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GEOCHEMISTRY OF BIOTITE AND ITS SIGNIFICANCE AS A GUIDE TO THE ORIGIN OF THE GRANITOID ROCKS OF EL-IMRA AREA, EASTERN DESERT, EGYPT.

By

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ABSTRACT

Biotites from the granitoid rocks of El-Imra, Eastern Desert, Egypt have been examined. The chemical data of 8 new analyzed biotites are presented. The behaviour of major and trace elements in the examined biotites are discussed according to different variation diagrams. The chemical composition of biotites has proved a reasonable guide to the magmatic origin of the host granitic rocks.

INTRODUCTION

The present study deals with the geochemistry of biotites separated from some granitoid rocks of El-Imra area, Eastern Desert, Egypt (Fig. 1). The granitic stock of El-Imra consists mainly of pink, pinkish - white and grey granites. They comprise porphyritic and even-grained, non-porphyritic types. Biotite is generally the sole mafic mineral in these granites. The biotite is mostly pleochroic from straw - yellow to chest nut brown. It occurs largely as irregularly-shaped flakes reaching 0.18 mm in length. In some varieties, biotite shows subparallelism and is associated with clusters of minute epidote granules. Occasionaly it froms stout flakes with torn ends. Rarely muscovite is present in the groundmass as marginal gradation around biotite. The main inclusions present in biotite are zircon, apatite and iron ores.

The work reported in this paper forms part of a continuing research program carried out in the Earth Sciences Laboratory, National Research Centre, by Kabesh and co-workers (Kabesh and Salem, 1981 & Kabesh *et al.*, 1982)

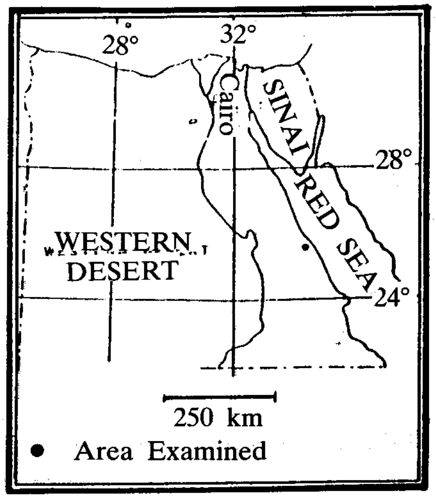

Fig. 1: Location map.

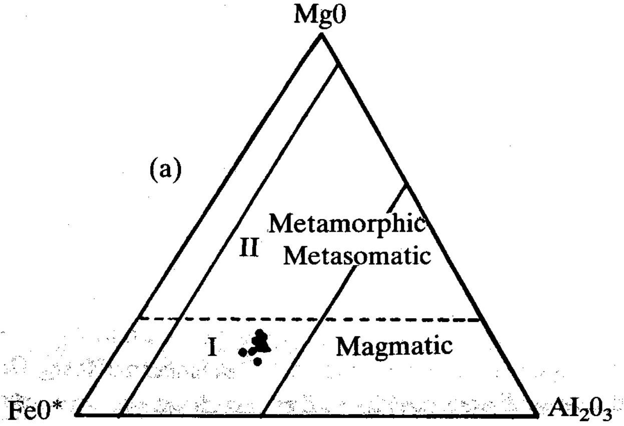

Fig. 2: Plot of AI_20_3, Mg0 and Fe0 (total iron) in the investigated biotites

- ● Analysed Samples
- ▲ The average analyses of biotites

ANALYTICAL METHODS

The samples of the host granitic rocks were crushed to pass through a 100-mesh and 120 mesh sieve (U.S). The crushed fraction was individually separated with bromoform, followed by removal of magnetite by hand magnet. Biotite separated from heavy fraction was purified by using the Frantz Isodynamic separator. Finally, the pure sample of biotite was pulverized in agate mortar under acetone untill all pass through 200-mesh sieve (U.S). The chemical analysis was carried out by using volumetric, gravimetric and colourimetric methods of silicate analysis according to Bennett & Read (1971) and Vogel (1968). Trace elements were determined by inductively coupled plasma emission spectrometry at the Nuclear Materials Corporation, Cairo using the technique described by Walsh (1980) and Mclaren *et al.*, (1981).

