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CONTRIBUTIONS TO THE GEOLOGY OF GABAL HADAYIB AND GABAL UM RISHA RING COMPLEXES, SOUTH-EASTERN DESERT, EGYPT

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ABSTRACT

Gabal hadayib includes two superimposed ring structures composed essentially of alkali syenites and alkali quartz syenites intruding alkali trachyte masses which represent remmants of the original volcanic cone. Gabal Um Risha is formed mainly of various alkali syenites, but alkali granites form an incomplete outer ring surrounding the syenites. Trachytes represent the uplifted parts of the old volcanic cone.

Syenites are composed of perthitic orthoclase, albite, antiperthite, quartz, aegirine-arfvedsonite-riebeckite alteration series, less commonly biotite and acmite. In the alkali granites, the amount of quartz increases, orthoclase and microcline are essential constituents.

The resemblance of the major elment chemistry and distributionb of the minor elements, in the two complexes, reveal their common parentage. The saturation of the rocks with silica, alkalic character and sodic tendencies are clear.

The general differention sequence of the rocks is found to be parallel to their order of emplacement in the field which started with the alkali trachytes followed by the alkali syenites and finally the alkali granites.

The rocks of the two complexes were formed through differentiation processes from a liquid melt, and are believed to bave a deep crustal source of mixed material from the mantle.

INTRODUCTION

Gabal Hadayib ring complexes lies at the intersection of latitude 23° 08 ' N, and longitude 33° 33' E, whereas Um Risha ring complex is located at the intersection of latitude 23° 18' N, and longitude 33° 18 ' E (Fig. 1).

These two ring complexes are among fifteen ones encountered in the Eastern Desert of Egypt. They represent the northward continuation of the chain of ring complexes that associate the East African rift system.

El-Ramly and others (1969, 1970, 1971, 1979, 1982 & 1985), grouped the Egyptian ring complexes into five groups on the basis of their magmatic differentiation, and the degree of development of the ring nature and complexity of the structure (Table 1).

These two ring complexes are included in the photogeological map scale 1 : 500,000 prepared by Hunting Geology and Geophysics (1967). On this map Gabal Um Risha complex is shown as a mass of syntectonic to late tectonic granite and granodiorite, whereas Gabal Hadayib complex is considered as a small stick of younger granite.

El-Ramly et al. (1979) refered briefly to their geological setting and petrography. The following field relations are based on this work (op. cit.).

Gabal Hadayib complex is intruded into metavolcanic rocks to its west and a variety of granitoids to its north and east. It includes two superimposed ring structures. The southern structure is constructed of an outer ring ridge and a conical central stock separated by a ring wadi. Both are composed of alkali syenite and alkali quartz syenite. The northern structure is formed of successive incomplete ring ridges of alkali quartz syenite and alkali syenite covered in part by alkaline trachyte porphyry with minor trachytes and pyroclastics which represent remnants of the volcanic cone invaded and uplifted by the intruding syenites.

Gabal Um Risha is a relatively larger structure, it is partly covered by Nubia sandstone. The complex is built up of an outer ring of alkali granite enclosing a mass of alkali syenite and alkali quartz syenite intruding remnants of the trachytic volcanic cone.

PETROGRAPHY

The syenites forming Gabal Hadayib and the central part of Gabal Um Risha are differentiated petrographically according to the classification of Streckeisen (1976) into two main types; alkali quartz syenites and alkali syenites (Fig. 3). These two varieties are similar in their mineralogical composition, but differ only in their model composition (Table 2).

Alkali feldspares are essentially perthite and antiperthite portray string, vein and braided varieties. It is clear that perthitization began from the peripheries. the boundaries between the perthite crystals are irregular and develop secondary albite intergrowths may show reaction zones on these boundaries. One phase of perthite may be observed to protrude the other. Antiperthite is usually fractured, with secondary albite growing on its expense. Secondary quartz may also attach the prepheries of the perthitized feldspars.

Mafic minerals are represented mainly by aegirine, arfvedsonite and riebeckitic arfvedsonite. Aegirine is generally altered to arfvedsonite and this alteration may continue to the development of riebeckite, thus forming the inseperable aegirine-arfvedsonite-riebeckite alteration series. It is strongly pleochroic in shades of deep grass green to brownish green with the most common formula X = emerald green, Y = grass green and Z = brownish green. Alkali small feldspar crystals are sometimes included in the aegrine.

Arfvedsonite subhedral corroded crystals are strongly pleochroic with the X = Bluish green, Y = yellowish brown and Z = greenish yellow.

Brown biotite occurs as coarse flakes enclosing fine crystals of alkali feldspar. It was noticed that biotite-bearing syenites are localized in the surroundings of the ring dyke encountered in the southern part of the complex.

Accessories include opaque minerals, sphene, apatite and zircon.

Trachytes, In Gabal Hadayib and Gabal Um Risha are differentiated into alkali quartz trachytes and alkali trachytes. With the increase of quartz in these trachytes the rocks loose their trachytic texture and orthoclase becomes more granular.

The megacrysts in the porphyritic varieties are represented essentially by kaolinized perthitic orthoclase, and antiperthitic oligoclase. Aegirine-augite rimmed with aegirine may form megacrysts in some of these trachytes.

The groundmass is formed mainly of orthoclase laths, clear irregular quartz grains, and aegirine-augite and aegirine. These alkali pyroxenes are generally altered to arfvedsonite which in turn alters to riebeckitic arfvedsonite and uncommonly to riebeckite.

The alkali granites forming the peripheral parts of Gabal Um Risha complex are pink, medium grained rocks, their average model composition (Table 3) is 60.6% alkali feldspars, 26.7% quartz, 1.6% plagioclase, 7.4% alkali pyroxenes and amphiboles, and 3.3% opaques and accessories.

The alkali feldspars are represented mainly by kaolinized perthitic orthoclase. Microcline forms subhedral to anhedral crystals, and perthitic microcline protrudes antiperthite. Secondary albite grows in the reaction zone on the peripheries of perthite and antiperthite.

Plagioclase is represented by oligoclase, it is corroded by quartz, alkali feldspar and aegirine.

Quartz is either primary or secondary, the latter protrudes perthite with reaction rims along the contacts. Graphic quartz with string perthite is common.

Aegirine is strongly pleochroic with X = deep green, Y = grass green, and Z = brownish green. It has a small extinction angle (0° - 5°). Some aegirine crystals enclose arfvedsonite. Acmite is reddish brown, it grows generally with aegrine, and is weakely to nonpleochroic.

Arfvedsonite is pleochroic with X = greenish blue, Y = greyish violet, Z = blue grey. The corroded borders of arfvedsonite crystals are attacked by quartz and perthite.

Riebeckite forms small prismatic crystals embedded in aegirine-arfvedsonite large crystals.

Teared yellowish brown biotite flakes, enclosing zircon inclusions, are observed in one sample only.

Accessories are apatite, zircon and opaque minerals including magnetite, ilmenite and less commonly hematite.

PETROCHEMISTRY

The results of analyses of twelve samples from Gabal Hadayib (Table 4) and fifteen samples from Gabal Um Risha (Table 5) representing the different rocks varieties show clearly that the rocks of the two ring complexes are to a certain extent comparable with the averages of Egyptian syenites, but are more sodic than the World averages. Their sodic character is expressed in the common presence of sodic plagioclase, pyroxenes and amphiboles in their model composition. The high contents of iron oxide and titania express the fair amount of opaques and accessories recorded in the studied thin sections.

