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GEOLOGY AND PETROLOGY OF ABU DURBA–ABU HASWA GRANITOID ROCKS, SOUTHEASTERN SINAI, EGYPT

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ABSTRACT

The present work deals with the plutonic suite of Gabal Abu Durba–Gabal Abu Haswa area in the southwestern part of Sinai along the Gulf of Suez. It comprise an elongate granitoid belt covering collectively about 35km² and trending NW. This suite comprises two phases of granitoids where phase II younger granites (granodiorites) and phase III (monzogranite and alkali feldspar granite), intruded into dacite, rhyodacite, rhyolite and equivalent pyroclastics of the Dokhan volcanic type.

Geochemically, the granitoids of Gabal Abu Durba–Gabal-Abu Haswa area seem to have originated from metaluminous to peraluminous calc-alkaline magmas with many chemical features similar to I-type granites. The granitoiditic magmas were developed in an island arc tectonic setting whears the granitic ones were developed in a within-plate tectonic setting. The studied granitoids were generated at somewhat intermediate depths (9-21 km) equivalent to 3-7 Kb under temperature ranging from 760°-840°. This is consistent with the high K/Rb ratios, and the low K/Ba ratios indicate involvement of ocean sediments in magma generation.

The concentrations of U and Th in the granitoid rocks were controlled by magmatic processes which are clear from the positive relation between U and Th and U-Zr in addition to weak negative relation between U and K/Rb observed. They are also controlled by the presence of some accessory minerals (zircon and apatite) and iron oxides. Iron oxides and hydroxides are known to absorb U from circulating fluids.

INTRODUCTION

The Gabal Abu Durba and Gabal Abu Haswa granites form an elongate belt trending NW in the southwestern part of Sinai along the eastern side of Gulf of Suez (Fig.1). The area lies between long. 33° 16` to 33° 26` E and lat. 28° 25` to 28° 33` N. Gabal Abu Durba covers an area of about 20 km² (10 x2 km), whereas Gabal Abu Haswa covers an area of about 15 km2 (5x3 km) which extends southwards outside the study area.

Gabal Abu Durba is mapped in the geological map of Sinai, Sheet no.1, scale 1:250000, published by the Egyptian Geological Survey (1994) as coarse to medium grained alkali granites whereas the northeastern part of Gabal Abu Haswa is mapped as coarse to medium grained alkali granites while the western part is mapped as medium

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grained monzogranite. In the map published by Conco, 1:500,000, NH 36, 1987, the northern and southern parts of Gabal Abu Durba is represented by pink granites that is calc-alkaline and weakly deformed granites. whereas the central part is mapped as rhyolite to alkali feldspar rhyolite of Katherina volcanics that are dissected by Tertiary basaltic dykes and flows. The Gabal Abu Haswa, on the other hand, is mapped as pink granites of calc-alkaline nature and is dissected by Tertiary basaltic dykes and flow.

According to El Bialy (1998), Gabal Abu Durba granites pertain to phase III younger granites (coarse to medium grained leucogranites and muscovite granites). The southern part of Gabal Abu Haswa pertains to phase II younger granites (biotite granodiorite and porphyritic biotite granites), whereas the northern part pertain to phase III younger granites These granitoid rocks are intruded into volcanics mainly from pyroclastics, rhyolite and granite porphyries.

The present work aims to study the geology, petrology, geochemistry and petrogenesis of the granitoid rocks in Gabal Abu Durba and Gabal Abu Haswa.

Geologic Setting

El Bialy (1998) studied the basement rocks of G. Abu Durba-G. Abu Haswa area comprising the following units from oldest: younger granites phase II, younger granites phase III, post-granitic dykes, acidic porphyries, pyroclastics and lava flows of Tertiary basalts.

The present study shows that the northern part of G Abu Durba is occupied by phase II younger garnites (granodiorite) (Fig. 2a), intruded into volcanics of Dokhan type (Fig. 2b) and sends off-shoots and apophyses into the Dokhan volcanics (Fig. 2c.). The Dokhan volcanics comprise mainly dacites, rhyodacites, rhyolites and their equivalent pyroclastics (Fig. 2d, e). The Dokhan volcanics and younger granites are dissected by post-granite basic dykes of Tertiary age trending NW (Fig. 2b.). The phase III younger granites (mozogranites) located at the south-eastern part of G Abu Durba and are intruded into volcanics of Dokhan type (Fig. 2f). The Gabal Abu Haswa, on the other hand, is mainly composed of Phase II younger garnites (granodiorite) which is intruded by phase III younger granites (monzogranites and alkali feldspar granites).

Field work and petrography indicate that the area is occupied by the following rock units from the oldest: Dokhan volcanics, Phase II younger granites, Phase III younger granites, post-granite basic dykes of Tertiary age. This rock unit sequence is not conformable with the sequence reported by El Bialy (1998).

structural setting of the area a suggested by Moustafa and Khalil (1987) from their study of the Durba- Araba fault (DAF), as a representative of the north-northeast set of oblique faults (parallel to the left–lateral Dead Sea fault) affecting the Suez rift, indicates that the fault which bound the area from the eastis strike-slip fault with four kilometer of left-lateral displacement and dissects rocks of Precambrian to Early Miocene age. Field evidence indicate that the left-lateral slip on the DAF took place after the Lower Miocene Rudies carbonate rocks were deposited. The DAF post-dates the opening of the rift and it is probable that might have been formed in early rifting (Oligo-Miocene) stage as normal fault that was rejuvenated as a left -lateral strike slip fault. Moustafa and Khalil (1987) interprete that three north to north-northwest trending faults branch from Durba-Araba fault (DAF) and dissect the Gebel Abu Durba block. G. Abu Durba block is bounded on the west by a north- northwest clysmic fault parallel to the Gulf of Suez.