CHEMISTRY OF BIOTITES

Eight new chemical analyses of biotites from El-Imra granitoid rocks are used to elucidate the petrogenesis of these rocks. The major element compositions of the examined biotites are given in Table (1). In addition, one analysis of biotite from Kadabora granitic mass (Kabesh *et al.*, 1977) and one analysis from the granodiorite of Sierra Nevada Batholith (Dodge *et al.*, 1969) are given for comparison.

The chemical data are plotted on Gokhale variation diagram (Fig. 2), showing the ternary diagram Mg0, Fe0 and $AI_2 0_3$. It is observed that all the examined biotites fall within the zone drown by Gokhale (1968) for biotites of magmatic nature.

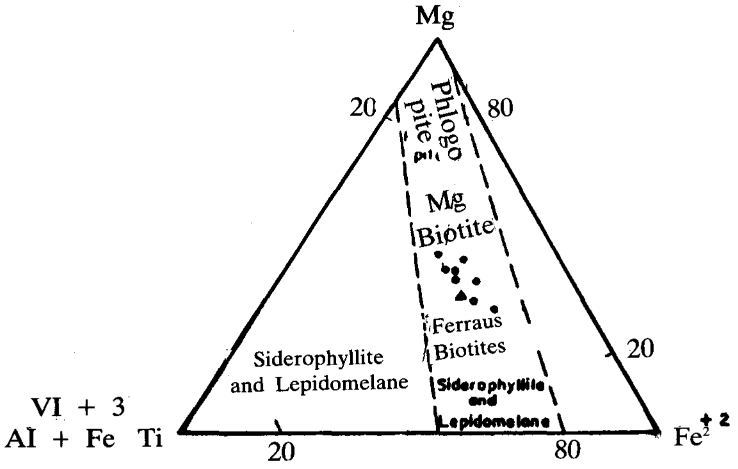

Fig. 3: Relation between octahedral cations of the studied biotite (after Foster, 1960).

Table 1

Chemical analysis of biotites from granitoid rocks of El Imra area.

Oxide	1	2	3	4	5	6	7	8	average	A	B	C
SIO_2	35.15	35.67	35.53	30.06	35.53	35.00	35.64	36.11	35.59	35.40	35.99	36.90
AI_2O_3	4.27	14.54	15.15	15.20	15.30	15.98	15.30	14.45	14.95	16.66	14.94	15.40
Fe_2O_3	36.36	6.43	6.47	5.06	7.01	5.78	7.23	5.56	6.24	5.17	6.11	3.90
Fe O	19.47	21.66	18.57	19.29	17.67	18.48	19.23	19.23	19.20	21.61	16.91	16.60
MnO	0.25	0.12	0.21	0.18	0.18	0.19	0.29	0.25	0.21	0.45	0.14	0.52
MgO	9.73	8.04	8.58	9.89	7.81	9.36	7.13	9.01	8.69	6.32	12.90	10.90
CaO	1.42	2.03	2.23	1.52	2.77	2.00	1.52	1.77	1.91	1.40	0.14	0.22
Na_2O	1.53	1.09	1.66	1.52	1.71	1.19	1.09	1.71	1.44	0.34	0.12	0.04
K_2O	7.30	6.22	7.38	7.60	7.08	6.94	7.20	6.60	7.04	6.34	7.81	9.10
Ti O_2	1.89	1.24	1.01	1.05	1.83	2.10	1.68	2.09	1.61	2.18	2.73	2.90
H_2O^-	0.15	0.20	0.30	0.21	0.16	0.46	0.35	0.26	0.26	0.32	- -	0.20
H_2O	2.52	2.59	2.91	2.42	2.42	2.95	3.11	3.30	2.83	3.10	2.50	3.10
Total		99.83	100	100	100	99.99	99.96	99.87	99.97	99.29	99.43	99.18

A. Biotite from Kadabora (Kabesh and Salem, 1981)

B- Biotite from Ras Barud, Eastern Desert, Egypt (Kabesh *et al.*, 1977)

C- Biotite from granodiorite from Sierra Nevade Batholith, California (Dodge *et al.* 1969).

