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GEOCHEMISTRY AND PETROGENESIS OF THE GRANITOID ROCKS OF GEBEL ABU MURRAT AREA, NORTH EASTERN DESERT, EGYPT

BY

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ABSTRACT

The granitoid rocks of Gebel Abu Murrat area are classified into three rock suites including; Old Granitoid, Phase III and I Younger Granitoids. The former constitutes the country terrain of the younger rocks. It has a granodioritic composition, a calc-alkaline nature and was developed under a compressional environment. All characteristics of the Old Granitoid support its classification as I-type granite, and the REE patterns are comparable with the models involving partial melting of amphibolite.

Phase I Younger Granite constitutes the main rock type of the study area and its emplacement was stucturally controlled by pre-existing fractures. It is represented by alkali-feldspar granite and shows alkaline affinity that intimately related to the extensional environment. The rock displays many common characteristics with the A-type granites.

Phase III Younger Granite is a monzo- to syeno- granite and shows a transitional aspects between the Old Granitoid and Phase I Younger Granitoids. However the majority of them confirm its tendency towards the latter and their similarities suggest a common source material. They show many characteristics equivalent to the high heat production (HHP) granites. Their origin comprising an evolving rift system which caused widespread heating and partial melting of crustal material comparable with Old Granitoid.

that these rocks in general are linked with each other by a systematic compositional evolution.

PETROGENESIS AND CONCLUSIONS

The granitoid rocks of Gebel Abu Murrat are classified according to geological, petrological and geochemical aspects into three rock suites including Old Granitoid, Phase III and phase I Younger Granitoids.

The Old Granitoid is more intermediate (compared with the Younger Granitoids) metaluminous and has a granodioritic composition. it displays a calc-alkaline differentiation trend, formed under compressional environment, and contains abundant xenoliths. These characteristics support its classification as I-type granite (Zhao and McCulloch, 1995). The REE patterns of the rock are comparable with the models involving partial melting of amphibolite (Arth and Barer, 1976; Arth et al., 1978 and Sengupta et al., 1983). These patterns show decreasing of the total REE and increasing positive Eu anomaly as would be expected if hornblende fractionation was operating to produce their melts. More specifically, we propose that fractionated parts of the LREE -enriched island arc type amphibolite would be the best candidate as a source of the Old Granitoid. The amphibolite yields Nb depletion (Fig.11) and shows the characteristic LREE - enriched patterns as required for the granite source (Zhao and McCulloch, 1995). The field observation shows abundant amphibolitic xenoliths within the rock and displaying variable degrees of assimilation. Similar conclution have been previously achieved by El-Ramly and Akaad (196O) and Akaad et al. (1973).

The younger alkali-feldspar granite (phase I) displays many common characteristics with the A- type rocks as defined by collins et al. (1982); Jackson et al. (1984), Clemens et al. (1986); Wallen et al. (1987) and Eby (199O). It is true granite according to Streckeisen classification, it occurs in anorogenic setting as high level intrusion, formed from high temprature, H_2O undersaturated completely molten magmas; Ca-poor, metaluminous, has high K_2O+Na_2O/Al_2O_3 and marked by a rather flat REE to somewhat HREE- depleted patterns (Fig.13).

The syeno- (monzo-) granite (phase III) commonly displays a transitional geological, petrographical and geochemical characteristics between the Old Granitoids and Phase I Younger Granitoids. However, the majority of these aspects, especially the REE geochemistry support its tendecy towards the latter .In fact ,the similarities of the two phases of Younger Granitoids suggest their common source material. The comparison with the average upper crust (Fig.14) suggest that it is very unlikely that they were derived from mafic igneous source. The most likely source material is therefore inferred to be upper crustal or granitic composition , such as the pre-existing Old Granitiod. The Younger Granitoids (phase I and III) show variable intensity of Nb anomaly. Such aspect cannot be attributed to either partial melting or crystal fractionation processes due to the lack of suitable phases to retain Nb during granite generation (Zhao and McCulloch, 1995). This Nb depletion must be a common signature in upper crustal materials. This observation implies that these granites must be derived from a source with inherit depletion in Nb as what has been noticed in the Old Granitoids.

Similar to the high heat production granites (HHP), the Younger Granitoids are rich in LIL- elements, espccially , Ba, K,Th and U and show similar REE patterns (flat patterns with marked negative Eu anomalies). Typical to the HHP granites, they post-date major deformation and intrude late- (phase III) to post- (phase I) orogenically at relatively shallow depths either as evolved calc-alkaline at destructive plate margins or as metaluminous alkaline rocks in post orogenic setting (e.g anorogenic rift-zones, Plant et al.,1985).

The origin of the Younger Granitoids in Abu Murrat area comprising an evolving rift system as described in Condie and Budding (1979). This model calls upon one or more mantle plumes which caused widespread heating and partial melting the lower crust producing large volumes of granitic magmas. Some of these magmas were emplaced directly (phase III), while the other underwent shallow fractional crystallization prior to emplacement (phase I).

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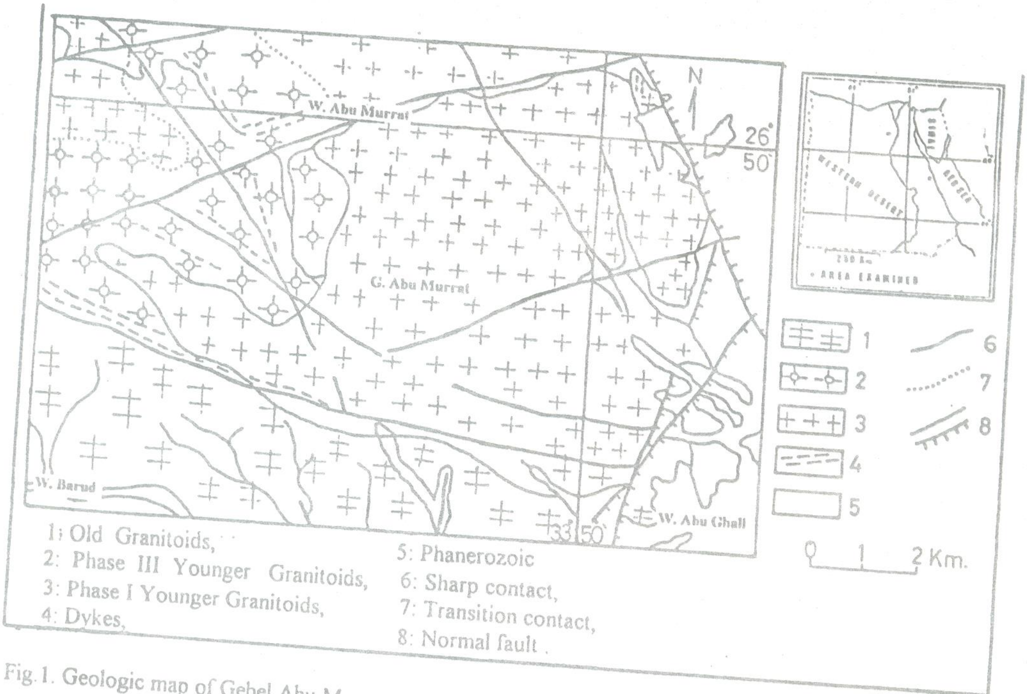

Fig.1. Geologic map of Gebel Abu Murrat area (Sabet et al., 1972).