The normative minerals of the rocks forming the two comlpexes (Table 6 and 7) as calculated using the modified method adopted by Hutchison (1974) compared with the World averages, indicating their sodic character.

Normative qualities are generally higher than that of the World averages and it is higher in the ricks of Um Risha relative to those of Hadayib. This is in accordance with the modal composition of these rocks. The appearance of corundum in the norm of most rocks indicates their enrichment in alumina.

Niggli values for the rocks of the two complexes (Tables 8 & 9), show that all values are higher than alk, followed by fm and finnaly c, indicating the general alkaline affinity of these rocks.

Petrochemical Relations of the Major Elements :

The plots of the Hadayib and Um Risha rocks on the FAM ternary digram (Fig. 5) show a certain correspondance with those of Gabal El Abyad complex (Baker et al., 1973) and Zukur-Hanish alkali series (Gase et al., 1973), but they have a more alkalic tendency.

On the K_2O - Na_2O - CaO diagram, the studied rocks (Fig. 6) show more sodic affinities than potassic. Sodium and calcium contents can be refered mainly to the alkali pyroxenes and amphiboles encountered in the rocks and observed clearly in their modal composition (Table 2 and 3) and explains the disposition of the plots in the plagioclase Or - An - Ab diagram diagram (Fig. 7). The boundary curve E - F on this diagram represents the trace of the two feldspar surface located by James and Hamilton (1969) on the quaternary system $CaAl_2Si_2O_8$ - $KAlSi_3O_8$ SiO_2, for liquids saturated with water at 1000 bar confining pressure. The plots are close to the Or-Ab side line beyond the terminal end of the boundary curve at which resorption rather than co-precipitation occurs (Tuttle and Bowen 1958, p. 133 - 134).

The plots of the samples on the SiO_2 - $NaAlSi_3O_8$ - $KAlSi_3O_8$ (normative Qz - Ab - Or) diagram (Fig. 8), lie mostly on the temperature vally (Tuttle and Bowen, 1958) in the sodic side and the samples with relatively high percent of model potash feldspar and minor amounts of alkali pyroxenes and ampniboles lie on the potash feldspar side. It is also noticed clearly that all samples lie far from the SiO_2 corner under the seperating line towards the Ab - Or side line. This indicates the crystallization of these rocks through differentiation processes from a liquid melt.

On Fig. (9), the silica rich rocks are to a certain extent comparable with the different complexes portrayed on the diagram particularly the volcanics of the Ethiopian plateau (Mohr, 1971), Hanish-Zukur (Gase et al., 1973), and Gabal El Abyad complex (Baker et al., 1973).

The plots of the Niggli values al against fm of the studied rocks (Fig 10) are located in the area of the salic-magma according to Niggli's classificaltion (Burri, 1959). The plots of the values alk. vs. al on the diagram after Burri (1964 p. 84) (Fig. 11) show that Hadayib rocks are enriched in alkalies relative to those of Um Risha.

Petrochemical Characters of Minor Elements :

Seven representative samples from each complex were analysed for Zr, Y, Sr, Rb, Ba, Nb, Be and La. The results are shown in Table 10 and 11.

The average Zr content of Gabal Hadayib is not far above the 500 ppm value reported by Turekian and Wedepohl (1961) but for the rocks of Gabal Um Risha it is much less. On the other hand, these averages are very low compared with that given by El-Reedy and El-Sokkary (1982) which is 864 ppm. These two authors (op. cit.) attributed the high Zr content in their samples to an additional independant mineral source for Zr, such as zircon, beside its presence in the structure of other minerals. Gabal Hadayib and Gabal Um Risha rocks plot close and on either side of the Zr limit of 550 ppm, separating the peralkaline from the albitized non-peralkline rocks defined by Bowden and Turner (1974).

The contents of the two lithophilic elements Zr and Nb in these two complexes increase with the increase in the modified differentiation index (Fig. 12) and this is in accordance with the process of magmatic differentiation of metals enriched in alkalies, which first give rise to miaskitic syenites and then to agpaitic rocks enriched in volatiles (F, Cl, ... etc.) and trace elements (Gerasimovsky et al., 1966 snd Varet, 1964).

The rocks of Gabal Hadayib and Um Risha complexes are generally miaskitic (Na + K < Al) and according to Gerasimovsky (1974), Zr in miaskitic syenites is bound in zircon and in the rock-forming minerals containing Ti.

Taylor (1965) quoted Ringwood (1955) finding that the high content of volatiles in the last stages of alkali magma differentiation leads to a decrease in polymerization of the magma and the subsequent concentration of elements such as Zr, Nb, Ta, Hf and the rare earthes and other complex-forming elements of high ionic potantial. The coherent relation of Zr and Nb can be noticed in the variation diagram (Fig. 12) where an increase in Nb with Zr is observed.

The high content of Nb (Table 10 & 11) in the samples compared with the average Nb content in igneous rocks (28 ppm) and that of E1 Reedy and E1

Sokkary (1982) which is 122 ppm, confirms the alkali magmatic origin of these rocks.

The averages of Y in the two complexes (Tables 10 & 11) are higher than that reported by Turekian and Wedepohl (1961) for syenites which is 20 ppm, but they are far below the average of 74 ppm given by El Reedy and El Sokkary.

Y in these two complexes tends to increase with the increase in the D. I. (Fig. 12). Alexiev (1970) believed that the increase in heavy rare earth elements (e.g. Y) is connected with trace elements overprinting of a magmatic complex by post-magmatic solutions enriched in rare earths together with Nb, Sr, Zr, Rb .... etc. Indeed Alexiev (op. cit.) postulated that there is a direct correlation between the degree of albitization and the rare earth abundance patterns. Y has the tendency to replace Ca^{++} during magmatic differentiation. It is expected to be captured in early Ca position. In the miaskitic syenites the R. E. E. concentrations are in Ca-bearing minerals namely apatite, titanite .... etc. (Gerasimovsky 1974).

The average La contents (Table 10 & 11) are in harmony with that of Turkish and Wedepohl (1961) for syenites.

No independant minerals are known for Ba, Rb and Sr elements in the saturated alkaline rocks. Their geochemistry is thus related to the rock-forming minerals. Sr accompanies Ca and is depleted with porgressive differentiation (Fig. 12). The inter-replacement between Ba and K is stronger than that between Ba and Ca. In the studied rocks Ba shows an increase with differentiation (Fig. 14). Rb substitutes K isomorphously in its minerals such as K-feldspars and increases with differentiation (Fig 12).

Sr content in Gabal Hadayib rocks (Table 10) is very low if compared with that reported by Turekian and Wedepohl (1961) for syenites and is still lower than the average of some Egyptian syenites given by El Reedy and El Sokkary (1982). In Gabal Um Risha Sr is also very low (Table 11).

Sr content in these miaskitic rocks may be used as a geochemical indicator for their origin, where rocks having low Sr content might be considered as products of palingensis (Gerasimovsky, 1974).

Rb content in Gabal Hadayib rocks is lower than the averages shown on Table 10, while that of Gabal Um Risha is very low (Table 11). Taylor (1965) defined the limits for normal K/Rb ratio to be 150 - 300 with an average of 230 for crustal rocks. The high K / Rb ratios of the present rocks (Table 10 & 11) indicate deep crustal source of mixed material from the mantle near a continental margin.

