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PAN AFRICAN BASEMENT OF BIR SAFSAF AREA EAST SAHARA AFRICAN CRATON

By

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صخور أساس البان - أفريقي بمنطقة شرق صحارى الدرع الافريقي

سيد أبو ضيف عزاز و مصطفى محمود سليمان و عاطف حسن ثابت
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صخور أساس البان - أفريقي بمنطقة شرق صحارى الدرع الافريقي ممثلة بصخور منطقة بئر صفصف والتي تقع في أقصى الجزء الجنوبي من الصحراء الغربية المصرية وهي مغطاة بصخور النيس والميجماتيت القارية القديمة ذات التركيب الجرانيتي والجرانوديوريتي والتوناليتي وصخور الميتاجابرو الهورنبلندي مع بعض الميتاجابرو الحامل للكوارتز . وصخور الميتاجابرو هذه ذات أصل ثيوليتي تكونت في بيئة قارية عند الجزء الجانبي من اللوح القاري وصخور الجرانيت القديم ذو اللون الرمادي والممثل بالكوارتز ديوريت والتوناليت والجرانوديوريت ذات خصائص جير قلوية متوسطة الالومينا وربما تكونت في بيئة غوص وانزلاق فوق نطاق بينوف بانصهار مواد الستاره مع أو بدون إضافات من صخور القشرة الأرضية .

وصخور الجرانيت الحديث ذو اللون الوردي والأحمر والمتكون من السيانوجرانيت والمونزوجرانيت مع بعض الكوارتز مونزونيت والمونزوديوريت ذات الخصائص القلوية متوسطة إلى عالية الألومينا والتي تظهر معظم خصائص الجرانيت المنشق من أصل ناري والمتكون بالانصهار الجزئي لصخور القشرة الابتدائية السفلى والوشاح العلوي .

Key Words: Geology, Metagabbros, Older granites, Petrogenesis, Petrography, Younger granites.

ABSTRACT

Bir Safsaf area occurs at the extreme southern part of the Western Desert of Egypt. It is covered by the Pan African Basement represented by the old continental gneisses and migmatites comprising granitic, granodioritic and tonalitic varieties, hornblende metagabbros with quartz-bearing varieties of tholeiitic nature formed in a continental environment at plate margrin. Grey Older Granites include quartz diorite, Tonalite and granodiorite are metalumnious and subduction related. Pink-red Younger Granites have essentially syenogranite, and monzogranite with subordinate quartz monzonite and monzodiorite varieties are metaluminous to Peraluminous and crustal-related. The both Older and Younger Granites are characterized by the most features of I-type granites and are formed through partial melting of the lower crust or upper mantle.

INTRODUCTION

The present study is dealing with the geology petrography and geochemistry of the Pan African Basement rocks cropping out in Bir Safsaf area at the extreme southern part of the Western Desert of Egypt, (Fig. 1). The area has been considered by Schandelmeir *et al.* [1] as part of the east Sahara craton.