Table 2
Structural Formulae of biotites

		1		2		3		4		5		6		7		8		average	
Si		5.52		5.63		5.56		5.57		5.53		5.56		5.55		5.63		5.57	
	Z		8		8		8		8		8		8		8		8		8.00
Al^{IV}		2.48		2.37		2.44		2.43		2.47		2.44		2.45		2.37		2.43	
Al^{IV}		0.16		0.33		0.35		0.33		0.33		0.43		0.35		0.28		0.32	
Fe^3		0.75		0.76		0.76		0.59		0.82		0.59		0.84		0.65		0.73	
Ti		0.22	6.02	0.07	6.08	0.12	5.66	0.60	6.34	0.21	5.49	0.21	5.94	0.20	5.59	0.24	5.81	0.38	6.00
Mg	Y	2.30		1.90		1.99		2.29		1.82		2.23		1.67		2.11		2.04	
Fe^2		2.55		3.00		2.42		2.48		2.29		2.45		2.49		2.50		2.50	
Mn		0.03		0.02		0.02		0.05		0.02		0.03		0.04		0.03		0.03	
Ca		0.24		0.34		0.37		0.25		0.46		0.36		0.25		0.29		0.32	
Na	X	0.46	2.16	0.33	1.92	0.05	1.90	0.46	2.21	0.52	2.39	0.34	2.10	0.27	1.95	0.51	2.11	0.22	1.95
K		1.46		1.25		1.48		1.50		1.41		1.40		1.43		1.31		1.41	
OH		2.72		2.72		3.04		3.06		3.06		2.22		3.42		2.94		2.86	
$Fe_t/(Fe_t+Mg)$		58.92		66.43		61.51		57.28		63.08		57.69		66.60		59.99		61.29	

STRUCTURAL FORMULAE OF BIOTITE

The structural formulae of the examined biotites are given in Table (2). The calculation is based on 24 (O, OH) to the general mica formulae X_2 Y_6 Z_8 O_{20} (OH, F, CI) and the results are listed in the same table.

Fig. (3) shows the ternary diagram Mg (Fe^3 + Ti/ + AI^{VI}) and Fe^2 (Foster, 1960). It is clear from the diagram that all the analysed biotites fall within the field Mg- iron rich varieties.

The value of the Y- group cations; Mg, (AI^{IV} + Fe^3 +Ti) and (Fe^2 + Mn) are plotted on Foster's diagram Fig. (4). It is evident from the figure that the analyzed samples of biotite fall within the fields granite and granodiorite.

Fig. (5) shows the relation between (Fe^2 / Mg) X 100 and AI^{IV} × 100 of the examined biotites. It is evident from the diagram that all the analyzed biotites fall in the field of the magmatic differentiation (Shibata *et al.*, 1966).

Fig. (6) shows that the division between phlogopite and biotite compositional field is arbitrarily chosen where Mg: Fe= 2:1 (Deer *et al.* 1966). The examined biotites are plotted on this figure which shows that all the analyzed samples fall within the biotite field.

TRACE ELEMENTS

Trace elements data of the analyzed biotites are listed in Table (3). Elemental ratios recalculated from the trace elements of the examined biotites are given in the same table.

It is clear from Table (3) that the elements; Sc, Zn, Cu, Cr, Nb, Co, Cu, Sc, Sr, Zr, Ni, Rb, Li, and Y are concentrated in the biotites of the examined area. It is believed that the trace elements: Sc, Zn, Cu, Co, Ni, Nb, Gr, V. and Ga substitute major elements in octahedral sites, although some Ga may substitute for Al in tetrahedral coordination. Li is strongly concentrated in biotites. Li and Sc follow Mg according to various authors (De Albuquerque, 1973). From the geochemical point of view barium and rubidium can be expected from their affinity to potassium to occur in high amount in the biotites.

Trace elements and elemental ratios are plotted on the following graphical representation:

The values of the function Fe_t / (Fe_t + Mg) (Table 3) are plotted against V. Co, Ni, Ca (Fig 7) and Cr. Ni,Co and Ga decrease with the increase of the value Fe_t / (Fe_t + Mg). Vanadium shows no definite trend.

