Acta Mineralogica-Petrographica, Szeged, XXIV/2, 257—269, 1980

PETROCHEMISTRY AND PETROGENESIS OF ABU DOB GRANITIC STOCK, EASTERN DESERT, EGYPT

MAHMOUD LOTFY KABESH, MOHAMED E. HILMY
and ABDEL-KARIM AHMED SALEM

ABSTRACT

The granitic rocks of Abu Dob stock, Eastern Desert, Egypt are petrochemically characterized. Results of 12 new chemical analyses are presented and processed according to several chemical parameters. The average chemical composition of Abu Dob granitic rocks agrees broadly with low-calcium granite of TUREKIAN and WEDEPOHL, [1961]. The granitic rocks belong to the calc-alkaline series. Modal and chemical classifications of these granitic rocks are advanced. Magmatic origin is suggested for the investigated rocks based on experimentally studied systems.

INTRODUCTION

EL-RAMLY and AKAAD [1960], SABET [1961] and EL-RAMLY [1972] regarded the granitic rocks of Abu Dob as belonging to the younger group of granitoids. SABET *et al.*, [1976] considered the granitic rocks of Abu Dob together with several granitic plutons in the Eastern Desert of Egypt as belonging to the late Proterozoic — Early Paleozoic intrusions. These authors also assigned such granitic plutons to the "Gattarian Group" and to the phase of the coarse — grained biotite granite and the leucocratic granite.

The investigated rocks of Abu Dob occur in the Central Eastern Desert of Egypt *(Fig. 1)*. The present work constitutes part of a continuing program aiming at the petrochemical characterisation and petrogenesis of the younger granitoids of Precambrian age in the Central Eastern Desert of Egypt, [KABESH *et al.*, 1974; KABESH *et al.*, 1975; KABESH *et al.*, 1976; REFAAT *et al.*, 1977; RAGAB *et al.*, 1979; KABESH *et al.*, in press — a) and KABESH *et al.*, 1980 b]. In the present study the petrochemical features and petrogenesis of Abu Dob granitic stock are discussed. A chemical classification of the granitic rocks is advanced based on normative feldspars.

GEOLOGIC SETTING OF ABU DOB AREA

Abu Dob area is dominantly formed of basement complex of Precambrian age. The rocks comprise schists, metavolcanics, diorites, granodiorites and granitic rocks. The previous basement rocks are cut by post-granitic dykes *(Fig. 2)*. The granitic rocks of Gebel Abu Dob form a roughly circular mass showing intrusive sharp contacts with the metasediments, the meta-volcanics and the dioritic rocks. The granitic rocks form moderately elevated features and comprise three major distinct field types; granodiorites, coarse-grained pinkish white granites and coarse-grained pink-red granites. The relative age of these granitic rocks is determined in the field

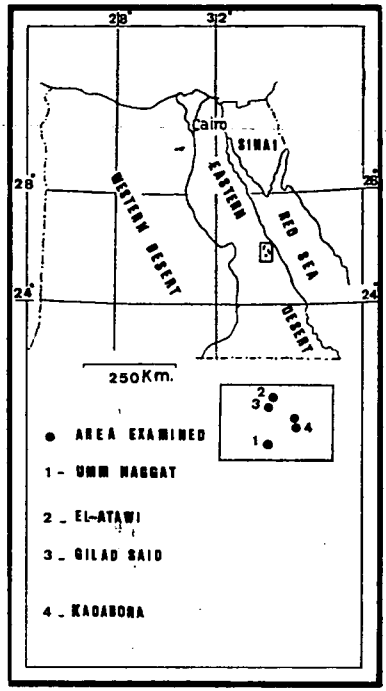

Fig. 1. Location map

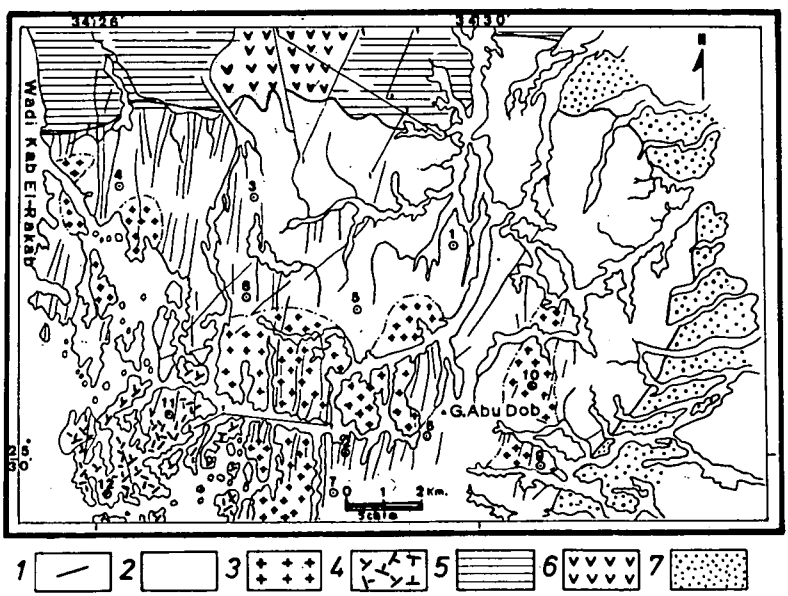

Fig. 2. Generalized geological map of Abu Dob area showing granitic types and sample location (after SALEM, 1972)
1. Post-granite dykes; 2. Pink and red granites; 3. Pinkish white granites; 4. Granodiorites; 5. Diorites; 6. Meta-volcanics; 7. Schists