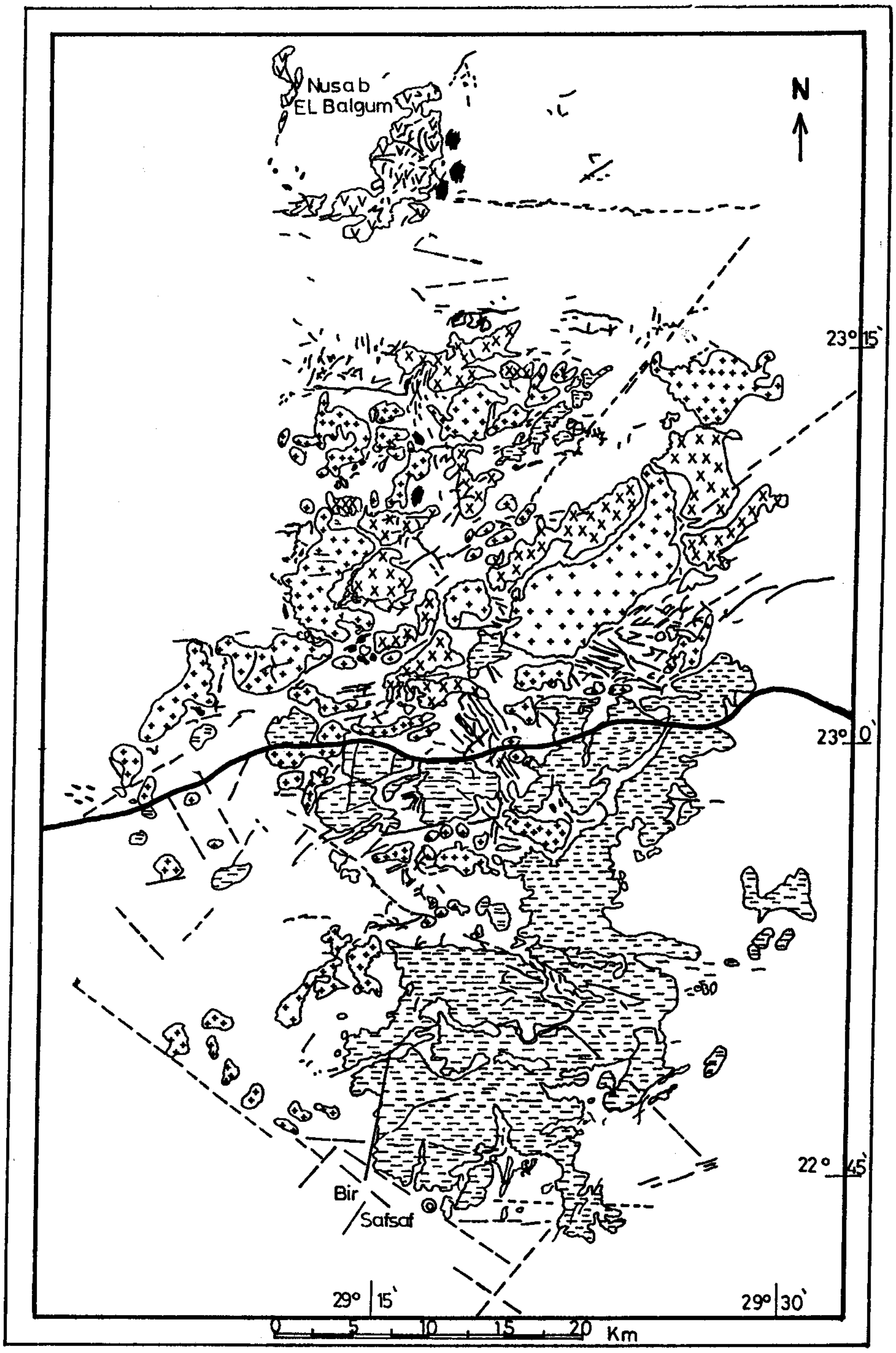

FIG. (1): PHOTOGEOLOGICAL MAP OF BIR SAFSAF AREA SOUTH-WESTERN DESERT, EGYPT.

LEGEND

- Recent alolian sand
- Mesozoic sandstone
- Volcanic & Pyroclastic
- Pink - red granites
- Grey granites
- Metagabbros
- Gneisses & migmatites
- Inferred] Faults
- Observed] Faults
- Dyke
- Asphaltic road
- Dry water well

The precambrian basement rocks west of the Nile in the southwestern Egypt, North Sudan, SE Libya, and NE Chad comprise high grade migmatitic gneisses, migmatites and some granulites with intercalated high grade supracrustal rocks like marbles, calc-silicates and amphibolites which are generally considered typical for cratonic areas [2]. The rock assemblages are significantly different in their lithology, structure, age and metamporphism than the volcaneo-sedimentary-ophiolitic sequences exposed east of the Nile in the late Proterozoic Arabo-Nubian Shiel [3]. Granites and some gneisses from the east Sahara craton yielded Rb/Sr whole rock ages ranging from 686 Ma to 665 [4]. The Nd model ages for these rocks ranges form 1400 Ma to 900 Ma and there is a close time-equivalence between these rock and a series of rocks from the Arabo-Nubian Shield [5]. Harries *et al.* [6] reported Nd model ages for these rocks between 1900 Ma to 1600 Ma.

The basement rocks of the southwestern Desert were first mentioned by Hume [7]. The basement exposures in the Bir Safsaf area are considered of Late pre-cambrain ag. Issay [8] reported that Bir Safsaf area is covered mainly by pink granite with rarely biotite hornblende gneisses. El-Baz *et al.* [9] and Dardir [10] described Bir Safsaf as granitic rocks. Bernau *et al.* [4] noticed that, the Bir Safsaf complex is characterized by a striking first order fracture system with a main trend of 80° (ENE-WSW). Bir Safsaf complex has been studied in detail using aerial photographs with field traversing to construct a geologic map of scale 1:50,000 and representative samples from the outcropping rock units were collected and subjected to petrographical and geochemical studies to elucidate the geochemical characters, petrogenesis and tectonic setting.

GENERAL GEOLOGY

The study area is covered by Precambrian rocks overlain in many parts by recent loose and a small outrops of Mesozonic Nubian Sandstone are recorded (Fig. 1). The Pan African basement rocks in the area include: (1) Othogneisses and migmatites, (2) Metagabbros, (3) grey Older Granites and (4) Pink-red Younger Granites.

Orthogneisses comprise granitic, granodioritic and tonalitic varieties, while the migmaties include granitic and trondhjemitic varieties. These migmatites are found inclose with gneisses in the southern and eastern parts of the mapped area (Fig. 1). Petrography and geochemistry of these gneisses and migmatites have been studied in detail by the present authors in Soliman *et al.* [11]. In some places the gnesisses and migmatites are clearly intruded by the older granites, indicating that, older age than the granites. The orthogneisses and migmatites of Bir Safsaf are (1900 Ma) are old continental rocks of magmatic origin and are not equivalent or correlated with gneisses of sedimentary origin (paragneisses). They can not also correlated with orthogneisses described from the Eastern Desert which were considered in the 1935's by Hume [7] and 1988's by El-Gaby *et al.* [12] to represent Fundamental gneisses of early precambrian age. Sabet [13] mentioned that the orthogneisses of the Eastern Desert are cataclastically deformed varieties of the very late Proterozoic Gatarian Pan-African Granites as they cut through the Proterozoic paragneisses and migmatites.

Metagabbros are of limited distribution in the study area (Fig. 1) occurring as irregular low lying scattered outcrops completely surrounded by recent aeolion sand. The rocks grade in composition from hornblende metagabbros to quartz bearing metagabbros with gradational contact, suggesting a passive emplacement. The contact of the metagabbros with the neighboring country rocks is not detected since it is covered by loose sand. The metagabbros are correlated with epidiorite-diorite association of Sabet [13].

Grey Older Granites are characterized by grayish to dark gray color, medium to coarse grained with hypidiomorphic and rarely porphyritic fabric and range in composition from quartz diorite through tonalite to granodiorite. They form low relief outcrops 2-5 m in height. In some parts, the quartz diorites grade into tonalite without obvious sharp contact, and there is no obvious direct contact between the tonalite and the granodiorites. The tonalities intrude the granitoid migmatites and are invaded by some dyke-like bodies of monzonite (Younger Granites). The tonalites and granodiorites carry many xenoliths of amphibolite and gneiss of variable sizes (from few cm to 1.93 m. accross). The studied Older Granites are correlated with tonalite-granodiorite-adamellite group of Sabe [13], the old granites of Akaad & Noweir [15]. The grey granites of El-Ramly [14] and the old grey granites of El-Gaby *et al.* [16].