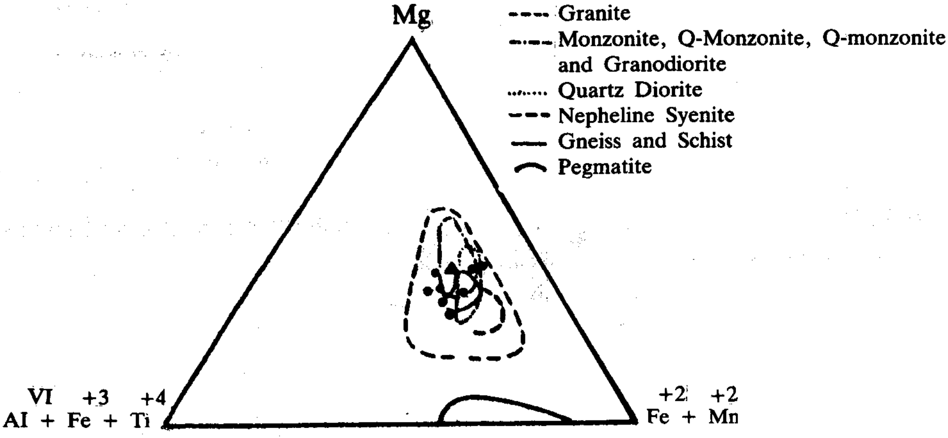

Fig. 4: Comparison of the composition of biotites in the granites of the studied masses with composition of biotites from igneous and metamorphic rocks.

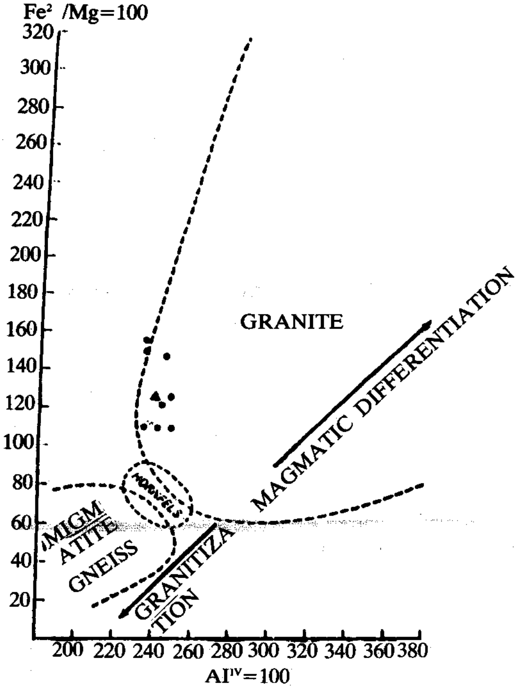

Fig. 5: The Fe^2 /Mg-Al$^{\text{IV}}$ relations in biotite formulas of granitic rocks of magmatic origin and metamorphic origin.

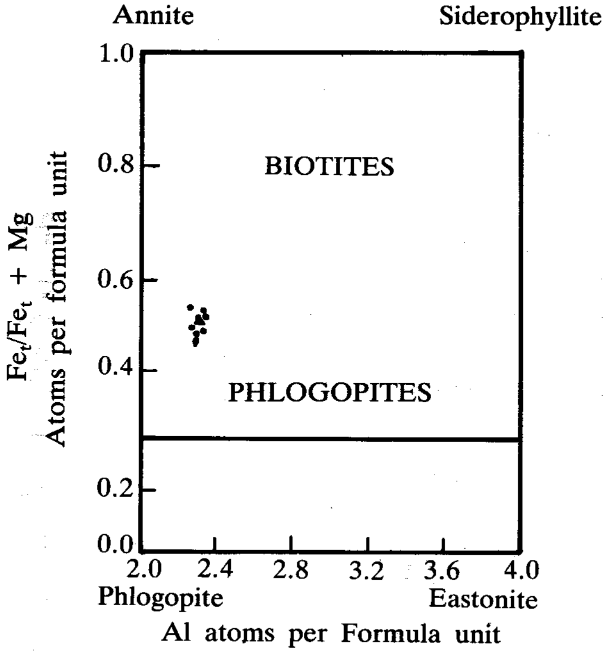

Fig. 6: Composition of biotite in terms of Fe_t/ Fe_t=Mg and AI, The division between phlogopite and biotite compositional fields is arbitrarily chosen where Mg: Fe = 2: 1 (Deer *et al,* 1966)