on the basis of cross-cutting relations and presence of included xenoliths of the country rocks within the host granites. Boundaries between the granitic types may be sharp but generally they are gradational and need not reflect major changes in mineralogy. It is assumed therefore that the granites of Abu Dob may be considered as homogeneous representing crystallization of the granitic magma in one phase of emplacement. They appear in a general way to have reached their present position probably by forcible intrusion and shouldering apart of the country rocks. Moreover, the emplacement was likely accompanied by some kind of granite tectonics [SALEM, 1972].

PETROGRAPHY

Petrographically, several types have been recognized namely biotite adamellite, biotite perthite-granite, muscovite perthite-granite, microcline-perthite granite and leuco-granite. Generally these granites exhibit holocrystalline hypidiomorphic granular texture. They are coarse-grained usually non-porphyritic and even-grained. Porphyritic types are not uncommon with megacrysts of quartz up to 5 mm across and microcline-perthite up to 3.5 mm across. The essential minerals are quartz, microcline-perthite, plagioclase (albite — oligoclase), biotite and muscovite. Few micrographic intergrowths are observed. Rare garnet crystals are seen in some of the pink — red granites.

The alkali feldspars particularly microcline — perthite are heavily charged with iron oxide inclusions along the cleavage planes which is responsible for the conspicuous red aspect imparted to these granites. Quartz is usually clear but is sometimes deformed by fracturing, showing strong undulose extinction and may enclose fine opaque trails. Biotite is the sole mafic and forms stout flakes with torn ends which may be chloritized. The brown variety is dominant while green biotite is rarely observed. Muscovite forms fine interstitial aggregates sometimes enclosed in quartz. Iron oxides, apatite, zircon, sphene and epidote are accessories.

MODAL COMPOSITION

The quantitative mineral composition for 12 representative samples from Abu Dob granitic rocks are given in Table 1.

TABLE 1

Modal analysis of Abu Dob granitic rocks

	1	2	3	4	5	6	7	8	9	10	11	12
Quartz	27.20	34.20	34.40	34.10	37.90	36.20	38.50	36.10	33.00	34.90	26.80	30.60
Potash feldspars	46.30	41.50	32.40	46.50	32.60	43.40	44.70	46.50	37.20	39.10	19.30	20.50
Plagioclase	21.20	15.50	28.20	16.40	15.50	15.10	14.40	15.40	25.20	22.30	44.30	36.00
Biotite	3.70	—	—	—	1.00	—	—	—	—	—	7.80	11.80
Muscovite	—	6.60	—	—	—	4.10	—	—	2.70	—	—	—
Accessories	1.60	2.20	5.00	3.00	4.00	1.20	2.40	2.00	1.90	3.70	1.80	1.10
Total	100	100	100	100	100	100	100	100	100	100	100	100

Fig. 3 shows the classification suggested by the IUGS Subcommission on the Systematics of Igneous Rocks, [1973]* which was further reviewed by STRECKEISEN

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

[1976], based on the modal quartz-alkali feldspar plagioclase relative proportions. According to this classification Abu Dob granitic rocks largely plot in the field of granites. However, one sample falls in the field of granodiorites.

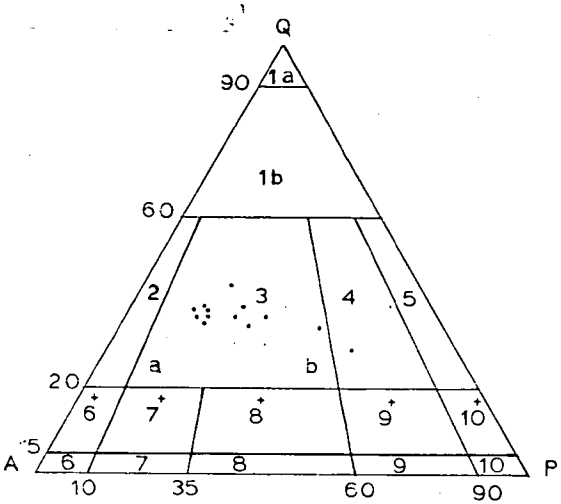

Fig. 3. Classification of Abu Dob granitic rocks on the basis of their quartz (Q), alkali feldspars (A) and plagioclase (P). (Diagram after the IUGS, 1973)
1a: Quartzolite (silexite); 1b: Quartz-rich granitoids; 2: Alkali-feldspar granite; 3: Granite; 4: Granodiorite; 5: Tonalite; 6: Alkali-feldspar 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, gabbro, anorthosite; (10^+: Quartz diorite, quartz gabbro, quartz anorthosite)

PETROCHEMICAL CHARACTERS

Petrochemical characters of the granitic rocks were deduced from the study of RITTMANN's suite index, normative minerals and NIGGLI values as calculated from chemical analysis.