The present work aims to study the geology, petrology, geochemistry and petrogenesis of the granitoid rocks in Gabal Abu Durba-Gabal Abu Haswa area.

Petrography

Granodiorites

These rocks are exposed at G. Abu Durba and G. Abu Haswa and they have coarse grained hypidiomorphic granular texture and some varities show cataclasis and deformation to give augen, foliation and mylonitic textures (Fig. 3a). It is composed mainly of plagioclase, quartz, alkali feldspar and biotite. Plagioclases are mainly andesine in composition with more sodic rim forming porphyritic texture. It forms subhedral to anhedral crystals with simple carlsbad twinning and sometimes sericitized. Plagioclases contain inclusions of biotite and iron oxide grains. It may be also present as inclusion within the microperthite. Quartz occurs as large crystals or as small interstitial grains. Potash feldspars are include orthoclase and microperthite. Biotite crystals are reddish brown colour with strong pleochroic from yellowish brown to dark reddish brown. They occur as short small crystals or as euhedral tabular crystals and sometimes as folded and bent laths and altered to chlorite .

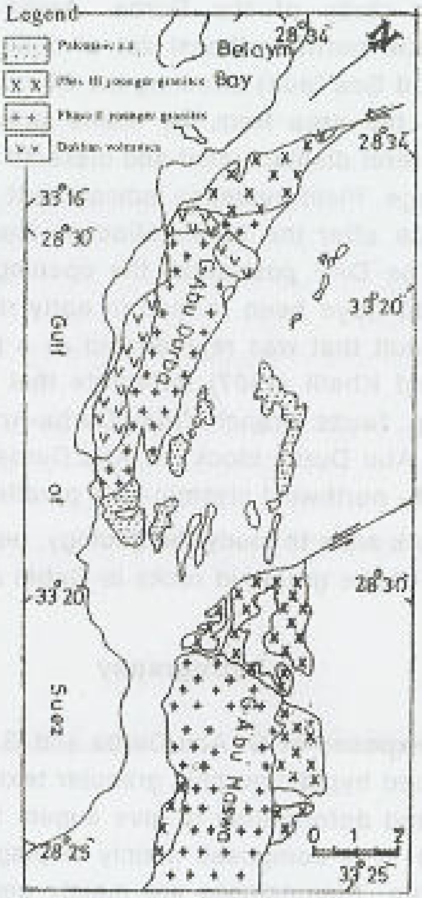
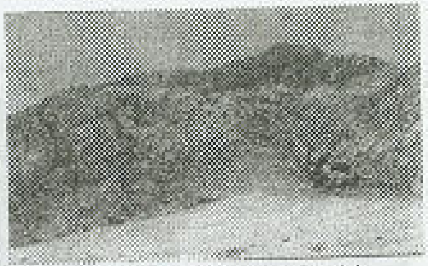


Fig 1: Geological map of G Abu Durba-G Abu Haswa area, Southwestern Sinai Egypt (modified after El Bialy, 1998)

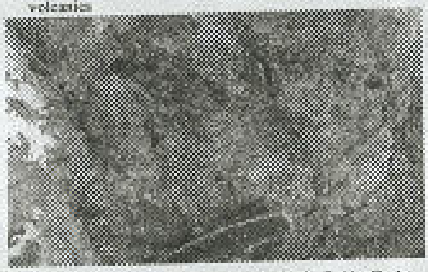
a- Phase II younger granite (granodiorite) at northern part of G.Abu Durba



b- Phase II younger granite (granodiorite) intruded in Dokhan volcanic at north of G.Abu Durba

c- A Popham of younger granite intruded in the Dokhan volcanics

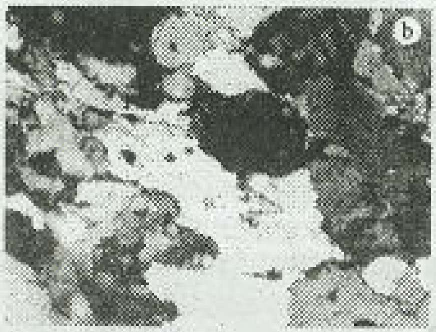
d- Pyroclastics of Dokhan volcanics in G.Abu Durba



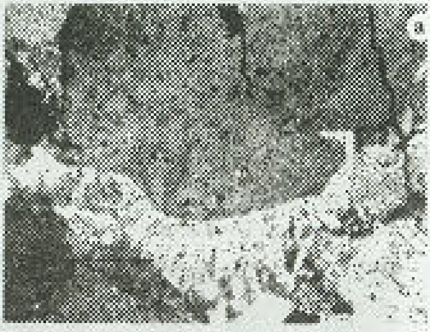
e- Acidic Pyroclastics of Dokhan volcanics in G.Abu Durba

f- Phase III younger granite intruded into Dokhan Volcanics in the Southeastern part of G.Abu Durba

Figure (2)