The pink-red Younger Granites cover the major part of the study area (Fig. 1). They form isolated boulders of low elevation usually less than 10 m above ground level. They are represented mainly by the monzogranite and syenogranite varieties, associated with minor quartz syenite, quartz monzonite and quartz monzodiorte.

Monzogranites are leucocratic, medium to coarse grained rocks, dissected by thin aplite veins and some lamprophyre dykes and traversed by two sets of joints trending NW-SE, NE-SW or E-W. Syenogranites are associated with monzogranites. They are hard, massive, coarse-to medium grained rocks with pink color, and are invaded by aplite, quartz and pegmatite veins differing considerably in thickness and extension. Quartz syenite; quartz monzonite and quartz monzodiorite form scattered outcrops or dyke-like bodies intruded into the tonalite; xenoliths of gneisses are recorded in them. The studied Younger Granites are equivalent to the Younger Granite of El-Ramly [14] and Akaad & Noweir [15], pink granite and red biotie grantie of Sabet [13] and the calc-alkaline younger Granite of El-Gaby *et al.* [16].

PETROGRAPHY

The modal composition of 48 representative samples of metagebbros. Older Granites and Younger Granites are given in Table 1 and plotted in Fig. 2. This figure shows clearly that, the metagabbros comprise gabbro and quartz gabbro varieties; the Old Granites comprise quartz diorite, tonalite and granodiorite varieties, and the Younger Granites contain essentially syenogranites and monzogranites with subordinate quartz monzonite and monzodiorite varieties.

Table 1
Modal composition of the studied metagabbros and granitoids of Bir Safsaf area.

Rock name	K.feld.	Plag.	Quartz	Biotite	Hornd	Accessories Opaques	Accessories Other	Secondary minerals	Color Index
Hb-metagabbro	--	47.03	4.21	---	45.15	0.20	0.70	1.10	48.76
" "	--	53.10	3.95	--	38.31	0.30	0.25	3.19	43.05
" "	--	60.97	2.75	--	32.11	0.50	0.13	3.54	36.28
Qz-metagabbro	--	44.10	8.15	7.61	34.19	1.60	2.05	2.30	47.75
" "	--	42.50	15.31	21.11	18.15	0.80	0.73	1.10	42.19
Quartz diorite	4.35	51.08	13.71	10.30	16.41	1.80	0.75	1.60	30.86
" "	2.51	41.03	14.23	16.33	18.91	0.75	1.83	3.41	42.23
" "	4.71	40.13	17.50	15.01	19.83	1.10	1.01	0.71	37.66
Tonalite	5.21	46.81	21.03	13.20	7.95	0.30	1.20	4.30	26.95
" "	2.15	40.10	20.12	19.30	15.10	0.40	1.55	1.33	37.63
" "	9.11	50.43	15.63	12.93	8.19	0.91	1.90	0.90	24.83
" "	8.19	35.36	23.01	12.63	17.63	1.50	2.79	0.22	34.27
Granodiorite	17.16	41.65	20.21	12.11	7.85	7.30	0.69	--	20.98
" "	13.12	40.40	19.17	18.01	10.12	2.10	4.20	0.90	27.31
" "	18.13	40.10	21.01	11.19	7.76	0.81	0.76	0.24	20.76
Monzogranite	30.75	32.24	25.05	6.85	3.74	0.90	0.10	0.36	11.96
" "	32.09	26.33	28.10	10.21	--	0.61	1.95	0.70	13.48
" "	36.90	27.95	32.29	0.89	--	0.71	1.10	0.15	2.86
Blotite Syenogranite	36.60	25.03	31.62	5.65	--	1.03	0.70	0.10	6.75
" "	34.39	24.17	28.15	9.08	--	1.70	1.50	0.90	13.29
" "	35.91	19.80	34.23	6.71	0.70	0.90	1.10	0.68	10.06
Bi-Hb. Syenogranite	35.87	18.95	31.12	8.15	3.34	1.30	1.70	0.17	14.06
" "	30.10	27.20	32.50	7.32	0.16	0.81	1.01	0.08	9.38
" "	37.20	21.89	30.72	8.10	1.07	1.04	0.60	0.20	10.19
Hb-Bi, Syenogranite	49.30	11.52	25.42	3.31	8.35	0.80	1.20	0.10	13.76
" "	40.11	20.42	26.88	4.61	6.23	0.50	1.10	0.15	12.59
" "	40.01	18.33	29.91	2.95	7.10	0.62	0.80	0.20	11.75
Syenogranite	43.97	34.55	13.09	4.70	--	1.10	2.10	0.46	8.39
" "	44.12	32.15	13.89	5.20	--	0.98	2.09	0.59	8.80
Quartz-monzonite	44.48	42.76	5.08	7.70	0.90	1.00	0.46	0.80	7.68
" "	33.03	45.51	8.21	6.33	4.10	0.91	1.10	0.81	13.25
Quartz Syenite	59.21	13.28	6.29	1.03	2.89	4.96	1.31	1.03	11.22
Qz-Monzodiorote	10.13	43.68	9.33	8.13	22.65	1.22	1.31	3.55	36.85
" "	25.95	55.63	1.36	3.10	--	1.15	3.50	9.31	17.06
" "	25.19	47.85	1.62	7.11	--	3.09	3.41	10.11	25.34

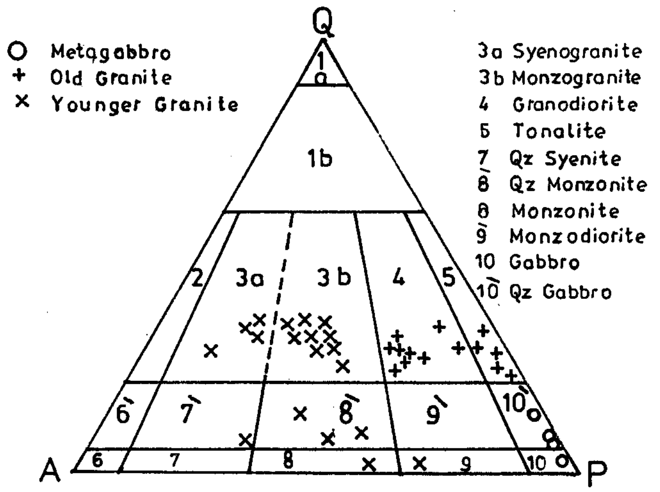

Fig. 2: Modal composition of the studied rocks of Bir Safsaf area (after Streckeisen, [17]).