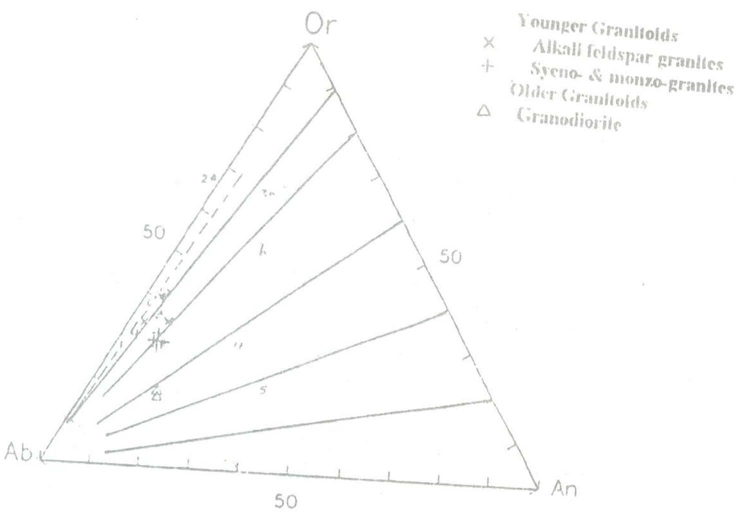

Fig.2. Normative feldspar triangular diagram (Streckeisen, 1976).
2a - alkali granite; 2b - alkali feldspar granite;
3a - syeno-granite; 3b - monzo-granite;
4 - granodiorite.

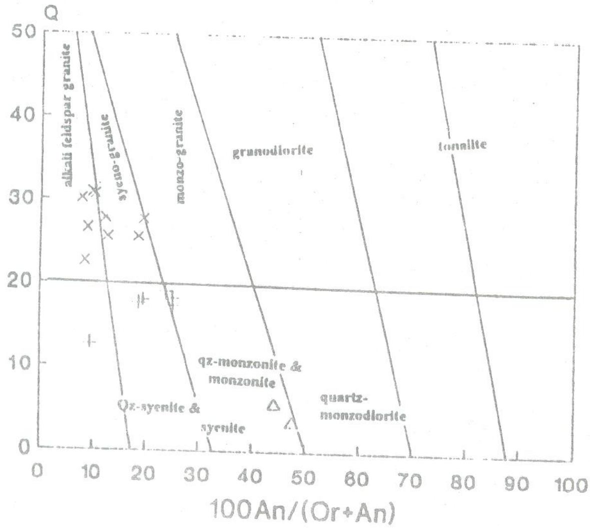

Fig.3. Normative Q - 100An/(Or+An) classification of granitoid rocks (Streckeisen and Le-Maitre, 1979).

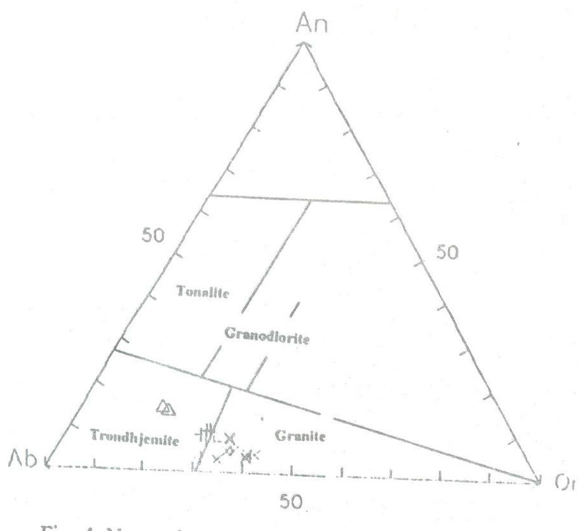

Fig. 4. Normative Ab-An-Or diagram (O'Connor, 1965).

INTRODUCTION

Gebel Abu Murrat area is dominantely covered by Late Proterozoic Old Granitoid, Phase III and I Younger Granitoids arranged from older to younger. This area was mapped by Sabet et al. (1972) who divided the granitoid rocks into Older synorogenic tonalite-granodiorite-adamellite rocks and late-orogenic pink-granite. They (op. cit.) concluded that the adamellites represent clearly a transitional phase or linkage between the granodiorite and the pink granite.

The Younger Granitoids were classified by many authors (e.g. El-Gaby, 1975; Sabet et al., 1976; Akaad et al., 1979; Greenberg, 1981; Hussein et al., 1982; El-Shatoury et al., 1984; and Noweir et al., 199O. The classification of Greenberg (op.cit.) is adopted here.

The present study deals with the geochemical characteristics of these granitic phases with special emphasis on the trace and rare earth elements geochemistry. The integrated constraints will be used to better constrain the origin of these rocks.

GEOLOGICAL SETTING AND PETROGRAPHY

The geologic setting and petrography of the granitoid rocks of Gebel Abu Murrat area have been given previously by Sabet et al.(1972), therefore only a brief summary is given here.

The Old Granitoids constitute the country terrain of the concerned Younger Granitoids (Fig.1). They form a relatively low land which have a light grey to slightly pinkish colour and sometimes display the gneissose structure. The rocks contain abundant amphibolitic xenoliths which have varying shapes and sizes, and showing variable degrees of assimilation. These Old Granitoids are in places intruded by Phase I alkali granites which send apophyses, dykes and pegmatitic veins cutting through

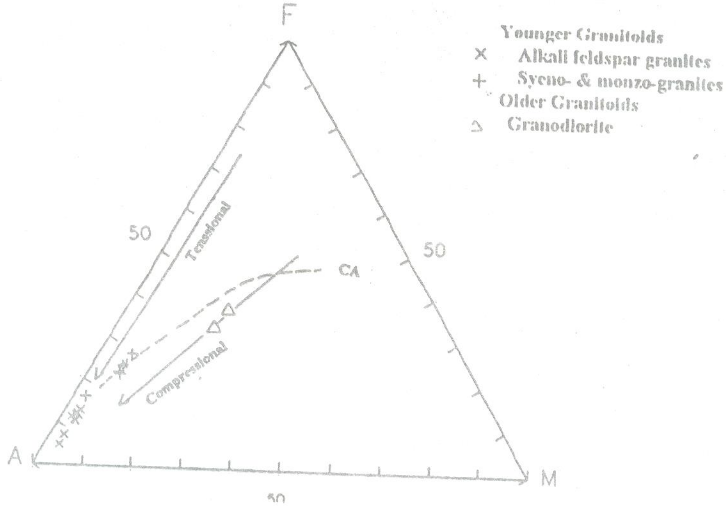

Fig.5. AFM ternary diagram. Compressional and Tensional trends after Petro et al., 1979. CA is the calc-alkaline trend of Sierra-Nevada batholith (Carmichael et al., 1974).

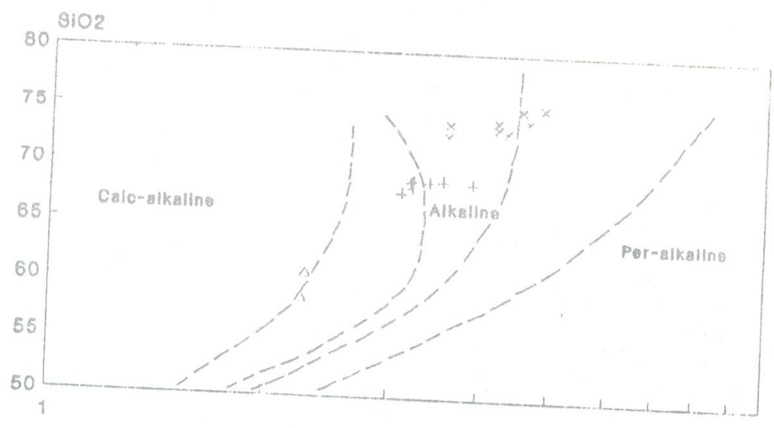

Fig.6. Alkalinity ratio (A.R.) - SiO2 variation diagram (Wright, 1969)

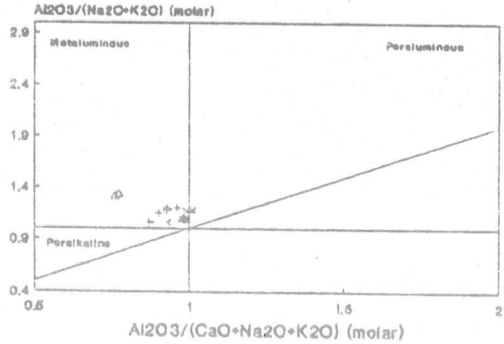

Fig.7. Al2O3/CaO+Na2O+K2O vs Al2O3/Na2O+K2O molar variation diagram.