- Cataclasis and deformation in granodiorite

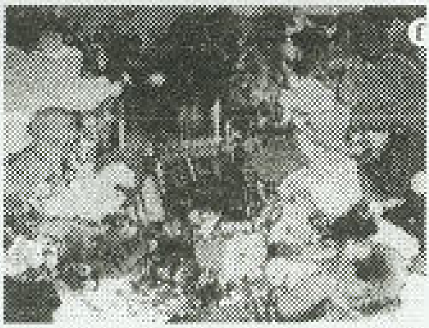


b- Porphyritic and myrmakitic texture in grani

:- Perthitic and hybidomorphic texture in monzogranite

d- Veined Perthite in alkali Feldspar granite

:- Perthite Phenocrysts in Porphyritic granite



f- Perthite Phenocrysts and myrmakitic texture in porphyritic granite

Figure (3)

Monzogranites

These rocks are exposed at the southern part of G. Abu Durba and in the western part of G. Abu Haswa. They are composed of quartz, plagioclases, microcline and perthites together with variable proportion of biotite. Iron oxide, sphene and zircon are the main accessories whereas chlorite is the main secondary mineral. petrographic features include myrmekitic and graphic textures in porphyritic types (Fig. 3b). Hypidiomophic texture is common in these rocks (Fig. 3c), whereas some varities show foliation and protomylonitic texture. Quartz occurs as interstitial grains or as larger interlocked crystals. It occurs in the mechanical shearing varities as small highly strained and shows undulatory extinction. Alkali feldspars are represented by microcline, microperthite and mesoperthite. It occurs as megacrysts in vein and zoned perthite forms. Plagioclases are mainly of oligoclase composition and occur as subhedral to anhedral crystals. They show simple twinning and are partly sericitized in the cores of crystal. Biotite occurs as subhedral green crystals partly altered to chlorite. It shows strong pleochroism with X= yellowish green, and Y=Z= dark green. Zircon and apatite occur as small prismatic crystals included in biotite crystals.

Alkali Feldspar Granites

The alkali feldspar granites occur in the northeastern part of Gabal Abu Haswa. The rocks are coarse grained, massive of pale pink to white colour. They are characterized by hypidiomorphic–granular texture and some varities are porphyritic. They consist essentially of potash feldspars, quartz and plagioclases. Flourite, zircon and apatite are the common accessory minerals.Potash Feldspars form euhedral to subhedral crystals and are represented mainly by perthite and minor microcline. The perthite is mainly represented by microcline microperthite (exsolution type) and contains inclusions of irregular quartz and plagioclase .It is actively replaced by plagioclase which is marked by lobate leaf-like myrmekitic texture and sometimes exhibit vein perthitic form (Fig. 3d). The alkali feldspars in the porphyritic varities represent the main constituent and occur in the groundmass and as phenocrysts (Fig. 3e). It is represented by orthoclase and microcline microperthite in less developed habit. Quartz forms anhedral to subhedral crystals filling the interstices between the feldspar crystals. It contains inclusions of plagioclase, apatite and zircon. Plagioclases are commonly oligoclase and albite and forms twinned tabular crystals according to albite and carlsbad laws.

Microgranites

The microgranites is grey to buff in colour with fine grained granular texture. They consists of potash feldspar, quartz and plagioclase having graphic, myrmekitic texture (Fig. 3f). Iron oxides and zircon are common accessory minerals while the kaolinite represents the secondary mineral. Potash feldspars occur as is a major constituent represented by orthoclase and perthites commonly intergrown with quartz having graphic, texture. Plagioclase occurs as anhedral to subhedral crystals and mainly albite and oligoclase. Quartz is a common constituents and occurs either as anhedral to subhedral interstial grains or as inclusions in alkali feldspars.

Geochemistry

In this section, it is intended to determine the petrochemical features of granitoid rocks of G. Abu Durba– G. Abu Haswa area and to solve the genetic relation between these rocks. Also, to determine the magma types and the tectonic settings under which these granitoid magmas were generated. To achieve these objectives, 17samples including G. Abu Durba (7 samples) and G. Abu Haswa (10 samples), were chemically analyzed in the laboratory of Nuclear Material Authority (NMA) for major oxides (wet chemistry) and the trace elements Rb, Sr, Ba, Y, Zr, Nb, Cu, Zn, Ni, Co, Cr, V and Ga. by XRF technique. The analytical results of the major oxides and trace elements are shown in Tables (1 and 2). The tables also show the CIPW normative compositions and some petrochemical parameters.

Geochemical Classification

Middlemost (1985) used the binary relation between SiO_2 and Na_2O+K_2O (wt%) to differentiate between different plutonic rock types shown in (Fig. 4). It is clear from the figure that the studied samples of G. Abu Durba plotted in the granodiorite and granite fields but the samples of G. Abu Haswa area are lie in the alkali granite, granite and granodiorite fields.

The total alkali-silica (TAS) of Le Maitre, (1989) (Fig. 5) shows that the granodiorites of of G. Abu Durba plot in the tonalite field, and those of G. Abu Haswa plot in the granodiorite field. The studied granites plot in the granite field.

The studied granitoids can also be classified according to their normative Ab, An, and Or contents using the following diagrams.