Metagabbros

The metagabbro varieties show cataclastic texture and recrystallization of fine-grained hornblende and plagioclase. They are made of plagioclase, hornblende, actionlite and minor relices of pyroxene. Apatite, sphene and iron oxide are common accessories, whereas, quartz, chlorite and epidote are subordinate constituents. Amphibole is formed at the expense of pyroxene. Quartz metagabbro variety has more biotite and quartz with some arfvedsonite. Plagioclase (An 25-27) occurs in three generations. Recrystallized xenomorphic plagioclase crystals are typically associated with uralite and quartz. Hornblende is the dominate ferromagnesian mineral occurring in two phases corroding each other. They form megacrysts and aggregates up to 6.1 x 3.9 mm occasionally associated with few arfvedsonite crystals 0.12 x 0.37 mm of bluish green color. Actinolite occurs as fine to medium fibrous, needle shaped, green crystals, replacing hornblende along peripheries. Relics of augite and diopside are rarely encountered in the cores of hornblende crystals.

Grey Older Granites

They comprise quartz-diorite, tonalite, and granodiorite with some monzogranite. These rocks acquire hypidiomorphic, equigranular and porphyritic textures. They are made up mainly of plagioclase and quartz with variable proportions of potash feldspars, biotite and hornblende. The accessory minerals are sphene, zircon allanite, apatite and opaques, whereas chlorite, epidote (pistachite), sericite, calcite, Kaolinite, muscovite are secondary components.

Plagioelase (An 19-36) is fresh and twinned and shows normal and oscillatory zoning. Occasionally it is kaolinized, sericitized and saussuritized and are perforated by fine secondary quartz. Quartz occurs as anhedral grains. Myrmekitic quartz bodies occur within the potash feldspar, suggesting exsolution origin. Potash feldspars are microcline, microcline-perthite, orthoclase, orthoclase-microperthite. They are rarely encountered in quartz-diorite and occur in subordinate amounts in the tonalite as subhedral and anhedral interstitial crystals up to 3.4 x 2.1 mm., Large patches of orthoclase, and microcline-perthite with a few nonperthitic crystals occur in the granodiorite. Stringlets, string and flame perthites are commonly of even distribution, through the K-feldspar host, suggesting intergrowth origin. Biotite is common and partly to completely altered to chlorite. Hornblende is the dominant ferromagnesian minerals in the quartz diorite and tonalite and occasionally in the granodiorite. In tonalite non-cleaved hornblende sometimes associated with fine actinolite and in parts arfvedsonite is also observed.

Pink-red Younger Granites

They include mainly monzogranite and syenogranite associated with rare quartz-syenite, quartz - monzonite and quartz monzodiorite, varieties. They sometimes show cataclastic deformation; and gneissose texture. Saccaroidal granular texture characterizes the leucosyenogrnites. They are composed mainly of potash feldspar, quartz and plagioclase with variable amounts of biotite and hornblende. Apatite, sphene and opaques are the main accessories. The mineral proportion in the rock varieties are shown in Table 1.

K-feldspar is represented by microcline-, orthoclase-perthites and nonperthitic microcline. Perthites comprise evenly distributed Stringlets, strings, beads and flame types indicating intergrowth from homogenous liquid. Sometimes, K-feldspar is mantled by albitegiving rise to vinorgite-rapakive texture. Antiperthite texture is observed. Quartz is predominant and occurs in more than one generation. The graphic quartz is restricted to K-feldspar and is not detected at its contact with the plagioclase crystals, suggesting an intergrowth origin more than replacement origin. Plagioclase (An 6-28) occurs in more than one generation of subhedral zoned crystals up to 5.05 x 2.4 mm. In some cases K-feldspar contains myrmekitized plagioclase relics with the same orientation of the myrmekite rim, suggesting that, the myrmekite in this case is developed by reactions associated with the replacement of plagioclase with K-feldspar. The highly myrmekitized plagioclase inclusions are more classic, than the less myrmekitized plagioclase. Biotite crystals are medium to fine tabular plates measuring up to 1.9 x 1.5 mm. Occasionally, they are altered to chlorite. Hornblende occurs as subhedral prismatic crystals up to 1.25 x 0.60 mm. Few arfvedsonite crystals are recorded associated with the hornblende, especially in the quartz syenite and the quartz monzonite.

GEOCHEMISTRY

Seventeen representative rock samples from the metagabbros, grey Older Granites, pink-red Younger Granites and dykes of -Bir Safsaf area were chemically analyzed for major and selected 12 trace elements by means of X-ray flurensence techniques (Philips PW-1400). The analyses were carried out in the laboratories of the institute of Mineralogy, Karlsruhe University, Germany. The results are given in Table 2 and 3.

Metagabbros

The metagabbros are rare in the district and represented by the hornblende metagabbro and quartz metagabbro varieties. Chemical compositions show significant variations from hornblende metagabbro to quartz metagabbro. Comparing the chemical composition of Bir Safsaf hornblende metagabbros with those of the Ras Benas hornblende metagabbros of the Eastern Desert of Egypt reported by Takla *et al.* [18] Table 2. It is clear that both groups have nearly similar values of most major elements. However the Bir Safsaf rocks have higher values Y, Cr, Zr, Ni, Nb. and lower values of Ba, Sr and Cu relative to those of Ras Benas rocks.

Plotes of the studied metagabbros on Y/Nb - TiO_2 binary diagram of Pearce and Gale [20], (Figs 2 and 3) indicate that the studied metagabbros are tholeiitic in character, formed in a continental environment from a basic magma at plate margin.

