Acta Mineralogica-Petrographica, Szeged, XXXIV, 71—78, 1993

PETROGRAPHY, GEOCHEMISTRY AND K-AR DATING OF SOME METAGABBROS FROM THE CENTRAL EASTERN DESERT OF EGYPT

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ABSTRACT

Radiometric ages of some metagabbros using amphiboles were determined with the conventional K-Ar method. The ages of pargasitic hornblende from the Meatiq metagabbro gave 599±32 Ma, 544±21 Ma and 539±21 Ma. The latter two ages reflect some K incorporation after crystallization. The age of 599±32 is the time of total resetting and metamorphism of this rock. This age is slightly below the age of the Abu Ziran Orogeny (613±2 Ma) which cause the obduction of ophiolitic mélange onto the infracrustal basement (HABIB *et al.* 1985); culmination of metamorphism and deformation (STRUCHIO *et al.* 1982) or emplacement of Abu Ziran pluton and timing of major crustal movement (STERN and HEDGE 1985).

The age of tremolitic hornblende from El-Sid pluton gave 421±76 Ma, 440±18 Ma and 543±75 Ma. These ages are too young and their scatter is great due to the very low K content. Moreover, the tremolitic hornblende is strongly strained and sometimes occurred as aggregates of fibrous crystals, raising the possibility of continuous Ar loss. So, the given ages suggest either the termination of Ar diffusion at that time or partial loss during later events subsequent to the pluton's emplacement. A relationship to local tectonic movement might be suggested but is not well documented.

INTRODUCTION

The gabbroic rocks were collectively regarded as one group in the old classifications of the Egyptian Shield. SCHURMANN (1953) differentiated two types of gabbros; older metamorphosed and younger fresh gabbros. The former type was named "epidiorite" (AMIN *et al.* 1953), "epidiorite-diorite association" (EL-RAMLY and AKAAD 1960), "metagabbro-diorite complex" (AKAAD and ES-SAWY 1964, EL-RAMLY 1972). A discrimination scheme for the distinction between the metagabbros and fresh gabbros was proposed by TAKLA *et al.* (1981).

The metagabbros are considered as having been intruded during the climax of the orogenic folding and regional metamorphism after the emplacement of the ultramafic rocks (AKAAD and NOWEIR 1980) and have been closely followed by the intrusion of "grey granites" (AKAAD and EL-RAMLY 1960). They have been considered to originate from gabbroic magma by deuteric uralitization (EL-RAMLY

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and AKAAD 1960) or by autometamorphism (SABET 1972). NOWEIR and TAKLA (1974) concluded that the metagabbros have suffered medium grade regional metamorphism. Recently, ABU EL-ELA (1985) and ASHMAWY (1987) recognized ophiolitic gabbros and calc-alkaline gabbros related to island arc environment.

K-Ar age dating of metagabbros from Umm Rus area was given by KAMEL *et al.* (1983) which fall within the range 580—606 Ma. This relatively younger age was considered to be related to some thermal effect in the history of the gabbroic mass. COLEMAN *et al.* (1972) reported K-Ar ages for some layered gabbros in the Arabian Shield ranging from 415 to 702 Ma. Most of these ages were obtained on a wholerock and can not be evaluated. FLECK *et al.* (1976) introduced ages of unmetamorphosed gabbros which cluster about 625 Ma.

EXPERIMENTAL METHODS

Radiometric dating was carried out in the Institute of Nuclear Research of the Hungarian Academy of Science (ATOMKI), Debrecen. Flame photometry has been used for potassium determination. Pulverized minerals were digested in HF and $HClO_4$ acids and dissolved in 0.25 N LiCl has been added as internal standard and the solutions were buffered with sodium.

Samples were degassed by high frequency induction heating, the liberated argon has been spiked with ^{38}Ar. A 90° deflection magmatic mass spectrometer of 150 mm radius has been used in static regime for the argon determination. The argon extraction line and the mass spectrometer were developed in the ATOMKI, details of instruments and applied methods have been described elsewhere (BALOGH 1985).