The chemical analyses of 12 samples representing the different types of the granitic rocks of Abu Dob stock are given in Table 2, the location of the analysed samples is shown in *Fig. 2.*

RITTMANN'S INDEX

RITTMANN's suite indices [1957] for Abu Dob granitic rocks are given in Table 2 and are plotted graphically in *Fig. 4* against SiO_2. It is evident from the diagram according to the quantitative subdivisions of RITTMANN that the granitic rocks range between Pacific and average Pacific (1.58—3.19) which correspond to a calc-alkaline character. Compared with the average RITTMANN's Index for some younger granitoid plutons in the Eastern Desert, Umm Naggat (1.82), El-Atawi (1.95), Gilad Said (2.02), and Kadabora (2.59), it is clear that all these granitic plutons belong to a calc-alkaline suite.

Fig. 5 shows the relation between the agpaitic coefficient and SiO_2 percent. The agpaitic coefficient from the ZAVARITSKI parameter [c. f. BAILY and MACDONALD,

1970] is plotted against SiO_2 to show the nature of Abu Dob granitic rocks. According to the diagram all the investigated rocks are classified as miaskitic i. e. mol. ratio of Na_2O+K_2O/Al_2O_3 is less than unity.

The calculated NIGGLI values of the granitic rocks are given in Table 3. The values of *al* are plotted against *alk* values of NIGGLI *(Fig. 6)*. It is evident that nearly all the granitic rocks of Abu Dob fall within the relatively alkali-rich, with two samples (representing granodiorites) falling in the intermediate-alkali rocks according to BURRI [1964].

For purpose of comparison the average agpaitic coefficient and SiO_2 of the granitic plutons of Umm Naggat; [REFAAT *et al.*, 1975], El-Atawi [KABESH *et al.*, 1976],

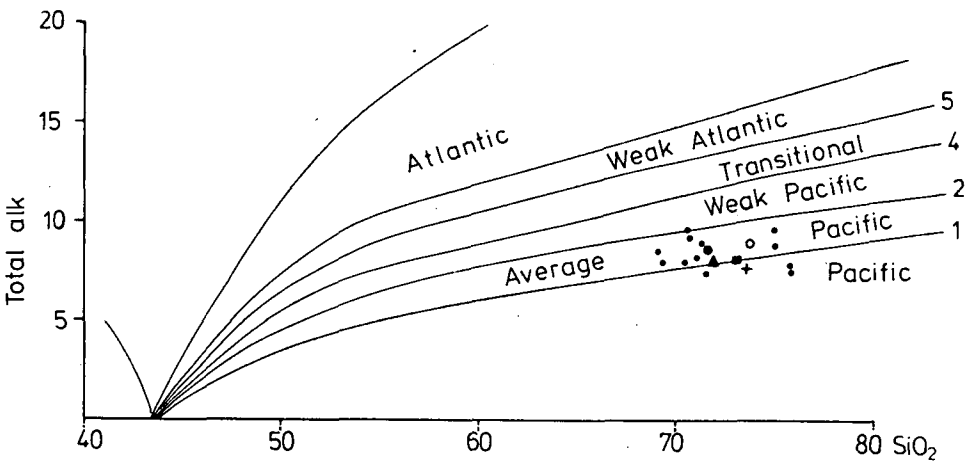

Fig. 4. Plots of RITTMANN's Index for Abu Dob granitic rocks and other localities
Key to symbols:
+ Um Naggat ■ El-Atawi ▲ Gilad Said
○ Kadabora ● Abu Dob (averages); · Single measurements

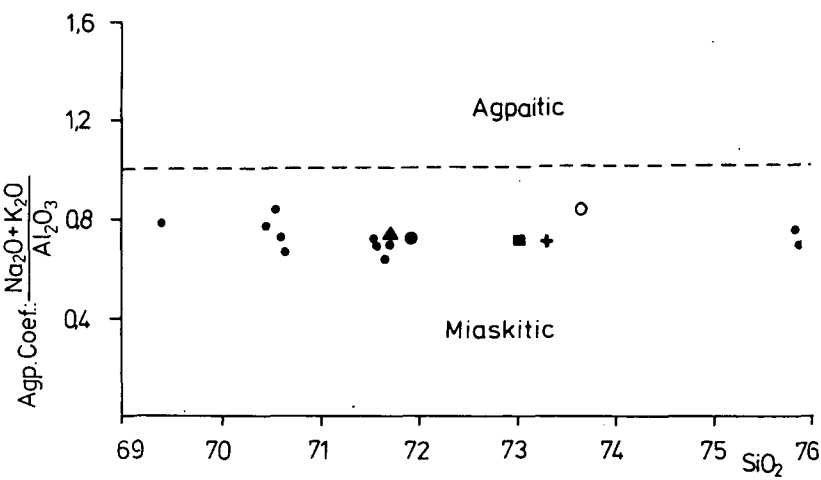

Fig. 5. Agpaitic Index versus SiO_2 diagram (symbols see in Fig. 4)