Rb / Sr ratios in Gabal Hadayib rocks ranges between 0.74 and 1.85 which places them in a zone of formation between the zone of continental granophyre and the zone of Red Sea granophyre (Coleman and Peterman, 1975). In the rocks of Gabal Um Risha this ratio ranges between 0.41 and 0.85 thus placing them in the zone of continental granophyre (Coleman and Peterman op. cit.).

Ba in both complexes increase with the increase in the differentiation index (Fig. 12).

Be substitutes Si and Al isomorphously in the minerals. It is enriched in the feldspars relative to the ferromagnesian minerals. In the two complexes Be decreases with the increase in the D. I. (Fig. 12) and it is essentially concentrated in the quartz-bearing varieties (Table 10 & 11).

DISCUSSION

The two ring complexes of Gabal Hadayib and Gabal Um Risha are similar to Gabal Mansouri complex (El Ramly and Hussein, 1982), in the variety of rock types they include and their structural setup.

The episode of alkaline magmatism in Egypt lasted for a long lapse of time from the Cambrian to the Upper Cretaceous (Serencsits et al., 1979). Lutz (1979) was the first to suggest that this magmatism was episodic and that a period of 52 Ma separates each episode from the next. The youngest episode dates back to 38 Ma age, this is the age of the most recent complex in Uweinat area, and the age of the first or oldest in 544 Ma during which the complex of Wadi Did was emplaced.

Accordingly, eleven intrusive cycles are predicted, six of which have been already recorded in Egypt, the others are not known as yet either because of the lack of age dating for all known ring complexes in Egypt or because they were formed but do not crop out on the present day surface of erosion. Unfortunately, the two studied ring complexes are among those which have not yet been dated, but the great similarity in the rock types forming them with those of Gabal Zargat Naam and the two Tarbties which gave age of 404 and 341 Ma respectively, the age of the fourth and fifth alkaline magmatic cycles, may suggest that these two complexes were emplaced during one or the other of these two cycles.

The Egyptian ring complexes including the two studied ones are distributed along lineaments parallel to the two trends N30W and ENE (El Ramly et. al., 1971). Thus, Gabal Hadayib and Gabal Um Risha together with Gabal Zargat Naam lie on an ENE line, and with Gabal El Gezira and Gabal Mansouri lie on a line trending NNW.

Garson and Krs (1976) suggested that the distribution of the ring complexes in Egypt is controlled by these two trends; the first (N60E) represent crustal block faults and shear zones, where the second (N30 W) represent deep-seated tectonic zones related to the opening of the red sea.

In a more recent publication de Gruyter and Vogel (1981) agreed with the idea of Garson and Krs (op. cit.) that the Egyptian ring complexes are intimately associated with major lineaments in the Nubian Shield and postulated that all of them had a similar origin not directly related to rifting and/or doming; an idea was previously emphasized by El Ramly et al., (1971) The alkaline melts which gave rise to these complexes are believed by de Gryter and Vogel (1981) to have been formed in the asthenosphere by shear heating caused by changes in plate motion. In support to this idea they mentioned that the ages of these alkaline complexes appear to be synchronous with changes of plate motion. The magma thus produced were emplaced along reactivated Pan-African fractures or pre-existing zones of weakness.

The two ring complexes are to a great extent geochemically similar, and this may indicate the common parentage of these rocks. Their saturation with silica, alkalic character and sodic tendencies are clear.

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Table (1) : Types of Ring Complexes

Lithology	WIDE RANGE OF ROCK TYPES.		LIMITED RANGE OF ROCK TYPES	
STRUCTURE	With Ne	Without Ne	With Ne	Without Ne
	I. ABU KHRUQ TYPE	II. CEZIRA TYPE		
Well Defined Ring Nature	1. Abu Khruq 2. El-Naga 3. El-Kahfa 4. Nigrub	1. El-Gezira		
Poorly Defined Ring Nature			III. MISHBEH TYPE	IV MANSOURI
			1. Mishbeh 2. Wadi Dib	1.Nansouri 2. Hadayib 3. Umn Risha
Ring Dykes				V. TARBTIE TYPE
				1. Tarbtie South 2. Tarbtie North

Table (2) : Modal Analysis of the rocks forming Gabal Hadayib Ring complex.

Rocke Name (Number of samples)	Alkali Quartz Syenite (6)	Alkali Syenite (4)	Alkali Quartz Trachyte (1)	AlkaliTrachyte (1)
Alkalifeldspars	71 - 88	88 - 94	81	79
Plagioclases	0 - 3	0 - 5	2	-
Quartz	5 - 8	1 - 2	12	5
Mafics	1 - 20	3 - 7	2	13
Opaques	1 - 6	1 - 7	3	3
Accessories	0 - 1	0 - 1	-	-
Color Index	7 - 24	5 - 10	5	16

Table (3) : Modal Analysis of the rocks forming Gabal Um Risha Ring complex.

Rocke Name (Number of samples)	Alkali Q Granite (7)	Alkali Quartz Syenite (2)	Alkali Syenite (3)	AlkaliQuartz Trachyte (2)	Alkali Trachyte (1)
Alkalifeldspars	57 - 65	76 - 87	83 - 89	72 - 80	74
Plagioclase	0 - 4	0	0	0 - 4	0
Quartz	20 - 30	5 - 9	2 - 3	8 - 14	2
Mafics	6 -13	5 - 10	6 - 12	0 - 2	22
Opaques	1 - 7	2 - 4	2	7 - 10	2
Accessories	0 - 1	1	0 - 1	1 - 2	0
Color Index	7 - 17	8 - 15	9 - 14	10 - 12	24

Table (4) : Majpr element contents (Wt. %) of Gabal Hadayib rocks

Rock / Type	Alkali Quartz Syenite						Alkali Syenite				Alkali Quartz Trachyte	Alkali Trachyte	I	II	III	IV	V
Sample No.	421	425	479	413	431	453	279	420	428	473	419	417					
SiO_2	64.44	66.11	71.20	63.01	65.30	64.39	64.33	65.46	64.28	64.33	65.60	63.11	62.97	58.58	61.86	62.70	61.21
TiO_2	0.30	0.12	0.05	0.47	0.17	0.48	0.56	0.73	0.68	0.52	0.62	0.60	0.54	0.84	0.58	0.50	0.70
Al_2O_3	15.26	16.28	14.24	16.65	16.75	16.28	16.03	16.24	16.56	16.05	16.36	16.64	15.43	16.64	16.91	15.69	16.96
Fe_2O_3	2.76	1.81	3.28	2.32	5.15	2.36	1.78	4.73	2.51	2.06	1.49	2.82	4.13	3.04	2.32	4.12	2.99
Fe O	4.01	1.27	0.42	4.41	0.39	2.55	1.61	1.12	3.34	1.64	3.15	4.04	2.65	3.13	2.63	3.07	2.29
Mn O	0.06	0.04	0.73	0.09	0.04	-	-	0.04	0.09	-	0.06	0.07	0.17	0.13	0.11	0.16	0.15
Mg O	1.74	0.44	0.22	1.15	0.22	0.89	0.90	0.22	0.22	0.66	0.09	0.53	0.73	1.87	0.96	1.20	0.93
Ca O	1.85	1.23	0.92	1.29	0.62	1.23	2.23	1.23	1.23	1.54	1.85	0.62	1.64	3.53	2.54	2.24	2.34
Na_2O	5.18	5.82	5.54	6.87	4.93	6.35	6.47	5.54	5.66	7.52	5.58	6.53	6.00	5.24	5.46	5.70	5.47
K_2O	3.40	4.58	2.82	2.32	4.94	4.10	4.58	3.36	4.06	4.10	3.54	3.40	4.55	4.95	5.91	4.10	4.98
P_2O_5	0.21	0.44	0.25	0.30	0.44	0.19	0.09	0.02	0.35	0.28	0.35	0.35	0.11	0.29	0.19	0.13	0.21
H_2O^+	0.31	1.33	0.09	0.88	0.41	0.66	0.93	0.83	0.77	0.80	0.91	0.98	-	0.99	0.53	-	1.15
H_2O^-	0.20	0.22	0.10	0.11	0.22	0.09	0.09	0.20	0.09	0.13	0.18	0.13	-	0.23	-	-	0.47
CO_2														0.28			0.09
D.I	10.48	12.59	12.63	10.18	13.70	12.01	11.68	11.97	12.37	11.91	11.78		11.88				