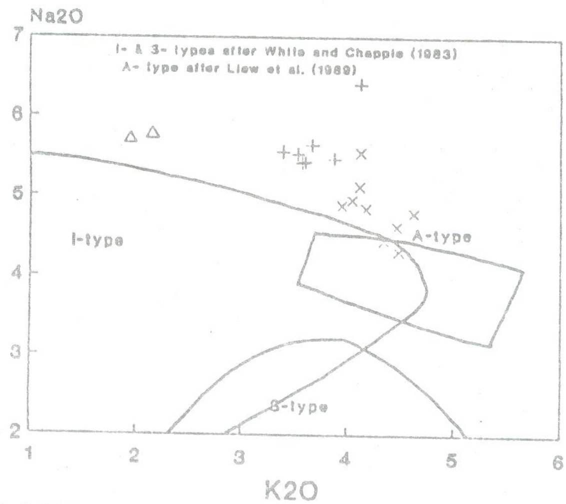

Fig.8. K2O vs Na2O variation diagram.

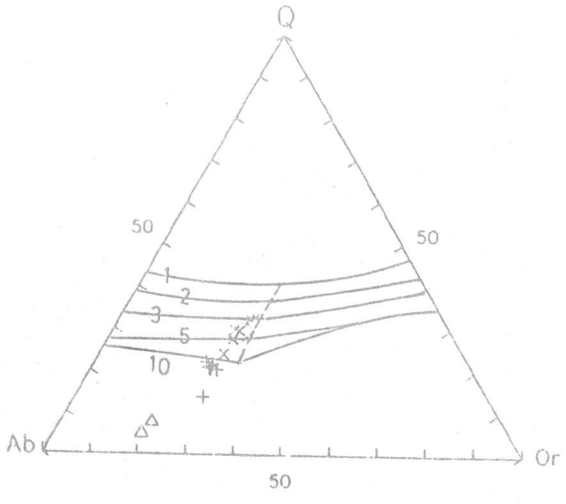

Fig. 9 Normative Qz-Ab-Or ternary diagram (Tuttle and Bowen, 1958).

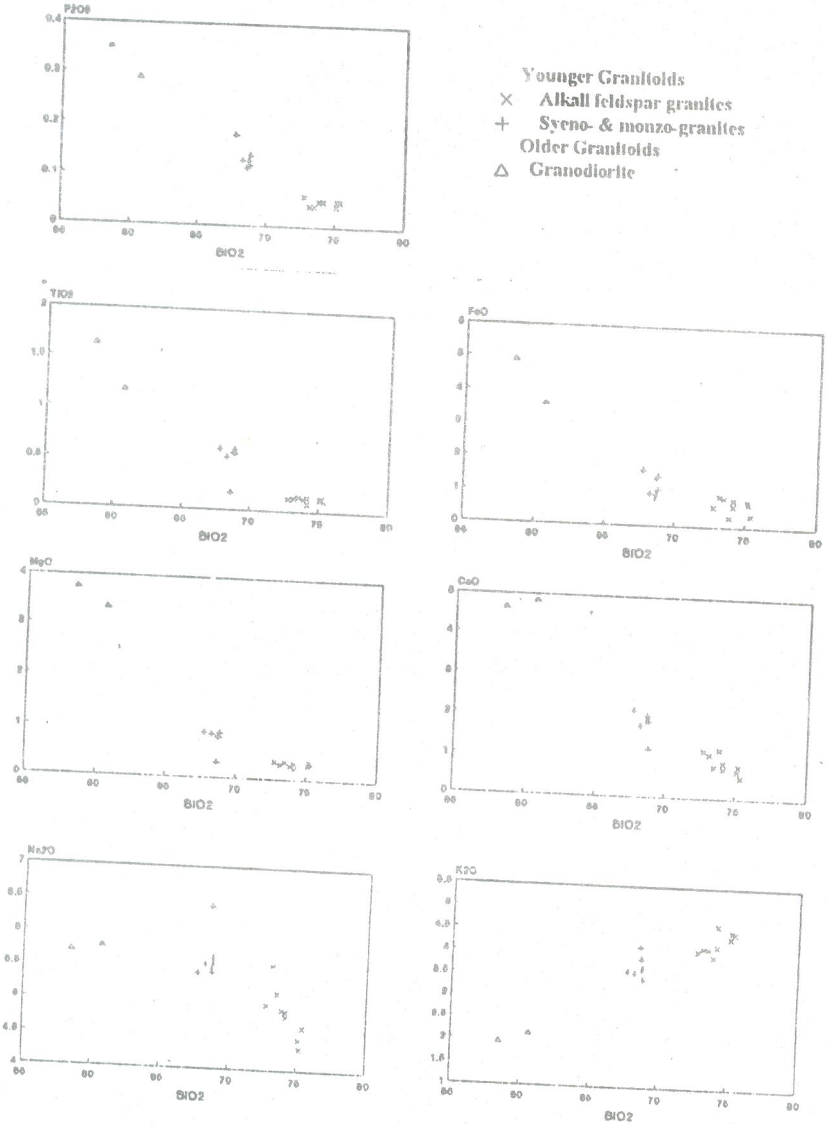

Fig.10.SiO2 - versus major elements.

