	31.99	19.62	12.68	8.67
c	8.14	9.35	6.65	8.42	5.71	14.25	7.91	10.87	15.06	19.45	11.28	19.53	19.40
alk	40.64	41.28	41.54	40.37	41.34	38.21	24.27	25.13	19.68	18.31	26.93	25.57	28.98
si	394.70	358.22	445.23	408.25	322.41	443.29	302.95	316.74	220.24	214.90	293.72	278.30	342.64
k	0.33	0.29	0.34	0.38	0.32	0.35	0.22	0.22	0.21	0.17	0.21	0.21	0.27
mg	0.47	0.18	0.45	0.11	0.07	0.19	0.28	0.48	0.41	0.40	0.21	0.50	0.35
qz	+132.14	+93.10	+179.07	+146.77	+127.05	+190.45	+105.87	+116.26	+41.52	+41.66	+86.00	+76.02	+126.72

TABLE 4

Norm values of the examined granitic rocks

Granite masses	El-Mueilha Granitic Pluton						Garf Granitic Mass			Um Huqab Granitic Body			
Sample No	1	2	3	4	5	6	7	8	9	10	11	12	13
qz	23.60	17.33	28.56	24.97	22.98	31.09	27.93	27.55	15.63	15.40	22.55	18.25	25.10
or	23.20	21.60	22.65	25.95	22.80	21.45	11.35	11.55	11.00	8.60	12.30	12.15	14.90
ab	47.05	53.85	43.15	41.65	48.30	39.70	39.40	40.00	40.75	41.45	45.70	44.95	41.30
an	1.70	5.43	3.48	6.48	4.40	3.70	6.40	8.68	17.45	16.35	11.30	18.60	13.58
c	—	—	—	—	0.32	—	6.88	3.78	2.08	—	2.05	—	—
w	1.88	1.04	—	0.02	—	2.88	—	—	—	3.64	—	0.82	1.88
en	1.40	0.14	0.78	0.12	0.14	0.28	2.46	4.16	6.10	7.08	1.78	2.82	1.18
fs	0.32	0.22	0.66	0.30	—	0.22	2.44	1.94	2.44	2.86	1.02	0.74	1.36
mt	0.62	0.21	0.12	0.29	0.60	0.48	1.34	1.05	2.58	3.29	2.63	0.78	0.29
il	0.02	0.02	0.04	0.06	0.02	0.04	1.20	0.52	1.22	0.98	0.40	0.52	0.24
ap	0.21	0.16	0.56	0.16	0.16	0.16	0.59	0.80	0.75	0.37	0.27	0.37	0.16
ht	—	—	—	—	0.28	—	—	—	—	—	—	—	—
Total	100	100	100	100	100	100	99.99	100	99.99	100	100	100	99.99
Diferentiation Index	93.85	92.78	94.37	92.59	94.09	92.24	78.68	79.10	67.38	65.46	80.55	75.35	81.30

water-vapour pressures which may indicate that the emplacement of these rocks was accompanied by a wide range of water-vapour pressure which may be interpreted in terms of multiphase origin for the examined rocks i.e. the investigated granitic rocks are formed of more than one phase.

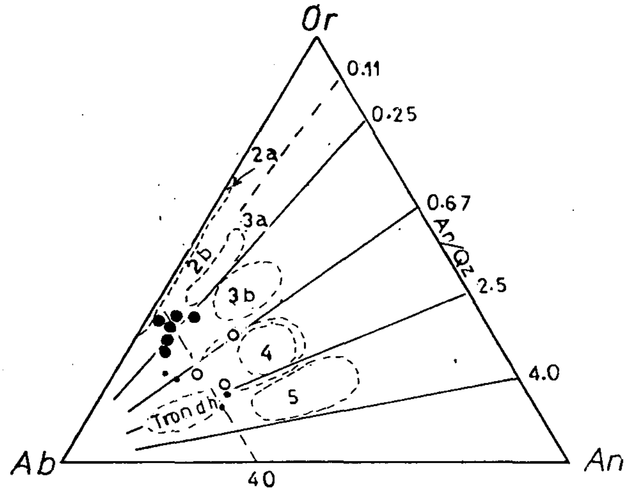

Fig. 9. Quartz-feldspar rocks (after STRECKEISEN, 1967) Symbols as in *Fig. 2.*

2a [Alkaline granite / Alkali rhyolite

2b [Alkali-feldspar granite / Rhyolite

3a [(Syeno-) granite / Rhyolite

3b [(Monzo-)granite / Rhyodacite

4 [Granodiorite / Dacite

5 [Tonalite / Plagidacite / Trondhjemite

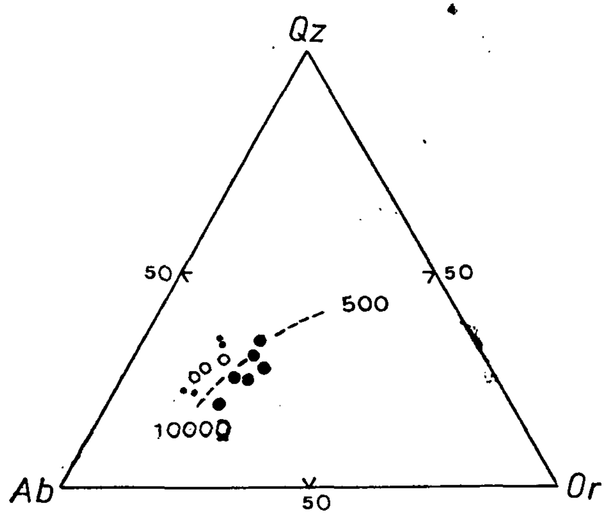

Fig. 10. Normative Qz — Ab — Or proportions for the studies granites. The solid line represents the variation in position of the minimum melting points in the granite system at water-vapour pressures from 500 to 10 000 bars (after TUTTLE and BOWEN, 1958). Symbols as in *Fig. 2.*

CONCLUSIONS

The granitic masses of El-Mueilha, Garf and Um Huqab of the Precambrian basement in the Southern part of the Central Eastern Desert of Egypt are petrochemically characterized. The examined granitic rocks are classified as synorogenic (Garf and Um Huqab) and late- to post-orogenic (El-Mueilha). The former are generally considered as belonging to the late Proterozoic intrusions "grey granites". The latter belonging to the third phase of the Gattarian granites and the muscovite-granite with the albitized types. The examined granites show a wide range of chemical composition with differentiation indices between 67.38—94.31 indicating a highly differentiated magma. Garf and Um Huqab granites range from trondhjemite to tonalite while El-Mueilha are of granite composition. The albitization of the latter is attributed to sodium metasomatism. All the examined granitic rocks are of miaskitic nature. Garf and Um Huqab granites are calc-alkali with sodic character while El-Mueilha granite has rather alkaline affinity with potassic tendency. It is argued that the examined granitic rocks are of magmatic origin. El-Mueilha granite pluton is probably derived by fractional fusion of crustal rocks. It is also suggested that the examined granitic masses are formed under compressional environments.

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