TABLE 2a

Chemical analyses of Abu Dob granitic rocks

	Pink-red granites								Pinkish white granites		Granodiorites		
	1	2	3	4	5	6	7	8	9	10	11	12	Average
SiO_2	74.90	71.66	70.48	70.55	71.66	71.58	75.82	75.82	70.62	70.62	69.48	69.48	71.88
Al_2O_3	13.80	15.60	15.80	14.60	15.90	15.60	13.70	13.20	15.87	15.90	15.40	15.20	15.05
Fe_2O_3	0.44	0.43	0.85	0.40	0.35	0.55	0.43	0.53	0.97	0.60	0.50	0.80	0.57
FeO	0.36	0.72	0.95	1.92	1.46	1.40	0.72	0.72	1.91	0.83	1.68	0.90	1.13
MnO	—	—	—	—	0.26	—	—	—	0.26	—	0.30	0.30	0.09
MgO	0.40	0.50	0.30	0.60	0.40	0.50	0.20	0.22	0.20	0.88	1.10	1.30	0.55
CaO	0.61	0.53	0.66	0.90	0.61	0.70	0.44	0.35	0.61	0.37	1.05	1.05	0.69
Na_2O	3.36	3.44	3.62	3.54	3.34	3.70	3.53	3.52	3.54	3.45	4.43	3.43	3.58
K_2O	5.54	4.93	5.94	5.84	4.40	4.50	3.68	3.86	4.39	5.38	4.33	4.25	4.75
TiO_2	0.03	0.03	0.03	0.03	0.04	0.09	0.07	0.05	0.06	0.04	0.03	0.09	0.04
P_2O_5	0.04	0.16	0.16	0.04	0.18	0.19	0.18	0.18	0.18	0.14	0.15	0.35	0.06
H_2O	0.45	1.10	1.00	0.78	0.87	0.62	0.86	0.96	0.70	0.96	1.00	1.00	0.89
Total	99.93	99.10	99.79	99.20	99.47	99.43	99.63	99.41	99.31	99.17	99.45	99.15	99.40
Agp. coef.	0.84	0.70	0.76	0.83	0.65	0.70	0.71	0.75	0.67	0.72	0.78	0.78	0.74
RITTMANN'S Index	2.48	2.44	2.32	3.19	2.09	2.35	1.58	1.66	2.28	2.82	2.90	2.23	2.45

TABLE 2b

Average of chemical analyses

	A	B	C	D
	Umm Naggat (21)+	El-Atawi (10)+	Gilad Said (20)+	Kadabora (20)+
SiO_2	73.31	73.06	71.72	73.74
Al_2O_3	14.09	14.28	14.70	14.09
Fe_2O_3	0.71	0.85	1.28	0.59
FeO	1.13	0.75	0.88	0.80
MgO	0.64	1.27	1.15	0.08
CaO	1.19	1.20	1.13	0.51
Na_2O	3.19	3.81	4.20	3.90
K_2O	4.24	3.84	3.41	5.03
MnO	0.08	0.04	0.01	0.02
P_2O_5	0.11	0.05	0.14	0.02
TiO_2	0.19	0.13	0.35	0.03
H_2O^+	0.43	0.43	0.57	0.61
H_2O^-	—	—	—	0.13
Total	99.31	99.71	99.54	99.55
Agp. coef.	0.70	0.73	0.72	0.84
RITTMANN'S Index	1.82	1.95	2.02	2.59

+ average of samples.

Gilad Said [RAGAB *et al.*, 1979] and Kadabora [KABESH *et al.*, 1980 b] are plotted. It is clear that Abu Dob granitic rocks are of the same miaskitic nature as all these plutons.

The calculated norm values of the investigated granitic rocks are given in Table 4.