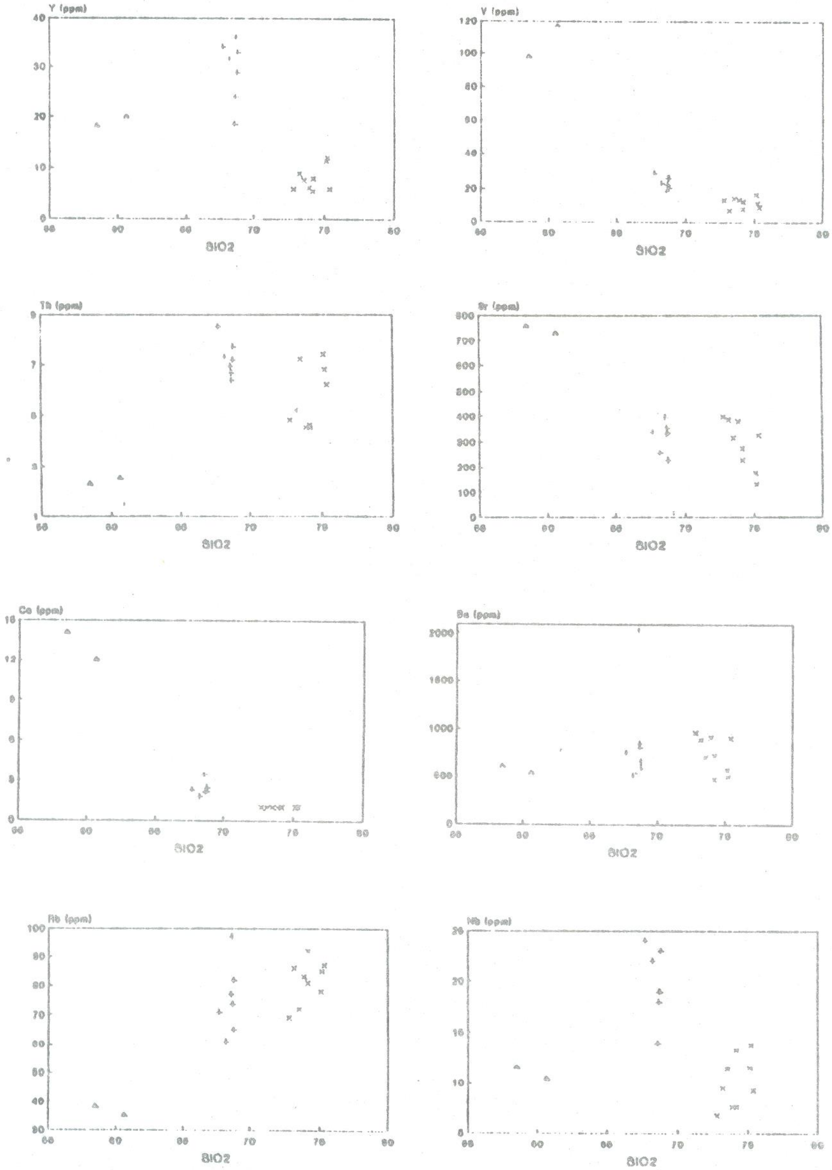

Fig.11a. SiO2 - versus trace elements.

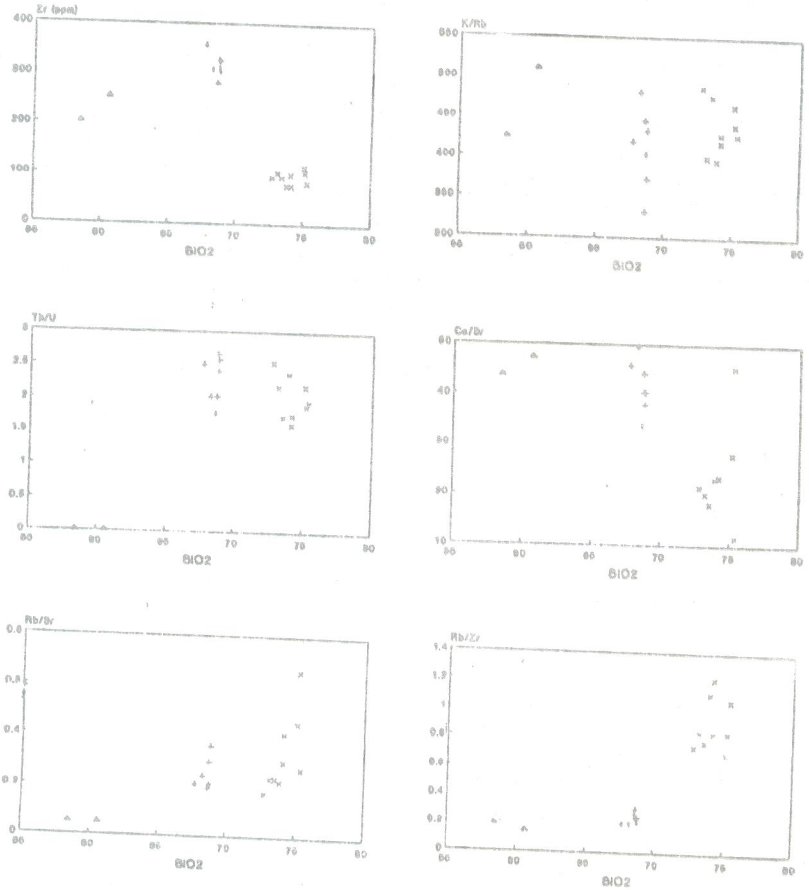

Fig.1 1b. SiO2 - versus trace elements.

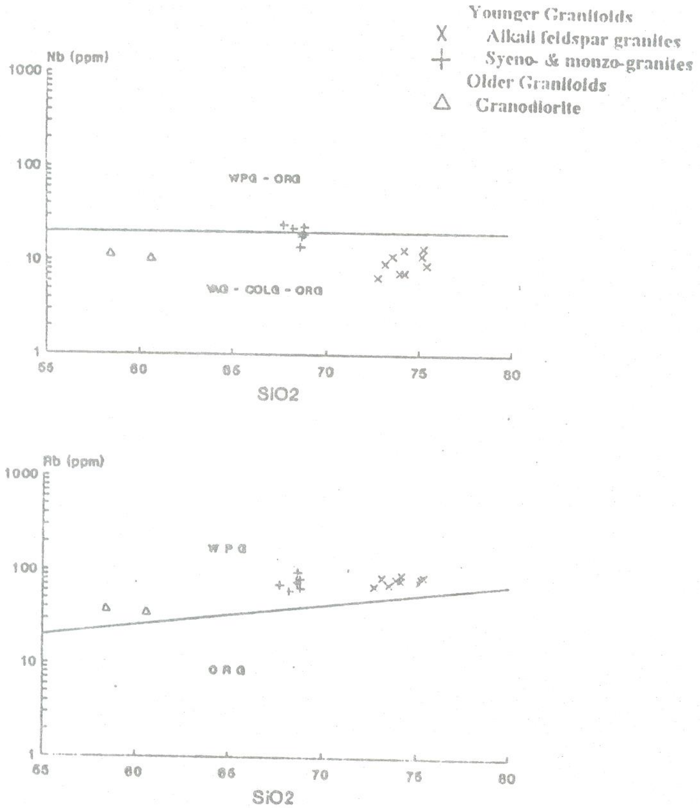

Fig.12. Discrimination diagrams of SiO2 vs Nb (a) and SiO2 vs Rb (b) after (Pearce et al., 1984).

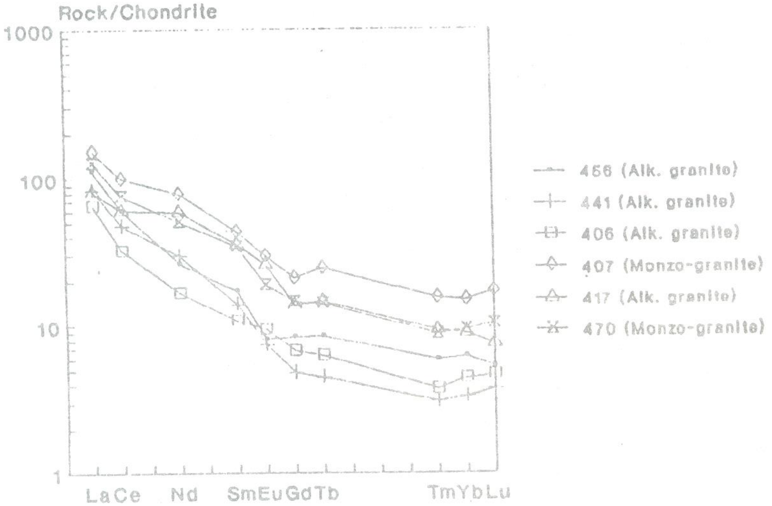

Fig. 13a. Chondrite normalized REEs patterns (Schmidt et al., 1963) for younger granitoids (Phases I & III).