Potassium and argon determinations have been controlled regularly using the Asia 1/65 (Soviet) and GL-O (French) interlaboratory standards.

Four samples of the dated amphiboles were also identified using X-ray diffraction analysis in the Minerology Department, Eötvös Loránd University (ELTE), Budapest.

GEOLOGIC SETTING

El-Sid metagabbro forms and elongated oval massif laying along the Qift-Quseir road. Its larger axis is about 7.2 km and trends N—S in parrallelism with the regional trend of the country rock. A brief field description of the massif have been given by NOWEIR (1986), NOWEIR and TAKLA (1974) and LEBDA (1988). They showed that the metagabbro body is bounded from the east by metavolcanics and from the west by serpentinites. The rock was invaded by the Fawakhir granodiorite particularly at the south-western sector (*Fig. 1*). The pluton was considered as part of ophiolite sequence by RIES *et al.* (1983).

The Meating metagabbro is named by the present authors after the Meating Dome which directly bounded the studied massif from the east. This dome is consisted of a core of granite-gneiss (Umm Baanib pluton) with a mylonitic carapace. The mylonite graded upward into nonmylonitic cover of low-grade ophiolitic rocks comprising the metagabbro which forms scattered elongated bodies of oval shape trending nearly NW—SE (*Fig. 1*). The field study proved that the metagabbro intruded subsequently to the serpentinites, immediately prior to the syntectonic tonalite and granodiorite. The contact between the rock and country is sharp and irregular and abundant isolated apophyses around the main mass are

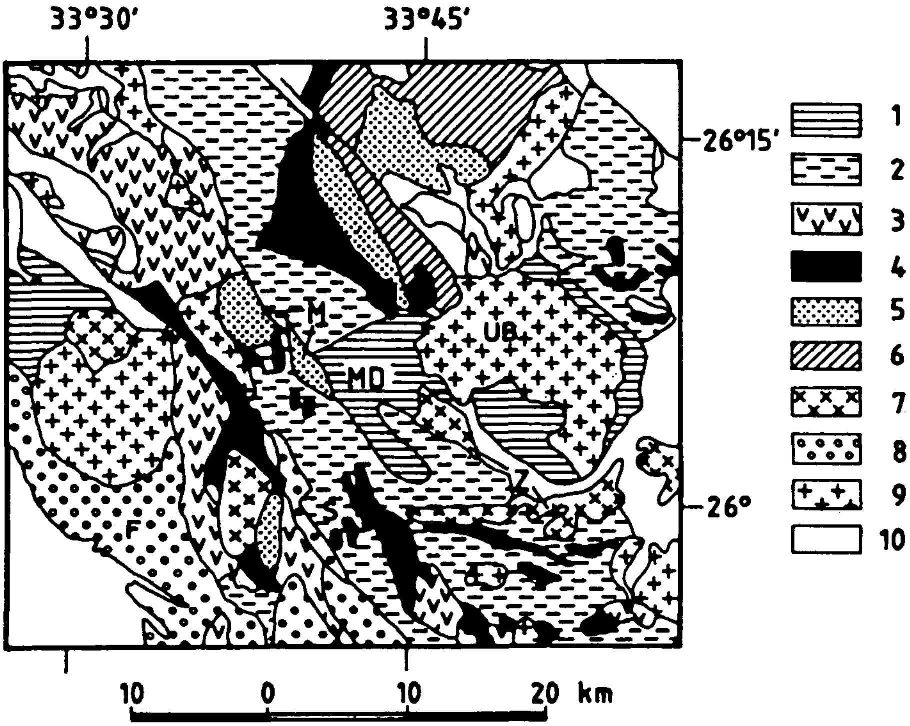

Fig. 1. Geological map of the basement complex of part from the Central Eastern Desert of Egypt (after EL-RAMLY 1972). M=Meatiq metagabbro; S=El-Sid metagabbro; MD=Meatiq Dome; Z=Abu Ziran Pluton; UM=Umm Baanib Pluton; F=Fawakhir Pluton. 1.) Gneiss Group. 2.) Metasediments. 3.) Metavolcanics. 4.) Serpentinite. 5.) Metagabbros. 6.) Diorites. 7.) Older granitoids. 8.) Unmetamorphosed sediments. 9.) Younger granitoids. 10.) Undifferentiated.

common. More details about the geology of this area were given by STRUCHIO *et al.* (1983), RIES *et al.* (1988), EL-GABY *et al.* (1984) and HABIB *et al.* (1985).