The (Or-Ab-An) diagram of Hitannen, (1963), shown in (Fig. 6), indicates that the granodiorites of G. Abu Durba and those of G. Abu Haswa plot in the monzonite field but the studied granites of G. Abu Durba and those of G. Abu Haswa plot in the quartz mozonite and granite fields.

The (Ab-An -Or) diagram of Streckeisen (1976), shown in (Fig. 7) indicates the studied granitoids of G. Abu Durba plot in the granodiorite and mozogranite fields but those of G. Abu Haswa plot in the granodiorite, monzogranite and alkali feldspar granite fields.

Table (1): Chemical analysis of major and trace elements of granitoid rocks of Gabal Abu Durba area.

	Granodiorite				Monzogranite		
S. No.	SA29-1	SA29-2	SA29-4	SA29-5	SA29-3	SA29-6	SA29-7
SiO2	66.20	67.00	66.10	66.00	73.90	74.00	73.20
TiO2	0.72	0.26	0.66	0.49	0.16	0.21	0.14
Al2O3	15.50	14.50	15.80	15.20	12.70	13.40	13.80
Fe2O3	2.10	1.42	1.42	2.42	2.27	1.21	1.90
FeO	2.20	1.79	2.50	1.30	0.24	0.44	0.44
MnO	0.02	0.05	0.07	0.04	0.05	0.01	0.08
MgO	1.30	0.51	2.30	1.20	0.00	0.08	0.03
CaO	3.10	3.30	2.50	3.92	1.40	1.34	1.50
Na2O	4.34	4.39	4.43	4.50	4.00	3.80	3.46
K2O	3.61	3.55	3.24	3.33	4.20	4.16	4.32
P2O5	0.26	0.10	0.22	0.13	0.01	0.01	0.01
LOI	0.60	2.40	1.50	1.20	0.90	0.90	0.80
Total%	100.00	99.47	99.64	99.93	99.83	99.56	99.73
CIPW norm							
Qz	15.93	17.6	17.41	17.02	29.27	29.66	29.75
Or	21.37	21.02	19.18	20.89	24.86	24.62	25.86
Ab	36.72	27.14	37.48	38.07	33.84	32.15	29.27
An	12.46	9.39	11.27	10.87	4.3	6.69	7.45
Di	1.3	6.65		6.87	2.48		
Hy	10.47	6.29	11.57	7.68	5.03	7.56	2.5
Cor			0.89			0.2	0.65
Mt	3.07	2.08	2.07	3.54	3.33	1.78	
Il	1.48	0.5	1.27	0.95	0.31	0.41	.27
Ap	0.62	0.24	0.53	0.31	0.02	0.02	0.02
Trace elements (ppm)							
Rb	99	100	98	67	93	87	88
Ba	521	488	513	420	408	382	238
Sr	420	300	460	369	22	18	19
Ga	1238	21199	28794	21159	26055	26387	24976
Nb	21.0	10.0	11.0	10.0	22.0	33.0	51.0
Zr	250	168	211	181	197	167	172
Y	19	17	16	18	43	30	33
Th	0.00	37.00	0.00	46.00	0.00	0.00	26.50
U	0.00	13.00	0.00	18.00	0.00	0.00	9.00
K	29968	29470	26896	29304	34865	34933	36277

Table (2): Chemical analysis of major and trace elements of granitoid rocks of Gabal Abu Haswa area.

S.No.	Granodiorite			Monzogranite				Alkali feldspar granite		
	SA33-6	SA33-1	SA33-8	SA33-2	SA33-5	SA33-7	SA33-10	SA33-9	SA33-3	SA33-4
SiO2	69.60	67.40	67.90	71.75	70.40	73.53	71.43	73.05	75.01	73.68
TiO2	0.30	0.40	0.39	0.45	0.36	0.46	0.23	0.09	0.07	0.06
Al2O3	14.56	15.30	15.98	14.36	13.69	13.48	14.70	13.31	12.52	12.50
Fe2O3	1.67	2.24	2.26	0.99	1.87	1.22	1.43	1.00	0.80	1.50
FeO	0.92	1.20	1.48	0.18	0.76	0.16	0.22	0.30	0.40	0.20
MnO	0.10	0.25	0.10	0.09	0.08	0.03	0.01	0.02	0.04	0.03
MgO	2.20	2.09	1.55	0.40	0.80	0.12	0.45	0.50	0.40	0.60
CaO	3.52	3.38	2.38	1.64	1.50	1.80	1.60	1.10	1.00	1.70
Na2O	3.67	3.49	3.86	4.17	4.60	3.15	3.21	4.82	4.50	4.09
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4.02	4.18	4.25	4.50	4.00	4.70
P2O5	0.01	0.02	0.02	0.03	0.04	0.01	0.01	0.23	0.23	0.24
LOI	0.50	0.90	0.97	1.52	1.79	1.82	1.54	0.53	0.86	0.70
Total%	99.72	99.47	99.59	99.82	99.91	99.96	99.48	99.47	99.83	[illegible]

