Sci. J. Fac. Sci. Menoufia Univ. Vol. XI (1995). *69 -102*

GEOCHEMISTRY AND PETROGENESIS OF THE UM HAD AND THE *FAWAKHIR* YOUNGER GRANITES, EASTERN DESERT, EGYPT

By

B.T. El-Dosuky

Geology Dept., Faculty of Science Tanta University, Egypt

ABSTRACT

Granitoid rocks can be broadly classified on the basis of their tectonic environment into orogenic and anorogenic classes. Orogenic granitoid rocks can be subdivided into IAG, CAG, CCG and POG. The anorogenic granitoid rocks can be subdivided into RRG, CEUG and OP. The present study reveals that the Um Had and the Fawakhir granites are of POG type of an orogenic tectonic environment, i.e. they introduced during the last phase of orogeny, generally after the deformation in the region has ceased. These granitoid rocks associated with the orogeny in both space and time. This high potassic, calc-alkaline granite situated in spreading center island and orogenic belt. These granites lie within syncollision to late collision field.

INTRODUCTION

The Eastern Desert Precambrian belt contains two distinct granitoid assemblages, older granite (880-610 m.y.) and a younger one (600-475 m.y.) which covers about 22.4% of the exposed total area of the Precambrian belt of the Eastern Desert of Egypt.

Akaad et al (1979) divided late to post tectonic granite on the basis of field evidence into three phases mentioned that most of the plutons have been apparently formed within a narrow time range of about 600 m.y. ago.

Noweir et al (1985) proved that the Um Had pluton pertain to magmatic rocks situated in island arc orogenic belt. Ries and Darbyshire (1984) stated that the Rb/Sr whole rock age of the Um Had is 596 $^{+}$11 m.y. with an Sr^{87}/Sr^{86} initial ration of 702 $^{+}$3. They also mentioned that the Um Had granite has within plate characteristics.

The present paper deals with the geochemistry of the Um Had and the Fawakhir younger granite and their associated biotite in order to obtain a more objective picture of the genesis of these granites and to throw some light on the tectonic environment of these granites. To do this task the geochemistry of the associated biotite is also studied.

Figure 1, shows the Um Had region which includes the granite pluton and intruded sedimentary beds of Hammamat Group. The area lies west of Wadi Atalla and north of Wadi Hammamat north of the Qift - Quseir road. Noweir (1968) described and mapped this area. Advanced field study was made by Akaad et al (1979) and Akaad and Noweir (1980). Rb/Sr rock age of the pluton was measured by Ries and Darbyshire (1984).

Figure 2, shows the Fawakhir region which includes the Fawakhir

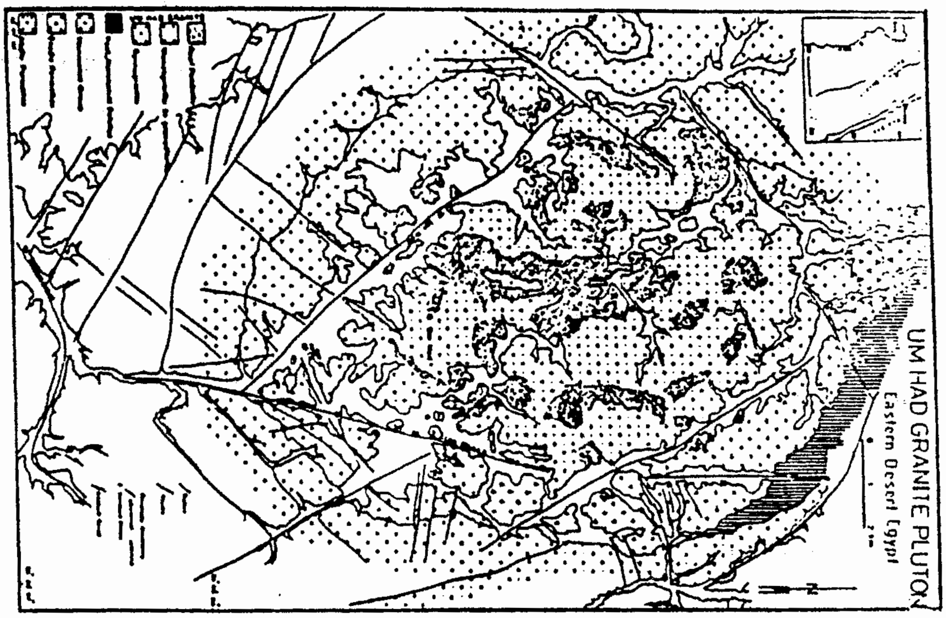

Fig. 1: Geological map of the Um Had granite pluton.

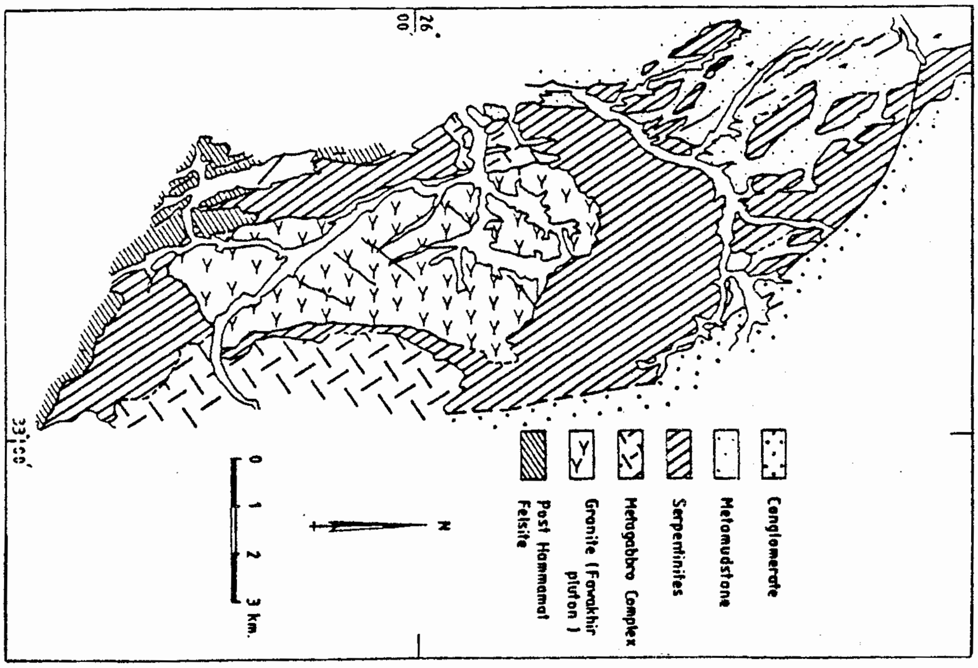

Fig. 2: Geological map of the Fawakhir granite pluton.

granite pluton and the surrounding older rocks of Atalla serpentinite range and the Sid metagabbros. Field relations, petrographic classification and photogeological study of the pluton was carried out by Oweiss (1965), Noweir (1968) and Akaad et al (1979).

GEOCHEMICAL INVESTIGATION OF GRANITES

Many chemical analyses were carried out on the Um Had granite by many workers, among of them, El Gaby (1975), Akaad et al (1979), Ghoneim (1982), Sewifi (1985) and Noweir et al (1990). On the other hand many chemical analyses were published on the Fawakhir granite, among of them had been done by Abd El Ghaffar (1975), El Gaby (1975) and Sewifi (1985).

Table 1, gives the major element chemical analyses of the Um Had and the Fawakhir granites. Twenty two representative samples from the Um Had and Fifteen chemical analyses of the Fawakhir granite. Table 2 represents the CIPW normative composition and some chemical ratios for the present studied rocks.

The proposed classification scheme has two major divisions, the sub-alkaline (which divided into tholeiitic and calc-alkaline) and alkaline rocks, and a third minor category, the peralkaline rocks. The alkali-silica diagram is convenient, it makes direct use of the analytical data. It has been established as effective means of distinguishing alkalic and tholeiitic (Mc Donald, 1968).

Irvine and Baragar (1971) constructed ($CNa_2O + K_2O$)vs. SiO_2 diagram to distinguish between the alkaline and sub-alkaline rocks. The

* FeO : total iron as FeO.

Table 1: Major elements analyses of the Um Had and the Fawakhir granites.

Oxides \ Sample No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
SiO_2	77.50	74.10	73.38	73.75	72.48	67.38	72.66	68.93	74.31	68.29	77.52	75.84	74.63	63.23	68.90	69.77	72.64	72.84	72.92
TiO_2	-	0.14	0.34	0.76	0.42	0.32	-	0.22	0.20	0.40	0.60	0.28	0.01	1.00	0.57	0.50	0.21	0.30	0.27
Al_2O_3	12.99	11.89	13.24	14.46	13.86	13.97	13.97	13.40	11.73	13.08	12.93	12.51	13.00	13.76	13.12	12.17	13.69	12.50	12.41
Fe_2O_3	1.10	1.40	1.29	1.88	0.13	0.57	0.90	1.24	1.73	3.16	0.33	1.22	0.33	2.03	2.16	1.27	0.72	0.29	2.24
FeO	1.06	1.15	0.89	5.54	1.49	3.91	0.80	2.71	1.65	2.52	0.62	1.24	0.34	5.74	3.32	3.78	1.73	2.40	1.29
MnO	0.01	0.05	0.04	0.18	0.06	0.10	0.02	0.08	0.05	0.09	0.01	0.03	0.04	0.19	0.10	0.13	0.05	0.10	0.06
MgO	0.09	0.24	0.25	1.57	0.68	0.98	0.38	0.98	0.21	1.40	0.12	0.48	0.65	1.40	1.75	1.38	0.28	0.85	0.27
CaO	1.36	1.31	1.43	3.39	1.61	2.86	1.25	2.38	1.49	3.16	0.26	0.93	4.93	3.5ˀ	3.23	2.50	1.22	1.69	1.47
Na_2O	1.82	3.37	4.04	3.50	4.04	3.91	4.99	3.37	3.70	3.03	3.39	3.24	4.93	5.12	4.45	4.45	3.48	4.45	4.45
K_2O	1.61	5.64	3.19	3.60	3.91	3.49	3.61	4.46	3.61	2.47	4.83	3.99	4.08	2.53	1.57	2.71	4.62	3.62	3.19
P_2O_5	-	0.01	-	0.04	0.02	0.10	0.02	0.08	-	0.06	0.01	0.06	0.07	-	-	-	0.04	0.60	-
Total	97.54	99.30	98.09	108.67	98.70	97.59	98.60	97.85	98.68	97.66	100.62	99.82	103.01	98.53	99.17	98.66	98.68	99.64	98.57