PETROGRAPHY

El-Sid metagabbros are of highly heterogeneous nature and vary from amphibolite to metagabbro in composition. They are composed of variable ratios of highly altered andesine and tremolitic hornblende with subordinate amounts of chlorite and epidote. The tremolitic hornblende is commonly found as crystal aggregates which pseudomorph after pyroxene and occasionally are highly deformed. Andesine is usually highly turbid by kaolinite and replaced by sericite and epidote. Few crystals of orthopyroxene (enstatite) and less commonly augite are still preserved.

El-Meatiq metagabbro is dark green massive foliated rock. It is composed essentially of dark-green hornblende and highly altered andesine with subordinate amounts of chlorite, titanomagnetite and apatite. Hornblende pseudomorphs after orthopyroxene with the preservation of the schiller structure. The mineral usually grades to the bluish green pargasite which forms reaction rims surrounding the peripheries of the hornblende crystals. Andesine is partially or completely altered to sericite, epidote and kaolinite; and corroded and replaced by chlorite and hornblende.

GEOCHEMICAL CHARACTERISTICS

Six samples of the studied metagabbros were analysed for major elements in the Department of Petrology and Geochemistry, ELTE, Budapest. Table 1 shows the chemical composition and the calculated CIPW norm.

TABLE 1

K-Ar ages of the dated amphiboles.

No.	Sample		Mineral	K %	$^{40}Ar_{rad}$ cc STP / Gg	$^{40}Ar_{rad}$ %	K/Ar Age Ma
1807.	El-Sid;	S-50	Tremolitic hornblende	0.229	$3.9794 \cdot 10^{-6}$	40.0	440±18
1808.		S-60	"	0.074	$1.8201 \cdot 10^{-6}$	14.0	543±75
1809.		S-70	"	0.060	$1.1038 \cdot 10^{-6}$	9.0	421±76
1810.	El-Meatiq;	M-20	Pargasitic hornblende	0.889	$2.1922 \cdot 10^{-5}$	77.4	544±21
1811.		M-30	"	0.859	$2.0969 \cdot 10^{-5}$	70.6	539±21
1812.		M-40	"	0.530	$1.4637 \cdot 10^{-5}$	77.2	599±32

The AFM diagram (*Fig.* 2) confirms the distinction of the studied rocks into different types. The Meatiq metagabbro shows a pronounced tendency towards the enrichment of total iron with similar behaviour of the ferrogabbros (MONVISO 1979). On the other hand, El-Sid metagabbro displays slight tendency towards the M end which indicates that its parent melt was relatively magnesium rich. Generally, the studied metagabbros show diversity in magma type range from CA to TH series.

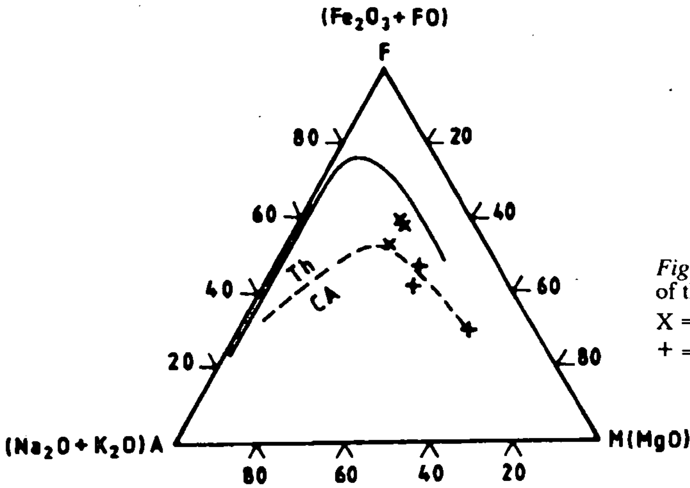

Fig. 2. AFM triangular diagram of the studied metagabbro.
X = Meatiq metagabbro;
+ = El-Sid metagabbro.