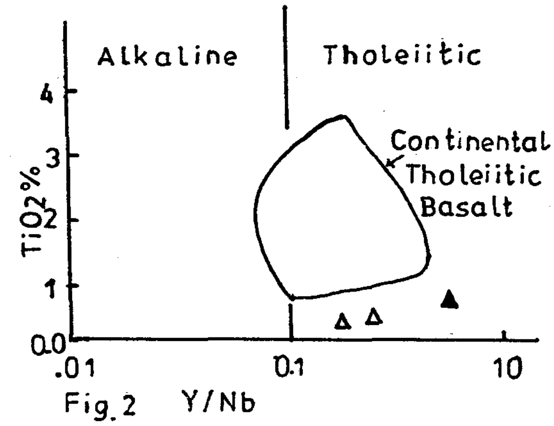

Fig. 3: TiO_2 (wt. %) against Y/Nb ratio on semilog plot after Winchester and Floyed, [19] of the studied metagabbros.

Granitic rocks

The chemical composition of 14 samples representing the examined grey Older Granites and pink-red Younger Granites along with the average chemical composition of syntectonic and lat-tectonic granites from the Eastern Desert of Egypt as given by El-Gaby [21] are given in Table 3; with the CIPW norm.

Element Distribution

Both older and younger granites of Bir Safsaf area have a wide range of chemical composition. This may reflect the multiphase nature of each intrusion (i.e. each intrusion was formed during more than one phase). The Bir Safsaf Older Granites have higher values of Al_2O_3, TiO_2, Fe2O3, MagO, CaO, P_2O_5, Nb, Zr, Ba, Sr, Ni and Cr and lower values of SiO_2,, and Na_2O relative to the corresponding rocks of El-Gaby [21], while the studied younger Granites have higher values of Al_2O_3, TiO_2, Fe_2O_3, CaO, K_2O, P_2O_5, Nb, Rb, Sr, Ba, Ni and Cr and lower values of SiO_2, MgO, MnO and Y.

PETROGENESIS AND TECTONIC ENVIRONMENT

The normative Q, Or, Ab Proportions of the examined granites are plotted on the experimental data of Tuttle and Bowen [22] (Fig. 4). It is observed that both intrusions fall separately in a rather limited region around the minimum melting curve. The majority of the younger granite is slightly more potassic. The Older Granite samples plot at the high water vapor pressure end of the minimum melting composition. Such a high PH_2O in turn, suggests that the batholith was formed from hydrous melts. More likely hydrous calc-alkaline melts associated with hydrous subduction zone melting. The Younger Granite samples have their composition close to the moderate to high water - vapor pressure end, suggesting that these rocks were formed through relatively less hydrous zone melting El-Gaby [21] and Zaghlul *et al.* [23] have shown that the field composition of some of the Egyptian Younger Granites is close to the minimum melting point at low to moderate pressures in the granite system of the Tuttle and Bowen [23]. According to them these granites are considered the early phase of the magma formed at higher water-vapor pressure, while the later phases were formed under progressively decreasing water-vapor pressures.

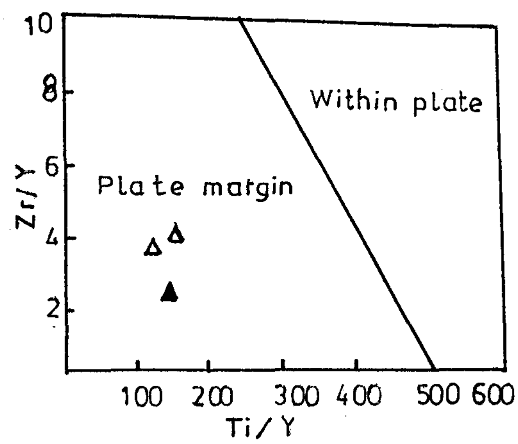

Fig. 4: Zr/Y-Ti/Y diagram (after Pearce and Gale, [20]) for the Bir Safsaf metagabbros.

The present data are plotted on the Ab-Q-Or ternary diagram of Winkler [24] (Fig. 5). This figure shows that the analysed rocks were formed at about 630 to 637°C. Winkler [24] has shown that most granitic melts could have been crystallized at temperature between about 800 and 680°C. According to the Shand, [25], the analysed samples of the Older Granites are metaluminous (A/CNK, i.e., mol $Al_2O_3/(CaO + Na_2O+K_2O)<1$.). The Younger Granites comprise metaluminous and peralumnous (A/CNK>1) varieties.

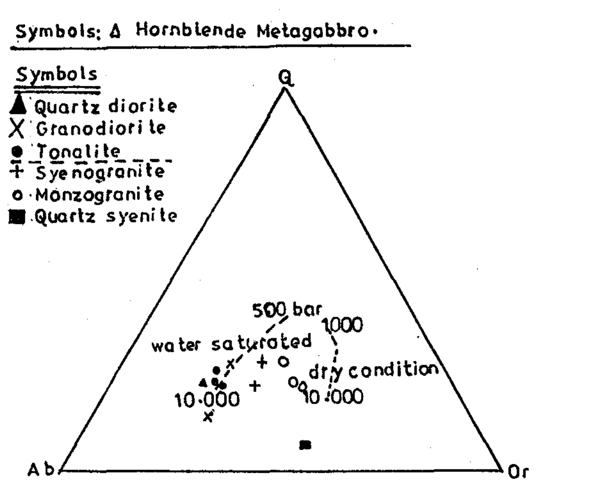

Fig. 5: Normative Ab-Q-Or proportions for the analyzed granitoid rocks. The dashed lines represent the trace of isobaric minima or ternary points of the granitic system under dry and water saturated conditions as indicated by Tuttle and Bowen, [22]. Symbols : = Quartz - diorite; =Grandiorite; tonalite + = Syenogranite; O =Monzogranite; = Quartz syenite.