CIPW norm

Qz	25.33	23.89	25.15	25.02	21.57	31.2	27.37	23.23	28.27	26.51
Or	15.82	26.38	15.99	25.1	23.8	24.76	27.54	26.62	23.67	27.81
Ab	31.05	29.53	32.66	35.28	38.92	26.65	27.19	40.78	38.07	34.61
An	15.42	15.18	12.03	7.42	4.85	9.07	8	1.4	2.16	1.87
Di	1.89	1.5		0.63	2.2			2.31	1.27	4.53
Hy	9.59	9.9	9.55	8	7.87	6.79	8.78	8.19	7.95	7.12
Cor	·		2.32				1.45	0.02	0.02	0.02
Mt	2.44	3.28	3.3	1.65	2.24	1.79		1.47	1.17	2.2
Il	0.58	0.77	0.75	0.78	0.7	0.89	0.43	61.17	0.14	0.12
Ap	0.02	0.05	0.05	0.07	0.1	0.02	0.63	0.61	0.55	0.58
Z	0.03							0.04	0.04	

Trace elements (ppm)

Rb	97	90	84	101	105	131	144	36	78	68
Ba	757	726	803	399	409	620	335	640	617	456
Sr	259	279	359	234	231	103	102	95	87	109
Nb	18.0	11.0	12.0	23.0	20.0	25.0	28.0	30.0	32.0	31.0
Zr	223	213	203	199	187	163	160	183	179	159
Y	16	17	16	27	28	36	43	20	37	34
Th	34.00	0.00	0.00	0.00	21.00	35.50	0.00	0.00	0.00	28.50
U	11.70	0.00	0.00	0.00	6.50	13.00	0.00	0.00	0.00	9.00
K	22164	25244	22414	33158	33371	34699	38601	37356	33205	39016

Magma Types

The magma types of the present granitoids are investigated using major and trace elements contents, some geochemical parameters and normative compositions (Tables 1 and 2).

Agpaitic index is a geochemical parameter defined as [(Na_2O+ K_2O)/ Al_2O_3] (in molecular proportion), (Goldschmidt 1954). The average agpaitic index of G. Abu Durba granites is about 0.78 and G. Abu Haswa about 0.91 which means that the studied granitoid rocks are miaskitic in nature.

The total alkalies of the studied samples are plotted against SiO_2 content (Irvine and Baragar, 1971) shown in (Fig. 8),where the studied samples plot in subalkaline field.

Maniar and Piccoli, (1989) used the Shand index to distinguish between the peralkaline, metaluminous and peraluminous rocks as shown in (Fig. 9), where the data points of G. Abu Durba– G. Abu Haswa granitoid rocks plot in the metaluminous and peraluminous fields.

Bailey and McDonald (1969) and McDonald and Bailey (1973) used the ternary diagram SiO_2–Al_2O_3-(Na_2O+K_2O) shown in (Fig.10) to distinguish between the calc-alkaline, alkaline and peralkaline rocks where the data of G. Abu Durba– G. Abu Haswa granitoid rocks plot in the calc- alkaline field.

Figure (11) shows AFM diagram (Irvine and Baragar, 1971) for the studied granitoid rocks, where the studied samples plot in calc-alkaline field and the samples show a trend parallel to the compressional of the Petro *et al.*(1979).

Chappell and White, (1974) used the binary relation between Na_2O and K_2O to differentiate between S- and I-type granites shown in (Fig.12). The I-type granites include those which represent mantle derived rocks, while S-type granites are products of partial melting of crustal material during continental collision (Pitcher, 1983), the figure shows that the studied granitoid are I-type granites.

To summarize, the studied miaskitic Granitoid rocks originated from metaluminous to peraluminous calc-alkaline magma types.

Tectonic Setting

The tectonic setting of the studied granitoids is determined using bivariante plot of Rb/Zr vs. SiO_2 (Harris *et al.*, 1984) which discriminate between the syn-collisional granites and volcanic arc granites as shown in (Fig. 13), where the studied samples plot in the volcanic arc granite (VAG) field.

The variation diagram of Nb-Y discriminates between the oceanic ridge granites which is enriched in Y contents and volcanic arc and collision granites which are depleted in Y (Pearce *et al.*, 1984) as shown in (Fig. 14). The data of the studied granitoid samples plot in the volcanic arc granites field to within plate field.