The variation diagram (*Fig. 3*) of total alkali versus SiO_2 (MACDONALD and KATSURA 1964) shows that there are pronounced alkali additions during alteration and metamorphism of the studied rocks especially the Meatiq metagabbros. An erratic variation of total alkali with SiO_2 can be recognized within El-Sid pluton.

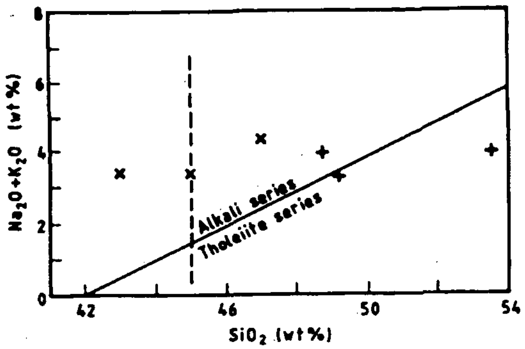

Fig. 3. Variation diagram of total alkalies versus SiO_2 of the studied metagabbros. Symbols as in *Fig. 2.*

GEOCHRONOLOGY

Gechronologic investigations of the Egyptian shield have progressed to the point where some generalization and interpretation of igneous and metamorphic history can be made (e.g. HASHAD 1980; GILLESPIE and DIXON 1983; STERN and HEDGE 1985 and others). Some ages for rocks from the Meatiq dome and the surrounded area were given by STRUCHIO *et al.* (1982) and STERN and HEDGE (op. cit.). The former authors demonstrated concordant Rb–Sr (wholerock and feldspar) and U–Pb (Zircon) isotopic ages. They concluded that the culmination of metamorphism, deformation, and tonalite intrusion occurred at 613±2 Ma. The quartz-monzonite (Umm Baanib pluton) intruded the dome at 579±5 Ma, synchronous with the regional Pan-African plutonism. A Rb- Sr whole-rock of granitic gneiss and mylonitic rocks indicated that the protolith of these rocks had an age of 626±2 Ma. STERN and HEDGE (1985) demonstrated similar age of the emplacement of the tonalite and granodiorite of Abu-Ziran pluton (614±8 Ma, combined Rb- Sr and U-Pb Zircon techniques). They consider it to represent the timing of major crustal movement in this part of the Eastern Desert. These ages were later discussed by EL-GABY *et al.* (1984) and HABIB *et al.* (1985). The older age of 626±2 Ma was referred to the Meatiqian orogeny where granite - gneiss, migmatitic- gneiss and migmatized amphibolite were formed. The next age denotes the Abu-Ziran orogeny which culminated at 613±2 Ma, where the supracrustal cover represents a part of an extensive ophiolitic mélange obducted into the infracrustal basement. Later, both the infracrustal basement and the overlying supracrustal cover were isostatically uplifted, subjected to complex shallow folding giving rise to the major Meatiq domal structure, and were intruded by postkinematic adamellite (Umm Baanib pluton) at 579±6 Ma.

The measured K–Ar ages of the pargasitic hornblende separated from the Meatiq metagabbros gave 599±32 Ma, 544±21 Ma and 539±21 Ma (Table 2). The latter two ages must be excluded as they show greater K content which reflect some K incorporation after the crystallization of hornblende. This phenomenon was also reflected on the total alkalies vs. SiO_2 variation diagram and from the petrographic investigation. The age of 599±32 Ma is either the true time of formation of the Meatiq metagabbro or the time of total resetting and metamorphism of the age of this rock. The pronounced recrystallization and obliteration of its igneous texture support the latter interpretation. This age is in accordance with the age of Abu Ziran orogeny (613±2 Ma) which causes the obduction of ophiolitic mélange into the infracrustal basement (HABIB *et al.* 1985), culmination of metamorphism and deformation (STRUCHIO *et al.* 1982) or emplacement of Abu- Ziran pluton and timing of major crustal movement (STERN and HEDGE 1985).