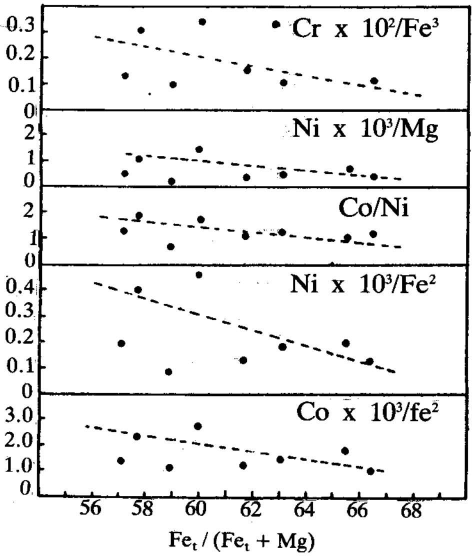

Fig. 7: Variation diagram of the trace elements of the biotites

Table 3

Minor elements in biotites from granitoid rocks of El Imra with some other localities for comparison

	1	2	3	4	5	6	7	8	A	B	C
Ga	20	27	31	19	33	133	29	121	95	90	44
V	211	253	227	220	333	103	212	109	90	100	180
Cr	44	53	72	47	55	127	60	133	130	80	10
Nb	27	33	37	44	28	19	30	17	- -	- -	20
Co	18	17	18	22	19	33	27	40	60	40	34
Cu	11	8	13	7	6	30	8	28	☆	25	50
Zn	0.2	0.3	0.2	0.2	0.5	1.5	0.5	1.5	☆	☆	--
Sc	7	5.5	3.5	5.5	4.5	33	4.5	4.1	☆	☆	44
Sr	3	7	5	7	8	17	4	22	6	6	20
Ba	2440	2360	2010	2518	2500	1122	2019	1215	450	340	☆
Zr	62	57	70	50	73	40	60	33	☆	57	60
Ni	13	22	19	30	25	62	30	72	95	25	10
Rb	930	1003	988	818	1111	630	1117	701	240	☆	☆
Li	150	165	140	111	159	277	172	301	310	☆	☆
Y	2	3	2	3	2	7	2	8	☆	☆	☆

☆ not detected

A. Biotite from Kadabora (Kabash and Salem, 1981)

B. Biotite from Ras Barud, Eastern Desert, Egypt (Kabesh *et al.*, 1977)

C. Biotite from granodiorite from Sierra Nevade Batholith, California (Dodge *et al.* 1969)

The values of Fe_t / (Fe_t + Mg) are also plotted versus some elemental ratios Fig. (8). It is clear from the figure that $Ni \times 10^3 / Fe^2$, $Ni \times 10^3 / Mg$, Co/Ni, $Crx10^2 / Fe^3$ and $V \times 10^2/Fe^3$ decrease with the increase of the value of the function $Fe_t/(Fe_t+Mg)$.

It is clear that the behaviour of the trace elements of the investigated biotites agrees fairly well with the expected behaviour of trace elements of biotites from the granitic rocks, North Portugal (De Albuquerque, 1973).

Fig. (7) shows the relation between Rb% against the value of K/Rb of biotite according to Stavrov (1971). It is observed from the figure that all the biotites fall in the field of magmatic differentiation.

Table 4

Elemental ratios of the examined of biotites

	1	2	3	4	5	6	7	8
Cox10^3/Fe^2	0.12	0.10	0.12	0.14	0.14	0.23	0.18	0.27
Nix10^3/Fe^2	0.09	0.13	0.13	0.20	0.18	0.43	0.20	0.47
Nix10^3/Mg	0.22	0.46	0.31	0.51	0.53	1.10	0.70	1.39
Crx10^2/Fe	0.10	0.12	0.16	0.13	0.11	0.31	0.34	0.34
Vx10^2/Fe	0.47	0.56	0.50	0.62	0.68	0.25	0.42	0.28
K/Rb%	51.5	65.2	62.0	77.0	53.0	91.4	53.5	68.2
Ni/Co	0.72	1.24	1.01	1.36	1.32	1.88	1.11	1.75