Table 2
Chemical composition of metagabbros of Bir Safsaf area compared with those of the Ras Benas metagabbros of Takla *et al.* [18]

	Bir Safsaf				Ras Benas
	Hornblende metagabbro		Qz-metagabbro	Average	Average
Sample No.	114	115	120		n = 2
Major oxides (wt. %)					
SiO_2	51.17	47.62	48.42	50.07	46.6
TiO_2	0.63	0.24	0.23	0.24	0.34
Al_2O_3	13.19	21.16	22.16	18.84	21.22
Fe2 O3	11.94	7.10	7.02	8.68	6.61 (t)
MnO	0.21	0.11	0.11	0.14	0.15
MgO	6.93	6.20	5.75	6.29	6.86
CaO	9.81	15.21	14.69	13.23	13.2
Na_2O	1.8	0.98	1.42	1.4	1.0
K_2O	0.6	0.16	0.25	0.33	0.13
P_2O_5	0.22	0.03	0.05	0.1	0.03
L.I.O.	0.95	0.66	0.83	0.8	2.9
	100.44	99.47	100.93	100.12	99.04
Trace elements (ppm)					
Rb	12	1	4	2.5	2.3
Sr	172	218	240	229	341
Ba	205	61	71	66	135
Y	28	12	10	11	3.5
Zr	71	43	44	43.5	23
Nb	5	5	6	5.5	1
Cr	738	778	1070	924	204
Ni	72	81	110	95.5	75
Zn	147	120	275	199	60.5
Ga	3	5	4	--	--
Pb	--	--	--	--	--
Cu	93	23	14	18.5	38.5
Geochemical Parameters					
M.D.I.	-2.25	-7.06	-6.22		
F.I	19.66	6.97	10.21		
M.I	63.68	53.77	55.36		
Normative Composition (CIBW - Norms)					
Q	4.28	3.33	15.05		
Qr	0.95	1.48	3.55		
Ab	8.3	12.03	15.25		
An	52.88	53.36	26.13		
He	7.1	7.02	11.94		
Il	0.46	0.44	1.18		
Ap	0.07	0.12	0.52		
Wo	9.35	8.02	8.81		
En	8.0	6.86	7.49		
Fs	0.11	0.1	0.17		
En	7.44	7.46	9.77		
Fs	0.1	0.11	0.22		

Table 3
Chemical composition of the studied granitoid rocks

	Older Granites								
	Qz diorite		Tonalite		Granodiorite				
	176	178	46	32	123	125	203	145	average
Major Oxides (Wt %)									
SiO_2	60.11	55.27	63.31	60.17	65.14	65.03	59.88	60.73	61.21
TiO_2	0.77	1.28	0.6	0.95	0.45	0.57	0.9	0.77	0.78
$Al_2 O_3$	15.6	15.32	16.2	14.89	16.17	15.24	16.73	15.87	15.75
$Fe_2 O_3$	6.3	7.76	4.36	6.49	3.74	4.08	5.69	5.79	5.58
MnO_3	0.09	0.13	0.07	0.11	0.07	0.07	0.11	0.09	0.09
MgO	3.52	4.52	2.17	3.93	2.31	1.97	2.56	3.11	3.01
CaO	5.66	6.89	4.31	5.71	4.37	3.79	5.35	5.06	5.14
$Na_2 O$	3.94	3.57	4.46	3.73	4.48	4.17	4.72	4.14	4.15
$K_2 O$	2.12	2.34	2.73	2.54	2.56	3.01	2.79	3.09	2.64
$P_2 O_5$	0.29	0.59	0.25	0.53	0.28	0.2	0.53	0.51	0.39
L.O.I.	1.11	1.07	0.61	0.81	0.6	0.58	0.62	0.42	
Total	99.5	9.17	99.09	99.87	100.17	99.11	99.88	99.58	98.74
Trace elements (p p m)									
Rb	44	122	49	40	41	57	50	58	57.6
Sr	658	631	676	640	577	550	594	656	622.8
Ba	1136	1230	1404	1485	1129	1151	1464	1252	128.3
Y	22	33	24	34	20	23	41	24	27.6
Zr	212	245	149	224	186	251	471	250	248.5
Nb	13	21	15	18	10	16	19	14	15.8
Cr	574	848	505	677	108	554	701	888	613.1
Ni	227	117	128	281	17	197	77	110	144.3
Zn	85	196	79	84	71	76	108	192	111.4
Ga	16	13	16	6	10	12	15	16	13
Pb	8	18	15	16	16	19	15	17	15.5
Cu	31	36	15	12	14	8	15	29	20
Indices and Ratios:									
MDI	4.95	2.96	7.74	5.03	7.76	8.73	5.82	6.53	
Al/Ca + Na + K	0.82	0.73	0.894	0.77	0.89	0.9	0.82	0.82	
Al/Na + Na +	1.78	1.82	1.571	1.68	1.59	1.51	1.55	1.56	
K/Rb	400	159.02	463.27	527.5	809.76	438.6	464	443.1	
Rb/Sr	0.07	0.19	0.07	0.06	0.07	0.1	0.08	0.09	
C.I.P.W. Norms									
Q	14.07	8.5	15.86	13.98	17.99	19.44	9.33	12.03	
Or	12.53	13.83	16.13	15.01	15.12	17.79	16.49	18.26	
Ab	33.37	30.24	37.78	31.55	37.9	35.32	39.98	35.07	
An	18.59	18.84	16.09	16.39	16.46	13.95	16.19	15.57	
C	6.3	7.76	--	--	--	--	--	--	
He	1.46	2.43	4.38	6.49	3.74	4.48	5.69	5.79	
Il	0.68	1.39	1.14	1.8	0.85	1.08	1.71	1.46	
Ap	3.17	4.79	0.59	1.23	0.66	0.47	1.25	1.2	
Wo	2.7	4.08	1.53	--	--	1.48	2.88	2.59	
En Di	0.05	0.09	1.3	7.08	2.84	1.26	2.43	2.2	
Fs	6.06	7.18	0.03	--	--	0.03	0.07	0.05	
En	0.12	0.15	4.11	7.78	5.24	3.65	3.95	5.54	
Fs Hy	--	--	0.1	--	--	0.1	0.13	0.12	

Table 3 Cont.