D.I. : Differentiation Index (1/3 Si + K) - (Ca + Mg), (Nockolds. and Allen, 1953).
I : Average Egyptian syenites (Aly and Mostafa, 1984).
II : Average World syenites (Le Maitre, 1976).
III : Average alkali syenites (Nockolds, 1954).
IV : Average Egyptian trachytes (Aly and Mostafa, 1984).
V : Average World trachytes (Le Maitre, 1976).

Table (5) : Major Element contents (Wt %) of Gabal Um Risha rocks.

Rock Type	Alkali Granite							Alkali Quartz Syenite		Alkali Syenite			Alkali Quartz Trachyte		Alkali Trachyte							
Sample No.	313	596	608	618	619	629	665	624	631	615	666	675	616	671	632	I	II	III	IV	V	VI	VII
SiO_2	69.36	72.33	70.00	68.73	63.55	69.71	69.01	60.91	64.59	63.71	68.41	66.58	68.66	68,57	60.33	62.97	58.58	61.86	75.31	74.84	62.70	61.21
TiO_2	0.28	0.27	0.32	0.27	0.78	0.15	0.54	1.88	2.01	0.60	0.38	0.88	0.68	0.27	1.66	0.54	0.84	0.58	0.30	0.07	0.50	0.70
Al_2O_3	15.20	11.23	12.20	15.41	16.42	14.15	13.20	13.05	13.56	15.75	15.30	15.99	13.43	12.69	14.03	15.43	16.64	16.91	11.98	11.24	15.69	16.96
Fe_2O_3	3.91	3.76	4.75	3.97	4,70	2.73	4.33	2.53	3.45	3.54	3.00	1.82	4.87	5.12	2.90	4.13	3.04	2.32	2.03	1.06	4.12	2.99
FeO	1.33	0.55	2.44	1.27	1.15	0.97	1.21	6.25	5.89	2.00	1.00	1.88	0.42	1.10	5.52	2.65	3.13	2.63	2.48	1.27	3.07	2.29
MnO	-	0.13	0.16	0.11	0.04	0.0.9	0.10	0.13	0.10	0.08	0.18	0.15	0.21	0.07	0.08	0.17	0.13	0.11	0.06	0.02	0.16	0.15
MgO	0.87	0.36	0.44	0.23	1.31	1.74	0.94	0.87	0.44	0.98	0.22	1.13	0.68	0.22	2.18	0.73	1.87	0.96	0.21	0.11	1.20	0.93
CaO	0.92	1.60	1.21	1.02	2.23	0.92	2.16	4.84	1.23	2.03	1.32	3.08	1.21	3.02	3.02	1.64	3.53	2.54	0.80	0.54	2.24	2.34
Na_2O	3.46	4.59	4.35	3.87	4,31	3.73	4.77	5.54	5.18	6.87	5.52	4.44	5.18	4.02	6.07	6.00	5.24	5.46	3.89	4.29	5.70	5.47
K_2O	3.11	4.41	3.54	4.18	3.92	4.95	2.36	2.71	2.31	3.58	3.72	3.33	3.48	3.71	3.07	4.55	4.95	5.91	4.13	4.28	4.10	4.98
P_2O_5	0.46	0.18	0.09	0.18	0.41	0.23	0.39	0.14	0.18	0.23	0.32	0.12	0.16	0.14	0.39	0.11	0.29	0.19	0.07	0.01	0.13	0.21
H_2O^+	0.64	0.33	0.29	0.33	0.35	0.35	0.66	0.42	0.39	0.28	0.26	0.50	0.26	0.31	0.29		0.99	0.53		0.03		1.15
H_2O^-	0.20	0.17	0.11	0.11	0.10	0.13	0.18	0.18	0.10	0.09	0.02	0.11	0.11	0.11	0.08		0.23			0.04		0.47
D. I.	12.22	13.54	12.71	13.30	10.76	13.25	10.59	7.74	10.82	10.85	12.67	10.14	10.85	11.46	8.10							

D.I. : Differentiation Index (1/3 Si + K) - (Ca + Mg), (Nockolds. and Allen, 1953).
I : Average Egyptian syenites (Aly and Mostafa, 1984).
II : Average World syenites (Le Maitre, 1976).
III : Average alkali syenites (Nockolds, 1954).
IV : Average Egyptian trachytes (Aly and Mostafa, 1984).
V : Average World trachytes (Le Maitre, 1976).
VI : Average Egyptian trachytes (Aly and Mostafa, 1984).
VII : Average world trachytes (Le Maitre, 1976).

Table (6) : CIPW norm values of Gabal Hadayib rocks.

Rock Type	Alkali Quartz Syenite						Alkali Syenite				Alkali Quartz Trachyte	Alkali Trachyte	I	II	III	IV	V
Sample No.	421	425	479	413	431	453	279	420	428	473	419	417					
O	13.34	12.03	26.74	8.00	16.88	7.27	5.17	17.79	12.80	2.83	14.90	9.49	6.70	0.83	1.85	7.39	5.00
C	0.41	0.51	1.12	1.22	3.06			1.53	1.73		1.02	2.14					
Or	20.04	27.28	16.70	13.92	29.50	24.49	27.28	20.04	23.94	24.49	21.15	20.04	27.02	29.29	34.96	24.22	29.41
Ab	44.05	49.30	46.67	58.21	41.96	54.02	54.54	46.67	47.72	59.79	47.20	55.06	54.15	44.34	46.15	51.18	46.26
Am	7.23	3.34	2.78	4 17	0.28	3.62	1.11	5.29	3.34		6.40	0.28	1.74	7.24	4.13	5.12	7.05
Ac										3.24							
En													0.35			1.88	
Fs													0.13			0.82	
Di						1.37	5.76			4.79			4.57	5.35	5.94	4.12	2.14
Wo							0.81										
Hy	9.07	1.90	0.60	8.32	0.60	3.53		0.60	3.64	0.67	3.90	5.40		4.16	1.43		2.06
Mt	3.94	2.55	3.47	3.47	1.16	3.47	2.55	1.85	3.71	1.37	2.09	4.17	4.34	4.41	3.36	4.31	4.33
Il	0.61	0.31	0.15	0.91	0.31	0.91	1.06	1.37	1.37	1.06	1.22	1.22	0.76	1.60	1.10	0.70	1.34
Hm			0.96		4.31			3.51									
Ap	0.67	1.01	0.67	0.67	1.01	0.34	0.37	0.34	1.01	0.67	1.01	1.01	0.23	0.70	0.45	0.27	0.49
Cc														0.64			0.20

I, II, III, IV, V, same as in table 4.