Oxides \ Sample No.	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	
SiO_2	73.55	74.17	74.60	65.17	66.81	66.00	66.47	67.01	72.30	67.12	66.74	66.14	66.05	66.26	71.32	74.87	73.49	74.14	
TiO_2	0.30	0.08	0.01	0.80	0.44	0.64	0.84	0.60	0.41	0.19	0.12	0.64	0.20	0.16	0.26	0.08	0.19	0.08	
Al_2O_3	12.12	14.24	13.48	15.42	15.26	14.69	15.37	15.61	14.00	15.21	15.49	15.06	14.80	14.75	14.20	14.25	14.06	13.75	
Fe_2O_3	1.01	1.04	0.56	1.20	0.67	1.60	1.20	0.87	0.38	1.11	1.04	1.11	0.44	1.60	0.98	0.96	1.37	0.85	
FeO	1.46	0.22	1.19	3.29	3.15	2.94	2.75	3.04	1.94	2..79	2.90	3.13	3.51	3.06	0.14	0.18	0.08	0.24	
MnO	0.07	0.03	0.15	0.08	0.20	0.09	0.07	0.09	-	0.09	0.08	0.10	0.11	0.09	0.09	0.05	0.04	0.08	
MgO	0.42	0.13	0.13	1.15	1.49	0.85	1.10	1.02	0.58	0.87	1.06	1.27	1.49	1.23	0.66	0.14	0.41	0.30	
CaO	1.91	0.45	0.81	2.86	2.62	2.92	2.44	2.74	1.82	2.92	2.59	3.10	3.28	3.87	1.68	0.11	1.70	0.37	
Na_2O_1	4.58	3.43	4.05	4.31	4.08	4.85	4.38	4.18	4.36	4.05	4.28	5.05	4.51	4.92	5.76	4.32	4.10	3.66	
K_2O	3.62	5.15	4.25	4.85	4.25	4.33	3.49	3.86	3.77	3.49	3.68	3.93	2.53	2.41	3.76	3.91	3.40	4.49	
P_2O_5	-	0.01	0.02	0.12	0.09	0.11	0.10	0.01	0.14	0.10	-	0.07	0.09	0.09	0.09	0.03	0.04	0.06	-
Total	99.04	98.95	99.25	99.25	99.06	99.02	98.21	99.03	99.69	97.94	97.98	98.70	97.01	98.44	98.94	98.90	98.88	98.02	

N.B: Samples from 1-22 are from the Um Had Granite.
Samples from 23-37 are from the *Fawakhir Granite*.

Table 2 : (Cont.)

Sample # / CIPW Norm	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
Q	29.31	33.38	32.00	13.24	17.36	14.33	19.77	18.95	27.11	21.26	18.76	16.20	19.08	18.27	20.38	34.42	32.49	34.59
C	0.00	2.23	0.79	0.00	0.00	0.00	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.78	0.64	2.34
Or	21.40	30.44	25.12	28.67	25.12	25.59	20.63	22.81	22.28	20.63	21.75	17.91	14.95	14.24	22.22	23.11	20.10	26.54
Ab	38.75	29.02	34.27	36.47	34.52	41.04	37.06	35.37	36.89	34.27	36.21	42.73	38.16	41.63	48.73	36.55	34.69	30.97
An	1.83	2.17	3.89	8.41	10.78	5.53	11.45	12.44	7.50	13.02	12.19	9.48	12.67	11.05	1.79	0.35	8.17	1.44
Di	5.04	0.00	00.00	4.18	1.36	6.91	0.00	0.92	0.52	0.69	0.56	4.55	2.53	6.32	3.55	0.00	0.00	0.00
Wo	0.68	0.00	00.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.58	0.00	0.00	0.00
Hy	0.00	0.32	2.31	4.65	7.90	1.83	5.54	6.12	3.75	5.88	6.78	4.85	8.39	4.10	0.00	0.35	1.02	0.75
Ol	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mt	1.46	0.57	0.81	1.74	0.97	2.32	1.74	1.26	0.55	1.61	1.51	1.61	0.64	2.32	0.00	0.51	0.00	0.80
Hm	0.00	0.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.98	0.61	1.37	0.30
Il	0.57	0.15	0.02	1.52	0.84	1.22	1.60	1.14	0.78	0.36	0.23	1.22	0.38	0.30	0.49	0.15	0.25	0.15
Ap	0.00	0.02	0.05	0.28	0.21	0.26	0.24	0.02	0.33	0.24	0.00	0.17	0.21	0.21	0.21	0.07	0.09	0.14
Total	**99.04**	**98.94**	**99.26**	**99.26**	**99.06**	**99.03**	**98.22**	**99.03**	**99.71**	**97.96**	**97.99**	**98.72**	**97.01**	**98.44**	**98.93**	**98.90**	**98.88**	**98.02**
Green Param. %																		
Qtz	95.75	99.71	98.34	86.45	89.00	86.81	93.57	91.94	96.29	93.19	91.65	87.75	88.37	87.78	95.40	99.70	99.08	99.36
Ol	0.00	0.29	1.66	7.14	9.38	2.75	6.43	7.00	3.26	6.09	7.72	6.33	8.92	4.80	0.00	0.30	0.92	0.64
Di	4.25	0.00	0.00	6.41	1.62	10.44	0.00	1.06	0.46	0.72	0.64	5.92	2.71	7.42	4.60	0.00	0.00	0.00
Walker Param. %																		
Pl	86.55	100.38	95.74	83.04	83.90	82.29	86.30	86.17	90.57	86.15	86.21	82.40	82.23	80.14	90.76	101.60	95.31	99.79
Ol	3.16	8.32	7.15	10.63	13.53	7.84	13.54	12.46	7.42	12.04	13.00	10.90	13.43	10.45	1.39	9.17	6.82	9.11
Di	10.29	-8.70	-2.89	6.34	2.57	9.88	0.16	1.37	2.01	1.81	0.79	6.70	4.35	9.40	7.84	-10.77	-2.12	-8.90
Groves Param. %																		
Qtz	76.01	78.04	76.38	55.78	61.32	56.50	62.61	62.46	71.86	64.74	61.41	56.92	60.82	58.98	64.19	75.31	75.70	77.77
Ol	-0.34	1.86	1.91	3.98	5.94	1.64	3.99	4.456	1.99	4.38	5.56	3.77	5.91	3.74	-1.12	2.06	0.83	2.09
Pl	24.33	20.10	21.71	40.24	32.74	41.86	33.40	33.08	26.14	30.88	33.03	39.31	33.27	37.28	36.94	22.63	23.47	20.14

N.B. Samples from 1-22 are from the Um Had Granite.
Samples from 23-37 are from the Fawakh8ir Granite.

Table 2 : CIPW normative composition and some ratios for the Um Had and the Fawakhir ganites

Sample # / CIPW Norm	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Q	57.22	30.65	34.20	27.36	28.68	21.78	26.50	24.87	35.42	31.93	38.61	38.70	23.72	12.92	26.90	25.23	30.73	28.37	31.80
C	5.78	00.00	00.54	00.00	00.10	00.00	0.00	0.00	0.00	0.00	1.68	1.32	0.00	0.00	0.00	0.00	0.84	0.00	0.00
Or	9.52	33.34	18.85	21.28	23.11	20.63	21.34	26.36	21.34	14.60	28.55	23.58	24.11	14.95	9.28	16.02	27.31	21.40	18.85
Ab	15.40	28.51	34.18	29.61	34.18	33.08	42.22	28.51	31.31	25.64	28.68	27.41	41.71	43.32	37.65	37.65	29.44	37.65	37.65
An	6.75	00.66	7.09	13.12	7.86	10.26	5.06	8.27	4.74	14.80	1.22	4.22	1.30	7.10	11.19	5.23	5.79	3.45	4.47
Di	0.00	2.83	00.00	2.91	0.00	2.79	0.83	2.53	2.26	0.39	0.00	0.00	4.26	8.84	3.97	6.02	0.00	0.86	1.80
Wo	0.00	1.00	00.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.25	0.00	0.00	0.00	0.00	0.00	0.24
Hy	1.28	0.00	0.70	10.13	3.74	7.38	1.30	4.90	0.73	4.82	0.30	2.06	0.00	6.56	5.96	5.72	3.03	5.54	0.00
Ol	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mt	1.59	2.03	1.87	2.73	0.19	0.83	1.30	1.80	2.51	4.58	0.29	1.77	0.48	2.94	3.13	1.84	1.04	0.42	3.25
Hm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Il	0.00	0.27	0.65	1.44	0.80	0.61	0.00	0.42	0.38	0.76	1.14	0.53	0.02	1.90	1.08	0.95	0.40	0.57	0.51
Ap	0.00	0.02	0.00	0.09	0.05	0.24	0.05	0.19	0.00	0.14	0.02	0.14	0.17	0.00	0.00	0.00	0.09	1.42	0.00
Total	97.54	99.31	98.08	108.67	98.71	97.60	98.60	97.85	98.69	97.66	100.62	99.82	103.02	98.53	99.17	98.66	98.67	99.68	98.57
GREEN PARAM.%																			
Qtz	99.47	97.67	99.41	90.08	96.82	90.31	97.94	93.20	97.93	95.84	99.77	98.61	95.36	78.91	91.53	89.86	97.71	94.83	98.49
Ol	00.53	00.00	0.59	7.69	3.18	6.99	1.27	4.48	0.50	3.85	0.23	1.39	0.00	8.90	5.12	4.92	2.29	4.47	0.00
Di	00.00	2.33	00.00	2.24	0.00	2.70	0.79	2.33	1.58	0.30	0.00	0.00	4.64	12.19	3.35	5.21	0.00	0.70	1.51
WALKER PARAM. %																			
Pl	108.01	88.30	93.85	75.27	92.47	82.39	93.39	83.61	87.64	78.14	100.07	92.87	82.15	73.07	76.23	77.14	93.48	85.77	87.71
Ol	27.21	3.67	8.33	20.50	7.74	12.71	5.11	11.83	8.44	20.65	6.90	12.04	-9.47	15.74	17.68	13.82	9.38	7.69	8.37
Di	-35.23	8.03	-2.18	4.23	-0.21	4.90	1.49	4.56	3.92	1.21	-6.97	-4.91	27.32	11.19	6.10	9.04	2.86	6.54	3.91
GROVES PARAM. %																			
Qtz	83.93	82.03	77.02	70.89	73.95	66.98	70.29	72.78	80.39	75.16	82.29	81.13	73.13	52.26	68.75	70.27	76.58	73.54	76.13
Ol	3.34	-0.21	1.05	6.04	2.08	4.88	1.31	3.72	0.93	3.92	0.83	2.12	-9.36	5.74	4.26	3.87	2.45	2.27	0.57
Pl	12.67	18.18	21.93	23.08	23.98	28.13	28.41	23.51	18.67	20.92	16.88	16.74	33.23	42.00	26.99	25.86	20.97	24.19	23.30

plotting demonstrates that the Um Had and the Fawakhir samples lie within the sub-alkaline field (Fig. 3). The Um Had and the Fawakhir samples are plotted into a FeO^*/MgO vs. SiO_2 (Fig 4) diagram of miyashiro (1974) and the boundary line to separate the fields of calc-alkaline and tholeiitic series rocks. This plotting (Fig. 4) shows that the samples lie within calc-alkaline series.