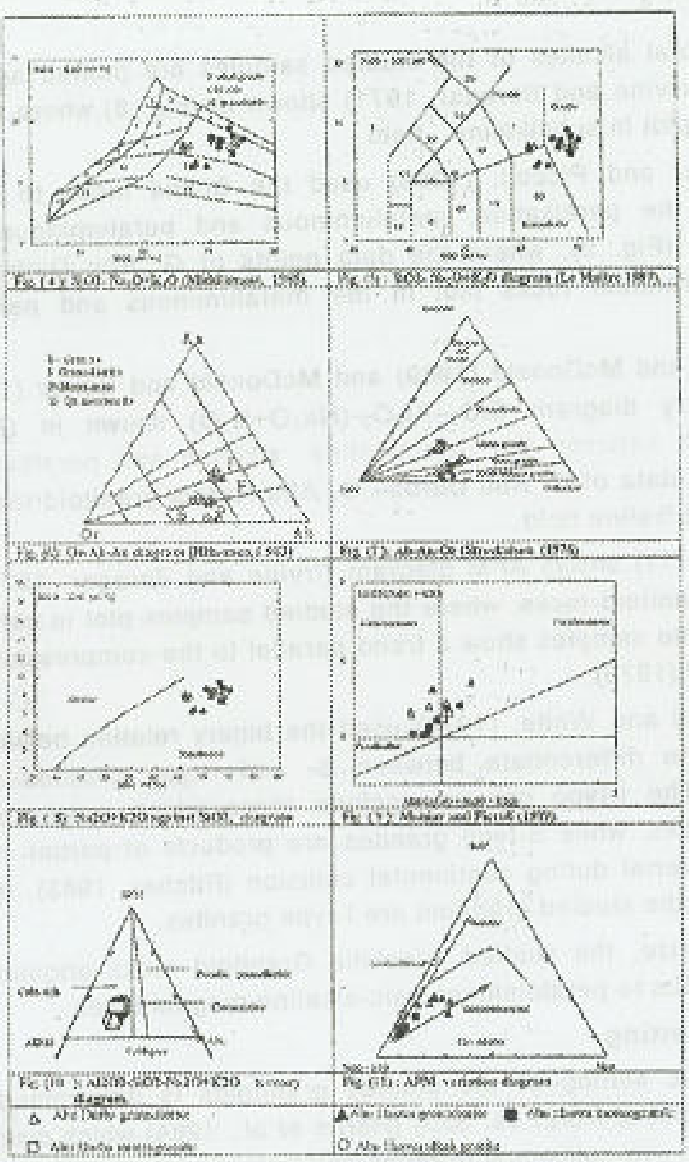


Fig (4): SiO2-Na2O-K2O (Middlemost, 1985)

Fig (5): SiO2-Na2O+K2O diagram (Le Maitre, 1987)

Fig (6): Or-Ab-An diagram (Hibbard, 1983)

Fig (7): Ab-An-Or (Streckeisen, 1976)

Fig (8): Na2O+K2O against SiO2 diagram

Fig (9): Maniar and Piccoli (1989)

Fig (10): Al2O3-CaO-Na2O+K2O ternary diagram

Fig (11): AFM variation diagram

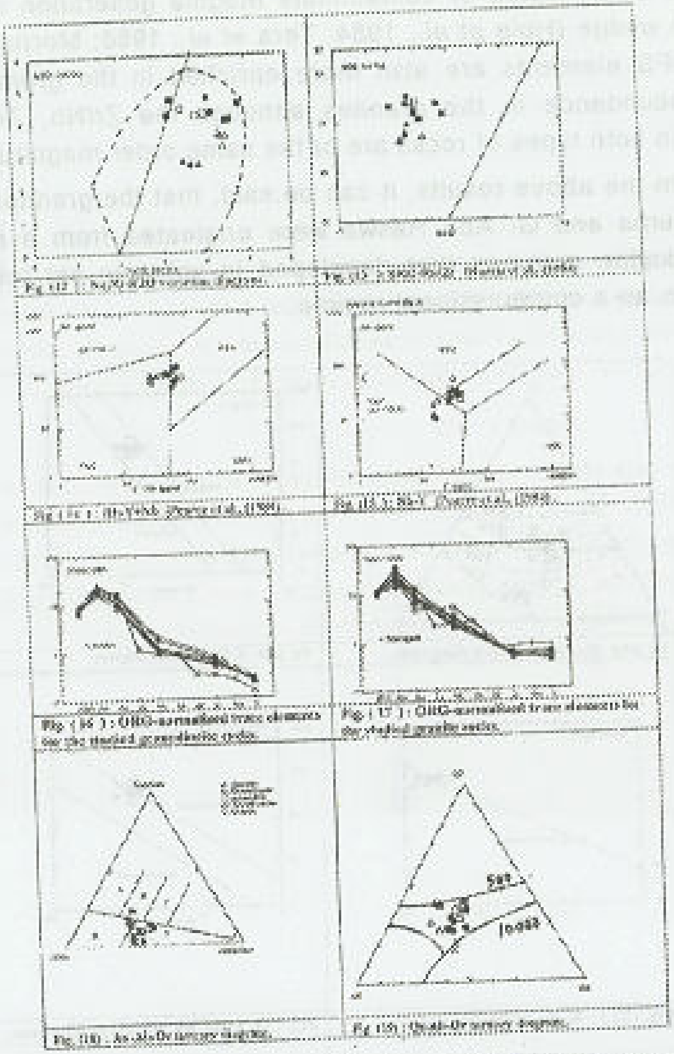


Fig. (16): ORG-normalized trace elements for the studied granodioritic rocks.

Fig. (17): ORG-normalized trace elements for the studied granitic rocks.

The variation diagram Rb-Y+ Nb is used to discriminate between volcanic arc granites depleted in Rb contents and collision granites enriched in Rb as shown in (Fig. 15). This indicates that the granitoid of G. Abu Durba and G. Abu Haswa plot in the volcanic arc granites field and within-plate field.

The studied rocks show a very common trace elements abundance pattern as shown by spider diagrams (Figs. 16 and 17). The granodiorite rocks are depleted in Rb indicate a deeper source for the granodiorites than the granites. Also, Ba is much more enriched in the granodiorites compared to the granites and the source of Ba has commonly been attributed to pelagic oceanic sediments which probably can be incorporated or contaminate magma generation regions in the mantle wedge (Hole *et al.*, 1984; Tera *et al.*, 1986; Morris *et al.*, 1990). The HFS elements are also more enriched in the granodiorite rocks than abundance in the granites although the Zr/Nb, Zr/Y and Y/Nb ratios in both types of rocks are of the same order magnitude.