Table (7) : CIPW norm values of Gabal Um Risha rocks.

Rock Type	Alkali Granite							Alkali Quartz Trachyte		Alkali Syenite			Alkali Quartz Trachyte		Alkali Trachyte	I	II	III	IV	V	VI	VII
Sample No.	313	597	608	618	619	629	665	624	631	615	666	675	616	671	632							
Q	33.47	27.94	28.12	28.30	17.61	25.29	27.40	8.53	20.19	6.43	19.17	19.59	22.53	26.38	4.45	6.70	0.83	1.85	32.51	35.05	7.39	5.00
C	5.51			3.06	1.94	1.73			0.51		0.41											
Or	18.37	26.16	21.15	24.49	23.38	29.50	13.92	16.14	13.92	21.15	22.27	19.48	20.04	21.71	18.37	27.02	29.29	34.96	24.78	25.29	24.22	29.41
Ab	29.37	33.04	37.23	35.52	36.71	31.47	40.38	46.67	44.05	58.21	46.67	37.76	44,05	14.09	51.37	54.15	44.34	46.15	35.48	33.98	51.18	46.26
An	1.67		3.06	4.17	8.35	2.50	7.79	2.78	5.29	1.67	4.73	13.91	3.34	5.84	1.95	1.74	7.24	4.13	0.58		5.12	7.05
Ac		5.08																		1.11		
En																0.35					1.88	
Fs																0.13					0.82	
Di		1.95	1.77				0.43	16.90		4.98	1.30	0.44	1.52	1.30	8.52	4.57	5.35	5.94	2.39	1.02	4.12	2.14
Wo		1.97						0.23						2.79						1.03		
Hy	2.21		0.53	0.60	3.31	4.32	2.11		5.85	0.10		3.76	1.00		6.34		4.16	1.43		0.85		2.06
Mt	3.47	1.62	6.95	3.94	1.62	3.01	2.08	3.70	5.09	4.86	2.78	2.78	0.23	3.01	4.17	4.34	4.41	3.36	2.16	0.98	4.31	4.33
Il	0.61	0.46	0.61	0.46	1.52	0.30	1.37	3.64	3.79	1.21	0.76	1.67	1.21	0.46	3.19	0.76	1.60	1.10	0.42	0.13	0.70	1.34
Hm	1.60	0.96		1.28	3.51	0.64	2.87			0.16	1.12		4.79	3.04								
Ap	1.01	0.34	0.34	0.34	1.01	0.67	1.00	0.34	0.34	0.67	0.67	0.34	0.34	0.34	1.01	0.23	0.70	0.45	0.15	0.02	0.27	0.49
Cc																	0.64					0.20

I, II, III, IV, V, VI, VII, same as in table 5.

Table (8) : Niggli values of Gabal Hadayib rocks.

Rock Type	Alkali Quartz Syenite						Alkali Syenite				Alkali Quartz Trachyte	Alkali Trachyte				
Sample No.	421	425	479	413	431	453	279	420	428	473	419	417	I	II	IV	V
al	34	42	41	37	43	39	41	41	40	38	42	39	34.81	33.09	33.77	37.51
fm	31	14	19	27	20	21	15	21	21	16	17	25	25.09	26.33	27.73	21.30
c	8	6	5	5	3	5	9	6	6	7	8	3	6.73	12.76	8.77	9.40
alk	27	38	35	31	34	35	35	32	33	39	33	33	33.37	27.82	29.73	31.80
si	246	292	394	238	282	257	247	280	264	257	282	249	241.06	197.76	229.03	229.74
k	0.300	0.343	0.252	0.184	0.399	0.299	0.320	0.288	0.321	0.267	0.297	0.255	0.33	0.38	0.32	0.37
mg	0.321	0.212	0.094	0.240	0.078	0.250	0.333	0.072	0.070	0.258	0.031	0.123	0.17	0.36	0.24	0.24
qz	38	40	109	14	46	17	7	52	32	4	50		17			10.09
	2.55															

I, II, III, IV, V, same as in table 4.

Table (9) : Niggli values of Gabal Um Risha rocks.

Rock Type	Alkali Granite							Alkali Quartz Trachyte		Alkali Syenite			Alkali Quartz Trachyte		Alkali Trachyte	I	II	IV	VI
Sample No.	313	597	608	618	619	629	665	624	631	615	666	675	616	671	632				
al	43	34	34	43	38	39	35	27	33	36	41	39	37	34	29	34.81	33.09	36.77	33.77
Rm	26	20	30	22	26	26	26	30	34	22	17	21	24	23	34	25.09	26.33	22.33	27.73
c	5	9	6	5	9	4	11	18	6	8	7	14	6	15	11	6.73	12.76	4.83	8.77
alk	26	37	30	30	27	31	28	25	27	34	35	26	33	28	26	33.37	27.82	36.07	29.73
si	335	369	325	326	251	322	314	214	267	243	313	274	316	309	204	241.06	197.76	424.14	229.03
k	0.371	0.388	0.349	0.415	0.375	0.470	0.245	0.246	0.229	0.255	0.310	0.327	0.300	0.375	0.252	0.330	0.380	0.410	0.320
mg	0.242	0.134	0.103	0.079	0.306	0.467	0.242	0.154	0.080	0.247	0.98	0.338	0.193	0.070	0.321	0.170	0.360	0.080	0.240

I, II, IV, VI, same as in talbe 5

·le (10) . Distribution of Minor Elements (ppm) in the rocks of Gabal Hadayib.

·k Type	Alkali Quartz Syenite				Alkali Syenite		Alkali Trachyte	Average Syenites	
ıple No.	421	413	431	453	279	420	417	I	II
	622	840	513	500	430	396	560	500	864
	32	51	41	19	18	28	49	20	74
	110	60	91	51	41	61	70	200	110
	93	111	67	92	70	45	81	110	99
	631	731	1100	510	400	680	815	1600	339
	205	190	140	100	103	119	171		83
	6.1	5.2	7.3	4.2	3.6	3.3	4.0		
	67	91	82	43	63	56	101	70	
/ Rb	303	174	612	370	543	620	348		
·/ Sr	0.85	1.85	0.74	1.80	1.74	0.74	1.16		

Average syenites after Turekian and wedepohl, 1961.

Average of 10 samples of Egyptian alkaline syenites from the ring complexes of Gabal Tarbti, Gabal Nigrib El Tahtani and Gabal El Gezira, after El Reedy and El Sokkary, 1982.