For measuring the alkalinity parameter of rocks, Wright (1969) formulated a simple alkalinity ratio of Al_2O_3 + CaO total alk / Al_2O_3 + CaO - total alk. Table 3, gives the numerical values of Wright's alkalinity ratio of the present analysed Um Had and the Fawakhir granites. The graphical representation of the logarithmic values of the alkalinity ratio (Fig. 5) indicates that nearly all the studied samples lie within the calc-alkaline field, the Um Had and the Fawakhir granites are characterized by (Na_2O + K_2O) exceeds CaO. El Shazly (1976) proved that the Fawakhir granites are alkaline and some samples were found to lie in the calc-alkaline field.

Irvine and Baragar (1971) constructed a triangular diagram of FeO^* - (Na_2O + K_2O) - MgO to differrentiate between calc-alkaline and tholeiitic series (Fig. 6) which demonstrates that the present rocks lie within the calc-alkaline field.

Le Bas et al (1989) demonstrated the chemical classification of volcanic rocks based on the total alkali-silica diagram (TAS). By using this diagram (Fig. 7) all the plotted samples lie in the acidic zone within the fields illustrated in Table 4.

Maniar and Piccoli (1989) used the molecular weights to construct AFM and ACF triangular diagrams; where A = Al_2O_3 + Na_2O + K_2O, F=FeO^*, M = MgO and C = CaO. The specimen plot on these diagrams

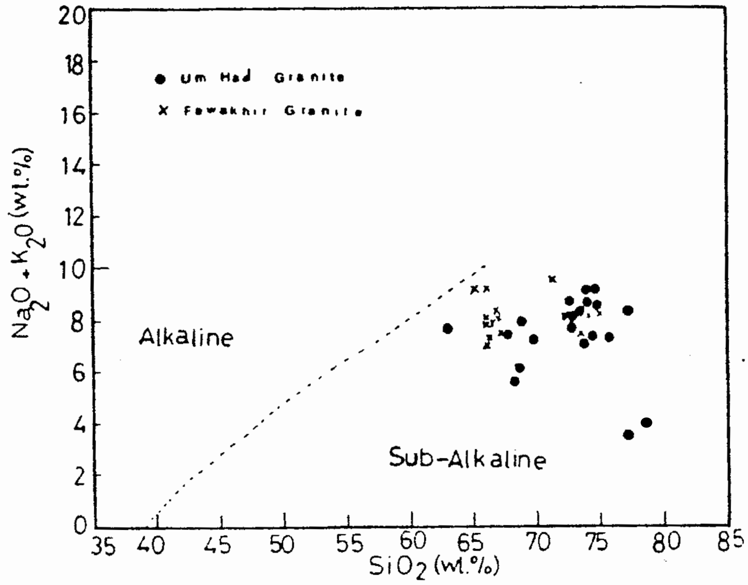

Fig. 3: Alkalies - Silica plots of Irvine and Baragar (1971), the dashed line is the line chosen for making a general distinction between alkaline and sub-alkaline granites.

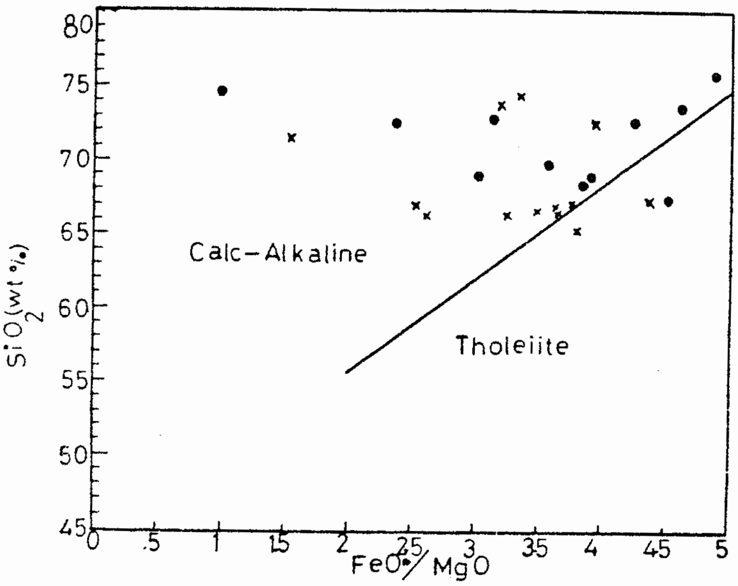

Fig. 4: The plotting of FeO*/MgO vs. SiO_2 (Miyashiro, 1974) symbols as in Fig. 3.

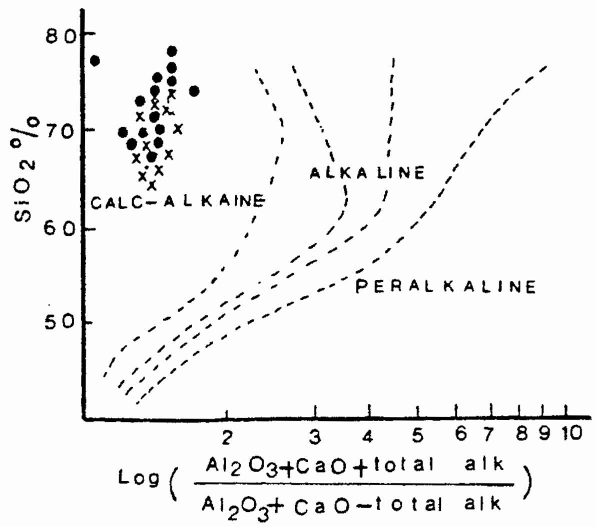

Fig. 5: Log. alkalinity ratio vs. SiO_2 (wt%) diagram (Wright, 1969), symbols as in Fig. 3.

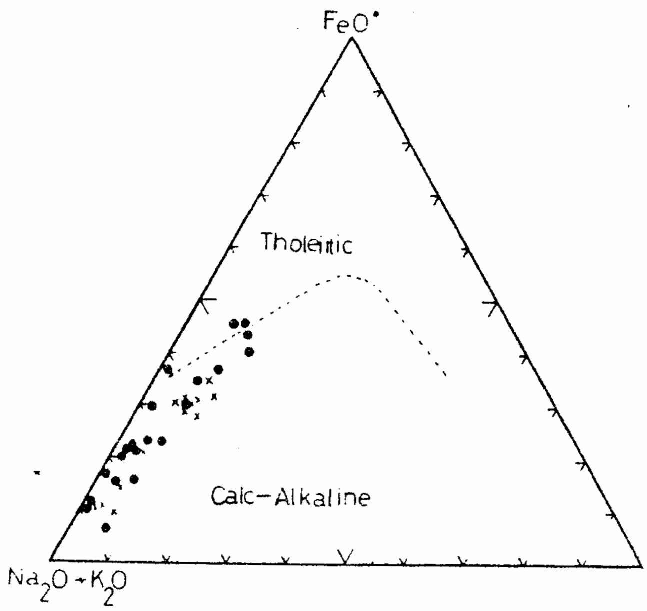

Fig. 6: Irvine and Baragar (1971) triangular diagram of FeO^*-(Na_2O+K_2O) - MgO all in wt%. The dashed line serves to separate tholeiitic and calc-alkaline, symbols as in Fig. 3.

Table 3: **The numerical values of the Wright's alkalinity ratios for the Um Had and the Fawakhir Granites.**

Sample No.	SiO_2%	Alkalinity Ratio	Sample No.	SiO_2	Alkalinity Ratio
1	77.50	1.63	20	73.55	3.81
2	74.10	5.30	21	74.17	3.80
3	73.38	2.94	22	74.60	3.77
4	73.75	2.32	23	65.17	3.01
5	72.48	3.11	24	66.81	2.74
6	67.38	2.57	25	66.00	3.18
7	72.66	3.60	26	66.47	2.58
8	68.93	2.97	27	67.01	2.56
9	74.31	3.47	28	72.30	3.11
10	68.29	2.02	29	67.12	2.42
11	77.52	4.31	30	66.74	2.57
12	75.84	3.33	31	66.14	2.60
13	74.63	3.02	32	66.05	2.28
14	63.23	2.59	33	66.26	2.30
15	68.90	2.17	34	71.32	4.02
16	69.77	2.91	35	74.87	3.69
17	72.64	3.38	36	73.49	2.82
18	72.48	3.64	37	74.14	3.73
19	72.92	3.45			

N.B.: **Samples from 1-22 are from the Um Had Granite.**
Samples from 23-37 are from the Fawakhir Granite.

Table 4: Relation between field symbols and rock names as in Fig. 7 (Le Bas et al, 1986)

FIELD SYMBOLS	ROCK NAMES
R	Rhyolite
T	Trachyte, Trachy dacite
O_1	Basaltic andesite
O_2	Andesite
O_3	Dacite
S_1	Trachy basalt
S_2	Basaltic Trachy andesite
S_3	Trachy andesite
U_1	Basanite
U_2	Phonotephrite
U_3	Tephrite phonolite
Ph	Phonolite
F	Foidite
Pc	Picrobasalt

Table 5 : Major elements analyses of the present biotite of the Um Ifad and the Fawakhir granites.