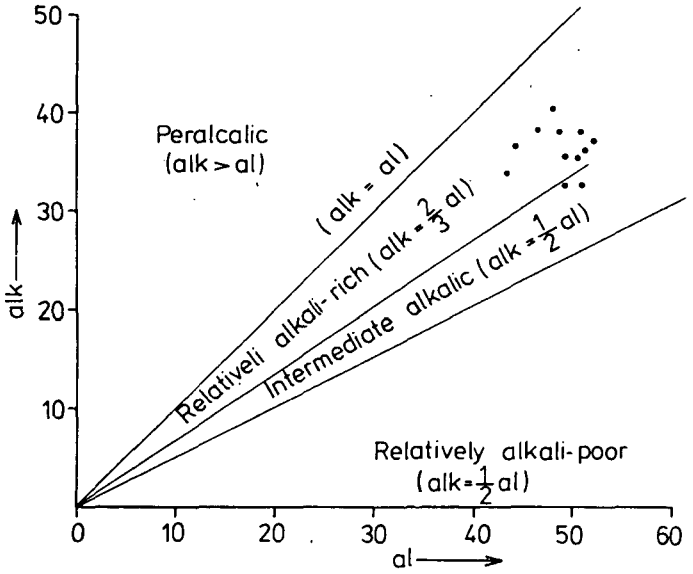

Fig. 6. al — alk diagram of Niggli

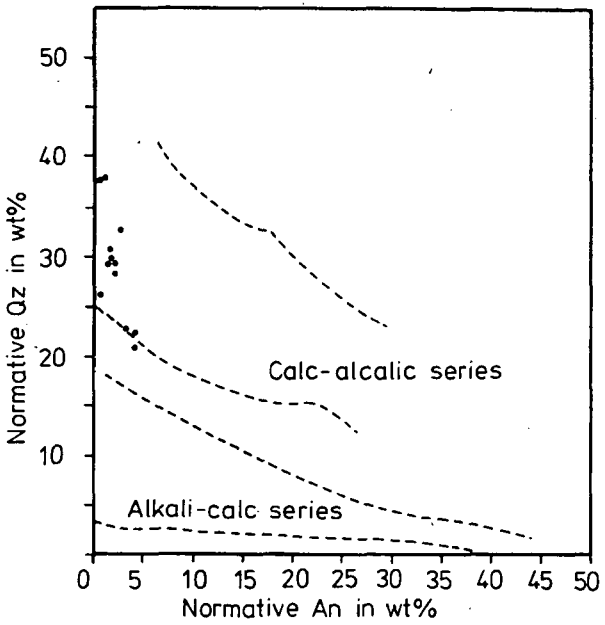

Fig. 7, Normative *Qz — An* relation for the investigated granites

Fig. 7 shows the normative quartz plotted against normative anorthite. From the diagram, it is evident that the examined granitic rocks fall within the calc-alkalic series.

TABLE 3

NIGGLI *values for the examined granites*

	1	2	3	4	5	6	7	8	9	10	11	12
qz	+184.07	+155.43	+115.07	+114.73	+74.06	+151.94	+239.48	+240.73	+139.43	+129.07	+97.11	+100.93
al	48.39	51.33	48.50	44.06	51.01	50.62	51.96	50.65	49.01	49.32	43.36	43.41
fm	7.31	9.33	9.80	14.34	12.52	9.70	7.87	8.65	14.91	12.93	17.56	17.19
c	3.89	3.17	3.68	4.94	3.56	4.13	3.03	2.44	3.42	2.09	5.37	5.45
alk	40.41	36.17	38.02	36.65	32.91	35.55	37.13	38.25	32.66	35.66	33.71	33.95
mg	0.48	0.45	0.24	0.32	0.26	0.42	0.24	0.25	0.10	0.53	0.45	0.55
K	0.52	0.48	0.52	0.52	0.46	0.44	0.41	0.42	0.45	0.51	0.39	0.39
si	445.71	400.11	367.15	361.33	305.70	394.14	488.00	493.73	370.07	371.71	331.95	336.73

TABLE 4

Norm values for the investigated granites

	1	2	3	4	5	6	7	8	9	10	11	12
qz	30.23	29.34	23.35	22.17	30.97	29.17	38.02	38.05	29.08	26.28	20.82	22.14
or	33.10	29.85	35.60	35.15	26.55	27.15	22.25	23.45	26.55	32.40	25.90	25.45
ab	30.55	31.65	32.95	32.40	30.65	33.95	32.45	32.50	32.55	31.55	40.25	40.35
an	2.80	1.60	2.20	4.30	1.95	2.30	1.10	0.65	1.95	0.95	4.25	3.05
c	1.39	4.50	2.90	1.02	5.52	4.27	3.94	3.36	5.13	4.52	2.08	2.45
en	1.12	1.42	0.84	1.68	1.12	1.40	0.56	0.62	0.56	2.48	3.08	3.64
fs	0.22	0.88	0.86	2.72	2.42	0.64	0.74	0.35	2.72	0.82	2.74	1.22
mt	0.46	0.45	0.90	0.42	0.37	0.58	0.46	0.57	1.03	0.64	0,52	0.84
il	0.04	0.04	0.04	0.04	0.06	0.12	0.10	0.06	0.04	0.06	0.04	0.12
ap	0.08	0.35	0.35	0.08	0.37	0.40	0.37	0.37	0.37	0.29	0.32	0.73
Total	99.99	100	99.99	99.98	99.98	99.98	9.99	99.98	99.98	99.99	100	99.99

CHEMICAL CLASSIFICATION

The chemical classification of Abu Dob granitic rocks is presented based on their normative feldspars.

Fig. 8 is the normative classification of HIETANEN, [1963]. It is clear that all the granitic rocks of Abu Dob fall within the field of granite.

Fig. 9 shows the normative classification suggested by STRECKEISEN [1976] for the quartz-feldspar rocks. It is evident that the granitic rocks of Abu Dob fall largely within the field of alkali granites.