Chemical Composition of the studied granitoid rocks

	Younger Granites							Older Granite	Younger Granite
	Monzogranite			Syenogranite		Qz Syenite		E-Desert	
	18	195	8	154	107	169	Average	El-Gaby [21]	
Major Oxides (Wt %)									
SiO_2	68.61	67,82	69.66	70.55	69.59	60.88	67.85	69.86	75.37
TiO_2	0.27	0.52	0.27	0.30	0.39	0.69	0.41	0.59	0.24
Al_2O_3	15.23	15.22	16.17	14.62	15.09	17.48	15.64	14.79	13.08
Fe_2O_3	2.37	2.80	2.02	2.77	2.22	5.81	3.00	3.32	1.62
MnO_3	0.03	0.03	0.04	0.05	0.03	0.13	0.05	0.07	0.60
MgO	0.34	0.42	0.30	0.45	0.69	0.37	0.43	1.01	0.29
CaO	1.69	1.91	1.52	1.57	1.87	2.61	1.86	2.73	0.88
Na_2O	3.68	3.63	4.93	3.62	4.26	3.91	4.01	4.51	4.50
K_2O	5.99	5.99	4.57	5.22	4.41	7.20	5.56	2.24	4.46
P_2O_5	0.12	0.20	0.08	0.17	0.20	0.17	0.16	0.13	0.04
L.P.I	0.99	0.49	0.05	0.03	0.58	0.88	0.50	--	--
Total	99.32	99.03	99.61	99.35	99.33	100.1	99.47	99.25	101
Trace Elements (p p m)									
Rb	233	248	109	98	186	95	162	51	115
Sr	257	271	725	303	745	74	396	287	111
Ba	1005	1135	1279	1027	1290	424	1027	568	528
Y	34	37	13	26	13	35	26	22	48
Zr	363	578	163	259	201	898	410	141	226
Nb	28	30	16	16	16	30	23	2	5
Cr	783	786	783	842	234	600	671	28.1	7.5
Ni	85	74	79	105	33	44	70	10.7	4.9
Zn	73	191	86	75	91	168	114	--	--
Ga	17	22	23	19	22	23	21	--	--
Pb	51	59	45	20	52	24	45	--	--
Cu	9	9	9	6	16	14	10	15.5	9.2
Indices and Ratios:									
MDI	14.23	13.91	13.37	13.93	12.95	13.37			
Al/Ca+Na+K	0.98	0.96	1.02	1.01	0.99	0.92			
Al/Na+k	1.21	1.22	1.24	1.26	1.28	1.23			
K/Rb	213.3	200.4	347.7	441.8	196.8	629.5			
Rb/Sr	0.91	0.92	0.15	0.32	0.25	1.28			
C.I.P.W Norms									
Q	20.49	19.71	19.96	25.90	23.42	4.51			
Or	35.40	35.40	27.01	30.85	26.06	42.55			
Ab	31.17	30.75	41.73	30.66	36.08	33.12			
An	7.34	7.54	7.02	6.67	7.79	8.88			
C	---	--	0.53	0.56	0.38	--			
He	2.37	2.80	2.02	2.72	2.22	5.81			
Il	0.51	0.99	0.51	0.57	0.74	1.31			
Ap	0.28	0.47	0.19	0.40	0.47	0.40			
Wo	0.11	0.26	--	--	--	1.24			
En Di	0.09	0.22	--	--	--	0.89			
Fs	0.01	0.01	--	--	--	0.23			
En	0.76	0.83	0.75	1.12	1.72	0.03			
Fs Hy	0.05	0.04	0.07	0.09	0.06	0.01			

On Plotting the SiO_2 values versus log K_2O/MgO of the examined granitic rocks (Fig. 6), a big gab is observed between the two groups of granites. The Older Granites plot close to the "Subduction related" or calc-alkaline batholiths, whereas the Younger Granites fall in the "Crustal-related' of alkali granite field similar to the second phase of Egyptian younger Granites as defined by Rogers and Greenberg [26].

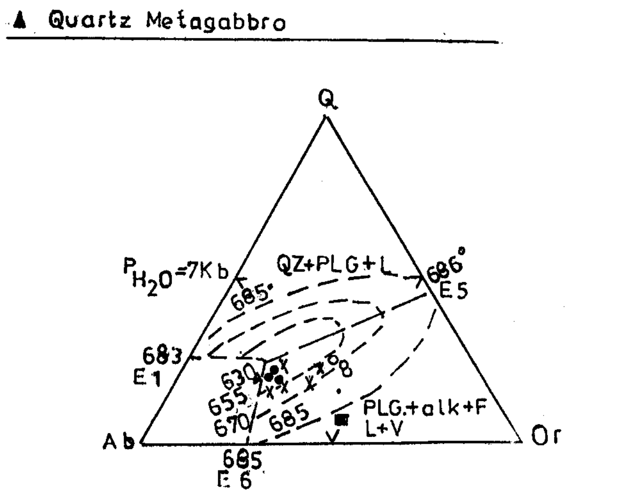

Fig. 6: Projection of the isobaric cottectic line P.ES and of isotherms on the three cottectic surfaces of the system Q-Ab-An-H_2O (after Winkler [24] at P H_2O = 7Kb. Symbols as on Fig. 5.

Fig. 7 shows that the studied older and younger Granites fall in the field of the I-type granites of Chappel and white [27], and are characterized by the most features of this type.