Oxides \ Sample No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
SiO_2	35.73	35.61	36.19	35.49	35.67	36.03	35.86	35.84	35.15	35.38	34.72	35.87	35.63	36.54	35.75	36.63
TiO_2	2.83	2.80	3.35	2.91	2..85	3.54	3.08	3.41	2.78	3.19	2.16	3.24	3.33	3.40	2.87	3.46
Al_2O_3	15.70	15.78	16.34	14.30	14.09	15.10	14.40	15.11	14.97	15.81	16.57	15.38	15.30	15.22	15.05	15.45
Cr_2O_3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fe_2O_3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FeO	27.29	27.55	26.55	26.38	26.52	25.25	25.52	24.04	28.03	29.40	29.16	29.16	28.39	24.10	28.12	24.60
MnO	0.48	0.46	0.43	0.48	0.57	0.54	0.50	0.52	0.55	0.45	0.60	0.54	0.63	0.55	0.61	0.55
MgO	4.36	4.25	4.12	6.38	6.41	5.75	6.66	6.64	4.73	4.30	5.14	4.30	4.64	6.54	5.21	6.58
Li_2O	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BaO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CaO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Na_2O	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
K_2O	9.51	9.40	9.58	9.58	9.72	9.54	9.69	9.60	9.07	9.21	7.86	9.39	9.16	9.80	9.05	9.72
Rb_2O	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cs_20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H_2O	3.81	3.80	3.83	3.81	3.80	3.84	3.83	3.86	3.79	3.86	3.80	3.86	3.79	3.86	3.80	3.86
F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cl	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
O=F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
O=Cl	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	99.71	99.65	100.39	99.33	99.63	99.59	99.54	99.02	99.07	101.60	100.01	101.74	100.87	100.01	100.46	100.85

Table 6 : Geochemical parameters of the Um Had and the Fawakhir biotite.

Sample No. / Geoparam.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
#Si IV	5.64	5.63	5.63	5.65	5.65	5.65	5.65	5.63	5.62	5.41	5.47	5.47	5.58	5.67	5.62	5.64
#Al IV	2.36	2.37	2.36	2.37	2.35	2.35	2.35	2.37	2.38	2.59	2.53	2.53	2.42	2.33	2.38	2.36
#Fe IV	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
#Ti IV	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T site	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
#Al VI	0.57	0.57	0.64	0.30	0.28	0.44	0.32	0.43	0.44	0.26	0.55	0.24	0.41	0.46	0.41	0.45
#Ti VI	0.34	0.33	0.39	0.35	0.34	0.42	0.36	0.40	0.33	0.37	0.26	0.37	0.39	0.40	0.34	0.40
#Cr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
#Fe+3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
#Fe +2	3.61	3.64	3.46	3.50	3.51	3.31	3.36	3.16	3.75	3.76	3.84	3.72	3.72	3.13	3.70	3.17
#Mn +2	0.06	0.06	0.06	0.06	0.08	0.07	0.07	0.07	0.07	0.06	0.08	0.07	0.08	0.07	0.08	0.07
#Mg	1.03	1.00	0.96	1.51	1.51	1.34	1.56	1.55	1.12	0.98	1.21	0.98	1.08	1.51	1.22	1.51
#Li	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
O Site	5.60	5.62	5.51	5.72	5.72	5.58	5.68	5.61	5.72	5.43	5.94	5.38	5.69	5.57	5.74	5.60
#Ba	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
#Ca	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
#Na	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
#K	1.92	1.90	1.91	1.94	1.96	1.91	1.95	1.92	1.85	2.73	1.58	2.78	1.83	1.94	1.81	1.91
#Rb	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
#Cs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A site	1.92	1.90	1.91	1.94	1.96	1.91	1.95	1.92	1.85	2.73	1.58	2.78	1.83	1.94	1.81	1.91
#O	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00
#OH	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
#F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
#C1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Charge	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FeOt	27.29	27.55	26.55	26.38	26.52	25.25	25.52	24.04	28.03	29.40	29.16	29.16	28.39	24.10	28.12	24.60
FeOt+MgO	31.65	31.80	30.67	32.76	32.93	31.00	32.18	30.68	32.76	33.70	34.30	33.46	33.03	30.64	33.33	31.18
FeOt/FeOt+MgO	0.86	0.87	0.87	0.81	0.81	0.81	0.79	0.78	0.86	0.87	0.85	0.87	0.86	0.79	0.84	0.79
Na2O+K2O	9.51	9.40	9.58	9.58	9.72	9.54	9.69	9.60	9.07	9.21	7.86	9.39	9.16	9.80	9.05	9.72
Fel+Mg+Na+KO	41.16	41.20	40.25	42.34	42.65	40.54	41.87	40.28	41.83	42.91	42.16	42.85	42.19	40.44	42.38	40.90
100MgO	436.00	425.00	412.00	638.00	641.00	575.00	666.00	664.00	473.00	430.00	514.00	430.00	464.00	654.00	521.00	658.00
S.I.	10.59	10.32	10.24	15.07	15.03	14.18	15.91	16.48	11.31	10.02	12.19	10.04	11.00	16.17	12.29	16.09
#Fe	3.61	3.64	3.46	3.50	3.51	3.31	3.36	3.16	3.75	3.76	3.84	3.72	3.72	3.13	3.70	3.17
#Fe+Mg	4.63	4.65	4.42	5.01	5.02	4.65	4.93	4.71	4.87	4.74	5.05	4.70	4.81	4.64	4.92	4.68
#Fe/Fe+Mg	0.78	0.78	0.78	0.70	0.70	0.71	0.68	0.67	0.77	0.79	0.76	0.79	0.77	0.67	0.75	0.68
#Al IV+Al VI	2.92	2.94	3.00	2.67	2.63	2.79	2.67	2.80	2.82	2.85	3.08	2.77	2..83	2.78	2.79	2.80

Table 6 : (Cont.)

Geoparam. \ Sample No.	17	18	19	20	21	22	23	24	25	26	27	28	29
#Si IV	5.52	5.64	5.54	5.65	5.59	5.68	5.61	5.62	5.71	5.66	5.67	5.66	5.60
#Al IV	2.48	2.36	2.46	2.35	2.41	2.32	2.39	2.38	2.29	2.34	2.33	2.34	2.40
#Fe IV	0	0	0	0	0	0	0	0	0	0	0	0	0
#Ti IV	0	0	0	0	0	0	0	0	0	0	0	0	0
T site	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
#Al VI	0.34	0.52	0.33	0.42	0.27	0.25	0.38	0.18	0.12	0.12	0.13	0.11	0.03
#Ti VI	0.44	0.35	0.45	0.43	0.51	0.48	0.45	0.52	0.38	0.39	0.38	0.47	0.51
#Cr	0	0	0	0	0	0	0	0	0	0	0	0	0
Fe+3	0	0	0	0	0	0	0	0	0	0	0	0	0
#Fe +2	3.41	3.23	3.38	3.14	3.27	3.25	3.26	3.33	3.08	3.13	3.11	3.33	3.52
#Mn +2	0.05	0.05	0.05	0.03	0.04	0.05	0.04	0.05	0.05	0.04	0.05	0.05	0.06
#Mg	1.51	1.49	1.51	1.56	1.53	1.60	1.52	1.57	2.15	2.15	2.16	1.74	1.62
#Li	0	0	0	0	0	0	0	0	0	0	0	0	0
O Site	5.74	5.64	5.72	5.58	5.62	5.63	5.63	5.64	5.79	5.83	5.82	5.69	5.73
#Ba	0	0	0	0	0	0	0	0	0	0	0	0	0
#Ca	0	0	0	0	0	0	0	0	0	0	0	0	0
#Na	0	0	0	0	0	0	0	0	0	0	0	0	0
#K	1.77	1.85	1.80	1.93	1.89	1.84	1.86	1.89	1.83	1.80	1.80	1.90	1.89
#Rb	0	0	0	0	0	0	0	0	0	0	0	0	0
#Cs	0	0	0	0	0	0	0	0	0	0	0	0	0
A site	1.77	1.85	1.80	1.93	1.89	1.84	1.86	1.89	1.83	1.80	1.80	1.90	1.89
#O	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00
#OH	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
#F	0	0	0	0	0	0	0	0	0	0	0	0	0
#C1	0	0	0	0	0	0	0	0	0	0	0	0	0
Charge	0	0	0	0	0	0	0	0	0	0	0	0	0
FeOt	26.40	25.02	25.87	24.14	25.05	25.02	25.40	25.84	23.92	24.18	24.00	25.56	26.70
Fe0t+Mg0	32.96	31.49	32.38	30.89	31.63	31.93	32.03	32.66	33.29	33.50	33.36	33.05	33.59
Fe0t/Fe0t+Mg0	0.80	0.79	0.80	0.78	0.79	0.78	0.79	0.79	0.72	0.72	0.72	0.77	0.79
Na20+K20	9.00	9.40	9.02	9.73	9.48	9.30	9.51	9.62	9.33	9.10	9.11	9.56	9.39
Fet+Mg+Na+K0	41.96	40.89	41.40	40.62	41.11	41.23	41.54	42.28	42.62	42.60	42.47	42.61	42.98
100MgO	656.00	647.00	651.00	675.00	658.00	691.00	663.00	682.00	937.00	932.00	936.00	749.00	689.00
S.I.	15.63	15.82	15.72	16.62	16.01	16.76	15.96	16.13	21.98	21.88	22.04	17.56	16.03
#Fe	3/41	3.23	3.38	3.14	3.27	3.25	3.26	3.33	3.08	3.13	3.11	3.33	3.52
#Fe+Mg	4.92	4.72	4.89	4.70	4.80	4.84	4.77	4..90	5.23	5.28	5.27	5.07	513
#Fe/Fe+Mg	0.69	0.68	0.69	0.67	0.68	0.67	0.68	0.68	0.59	0.59	0.59	0.66	0.68
#Al IV+Al VI	2.81	2.88	2.79	2.77	2.67	2.58	2.77	2.56	2.42	2.46	2.46	2.45	2.43

N.B: Samples from 1-16 are from the Um Had biotite.
Samples from 17-29 are from the Fawakhir biotite.

(Figs. 8 & 9) reflects that the specimens of the Um Had and the Fawakhir are closely related to the A - F boundary of these diagrams i.e. the specimens are relatively rich in alkalies and iron compared to calcium and magnesium. Generally these figures indicate that the liquid line of the magma through which the present granites were produced is rich in alkalies and iron and poor in Ca and Mg.

The tectonic discrimination scheme for granitoids was illustrated by Maniar and Piccoli (1989). These tectonic discriminations of granitoids are orogenic and anorogenic granitoids. The orogenic grnitoids can be subdivided into island arc granitoids (IAG), continental arc granitoids (CAG), continental collisions granitoids (CCG) and post orogenic granitoids (POG). The anorogenic granitoid rocks can be subdivided into rift related granitoids (RRG), continental epirogenic uplift granitoids (CEUG) and oceanic plagiogranites (OP).