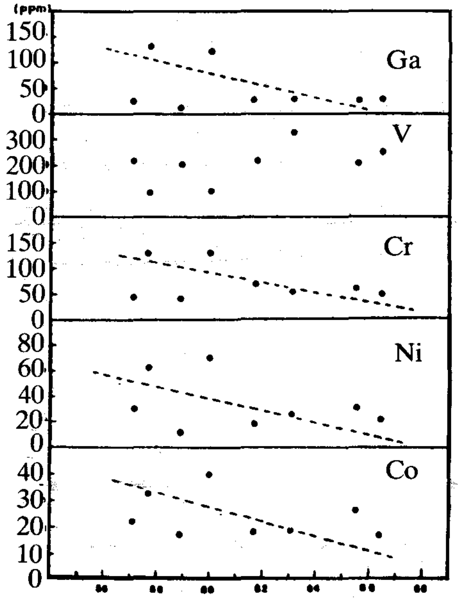

Fig. 8: Variation diagram of some trace elements ratios.

CONCLUSIONS

Biotites from the granitic rocks of El-Imra mass have been investigated by geochemical methods. The behaviour of both major and trace elements are discussed according to several variation diagrams, in which the values of the function $Fe_t/(Fe_t + Mg)$ increases with the decrease of the values of the elements; Co, Ni, Cr, & Ga as well as with elemental ratios.

It is concluded that the biotites of El-Imra confirm the magmatic origin of the host granitic rocks.

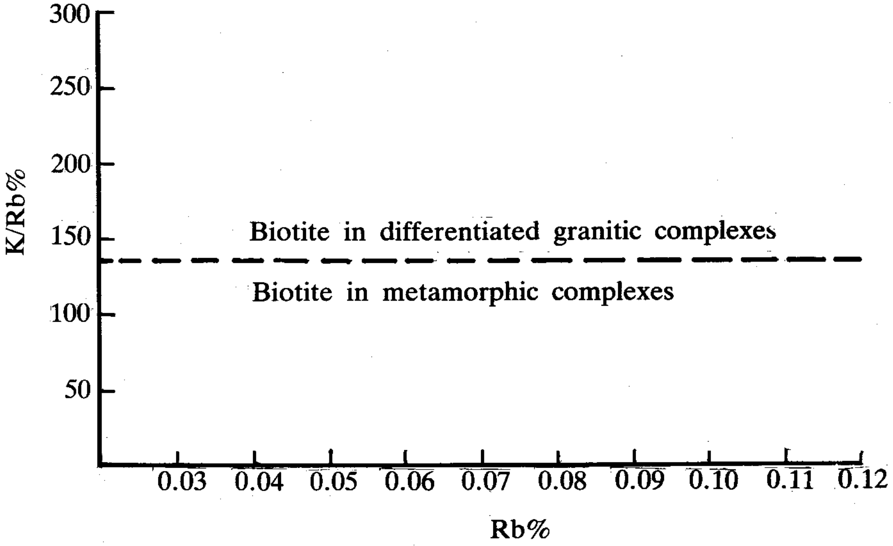

Fig. 9: Plot of K/Rb against Rb% for the investigated biotites (after Stavrov, 1971).

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جيوكيميائية البيوتيت ومدلولها كمؤشِّر لأصل الصخور الجرانيتية بمنطقــــة العِمـــرة

الصحـــراء الشرقيـــة ـ مصـــر

عبد الكريم احمد ســالم و محمد احمد حسن هيكل

محمـــود لطفي كابش و محمـــود احمد ســالم

يتضمن البحث دراسة جيوكيميائية لعدد ٨ (ثمانية) عينات من معدن البيوتيت تم فصلها من صخور منطقة جبل العِمرة الجرانيتية ـ الصحراء الشرقية ـ مصر .

تم مناقشة توزيع سلوك العناصر الأساسية والشحيحة باستخدام عديد من المتغيرات البيانية المختلفة . كما أن الدراسات الكيميائية والجيوكيميائية لعينات البيوتيت تعطي معلومات كثيرة عن السلوك الكيميائي للعناصر في البيوتيت ـ ويتميز هذا المعدن بأنه من النوع الغني بالحديد والمغنيسيوم .

ويتضح من ذلك أن الصخور الجرانيتية الحاوية لمعدن البيوتيت بكتلة العِمرة ذات أصل صهيري .