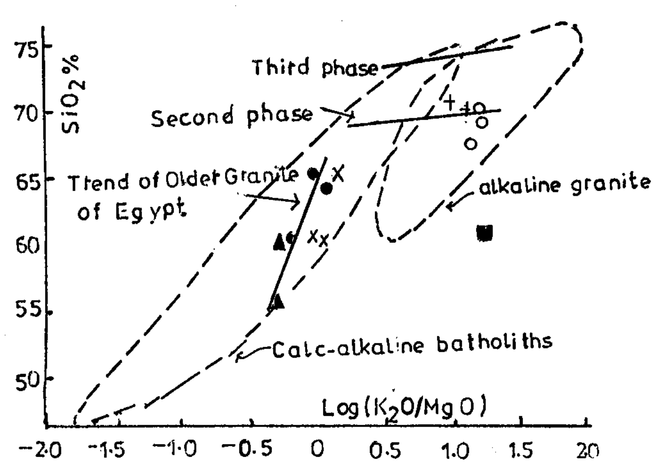

Fig. 7: Plots of the studied granitoid rocks on the SiO_2-log (K_2O/MgO) diagram of Rogers and Greenberg (1981). Symbols as on Fig. 5.

K/Rb ratio in the Older and Younger Granites is relatively high and Rb/Sr is low (Table 3). Heier [28] has shown that high K/Rb and low Rb/Sr ratios are characteristic features for rocks formed from the lower crust or upper mantle.

Based on the foregoing discussion, it is clear that, the granitoid rocks of Bir Safsaf district were formed by partial melting of parent mantle-derived material with little crustal melt contribution. This is further confirmed by plotting Ni versus Ba (Fig. 8). This diagram shows that the investigated granitoids follow the partial melting trend of Martin [28].

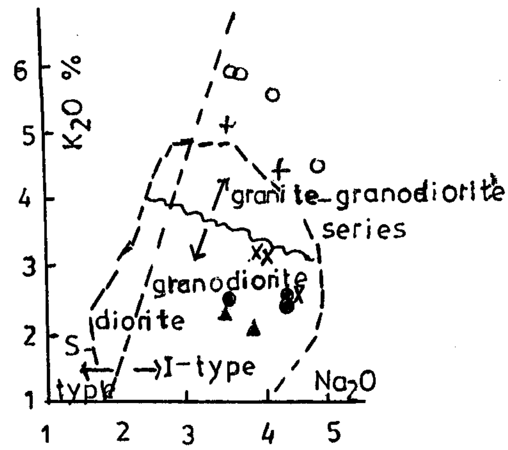

Fig. 8: K_2O-Na_2O diagram for the granitoid rocks of Bir Safsaf. The field defined after Chappell and White [27]. Symbols as on Fig. 5.

Plotting Nb versus Y of the studied granitoids on Pearce *et al.* [30] diagram. (Fig. 9), the analyses samples fall in the syncollision granite (SYN-COLG) and within plate granite (WPG), but the mol $Al_2O/CaO+Na_2O+K_2O$) ratio of Shand [25] reveals that the rocks are mainly of metaluminous nature, suggesting that they are not collision-related. Accordingly, these granitoids are probably related to the volcanic arc or within plate granite.

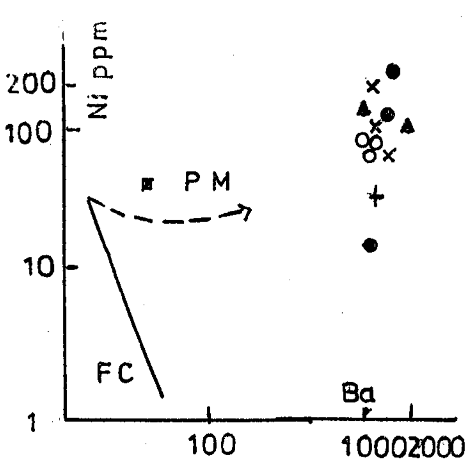

Fig. 9: Ni-Ba variation diagram for the granitoids of Bir Safsaf area. PM represents the partial melting rock trend and FC shows the fractional crystallization trend after Martin [29]. Symbols as on Fig. 5.

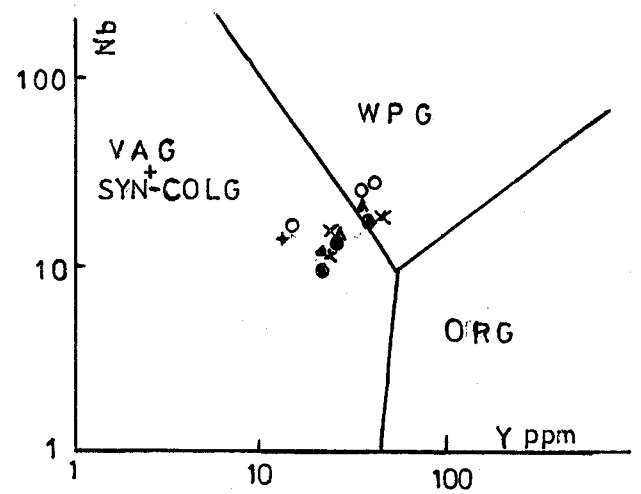

Fig. 10: Nb versus Y plot for Bir Safsaf granitoids (after Pearce *et al.* [30]). Symbols as on Fig. 5.

CONCLUSION

The Pan African basement in the East Sahara African Craton is represented by the cropping out rocks at Bir Safsaf area, Southwestern Desert of Egypt. These rocks are old continental gneisses and migmatites comprising granitic, granodioritic and tonalitic varieties, hornblende and quartz bearing metagabbros of the tholeiitic nature formed in the continental environment at plat margin. Grey Older Granites including quartz diorite; tonalite and granodiorite varieties, which are metaluminous and subduction related formed by the partial melting of the lower crust or upper mantle through hydrous melt. Pink-red Younger Granites comprising mainly syenogranite and monzogranite with subordinate varieties, of quartz syenite, quartz monzonite and quartz monzodiorite which are metalumnous and peraluminous nature were formed through partial melting of crustal rocks.

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