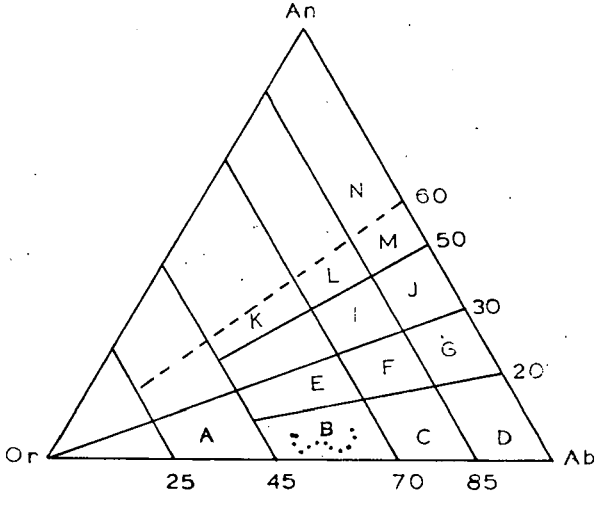

Fig. 8. Triangular diagram for An Ab and Or normative ratio in the granitic rocks (after HIETANEN, 1963)
A Potassium granite; B Granite; C Granite-trondhjemite; D Trondhjemite; E Quartz monzonite; F Monzonite; G Tonalite; H Calci-granite; I Granodiorite; J Quartz diorite; K Calci-monzonite; L Granogabbro; M Gabbro, N Mafic gabbro

PETROGENESIS

Consideration of the petrogenesis of Abu Dob granitic rocks is discussed on the basis of some experimentally studied systems using normative quartz-orthoclase and albite proportions of the examined granitic rocks (Table 4.)

Fig. 10 shows plots of the normative Qz — Or — Ab compared with experimental data of TUTTLE and BOWEN [1958]. It is clear from the figure that the majority of the granitic rocks have their composition close to the minimum melting point at low to moderate water vapour pressure in the $NaAlSi_3O_8$—SiO_2—H_2O system. From the close relationship between the minimum melting point for low water vapour pressure and the normative composition of the analysed rocks in WASHINGTON's tables [1917] in which normative Qz+Or+Ab are 80%, TUTTLE and BOWEN [1958] concluded that there can be little doubt that magmatic liquids are involved in the genesis of these granitic rocks.

The plots of Qz — Or and Ab of Abu Dob granitic rocks correlated with the synthetic system $NaAlSi_3O_8$—$KAlSi_3O_8$—SiO_2—H_2O [LUTH *et al.*, 1964] are shown

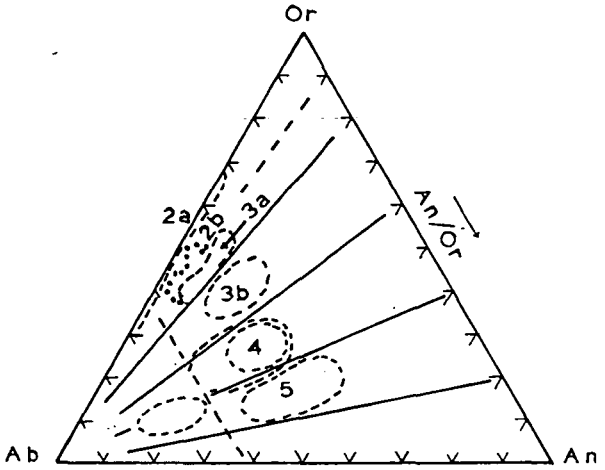

Fig. 9. Quartz — feldspar rocks (after STRECKEISEN, 1976)
2a Alkali granite, Alkali rhyolite; 2b Alkali-feldspar granite, Rhyolite; 3a (Syeno-) Granite, Rhyolite; 3b (Monzo-) Granite, Rhyodacite; 4 Granodiorite, Dacite; 5 Tonalite, Plagidacite, Trondhjemite

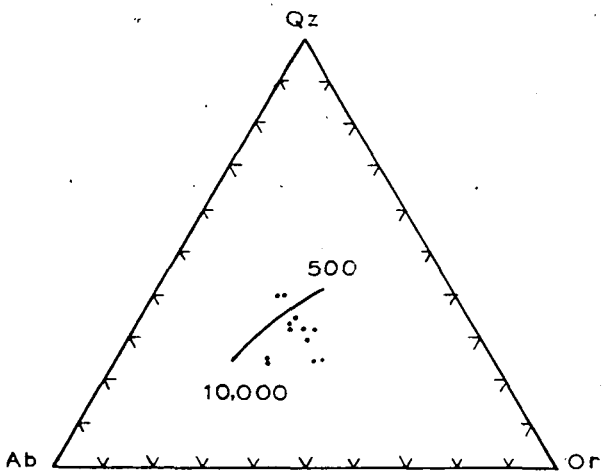

Fig. 10. Normative Qz, Or and Ab proportions for the investigated granite mass. The line represents the variation in position of the minimum melting points in the granite system at water vapour pressures from 500 to 10,000 bars (after TUTTLE and BOWEN, 1958)

in *Fig. 11*. The granitic rocks fall in a region corresponding to the liquidus in the minimum system Qz—Or—and Ab—H_2O at relatively low water-vapour pressures.