From the above results, it can be said, that the granitoid rocks of G. Abu Durba and G. Abu Haswa were originated from a metaluminous calc-alkaline magmas that developed in volcanic arc tectonic setting which is an a compressional regime.

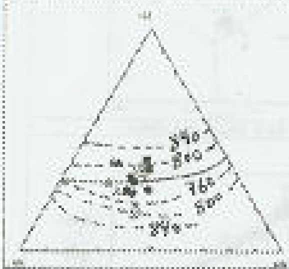


Fig. (20): Qz-Or-Ab ternary diagram.

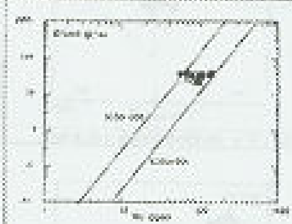


Fig. (21): K-Rb variation diagram.

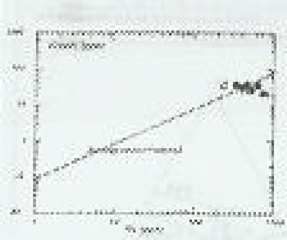


Fig. (22): K-Ba variation diagram

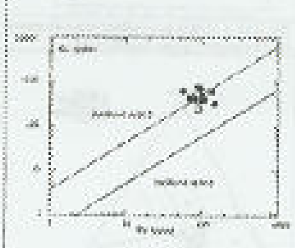


Fig. (23): Ba-Rb variation diagram.

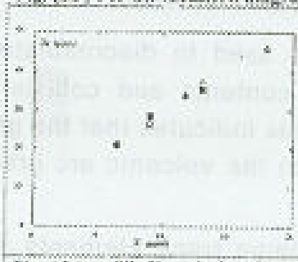


Fig. (24): Th-U variation diagram

Fig. (25): Th/U-U variation diagram.

Crystallization Conditions

The environmental conditions during the crystallization of the granitoid rocks can be deduced from the normative (Or– Ab–An) and (Qz–Ab–Or) systems as follow.

Figure (18) shows the normative Ab-An-Or system with the fields of rock types after O'Conner, (1965) and Barker, (1979). The effect of PH2O on the position of cotectic boundary between orthoclase and plagioclase at 1 Kb and 5Kb PH2O are also shown after Tuttle and Bowen (1958). The G. Abu Durba– G. Abu Haswa samples plot in the granite field and the magma was generated at somewhat intermediate depths equivalent to 3-6 Kb.

The Qz–Ab–Or system is shown in (Fig. 19). The cotectic boundaries at 0.5 and 10kb are also shown. The studied granitoid samples plot in the region which indicates formation at water pressure 3-7kb at depth range from (9 -21 km) Wilson, (1989).

Figures (20) show the quartz–albite-orthoclase system illustrating the temperature isotherms. The studied samples crystallized under temperature ranging from 760°-840° (James and Hamilton, 1969 ; Winkler *et al.* 1975).

Petrogenesis of Granitoid Rocks

The identification of the source regions from which granitic magmatic liquids were derived as well as the nature of these magmatic liquids can be recognized from the variation patterns and inter-relationships between some elements such as K, Rb, Sr and Ba because their behavior in these systems is strongly tied to the major minerals, e.g., plagioclase, K- feldspars, biotite and muscovite.

The K-Rb variation diagram of the studied granitoid rocks is shown in (Fig. 21).. The average values of studied granitoid are higher than the crustal average value of 250 (Taylor, 1965). The higher K/Rb ratio indicates sources regions for magma generation in the lower crust (Heier, 1973) or upper mantle (Gast, 1965). Also, the higher K/Rb ratios for the more fractionated granitic phase probably indicate magma generation mechanism involving dehydration of amphiboles at deeper levels in the lower crust (Griffin and Murthy, 1969).

The K-Ba variation diagram is shown in (Fig. 22). The valus of K/Ba is greater than the average crustal ratios line (K/Ba=65) which indicate that they are enriched in Ba.

The Ba-Rb variation diagram is shown in (Fig. 23). It can be used to signify the degree of fractionation of granitoid rocks. The line representing the average Ba/Rb ratio for the crust is about (4.4) (Mason, 1966). The Ba/Rb ratios of the studied granitoid show that they have high values than the average crustal ratio that is consistent with the suggestion that these samples originated from a enriched Ba source.

In order to understand the petrogenesis of the granitoid rocks, the origin and possible conditions of crystallization of these rocks can be discussed in terms of their chemical composition and discussed within the framework of the evolution of the Egyptian Shield. By about (660-650) Ma ago most of the Egyptian Shield had been unified into a single crustal plate, and subduction related (Na_2O-dominated) magmatism had ceased. The change to mainly crustal derived (K_2O- dominated) magmas was abrupt and characterized by onset of Dokhan type volcanism. (Abdel- Monem *et al.*, 1996). It should also be noted that the composition of the region controls the bulk chemistry of the initial melt. The degree and temperature of melting determine the CaO content of the melt which with high degrees of melting produces more calcic melts, (Wyllie, 1977).