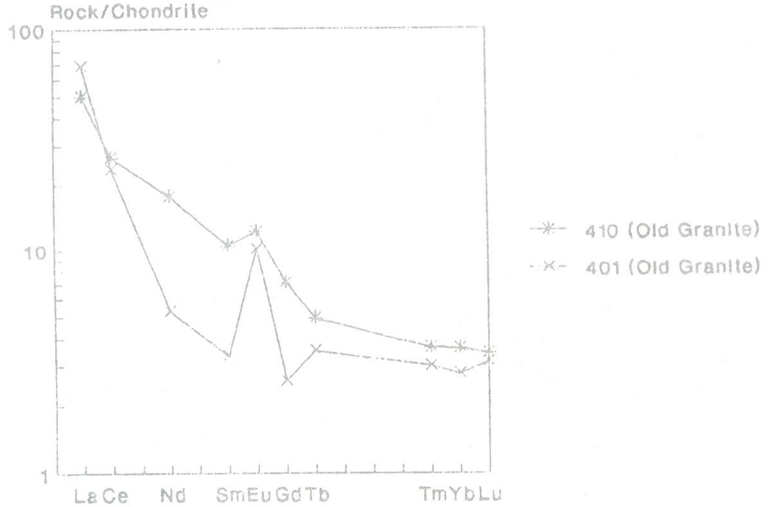

Fig. 13 b. Chondrite normalized REEs patterns (Schmidt et al., 1963) for the old granitoids.

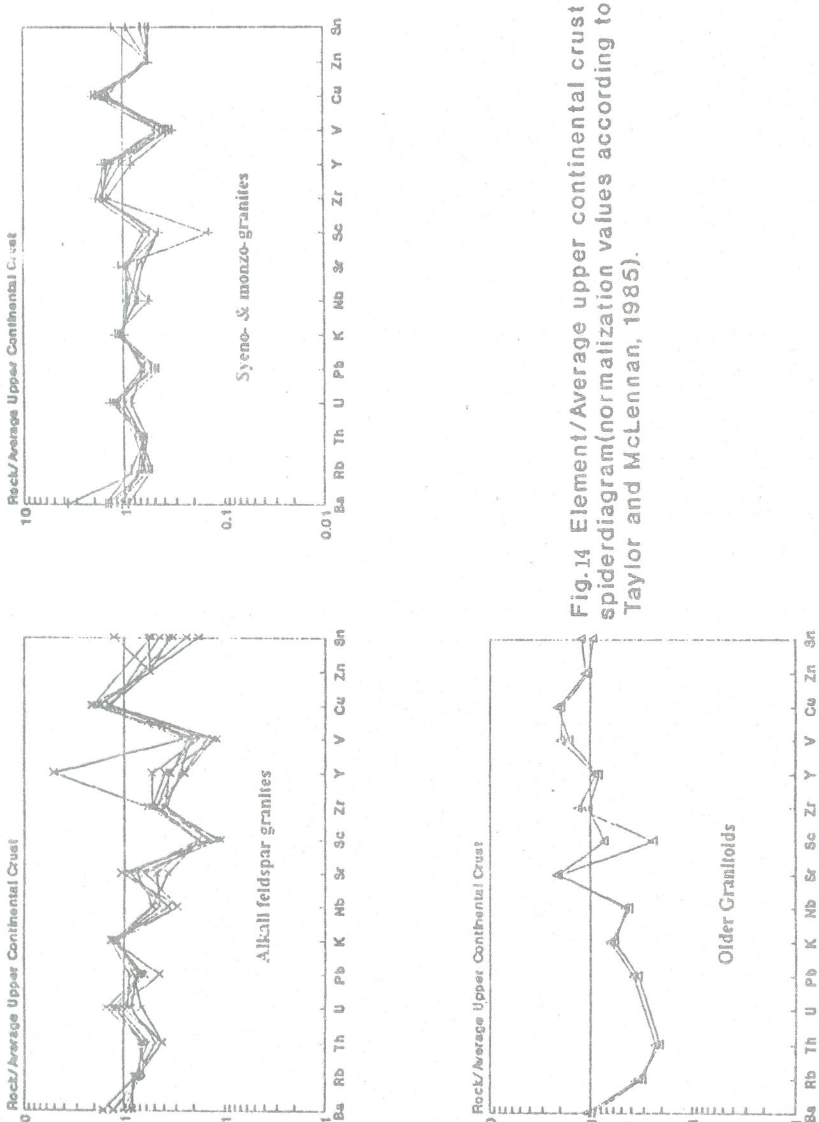

Fig.14 Element/Average upper continental crust spiderdiagram(normalization values according to Taylor and McLennan, 1985).

Table 1. Major element contents and CIPW values of Gebel Abu Murrat.

	Younger Granitoids															Older Granitoids	
	Alkali feldspar granites									Syeno- & monzo-granites						granodiorite	
	416	450	408	406	456	437	417	441	443	468	467	402	407	438	470	415	410	401
SiO2	75.39	75.22	75.13	74.18	74.16	73.89	73.52	73.18	72.77	68.80	68.79	68.70	68.68	68.60	68.22	67.71	60.63	58.47
TiO2	0.10	0.13	0.12	0.07	0.14	0.12	0.15	0.13	0.12	0.61	0.56	0.58	0.58	0.18	0.53	0.61	1.17	1.62
Al2O3	13.29	13.01	13.12	13.88	13.80	14.40	14.22	14.42	14.81	15.12	15.43	15.29	15.17	15.97	15.52	15.40	15.52	15.30
Fe2O3	0.15	0.54	0.52	0.45	0.53	0.42	0.57	0.42	0.50	1.93	1.53	1.57	1.87	1.25	1.68	1.81	1.94	1.80
FeO	0.33	0.66	0.73	0.78	0.59	0.28	0.84	0.90	0.57	1.09	1.49	1.41	0.95	0.81	0.98	1.67	3.60	4.90
MnO	0.03	0.03	0.04	0.03	0.04	0.02	0.05	0.06	0.03	0.01	0.15	0.12	0.09	0.05	0.09	0.12	0.16	0.15
MgO	0.29	0.36	0.30	0.22	0.32	0.27	0.35	0.30	0.35	0.89	0.91	0.81	0.83	0.33	0.88	0.91	3.33	3.72
CaO	0.51	0.81	0.67	0.73	0.89	1.21	0.79	1.08	1.18	1.88	1.22	2.00	2.01	1.87	1.76	2.15	4.79	4.61
Na2O	4.62	4.31	4.45	4.79	4.85	4.88	5.12	5.54	4.95	5.55	5.64	5.42	5.47	6.41	5.53	5.41	5.77	5.70
K2O	4.47	4.49	4.35	4.63	4.18	3.95	4.12	4.13	4.05	3.40	3.67	3.61	3.88	4.13	3.54	3.58	2.15	1.94
P2O5	0.05	0.05	0.04	0.05	0.05	0.05	0.04	0.04	0.06	0.14	0.12	0.12	0.13	0.15	0.13	0.18	0.29	0.35
LOI	0.47	0.44	0.54	0.27	0.49	0.49	0.42	0.37	0.41	0.73	1.02	0.43	0.60	0.49	0.81	0.45	1.21	2.17
Total	99.70	100.05	100.01	100.08	100.04	99.98	100.19	100.57	99.80	100.15	100.53	100.06	100.26	100.24	99.67	100.00	100.56	100.73
Na2O+K2O	9.09	8.80	8.80	9.42	9.03	8.83	9.24	9.67	9.00	8.95	9.31	9.03	9.35	10.54	9.07	8.99	7.92	7.64
ASI*	0.99	0.97	0.99	0.98	0.98	0.99	0.99	0.93	1.01	0.93	1.00	0.93	0.90	0.89	0.98	0.92	0.76	0.77
A.R.	4.86	4.51	4.53	4.63	4.19	3.60	4.20	4.32	3.58	3.22	3.54	3.19	3.39	3.89	3.21	3.10	2.28	2.25
Norms	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Q	30.12	30.89	30.69	26.62	27.78	27.71	25.56	22.57	25.57	19.14	18.06	18.59	17.70	12.64	18.22	17.36	5.51	3.40
Or	26.65	26.66	25.87	27.44	24.84	23.49	24.43	24.38	24.10	20.21	21.82	21.43	23.03	24.49	21.18	21.28	12.80	11.65
Ab	39.35	36.57	37.81	40.56	41.18	41.46	43.37	46.73	42.10	47.15	47.91	45.98	46.48	54.32	47.28	45.94	49.10	48.90
An	2.22	2.87	2.96	2.66	3.53	5.71	3.62	2.24	5.50	6.30	5.30	6.72	5.32	2.58	7.12	7.16	10.14	10.56
C	0.03	-	-	-	-	-	-	-	0.27	-	0.24	-	-	-	-	-	-	-
Di	-	0.69	0.10	0.54	0.48	-	0.04	2.39	-	1.68	-	1.96	2.99	2.26	0.67	1.91	9.57	8.39
Wo	-	-	-	-	-	-	-	-	-	-	-	-	-	1.22	-	-	-	-
Hy	1.11	1.18	1.49	1.28	1.06	0.68	1.78	0.74	1.37	1.46	3.11	1.65	0.70	-	1.91	2.61	7.17	10.55
Ol	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mt	0.22	0.79	0.76	0.65	0.77	0.61	0.83	0.61	0.73	2.08	2.23	2.30	1.68	1.82	1.94	2.64	2.83	2.65
He	-	-	-	-	-	-	-	-	-	-	-	-	0.72	-	0.36	-	-	-
Il	0.19	0.25	0.23	0.13	0.27	0.23	0.29	0.25	0.23	1.16	1.07	1.11	1.11	0.34	1.02	1.16	2.24	3.12
Ap	0.11	0.11	0.09	0.11	0.11	0.11	0.09	0.09	0.13	0.31	0.26	0.26	0.28	0.33	0.29	0.39	0.64	0.78