K_2O is very mobile constituent and it is possible for highly altered granitoid from any tectonic environment to have abnormally low K_2O values. The plotting of SiO_2 (wt%) vs. K_2O (wt%) (Fig. 10) is used to distinguish between OP and other types of granitoids. Figure 10 indicates that the Um Had and the Fawakhir granites are not oceanic plagiogranite. To determine the tectonic environment of these granites, Al_2O_3 (wt%) vs. SiO_2 (wt%) (Fig. 11) has been used by Maniar and Piccoli (1989). Figure 11 illustrates that the tectonic environment of the present granites lie in post orogenic zone. Therefore, we consider that the Um Had and the Fawakhir granites to have formed in an orogenic environment. Cahen et al (1984) and Rogers et al (1978) mentioned that the younger granites of Egypt are an example where POG are exposed.

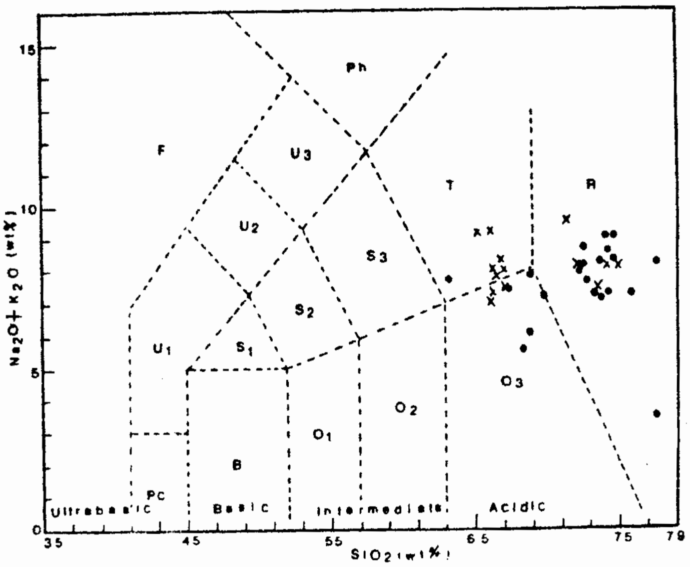

Fig. 7: The total alkali silica (TAS) diagram showing the location of the Um Had and the Fawakhir granites (Le Bas et al, 1986), symbols as in Fig. 3. and Table 4.

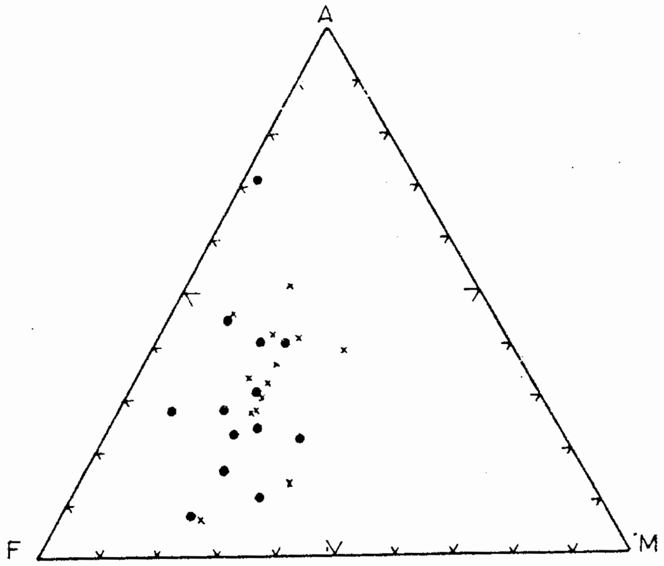

Fig. 8: AFM (all in molecular weights) triangular diagram for the studied samples (Maniar and Piccoli, 1989), symbols as in Fig. 3.

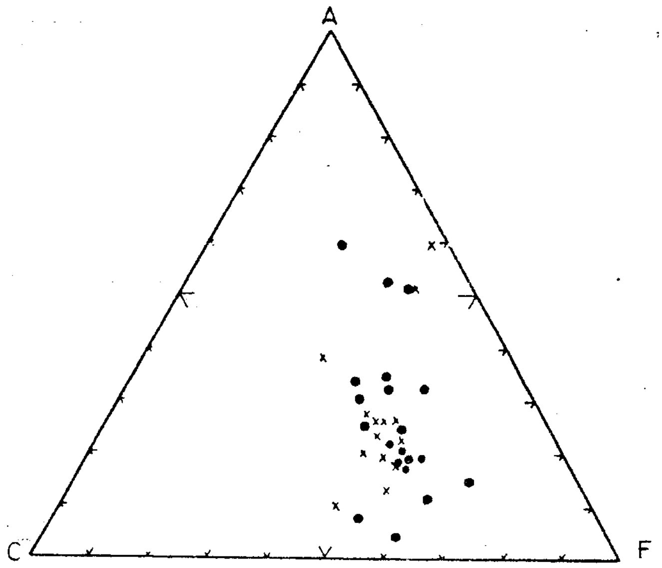

Fig. 9: ACF (All in molecular weights) triangular diagram (Maniar and Piccoli, 1989), symbols as in Fig. 3.

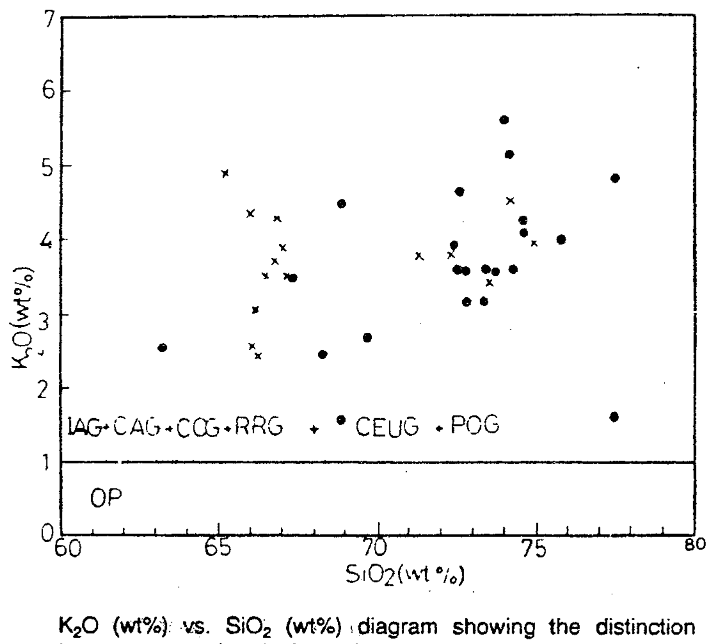

Fig. 10: K_2O (wt%) vs. SiO_2 (wt%) diagram showing the distinction between oceanic plagiogranites and granitoides from other environment (Maniar and Piccoli, 1989), symbols as in Fig. 3.

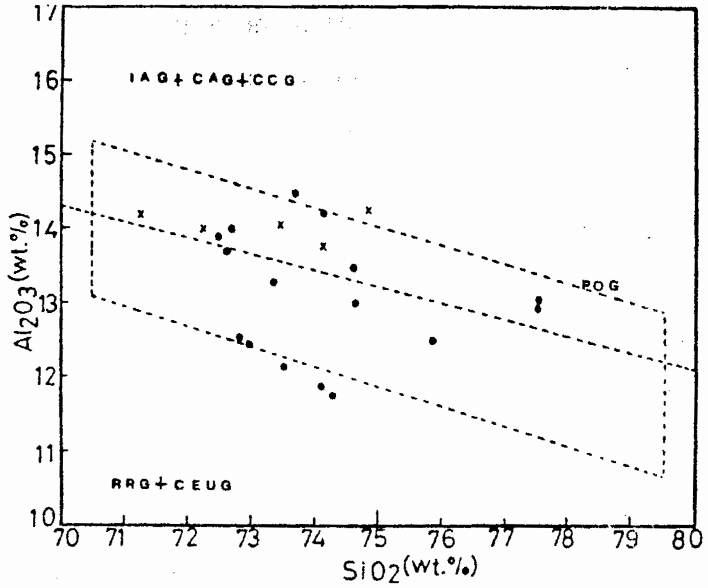

Fig. 11: Al_2O_3 (Wt%) vs. SiO_2 (Wt%) diagram showing the distinction of post orogenic granitoids from the other types (Maniar and Piccoli, 1989) symbols as in Fig. 3.

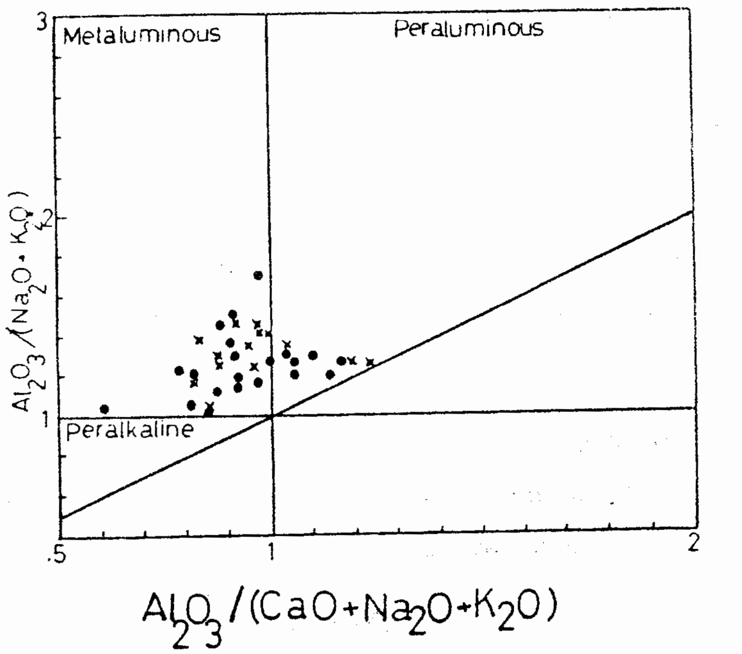

Fig. 12: Shand's index diagram (Maniar and Piccoli, 1989), symbols as in Fig. 3.

Shand (1927 and 1943) classified the granitic rocks according to Shand's index which depends upon the alumina saturation into three categories; peraluminous (A/CNK > 1.0), metaluminous (A/CNK = 1.0) and peralkaline (A/CNK < 1.0) where A = Al_2O_3, C = CaO, N = Na_2O and K=K_2O all in molar ratios, The plotting of Al_2O_3 / CaO + Na_2O + K_2O vs. Al_2O_3 / CaO + K_2O (Fig. 12) presents that most of the Um Had and the Fawakhir granites are clustered in a well defined field of metaluminous type (A/CNK > 1.0) and some samples lie within peraluminous field.