BOWES [1967] has concluded that the closeness of the normative Qz, Or and Ab proportions of some of the para-autochthonous and intrusive Lewisian granitic rocks to the minimum melting point composition at low water-vapour pressures in the system $NaAlSi_3O_8$—$KAlSi_3O_8$—SiO_2—H_2O indicates genesis by selective melting followed by crystallization at low water-vapour pressure. The normative Or — Ab —

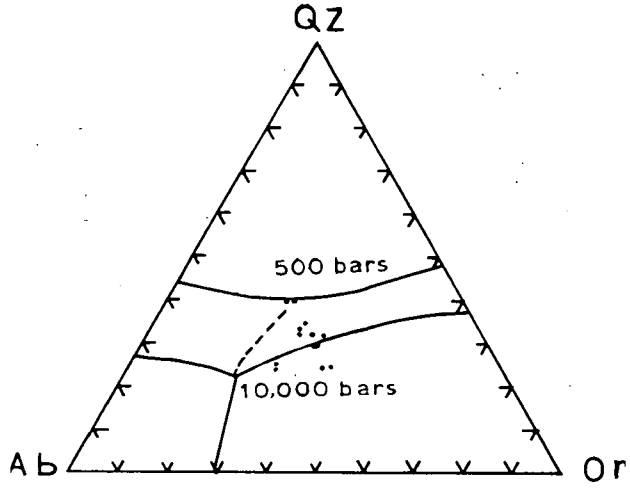

Fig. 11. Normative albite — orthoclase — quartz of the granitic rocks, plotted in the system $NaAlSi_3O_8$—$KAlSi_3O_8$—$SiO_2 \cdot H_2O$. Field boundaries at 500 and 10,000 bars are shown. Dotted line represents the trace of the isobaric minimum or eutectic point at intermediate water vapour pressures (after LUTH *et al.*, 1964)

and An proportions of the analysed granitic rocks have been plotted in a ternary diagram *(Fig. 12)*. It is evident that the majority of the plots are in the plagioclase field mostly close to the isobaric univariant curve indicating that crystal equilibrium was the dominant mechanism involved in the genesis of these granites [JAMES and HAMILTON, 1972].

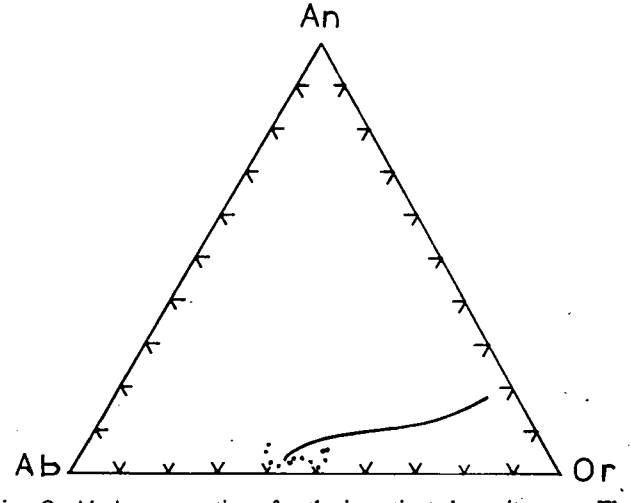

Fig. 12. Normative Or-Ab-An proportions for the investigated granite mass. The solid line represents the two feldspar boundary curve for the quartz saturated ternary feldspar system at 1000 bars water vapour pressure (after JAMES and HAMILTON, 1972)

CONCLUSION

The granitic rocks of Gebel Abu Dob from the Precambrian of the Central Eastern Desert, Egypt are petrochemically characterized. The average chemical composition of the examined rocks agrees fairly well with that of low-calcium granite of TUREKIAN and WEDEPOHL [1961]. Petrochemically Abu Dob granitic rocks belong to the calc-alkalic series and appear to represent a differentiated suite which comprise alkali granite and granite. They are of miaskitic nature and compare fairly well with the younger granitoids of Umm Naggat, El-Atawi, Gilad Said and Kadabora. Based on experimentally studied systems the granitic rocks of Abu Dob are believed to be of magmatic origin.

REFERENCES

BOWES, D. R. [1967]: The petrochemistry of some Lewisian granitic rocks, Miner. Mag., **36**, 342—363.

BAILY, K. and MACDONALD, R. [1970]: Petrochemical variation among mildly peralkaline comendite obsidians from the oceans and continents. Contr. Mineral. and Petrol. v. **28**, 340—391.

BURRI, C. [1964]: Petrochemical calculation, Basel Birkhauser Verlag, p. 304.

BURRI, C. and NIGGLI, P. [1945]: Die jungen Eruptivgesteine des mediterranean Orogens I. Publ. Vulkaninstitut Immanuel Friedaender, No. 3.