* ASI= Alumina saturation index.

Table 2. Trace element analysis of the studied granitoid rocks.

	Younger Granitoids																Older Granitoids	
	Alkali feldspar granites									Syeno- & monzo-granites							Granodiorite	
	416	450	408	406	456	437	417	441	443	468	467	402	407	438	470	415	410	401
Be	1.90	3.20	2.40	2.20	1.90	2.00	1.80	2.20	2.20	2.50	2.90	2.80	3.50	1.80	2.40	3.70	4.20	1.50
Sc	1.70	2.00	2.10	1.50	1.20	1.30	2.00	1.50	1.50	6.00	5.00	6.00	5.00	1.50	5.00	7.00	2.60	8.00
V	9.00	11.00	16.00	12.00	8.00	13.00	14.00	7.00	13.00	26.00	21.00	26.00	22.00	19.00	23.00	29.00	117.00	98.00
Cr	7.00	12.00	14.00	18.00	25.00	5.00	15.00	14.00	10.00	7.00	24.00	12.00	5.00	22.00	6.00	16.00	118.00	112.00
Co	-	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	2.20	2.50	2.20	2.10	3.40	1.80	2.30	12.00	14.00
Ni	3.00	6.00	4.00	5.70	9.00	3.00	3.00	5.00	4.00	3.80	5.60	3.50	3.70	3.80	5.40	4.70	51.00	47.00
Cu	43.00	54.00	52.00	35.00	37.00	35.00	47.00	34.00	32.00	38.00	46.00	52.00	42.00	43.00	36.00	48.00	49.00	53.00
Zn	-	40.00	-	-	40.00	40.00	40.00	-	40.00	45.00	40.00	40.00	40.00	40.00	40.00	40.00	75.00	80.00
Rb	87.00	85.00	78.00	92.00	81.00	83.00	72.00	86.00	69.00	65.00	82.00	74.00	97.00	77.00	61.00	71.00	35.00	38.00
Sr	321.00	128.00	172.00	225.00	271.00	375.00	312.00	382.00	395.00	332.00	229.00	353.00	325.00	395.00	254.00	335.00	725.00	754.00
Ba	905.00	493.00	564.00	457.00	717.00	914.00	699.00	887.00	958.00	663.00	591.00	806.00	851.00	2033.0	511.00	752.00	537.00	600.00
Y	5.80	11.80	112.00	7.90	5.40	6.10	7.60	8.80	5.80	33.00	29.00	36.00	24.00	18.60	31.50	34.00	19.80	18.20
Zr	82.00	103.00	113.00	76.00	98.00	75.00	93.00	102.00	93.00	304.00	325.00	312.00	328.00	281.00	308.00	359.00	252.00	202.00
Nb	9.20	13.80	11.50	7.60	13.20	7.60	11.40	9.50	6.80	23.00	19.00	19.00	18.00	14.00	22.00	24.00	10.40	11.50
Mo	3.90	6.10	6.50	7.00	5.00	6.80	8.00	6.00	4.50	4.50	5.20	7.20	5.90	9.80	5.80	9.00	8.00	9.00
Sn	1.30	3.20	3.00	1.80	7.00	1.00	2.00	2.50	1.50	3.00	5.20	7.20	3.80	3.30	3.10	3.70	5.20	6.80
Pb	9.20	13.60	12.80	18.00	14.40	16.50	13.90	15.10	14.80	12.60	9.10	12.80	10.80	9.80	13.20	13.50	7.50	6.90
Th	6.20	6.80	7.40	4.50	4.60	4.50	7.20	5.20	4.80	7.70	7.20	6.40	6.70	6.90	7.30	8.50	2.50	2.30
U	3.20	3.60	3.40	2.60	2.90	1.90	4.20	2.40	1.90	3.20	2.80	2.40	3.30	3.90	3.60	3.40	-	-
K / Rb	426.52	438.51	462.97	417.78	428.40	395.07	475.03	398.66	487.26	434.23	371.54	404.98	332.06	445.26	481.76	418.58	509.95	423.81
Rb / Sr	0.27	0.66	0.45	0.41	0.30	0.22	0.23	0.23	0.17	0.20	0.36	0.21	0.30	0.19	0.24	0.21	0.05	0.05
Rb / Zr	1.06	0.83	0.69	1.21	0.83	1.11	0.77	0.84	0.74	0.21	0.25	0.24	0.30	0.27	0.20	0.20	0.14	0.19
Th / U	1.94	1.89	2.18	1.73	1.59	2.37	1.71	2.17	2.53	2.41	2.57	2.67	2.03	1.77	2.03	2.50	-	-
Ca / Sr	11.36	45.23	27.84	23.19	23.47	23.06	18.10	20.21	21.35	40.47	38.08	40.49	44.20	33.84	49.52	45.87	47.22	43.70
Ca / Y	628.44	490.60	42.75	660.42	1177.9	1417.7	742.91	877.13	1454.0	407.16	300.67	397.06	598.56	718.54	399.33	451.94	1729.0	1810.3

them. Moreover, at Wadi Abu Murrat, the Older Granitoids grade imperceptibly into quartz syenites of Phase III due to the graditional increase of K-feldspars.