According to the relative amounts of Na_2O + K_2O by weight % Le Bas et al (1986) mentioned that the rocks are classified into "sodic" and "potassic". If (Na_2O-2) > K_2O then the rock may be considered "sodic" and if (Na_2O-2) < K_2O then "potassic" is appropriate.

Le Maitre (1984) constructed SiO_2 vs. K_2O diagram to determine the type of granite either low, medium, or high potassic. This diagram (Fig. 13) gives that most of the Um Had and the Fawakhir granites are high potassic where few samples are of medium potassic.

Pearce et al (1977) used FeO^* - MgO - Al_2O_3 triangular diagram to distinguish between different types of magma. The plotting of the present samples on this triangular diagram (Fig. 14) indicates a spreading island type.

R1 - R2 diagram (Fig. 15) is an example for the use of major element chemical composition to make inferences about the tectonic environment of granitoid rocks is given by Batchelor and Bowden (1985), where :

$$R1 = 4\ Si - 11\ (Na + K) - 2\ (Fe + Ti) \text{ and}$$

$$R2 = 6\ Ca + 2\ Mg + Al.$$

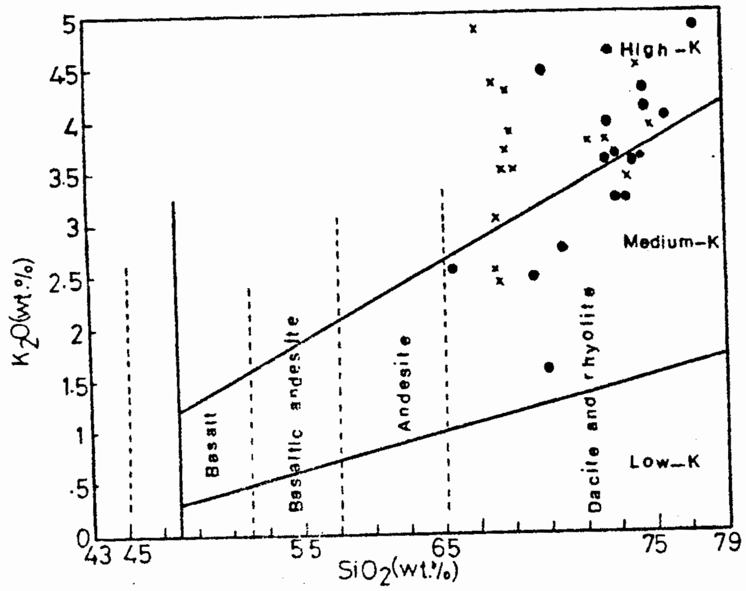

Fig. 13: The plotting of SiO_2 (wt%) vs. K_2O (wt%) showing the distinction between high, medium and low potassic granites (Le Maitre, 1984), symbols as in Fig. 3.

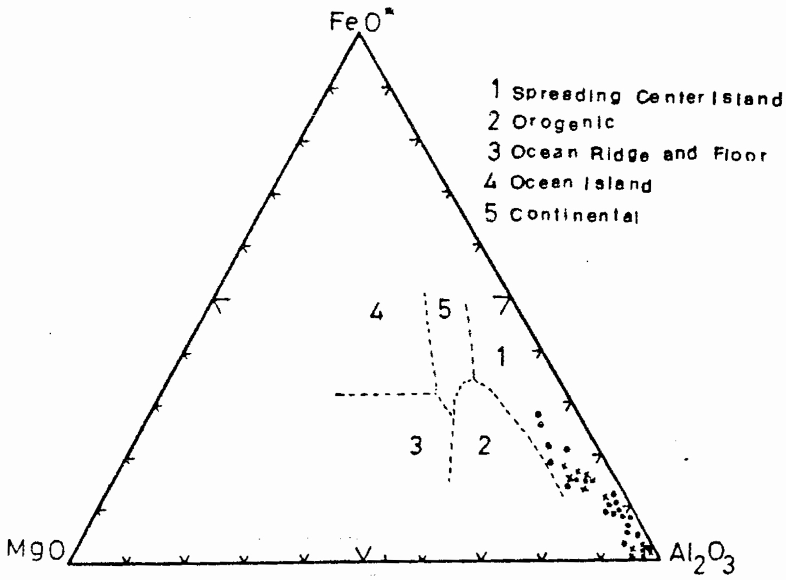

Fig. 14: Triangular diagram of FeO^*-MgO-Al_2O_3 (Pearce et al, 1977), symbols as in Fig. 3.

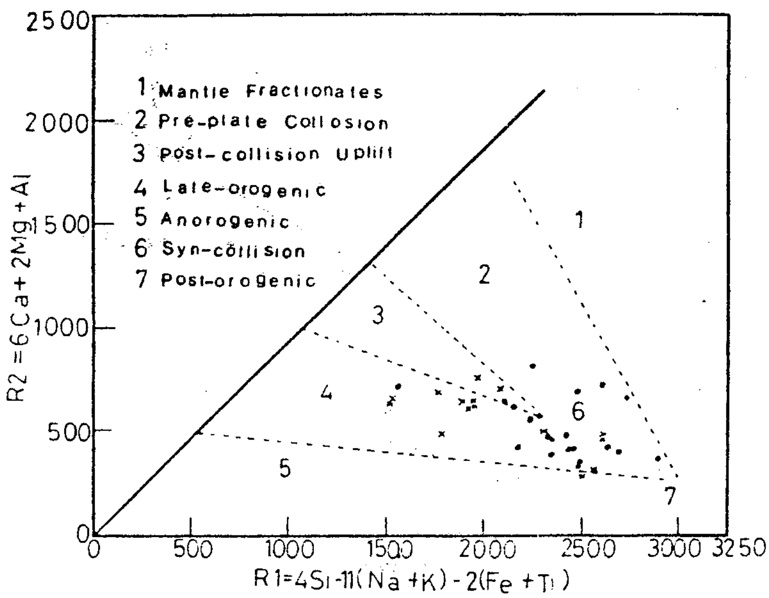

Fig. 15: R1-R2 diagram of Batchelor and Bowden (1985), symbols as in Fig. 3.

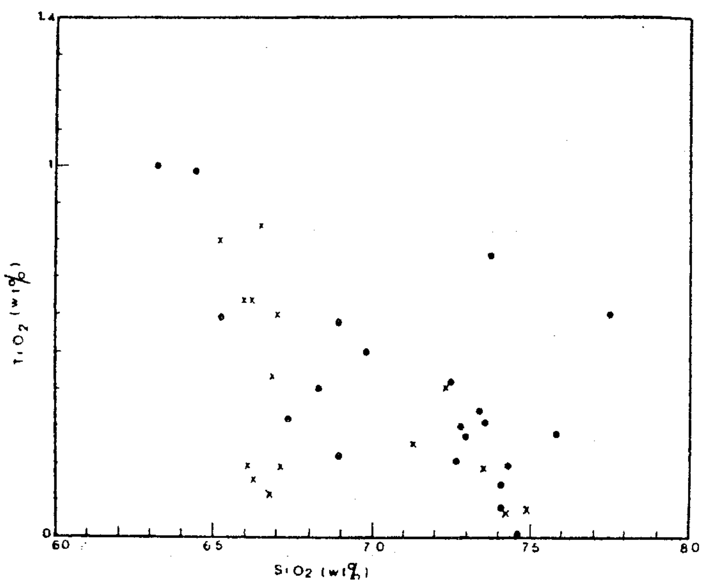

Fig. 16: TiO_2 (wt%) vs. SiO_2 (wt%) diagram of Maniar and Piccoli (1989), symbols as in Fig. 3.

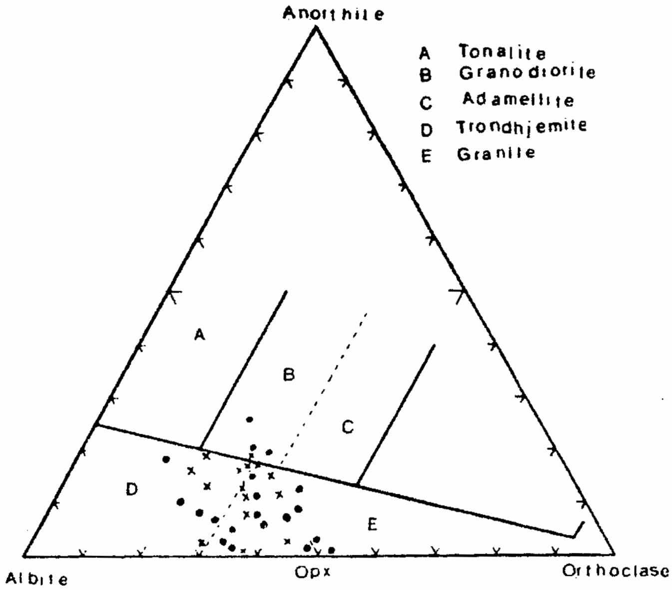

Fig. 17: Ab-An-Or triangular diagram for the studied granites, symbols as in Fig. 3.

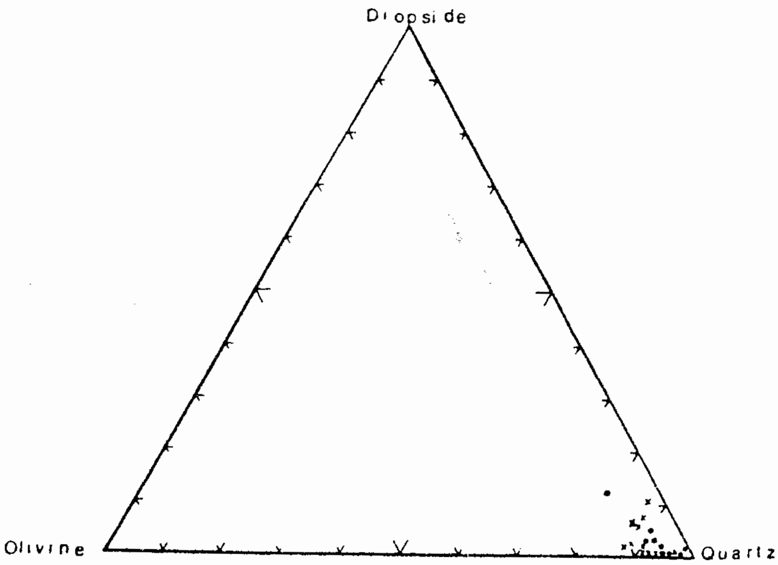

Fig. 18: Diopside - quartz - olivine triangular diagram, symbols as in Fig. 3.