EL-RAMLY, M. F. and AKAAD, M. K. [1960]: The basement complex in the Central Eastern Desert of Egypt, between Latitudes 24° 30' and 25° 40' N. Geol. Surv., Cairo.

EL-RAMLY, M. F. [1972]: A new geological map for the basement rocks in the Eastern and South — Western Desert of Egypt, Annals of the Geological Survey of Egypt, Vol. **II**, 1—12.

HIETANEN, A. [1963]: Idaho batholith near Pierce and Bungalow. Prof. Pap. U. S. Geol. Surv., **344—D**.

JAMES, R. S. and HAMILTON, D. L. [1972]: Phase relations in the system $NaAlSi_3O_8$—$KAlSi_3O_8$—$CaAl_2Si_2O_8$—SiO_2 at 7 Kilobar water vapour. Contr. Mineral. Petrol., **21**, 111—141.

KABESH, M. L., REFAAT, A. M. and ALI, M. M. [1975]: On the modal and chemical classification of the granitic rocks of Umm Naggat stock, Eastern Desert Egypt. Chem. Erde **34**, 293—301.

KABESH, M. L., and RAGAB, A. G. [1974]: The chemistry of biotite as a guide to the evolution trends of El-Atawi granitic rocks, Eastern Desert Egypt. N. Jb. Miner., **7**, 307—316.

KABESH, M. L. and RAGAB, A. G. [1976]: Some petrochemical characters of the granitic rocks of El-Atawi stock, Eastern Desert Egypt. Chem. Erde **35**, 185—191.

KABESH, M. L., SALEM, A. K. A. and SALEM, M. A. [1980a]: Petrochemistry and petrogenesis of El-Yatima granitic stock, Eastern Desert, Egypt. Chem. Erde (in press).

KABESH, M. L., HILMY, M. E. and SALEM, A. K. A. [1980b]: Behaviour of major elements in the granitic rocks of Kadabora pluton, Eastern Desert, Egypt. Acta Miner. Petr., Szeged, XXIV/2, 245—256.

LUTH, W. C., JAHNS, R. H. and TUTTLE, O. F. [1964]: The granite system at pressures of 4 to 10 Kilobars. J. Geophys. Research **69**, 759—773.

RAGAB, A. G., KABESH, M. L., HILMY, M. E. and KHALIL, M. M. [1979]: Petrography, petrochemistry and petrogenesis of Gilad granitic stock, Eastern Desert Egypt. N. Jb. Miner., **134**, 274—287.

REFAAT, A. M., KABESH, M. L. and ZEINAB, M. A. [1977]: Behaviour of major elements in Ras Barud granitic rocks Eastern Desert Egypt. J. Geol. **21**/1

RITTMANN, A. [1957]: On the serial cheracter of igneous rocks, Egypt. J. Geol., **1**, 23—48.

SABET, A. H. [1961]: Geology and mineral deposits of Gebel El-Sibai area Red Sea Hills, Egypt. Ph. D. Thesis, ITc., Delft, Holland.

SABET, A .H., V. V. BESSONENKO, B. A. BYKOV [1976]: The intrusive complexes of the Central Eastern Desert of Egypt. Annals of the Geol. Surv. of Egypt, **VI**, 53—73.

SALEM, A. K. A. [1972]: Geological and geochemical studies on Gebel Abu Dob area Eastern Desert, Egypt. M. Sc Thesis, Ain Shams Univer., Cairo.

SALEM, A. K. A. [1976]: Petrographical and petrochemical studies on the granitic rocks of Gebel Kadabora and Abu Iteila, Eastern Desert Egypt. Ph. D. Thesis, Ain Shams Univ., Egypt.

STRECKEISEN, A. [1976]: Classification of the common igneous rocks by means of their chemical composition. A provisional attempt. N. Jb. Miner., Monatshefte, 1—15.

STRECKEISEN, A., [1973]: To each plutonic rocks its proper name. Earth Sci. Rev., **12**, 1—33. (I U G S Subcommission on the Systematics of Igneous Rocks).

TUTTLE, O. F. and BOWEN, N. L. [1958]: Origin of the granite in the light of experimental studies in the system $NaAlSi_3O_8$—$KAlSi_3O_8$—SiO_2—H_2O. Mem. Geol. Soc. Am., **74**, 1—153.
TUREKIAN, K. K. and WEDEPOHL, K. H. [1961]: Distribution of the elements in some major units of the Earth's crust. Geol. Soc. Amer., Bull. **72**, 175—192.
WASHINGTON, H. S. [1917]: Chemical analyses of igneous rocks. U. S. Geol. Surv. Prof. Paper **99**.

Manuscript received, December 1, 1979

PROF. DR. M. L. KABESH
Earth Sciences Laboratory,
National Research Centre,
Cairo, Egypt
PROF. DR. M. E. HILMY,
Geology Department,
Ain Shams University,
Cairo, Egypt
DR. ABDEL-KARIM A. SALEM,
Earth Sciences Laboratory,
National Research Centre,
Cairo, Egypt