Under the microscope, the "Older Granitoids" are coarse to medium grained porphyritic and are essentially composed of oligoclase (An 15-28), quartz, alkali feldspar, biotite and hornblende. Allanite, apatite, sphene, epidote and magnetite are the common accessory constituents. The alkali feldspars are represented by orthoclase, nonperthitic microcline, and orthoclase cryptoperthite. The biotite flakes and associated hornblende show parallel orientation producing a characteristic gneissose structure. Elongated amphibolite bands are boundinaged into linear spindle-shaped bodies and seem to represent remnants of incompletely granitized metavolcanics (Sabet et al., 1972)

Phase III Younger granites are mainly syeno- to monzo- granites (Fig.2). They show a relatively higher relief than the Younger Granites of Phase I. They possess a graditional or mixed contacts with the "Old Granitoids" (Fig.1). Sabet et al. (1972) pointed out that these rocks represent a more advanced stage of the formation of the autochtonous "Old Granitoids". Moreover, these rocks sometimes display a graditional contacts with the Younger Granites (Phase I). Therefore, this granitic phase can be considered as a transitional or linkage rocks between the "Older Granitoids" and phase I Younger Granites. The rocks usually enclose rounded to oval xenoliths which have an amphibolitic composition.

Petrographically, the syeno-(monzo-) granite is commonly leucocratic with pinkish to greyish tints, medium to coarse grained and commonly porphyritic. It is essentially composed of K-feldspars, oligoclase and quartz. Biotite is the main mafic mineral which usually in clusters, whereas muscovite forms aggregates of radial crystals.

Table 3. REE concenteration of the studied granitoids.

	Younger Granitoids						Older Granitoids	
	alkali-feldspar granite				monzo-granite			
	456	441	406	417	470	407	401	410
La	36.00	27.00	21.00	26.00	41.00	49.00	22.00	16.00
Ce	55.00	43.00	29.00	55.00	69.00	91.00	21.00	24.00
Nd	15.00	17.00	9.50	34.00	29.00	45.00	3.00	10.00
Sm	3.60	3.12	2.25	7.50	7.20	9.20	0.70	2.20
Eu	0.60	0.55	0.70	1.90	1.40	2.20	0.75	0.90
Gd	2.60	1.50	2.10	4.30	4.50	6.50	0.80	2.20
Tb	0.43	0.23	0.32	0.75	0.72	1.25	0.18	0.25
Tm	0.19	0.01	0.12	0.30	0.28	0.05	0.07	0.18
Yb	1.12	0.60	0.80	1.60	1.70	2.70	0.50	0.65
Lu	0.17	0.12	0.15	0.24	0.33	0.55	0.10	0.11
REE	114.71	93.13	65.94	131.59	155.13	207.45	49.10	56.49
La(n)/Sm(n)	6.56	5.68	6.12	2.28	3.74	3.50	20.63	4.77
Ce(n)/Yb(n)	9.82	14.33	7.25	6.88	8.12	6.74	8.40	7.38
Tb(n)/Yb(n)	1.36	1.35	1.41	1.65	1.49	1.63	1.27	1.36
Eu/Eu*	0.64	0.75	1.08	1.04	0.78	0.92	3.43	1.38
Ce/Ce*	0.88	0.84	0.78	0.87	0.86	0.87	0.63	0.79
LREE	109.60	90.12	61.75	122.50	146.20	194.20	46.70	52.20
HREE	4.51	2.46	3.49	7.19	7.53	11.05	1.65	3.39
LREE / HREE	24.30	36.63	17.69	17.04	19.42	17.57	28.30	15.40

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بترولوجيا وجيوكيمياء واصل نشأة الصخور الجرانيتية فى منطقة جبل أبو ميرات بشمال الصحراء الشرقية بمصر

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تنقسم الصخور الجرانيتية فى منطقة جبل أبو ميرات الى ثلاث مجموعات تشمل على الجرانيت القديم والطورين الثالث والأول من الجرانيت الحديث. ويكون الجرانيت القديم أرضية الموطن للجرانيت الحديث ولدية تركيب مقابل للكوارتز مونزوديوريت وخصائص كلسى قلوية وقد تكون فى بيئة انضغاطية . وتؤيد جميع خصائص الجرانيت القديم اصله النارى الناتج من الانصهار الجزئى للامفيبوليت.

ويكون الطور الأول للجرانيت الحديث الصخر الاساسى فى منطقة الدراسة وتموضعه محكم بالوضع التركيبى الناشى عن كسور سابقة التكوين. ويمثل هذا الصخر بجرانيت الفلسبار القلى والتى ترتبط بالشد. كذلك يظهر العديد من الخصائص المشتركة مع جرانيت (النوع-أ).

والطور الثالث من الجرانيت الحديث لديه تركيب مكافى للكوارتز سيانيت ويبدى خصائص انتقالية بين الجرانيت القديم والطور الأول من الجرانيت الحديث. ومع ذلك فان اغلبية هذه الخصائص تؤيد حيوده تجاه الجرانيت الحديث وتشابهه مع الطور الاول يؤيد اصلهم المشترك الناتج عن الانصهار الجزئى لصخور قشرية مكافئة للجرانيت القديم .

Opaque minerals zircon, sphene and apatite are the common accessories. The K-feldspars comprise microcline, orthoclase and microperthite which are usually occur as phenocrysts.

Phase I Younger Granites are equivalent mainly to the alkali feldspar granite (Fig.2) which constitutes the main rock type of Gebel Abu Murrat massif. These rocks form the highest mountainous relief and are characteristically elongated in the NW-SE direction. Sabet et al. (1972) concluded that their emplacement might have been structurally controlled by pre-existing fractures. The granites usually display sharp intrusive contacts, however in some places they possess graditional contacts with the syeno-(monzo-) granites Few amphibolitic xenoliths are less commonly encountered in the alkali feldspar granite which show linear arrangement. This alkali-feldspar granite is leucocratic, coarse to medium grained and uncommonlly porphyritic. It has red , buff and pinkis white colours. The rock is essentially composed of alkali feldspars (orthoclase and microcline), which may form phenocrysts, and quartz. plagioclase (An7-13), brown and green biotite are subordinates, whereas muscovite and hornblend are relatively rare. The mafic minerals are usually associated with accessory grains of apatite, zircon, epidote, sphene and opaques.

CEOCHEMISTRY OF MAJOR AND TRACE ELEMENTS

Major and 19 trace elements of 18 samples of the granitoid rocks of Gebel Abu Murrat area are given in Table 1 and 2. The analyses were determined by X-ray fluorescence technique at the Mining Institute, Saint petersburg, Russian Federal Republic.

The normative feldspar triangular diagram (Streckeisen, 1976) shows that phase I is alkali feldspar granite to syeno-grantie and phase III is syeno- to monzo-granite. The Old Granitoids, however, have a granodioritic composition (Fig.2) These threefold classification can be also deduced from the chemical classifications of Streckeisen and Le Maitre (1978) and O'Connor (1965) given in (Figs.3 and 4).

On the AFM diagram (Fig.5), the alkali feldspar granite is plotted very close to the A corner due to its alkaline affinity that intimately related to the extensional environment of Petro et al. (1979). The older granodiorite is located inward reflecting a calc-alkaline nature which was developed under a compressional environment. Moreover, the syeno- (monzo-) granite is found at the felsic termination of the calc-alkaline trend (Carmichael et al., 1974) and possesses a transitional character between the tensional and compressional trends. Similar geochemical behaviour of the studied rocks can be also concluded from the alkalinity ratios on Wright 's (1969) diagram (Fig.6) The alkali-feldspar granite shows a mildy alkaline affinity, whereas the older granodiorite displays a typical calc-alkaline nature. Moreover, the syeno- (monzo-) granite has a transitional character between the calc-alkaline and alkaline fields.