Table 11. Distribution of Minor Elements (ppm) in the Rocks or Gabal Um Risha

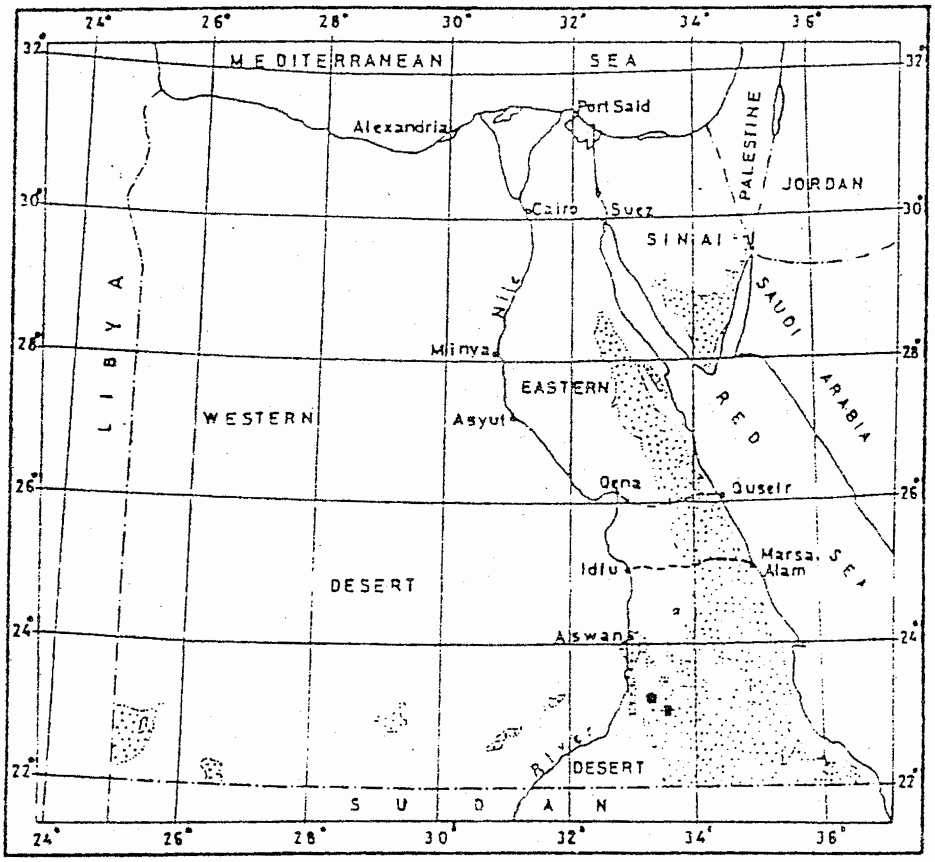
Rock Type	Alkali Granite	Alkali Quartz Syenite	Alkali Syenite			Alkali Quartz Trachyte	Alkali Trachyte	Average Syenites	
Sample No.	618	631	615	666	675	616	632	I	II
Zr	81	720	230	113	199	650	640	500	864
Y	21	41	22	62	17	39	49	20	74
Sr	75	65	56	76	60	41	68	200	110
Rb	31	42	29	35	30	35	39	110	99
Ba	641	913	480	303	400	870	790	1600	339
Nb	11	193	88	17	120	182	206		83
Be	2.2	5.6	1.2	6.6	1.8	5.2	4.8		
La	15	113	65	75	72	97	117	70	
K/Rb	1119	457	1024	883	920	814	654		
Rb/Sr	0.41	0.65	0.52	0.46	0.50	0.85	0.57		

I. Average syenites after Turekian and Wedepohl, 1961.

II. Average of 10 samples of Egyptian alkaline syenites from the ring complexes of Gabal Tarbti, Gabal Nigrib El-Tahtani and Gabal El Gezira, after El Reedy and El Sokkary, 1982.

KEY MAP

Fig. 1



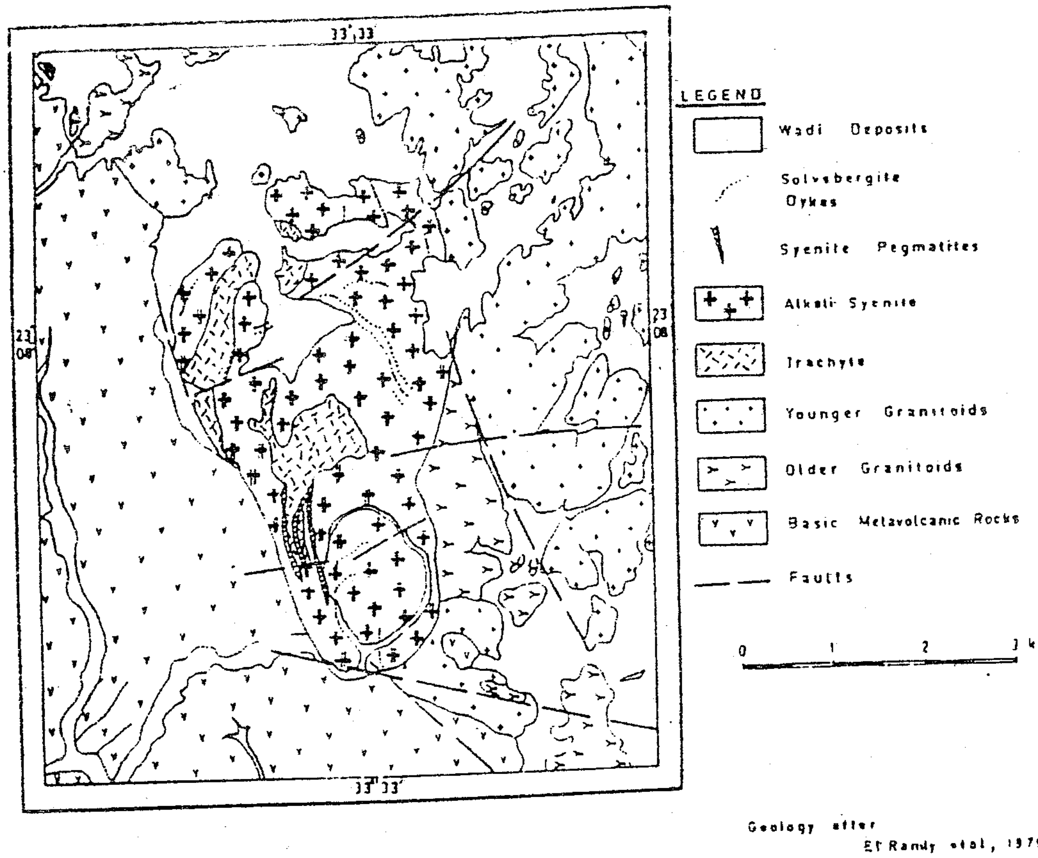
Scale 1: 10,000.000

Basement Complex

● Gabal Um Risha ■ Gabal Hadayib

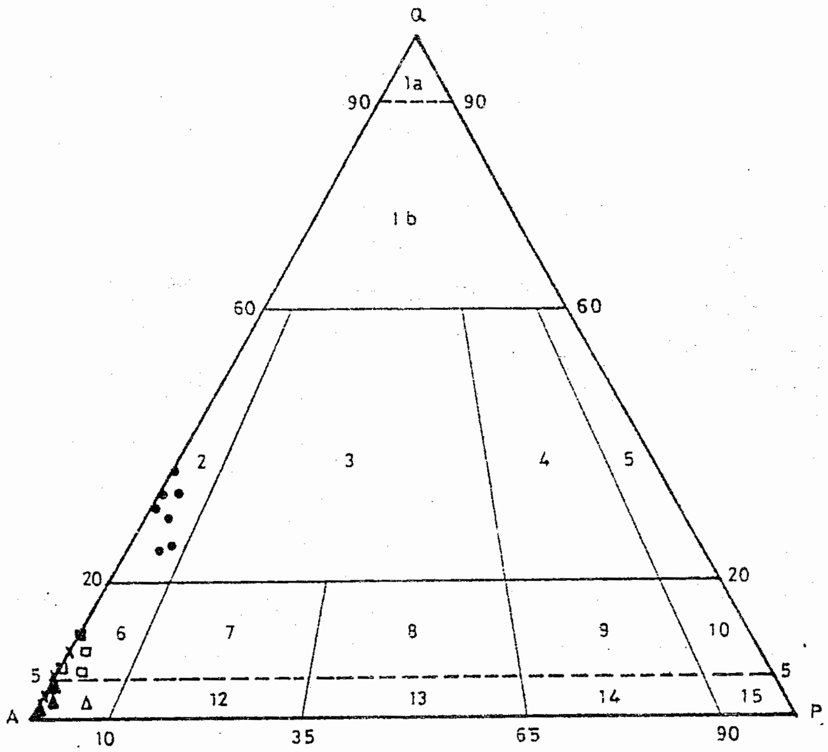
Fig. (2)