The initial melts of the Egyptian Shield calc-alkaline island arc volcanics and continental crust source regions are probably granitic in composition with moderate to high K_2O. The post-accretion granitic magmas with moderate to high CaO (>1.5%) probably reflect moderate to high degree of melting. The residual source regions after extraction of the initial granitic melts will be poor in the volatiles and alkalis and rich in refractory calcic plagioclases, pyroxenes, amphiboles and accessory minerals such as sphene, magnetite, apatite and zircon. High temperature melting of such residual source regions in the presence of volatiles derived either from the dehydration of residual amphiboles or biotite or degassing of basaltic magmas, (Hildreth, 1981) could account for the characteristics of the alkali and alkali feldspar granites in the Egyptian Shield (Collins *et al.*, 1982). The proposed deep source regions for the Egyptian post-tectonic granites are supported by the commonly observed low initial 87Sr/86Sr ratios (0.702-0.703).

Geochemistry of U and Th.

Uranium and thorium contents were determined chemically in 7 samples including G. Abu Durba (3 samples) and G. Abu Haswa (4 samples). The obtained results of the uranium and thorium analyses are indicated by ppm as well as Th/U are shown in Tables (1&2). From this table, the uranium content of G. Abu Durba granitoids range from 8.8 to 18 ppm with an average 13.3ppm and thorium ranges from 26.5 to 46 ppm with an average 36ppm. The uranium contents of the G. Abu Haswa granitoids range from 6.5 to 13 ppm with an average 9.5 ppm and thorium ranges from 21to 34 ppm with an average 30 ppm which is coincided with the average U of the granitic rocks of Clark *et al.*(1966), and also introduce in the range of the acidic intrusive rocks of Adams *et al.*(1959) and the silicic intrusive rocks of Rogers and Adams (1967).

The geochemical behaviour of U and Th is examined by the U-Th variation diagrams of the studied rocks which exhibits strong positive relations between the two elements as shown in (Fig. 24). This reflects the systematic enrichement of both elements with magmatic differentiation due to their incompatible behaviour during magmatic processes.

Figure. 25 shows that the variation of Th/U ratios versus U of the studied rocks, where the decreasing Th/U is accompanied with enrichment in U which may suggest the U and Th contents were controlled by the presence of some accessory minerals such as zircon (Fig. 26) and iron oxides whereas iron oxide and hydroxides are know to absorb U from circulating fluids.

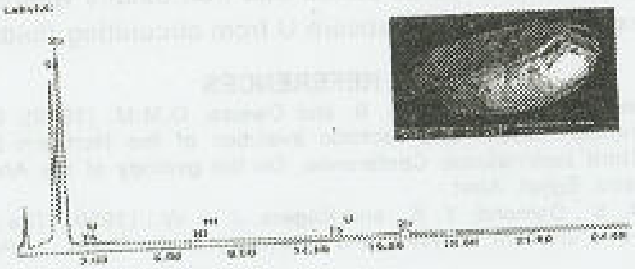


Figure (26): EDAX photomicrograph for some accessory minerals.

SUMMARY AND CONCLUSIONS

The Pan-African litho-tectonic rock units present in the studied area are including the granitoid rocks of G. Abu Durba– G. Abu Haswa area, comprise an elongate belt covering about 35 km2 and trending NW in the southwestern part of Sinai along the Gulf of Suez: The Granitoid rocks comprises intrusive bodies of phase III younger granites, which intruded into rhyolite, rhyodacite and equivalent pyroclastics of Dokhan volcanic type. Some granitic varities are porphyritic and others are mylonitized.

Geochmically, the granitoids of G. Abu Durba– G. Abu Haswa area are classified as granodiorite and granite (I-type) according to (Middlemost, 1985; Le Maitre, 1989; and Chappell and White, 1979). The granodiorites originated from metaluminous to peraluminous calc-alkaline magma that developed in volcanic arc setting. The granites originated from metaluminous to peraluminous calc-alkaline magma that developed within-plate. The studied granitoid rocks were generated at somewhat intermediate depths (9-21 km) equivalent to 3-7 Kb under temperature ranging from 760°-840°, (Wilson, 1989; James and Hamilton, 1969 and Winkler *et al.* 1975).

The concentrations of U and Th in the granitoid rocks were controlled by magmatic processes which are clear from the positive relation between U and Th and controlled by the presence of some accessory minerals such as zircon and iron oxides whereas iron oxide and hydroxides are know to absorb U from circulating fluids.

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جيولوجية وبترولوجية صخور الجرانيتدات في منطقة أبو دورية- أبو حصوة بالجنوب الشرقي لشبه جزيرة سيناء – مصر

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هيئة المواد النووية.

يتناول هذا البحث دراسة للصخور الجوفية بمنطقة جبل أبو دورية – جبل أبو حصوة الواقعة في الجنوب من شبه جزيرة سيناء وتشتمل على جرانيتدات من الطور الثاني (Phase II) والطور الثالث (Phase III) . وقد أوضحت الدراسة الجيوكيميائية أن هذه الجرانيتدات تكونت من ماجما كلسقلوية وافرة الألومنيوم (Peraluminous) في بيئة أقواس الجزر التكتونية بينما الماجما الجرانوايوراتية تكونت في بيئة داخل الألواح التكتونية (within-plate) وهذه الجرانيتدات تكونت على أعماق متوسطة ما بين (٩-١٢) كم في درجات حرارة ما بين (٧٦٠-٨٤٠) °م ترجع اشعاعية هذه الصخور الى تواجد عنصري اليورانيوم والثوريوم المرتبطين بالعمليات المجمائية وتواجدات بعض المعادن الاضافية مثل الزركون والأباتيت وأكاسيد الحديد.