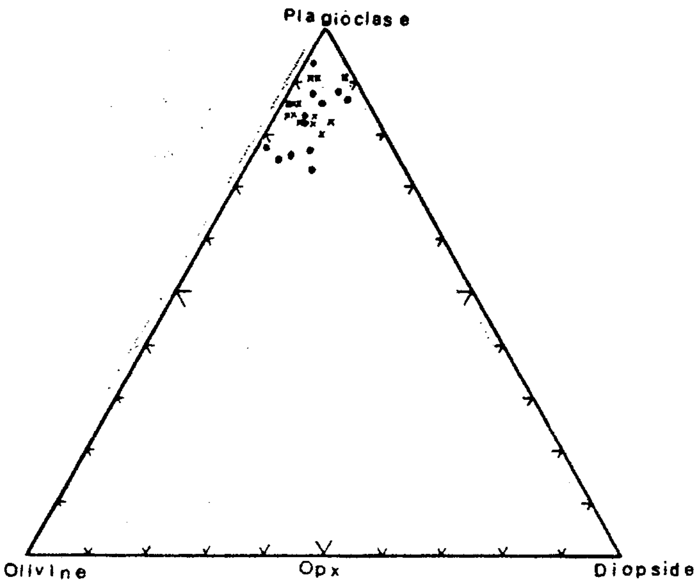

Fig. 19: Plgioclase - diopside - olivine triangular diagram (Walker, 1969) symbols as in Fig. 3.

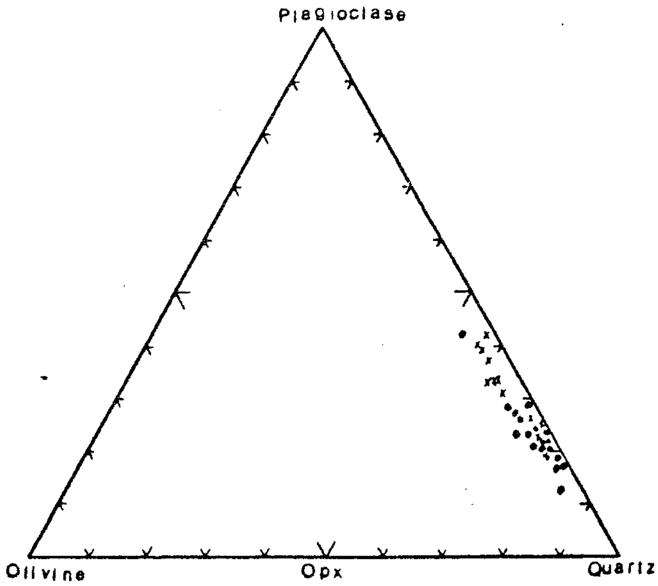

Fig. 20: Plagioclase quartz - olivine triangular diagram (Groves, 1937). symbols as Fig. 3.

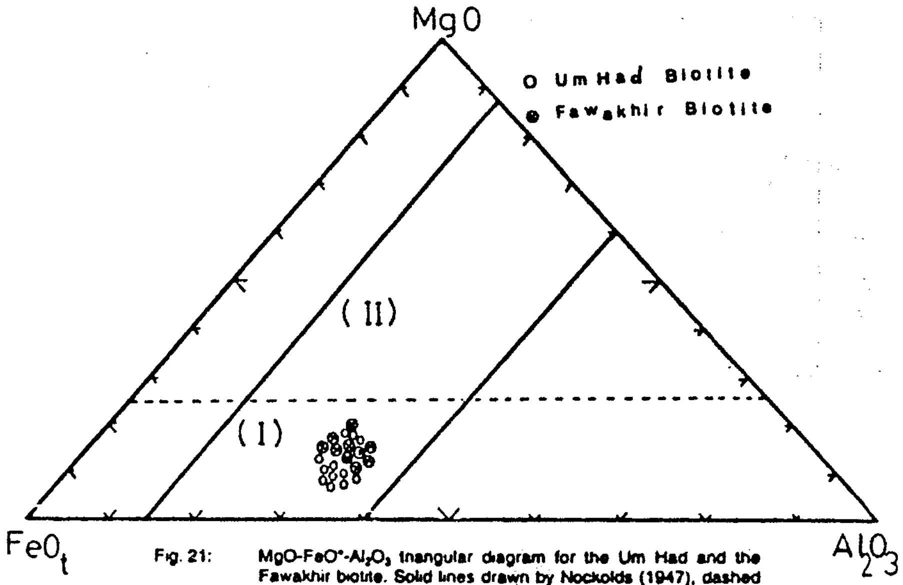

Fig. 21: MgO-FeO*-Al$_2$O$_3$ triangular diagram for the Um Had and the Fawakhir biotite. Solid lines drawn by Nockolds (1947), dashed lines drawn by Gokhale (1968), separating biotite of magmatic rocks (I) from those of metamorphic (II)

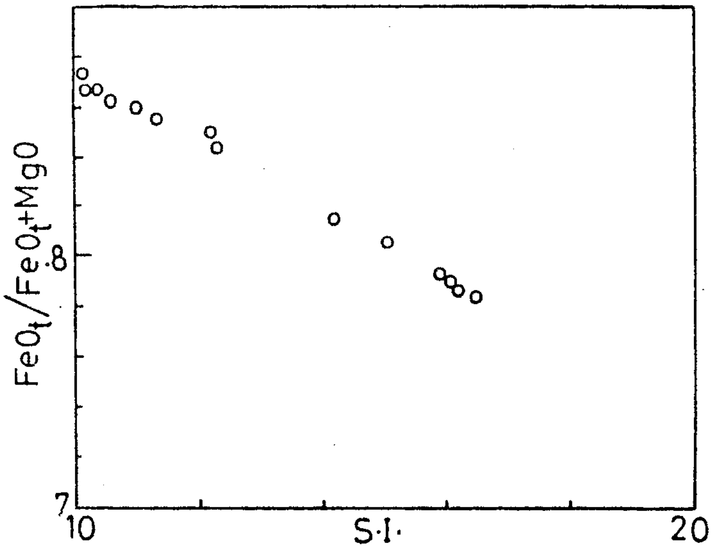

Fig. 22a: S.I. vs. FeO*/FeO*+MgO diagram of the Um Had biotite.

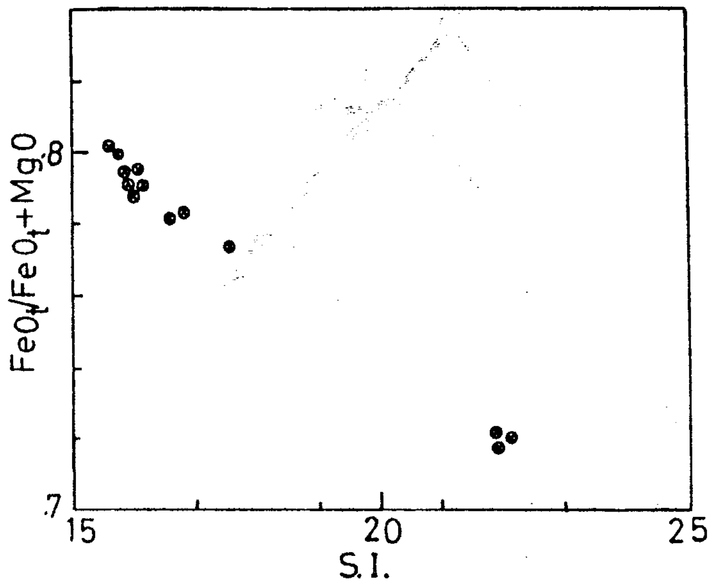

Fig. 22b: S.I. vs. FeO*/FeO*+MgO diagram of the Fawakhir biotite.

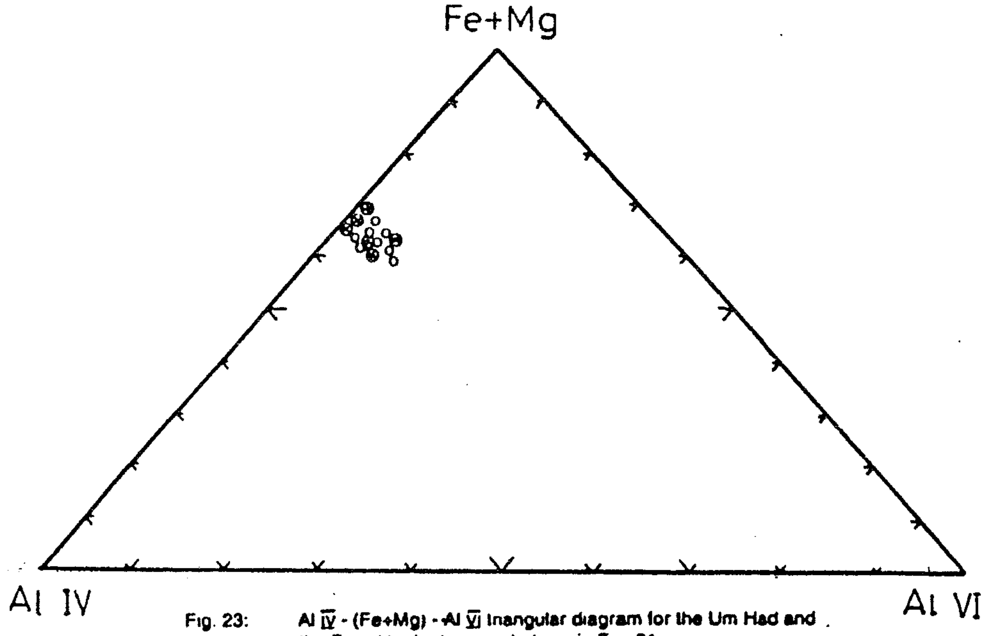

Fig. 23: Al $\overline{IV}$ - (Fe+Mg) - Al $\overline{VI}$ triangular diagram for the Um Had and the Fawakhir biotite, symbols as in Fig. 21.