PHOTOGEOLOGICAL MAP OF GABAL HADAYIB
RING COMPLEX



(Key to symboles for all figures)

Hadyib	Um Risha	
○	●	Alkali granite
□	■	Alkali quartz syenite
Δ	▲	Alkali syenite
x	▼	Alkali quartz trachyte
+	⊠	Alkali trachyte



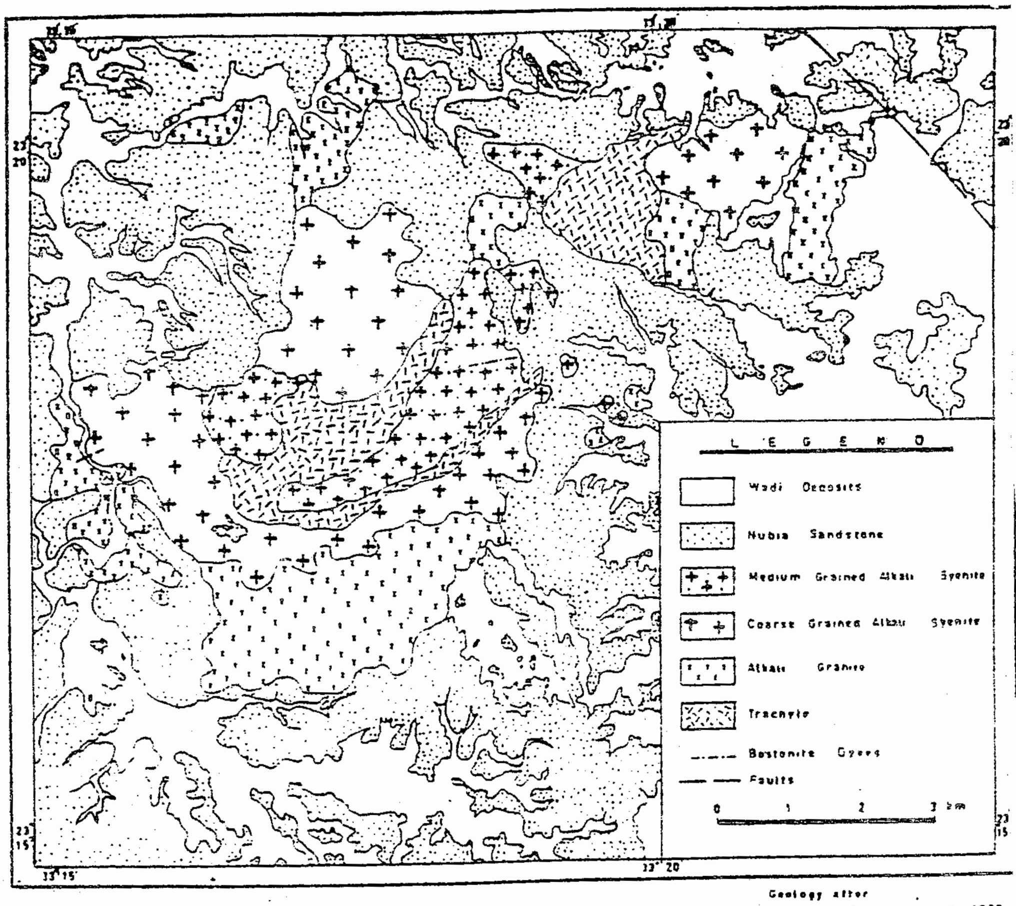
2 - Alkali feldspar granite

6 - Quartz alkali feldspar syenite

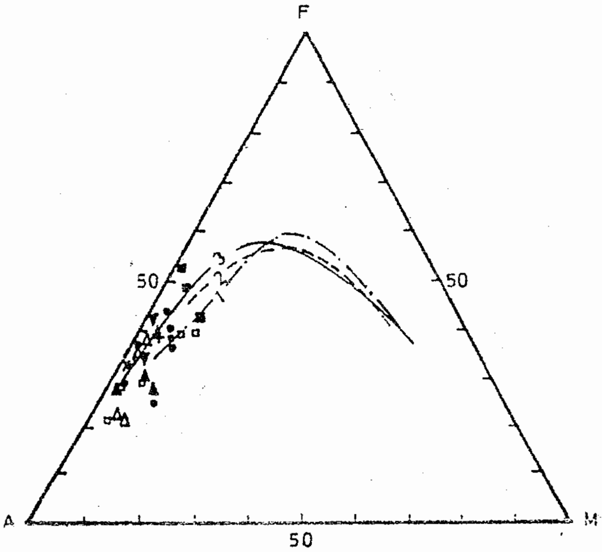
11 - Alkali feldspar syenite

Fig. 3. Classification and nomenclature of plutonic rocks according to their mineral content of Gabal Hadayib and Gabal Um Risha.

Fig. 4. PHOTOGEOLOGICAL MAP OF UM RISHA RING COMPLEX



Geology after
El Ramly et al., 1979



1 - Hawaiian alkalic series (Macdonald and katsura, 1964).
2 - Zukur-Hanish alkalic series (Gass et. al., 1973).
3 - Gabal El Abyad complex (Baker et. al., 1973).

Fig. 5. FAM ternary diagram for Gabal Hadayib and Gabal Um Risha

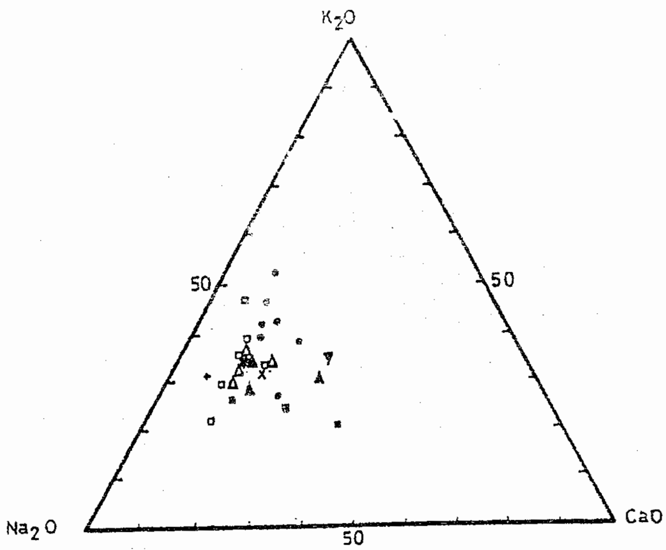
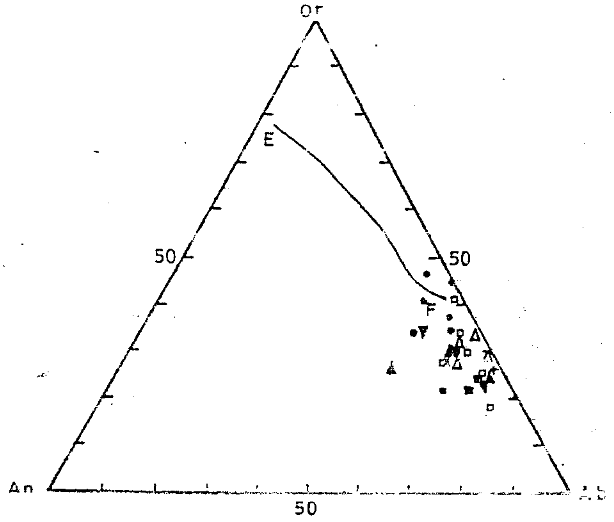


Fig. 6. K_2O - Na_2O - CaO ternary diagram for Gabal Hadayib and Gabal Um Risha.