TABLE 2

Chemical analyses and CIPW Norm for El-Sid and El-Meatiq metagabbros.

Locality	El-Sid Metagabbro			El-Meatiq Metagabbro		
Samp. No.	S-50	S-60	S-70	M-20	M-30	M-40
SiO_2	53.55	49.22	48.75	45.02	47.04	43.02
TiO_2	1.35	0.15	1.08	2.95	2.65	2.61
Al_2O_3	15.52	15.66	16.82	20.39	15.93	19.60
Fe_2O_3	2.18	0.92	1.58	2.48	1.33	1.98
FeO	5.50	5.42	8.73	9.93	10.26	10.55
MnO	0.13	0.12	0.16	0.13	0.13	0.12
MgO	6.40	11.38	7.82	5.65	5.75	5.00
CaO	8.93	11.23	9.95	8.34	9.25	10.16
Na_2O	3.25	3.12	3.39	1.92	2.86	1.97
K_2O	0.83	0.28	0.60	1.47	1.61	1.48
P_2O_5	0.28	0.25	0.16	0.38	0.32	1.96
Ig. Los.	1.68	2.27	1.82	2.26	2.88	1.90
Total	99.60	100.02	100.86	100.92	100.01	100.35
			CIPW NORM			
qz	4.23	—	—	—	—	—
Or	5.00	1.65	3.55	8.95	9.90	9.05
ab	29.75	27.80	30.45	17.75	26.70	18.30
an	25.80	27.70	28.98	40.00	26.90	38.95
c	—	—	—	1.59	—	1.12
Wo	7.00	10.40	7.74	—	7.46	—
Fs	5.40	2.90	4.02	6.79	2.95	5.01
en	17.98	11.74	7.76	16.85	4.07	6.01
fo	—	3.19	4.78	3.96	9.31	6.21
fa	—	12.93	9.22	2.48	6.74	5.19
mt	2.33	0.96	1.65	2.67	1.44	2.15
il	1.02	0.20	1.50	4.20	3.38	3.76
ap	0.59	0.53	0.35	0.83	0.69	4.25

Radiometric ages of El-Sid metagabbros (Table 2) gave 421±76 Ma, 440 Ma, 440±18 Ma and 543±75 Ma. These ages appear to be too young and the scatter of them is great. Samples S-60 and S-70 could be dated only with great error due to the very low potassium content. Elf-Sid pluton is intruded by the Fawakhir granodiorite of 574±9 Ma (FULLAGER and GREENBERG 1978). The age of this metagabbro must be older. El-Sid metagabbros has a tremolitic hornblende which is strongly strained and sometimes occurred as aggregates of fibrous crystals, raising the possibility of continuous argon loss. So, the given ages suggest either the termination of Ar diffusion at that times or partial argon loss during later events. This provided evidence of some thermal and/or tectonic activity subsequent to the emplacement. Moreover, these ages are younger than the Pan-African - age and suggest that deformation may have controlled argon loss because regional cooling could not produce an apparent age pattern as complex as observed (FLECK 1976). A relationship to local tectonic movement might be suggested but is not well documented.

Similar young ages were also recorded from the Arabian Shield. FLECK *et al.* (1976) demonstrated K-Ar measurements and concluded that the Shield was affected by two major thermal events between 610—560 Ma and 540—510 Ma. These events rejuvenated the apparent ages of most older rocks, frequently by 15—45 Ma (FLECK *et al.* 1979). The amount of rejuvenation is, however, so irregular in detail that K-Ar ages can at best be interpreted as minimum ages. BENTOR (1985) also concluded that the term Pan-African introduced by KENNEDY (1964) must be considered as a thermotectonic episode which caused widespread resetting of K-Ar ages in Africa to ~ 500 Ma.

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Manuscript received, 27 March, 1993