The relationship between $A12O3/Na2O+k2O$ versus $A12O3/CaO+Na2O+k2O$ (Manior and piccoli, 1989) confirms that all the studied rock are principally metaluminous (Fig. 7). Furthermore, the binary diagram of Na_2O against K_2O (Fig. 8) shows that the Older Granitoids are I-type granites and the Younger Granitoids are A-type rocks.

The normative Qz-Ab-Or proportions of the studied granitoid rocks are plotted on the experimental data diagram of Tuttl and Bowen (1958). The older granodiorite is located near the Ab corner which strongly indicates its emplacement at a relatively deeper depths in the earth's crust (Fig.9). On the other hand, the alkali- feldspar granite is plotted close to the low temperature minima at water vapour pressure from 5 to 3 kb. The syeno-(monzo-) granite, however, was intruded at intermediate depths close to 10 kb.

Plotting of the major oxides versus the silica content (Fig.10) confirms the subdivision of the concerned rock into three granitic groups which display an evolutionary trend with the silica increase. Phase I alkali-feldspar granite is relatively enriched in SiO_2 and K_2O and depleted in TiO_2, Al_2O_3, Fe_2O_3, FeO, MgO, CaO, Na_2O, and P_2O_5 as compared with the older granodiorite. Phase III syeno- (monzo-) granite usually displays an intermediate contents of the major oxides. All these trends strongly suggest a genetic relationship among the studied rock suites. A comparable conclusion can be deduced from the distribution of the trace elements among these rocks. The alkali-feldspar granite commonly displays higher abundances in Ba and Rb, and lower contents in Y,V,Co,Srand Zr relative to the older granodiorite. The syeno-(monzo-) granite usually possesses intermediate values, however, it is relatively enriched in Y, Nb and Zr.

Within the studied rocks, Rb displays an increase towards the more differentiated rocks and is strongly correlated with K_2O. Nb. varies only slightly with SiO_2, it is low except in the syeno-(monzo-) granite (~15-24ppm). K/Rb ratios usually vary between 400 and 500 which are considerably higher than the typical granitoid rocks (K/Rb = 200-300). Rb/Sr ratios vary between 0.66 and 0.17 in the alkali- feldspar granite, between 0.36 and 0.19 in the syeno- (monzo-) granite and are extremely low in the older granodiorite (0.05) These values reflect an upper crust origin for the Younger Granitoids and lower crust for the Older Granitoids (Schroll, 1976).

The Younger Granitoids display a comparable Th/U ratios which vary between 2.67 and 1.59 reflecting a coherence of these radioactive elements with total alkaies rather than potassium as suggested by Heier and Rogers (1963). Compared with the Older granodiorite, the alkali-feldspar granite shows higher ratios of Rb/Zr and lower Ca/Sr reflecting an advanced stage of differe-ntiation as distinguished by El-Gaby (1975) and Ahmed and El Mahallawi (1995).

Sr contents are higher in syeno- (monzo-) granite quartz-syenite (254-725 ppm) compared with the alkali-feldspar granite (128-395 ppm). Modal calculation indicates that these Sr- contents in the Younger Granitoids are in the hypothetical melts in equilibrium with residue containing 30-60% plagioclase (e.g. Arth and Hanson, 1975; Albuquerque, 1977).

The content of Ba is more or less equal in the Younger Granitoids (Fig.11). As the content of this element in the melt would be largely dependant on the percentage of biotite (or K-feldspars) in the residium (e.g. Albuquerque, 1977) that trend indicates that the syeno- (monzo-) granite and alkali feldspar granite were in equilibrium with equal modal biotite. Moreover, the Rb content of the alkali feldspar granite are slightly higher than the syeno-(monze-) granite (Fig.11) and the K/Rb ratios are nearly equal, which indicates that only small amounts of biotite would remain in the residium (Albuquerque, 1978). In addition, the simultaneous increase of K with decreasing Ti also negates any significant role of biotite (Bertrand et al., 1984).

The discrimination diagrams of Nb and Rb versus Silica (Figs.12 a b) shows that the Older Granitoids have a tectonic setting comparable with the volcanic arc granties (VAG), whereas the Younger Granitoids are rather intimated to the within-plate granites (WPG) as suggested by Noweir et al.(1990).

CEOCHEMISTRY OF RARE EARTH ELEMENTS

The contents of 10 REE in 8 samples of the studied granitic rock are given in Table 3. REE were determined by the Instrumental Neutron Activation Analysis (INAA) at the Institute of Nuclear physics, Moscow, Russian Federal Repubic. Table 3 shows also the normalized ratios Ce(n)/Yb(n), La(n)/Sm(n) and Tb(n)/Yb(n) which are used as a measure of the degree of fractionation of REE. light-REE and heavy-REE respectively. The Eu anomaly is also demonstrated as Eu(n)/Eu* [Eu* =(Sm(n)+Gd(n)/2].

The REE data reveal that there are characteristic differences between the different groups of granitic rocks of Gebel Abu Murrat area both regard to their total REE content, as well as the distribution patterns of these elements.

The sum of REE in the different samples is found to vary considerably (Table,3). Generally , all samples display lower contents compared with the average granitic rocks (250 ppm, Hermann, 1970). The Older Granitoids possess the lowest REE being 49 to 56 pmm, whereas the Younger Granites have a relatively higher contents; 155 to 207 ppm in the syeno- (monzo-) granite and 66 to 132 in the alkali granites. This geochemical trend of a closely associated granitoid suites has been previously distinguished by Sahama (1946), Rankama (1946) and Koljonen and Rosenberg (1974). Within the Younger Granitoids, however, the concentration of REE seems to decrease towards the acid end as recognized by Yajima et al. (1968) and Nagasewa and Schnetzler (1971).

Concerning the distribution REE-patterns of the studied rocks (Fig.13), there are pronounced differences. In principle, two basic types of patterns can be found The Old Grantioids show a smooth concave REE patterns with general decrease in concentration from La to Lu with marked positive Eu anomaly, whereas the Younger

Granitoids have a REE patterns showing a variable intensity of negative Eu anomalies. These patterns are similar to those of continental margin rocks which occur at large distance from the trench in an area of thick crust (Thorpe et al ., 1976; Bertrand et al., 1984).

The Old Granitoids display variable intensity of fractionation of LREE where the La(n)/Sm(n) ratios differ between 21 and 5 (Table ,3). Such variation is comparable with variable positive Eu anomaly (Eu/Eu*=1.38-3.4). Arth et al. (1978) distinguised that the fractionation of hornblende during partial melting of amphibolite produces granitic rocks marked by positive Eu anomaly and show reversible relationship between REE and Eu anomaly as found in the studied rocks.

The REE - patterns of the Younger Granitoids are typically similar to one another. They have a rather flattening form, LREE are less uniform where La(n)/Sm(n) varies between 2.3 and 6.6 and HREE are almost parallel and unfractionated with Tb(n)/Yb(n) varying between 1.4 and 1.7. All samples display neutral to pronounced negative Eu anomaly. Eu/Eu* ratios range between 1.1 to O.64 in the alkali feldspar granite and between O.92 to O.78 in the syeno- (monzo-) granite. This normaly observed negative Eu anomaly is best explained by removal of plagioclase from the granitic liquid during crystal fractionation, a conclusion which is consistent with the petrographic observation (e.g. early crystallization of plagioclase).

From what have been stated above, it is apparent that there is a systematic variation both in the total REE content and the REE distribution pattern among the studied rocks. This variation can be clearly related to the age of granites. This finding is in keeping with the earlier geological study of Sabet et al. (1972), which revealed