GEOCHEMISTRY OF BIOTITES

Biotites used as an indicator to the petrogenesis of the host granitic rocks. Twenty nine representative biotite samples associated with the present granitic rocks have been subjected to chemical analysis. Sixteen of them from the Um Had granite and thirteen from the Fawakhir granite. Heinrich (1946), Nockolds (1947), Gokhale (1968), Engel and Engel (1960), Sewifi (1985) and others, contributed to the chemistry of biotite and constructed different diagrams which serves as a guide to the perrogenesis of the host granitic rocks. Chemical composition (normalised calculations) and other different Fawakhir biotites are characterized by almost similarities in SiO_2, TiO_2, MgO and K_2O whereas the Um Had biotites have enrichment in FeO^* and Al_2O_3.

MgO - Al_2O_3 - FeO^* are plotted on Nockds (1947) triangular diagram (Fig. 21). It is obvious from this figure that the present biotite of the Um Had and the Fawakhir lie within the field of biotite of magmatic igneous rocks. The average ratio of $\frac{Fe\ (t)^* \times 100}{Fe\ (t) + Mg}$ of the examined Um Had biotite (73.75) is higher than that of the Fawakhir biotite (65.93). This means that the original magma of the Um Had granite is rich in Fe^{+2}. Generally speaking the biotites of the Um Had and the Fawakhir granites are characterized by high content of ferrous and low content of Mg. This result is confirmed and supported by Figs. (22 a, b), whereas there is an antipathetic relationship between the solidification index [100 MgO/MgO+ FeO^* + Na_2O + K_2O] and FeO^* / FeO^* + MgO ratio. The plotting of (Fe + Mg) - Al IV - Al VI triangular diagram (Fig. 23) indicates that these biotites are rich in ferrous and Al IV than Al VI which reflects the enrichment of the

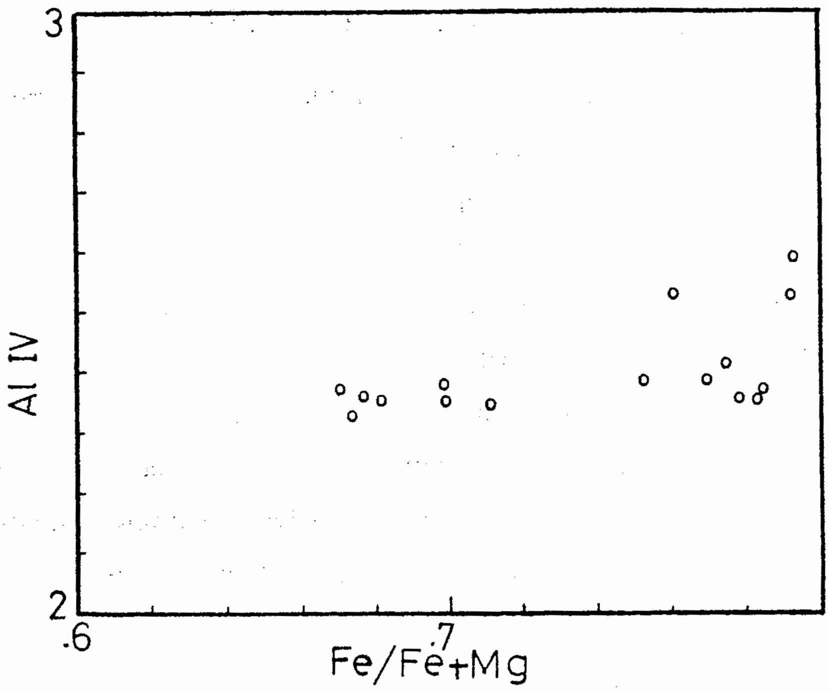

Fig. 24a: Al IV - Fe/Fe+Mg diagram for the Um Had biotite.

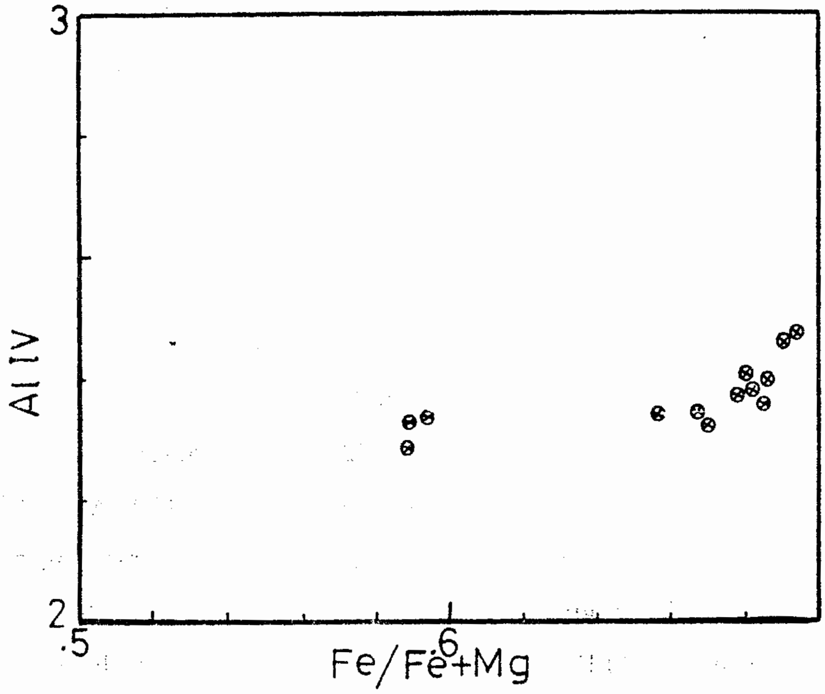

Fig. 24b: Al IV - Fe/Fe+Mg diagram for the Fawakhir Biotite

original magma with the Al IV more than Al IV. The same result can be obtained from Figs. (24 a, b) which reflect positive relationship between AlIV and Fe / Fe + Mg.

SUMMARY AND CONCLUSION

Regarding the geochemistry of these younger granites and their associated biotite, the following features can be summarized :

1) According to the alkalinity parameters the studied granite is fractionated from sub-alkali magma of calc-alkali type. The original magma from which these granites were produced is poor in MgO and TiO_2 and rich in alkalis, Al IV and ferrous iron.

2) The analyzed biotite has enrichment in ferrous iron predominates over that the ferric iron, Al IV predominates over that of Al VI and K_2O. MgO is lower than FeO. This conclusion is in a good parallelism with the chemical composition of the host granite which reflects the genesis of this host.

3) To throw some light on the tectonic discrimination of these granitoids, the following conclusion should be mentioned :

   a) SiO_2 v.s. K_2O variation diagram gives a satisfactory graphical representation that the present granite is not oceanic plagiogranite.

   b) SiO_2 vs. Al_2O_3 diagram demonstrates that the present granite lie within the (POG) field. The same result was proved by Cahen et al (1984) and Rogers et al (1978) for the younger granite of Egypt. So it has been suggested that the present granite represents the transitional phase of the continental stabilisation following the orogeny. The same result was mentioned by Rogers and Greenberg (1981 a, 1981 b).

4) Depending upon the alumina staturation the present granites are of metaluminous type, few samples are peraluminous.

5) Regarding to the origin and genesis of these granites the following points has been recorded :

a) CIPW normative plot on Ab - Or - An triangular diagram indicates that the plagioclase is mainly albite (An_{0-26} for the Um Had granite and An_{0-20} for the Fawakhir granite). which indicates low temperature crystallisation. Most of the Um Had samples lie within the fields of trondhjemite and granodiorite. Whereas most of the Fawakhir sampleas lie within the field of granite and few samples lie within the field of trondhjemite.

b) The plotting of Al_2O_3 - MgO - FeO^* for biotite indicates that all biotite samples lie within the magmatic field which illustrates that these plutons pertain to the magmatic igneous rocks.

c) The major discrimination plot of FeO^* - MgO - Al_2O_3 illustrates that the present studied rocks situated in a spreading center island and orogenic belt. Greenberg (1981) suggested that these granites were originated as an orogenic melts generated from beneath new immature continental crust.

d) R1 - R2 diagram (Batchelor and Bowden, 1985) reflects that the Um Had granite lies in syncollision field whereas the Fawakhir granite lie in syncollision to late collision field, and few samples lie within post collision uplift. Hussein et al (1982) concluded that the younger granites of Egypt have been formed by partial melting of the lower crust probably with some addition from mantle by collision at plate boundaries under compressional environment.

Finally it could be said that the present post orogenic biotite granitoids are magmatic igneous rocks of calc-alkaline type intruded during the last phase of an orogeny, generally after the deformation in the region has ceased. The original magma from which these granites were produced is rich in alkalies, ferrous iron, Al IV and TiO_2 and lacking in magnesium.

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جيوكيميائية والأصل الصخرى
لجرانيت متداخلتى أم هاد والفواخير
بالصحراء الشرقية المصرية

بثينة طه الدسوقى
قسم الجيولوجيا - كلية العلوم
جامعة طنطا

مازالت البيئة التكتونية والأصل الصخرى لجرانيت متداخلى أم هاد والفواخير حتى الآن موضعاً للجدال والمناقشة، لذا تناول البحث الحالى دراسة جيوكيميائية هذه الصخور من خلال نتائج التحليل الكيميائى لعدد (٣٧) عينة من الجرانيت ممثلة فى (٢٢) عينة من متداخل أم هاد، (١٥) عينة من متداخلة الفواخير، ولما كان معدن البيوتيت هو المؤشر الرئيسى لدراسة الأصل الصخرى لهذا الجرانيت لذا تضمن البحث أيضاً دراسه جيوكيميائيه لعدد (٢٩) عينة من البيوتيت المصاحب لهذا الجرانيت شملت (١٦) عينة من بيوتيت أم هاد، (١٣) عينة من بيوتيت الفواخير.

أثبتت الدراسة أن معدن البلاجيوكليز يتكون أساساً من الألبيت وأن المجما الأصلية كانت غنية بكل من الصوديوم والبوتاسيوم والحديدوز والألمنيوم الرباعى، كما أنها تفتقر إلى الماغنسيوم، وأن هذه التداخلات تظهر إتجاه تحت قلوى ينتمى إلى القلوى الكلسى، أى أن هذه المتداخلات تنتمى إلى الصخور النارية المجماتية الأصل والتى نشأت فى منطقة أوروجينية فى جزيرة مركزية، وقد وجد أن هذه المتداخلات لا تتبع الجرانيت البلاجيوكليزى المحيطى ولكنها تتبع الجرانيت البعد أوروجينى وأن هذه المتداخلات أشتقت من صهير أوروجينى نتجت من القشرة التكتونية وأنها تداخلت فى وضع يتسم بعمليات شد تصادمى متزامن وأحياناً شد تصادمى متأخر عن الحركات التكتونية وحتى بعد توقفها.