Curve E-F after James and Hamiton, 1969.

Fig. 7. Normative Or-An-Ab ternary diagram for Gabal Hadayib and Gabal Um Risha.

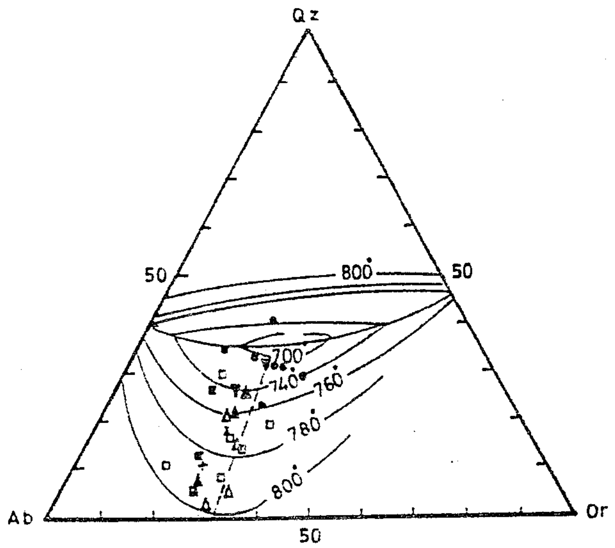
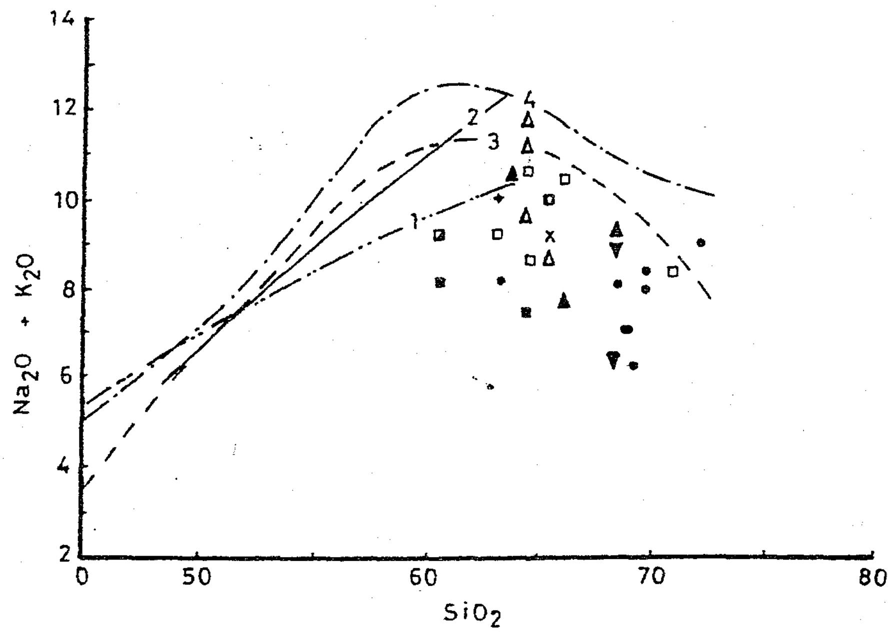


Fig. 8. Ternary diagram of the system SiO_2-$NaAlSi_3O_8$-$KAlSi_3O_8$ for Gabal Hadayib and Gabal Um Risha rocks.



1 - Hanish - Zukur alkalic series (Gass et. al., 1975) .
2 - Hawaiian alkalic series (Macdonald and katsura, 1964).
3 - Ethiopian Plateau volcanics (Mohr, 1971) .
4 - Gabal El- Abyad complex (Baker et. al., 1973) .

Fig. 9. SiO_2 vs total alkalies plot for Gabal Hadayib and Gabal Um Risha .

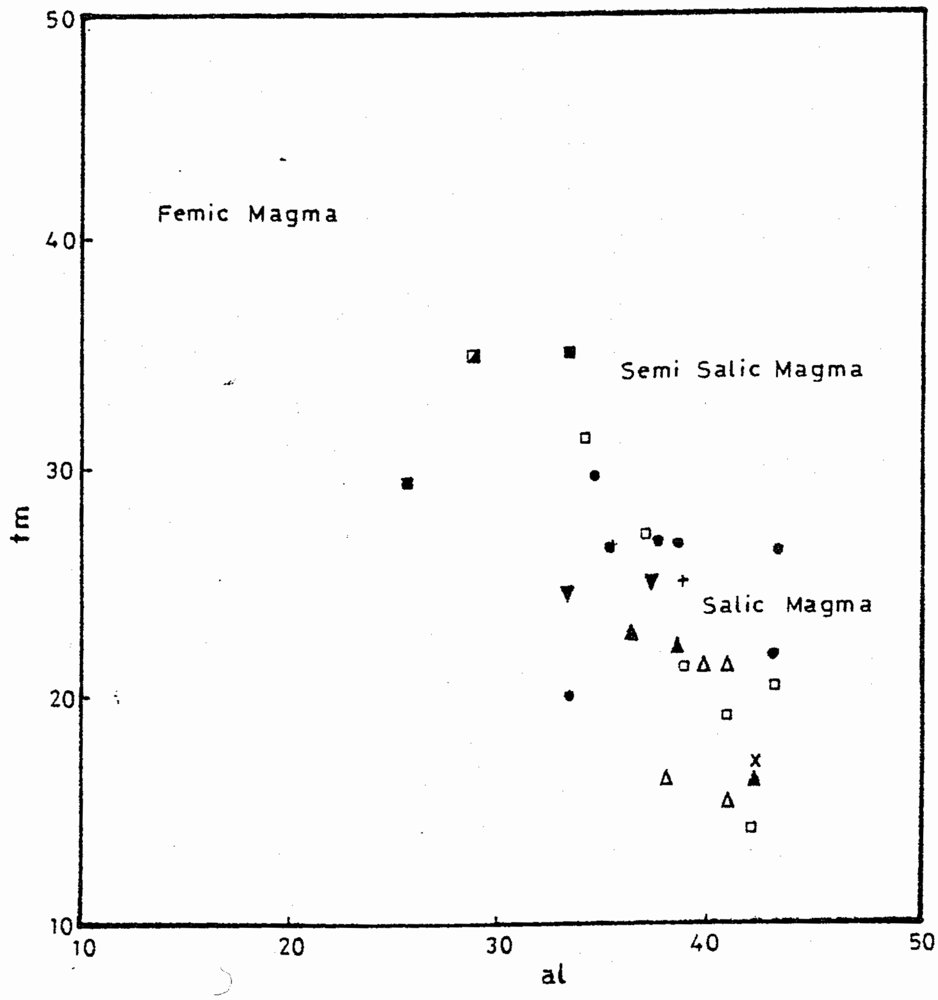


Fig. 10. Plot of Niggli values al vs fm for Gabal Hadayib and Gabal Um Risha.

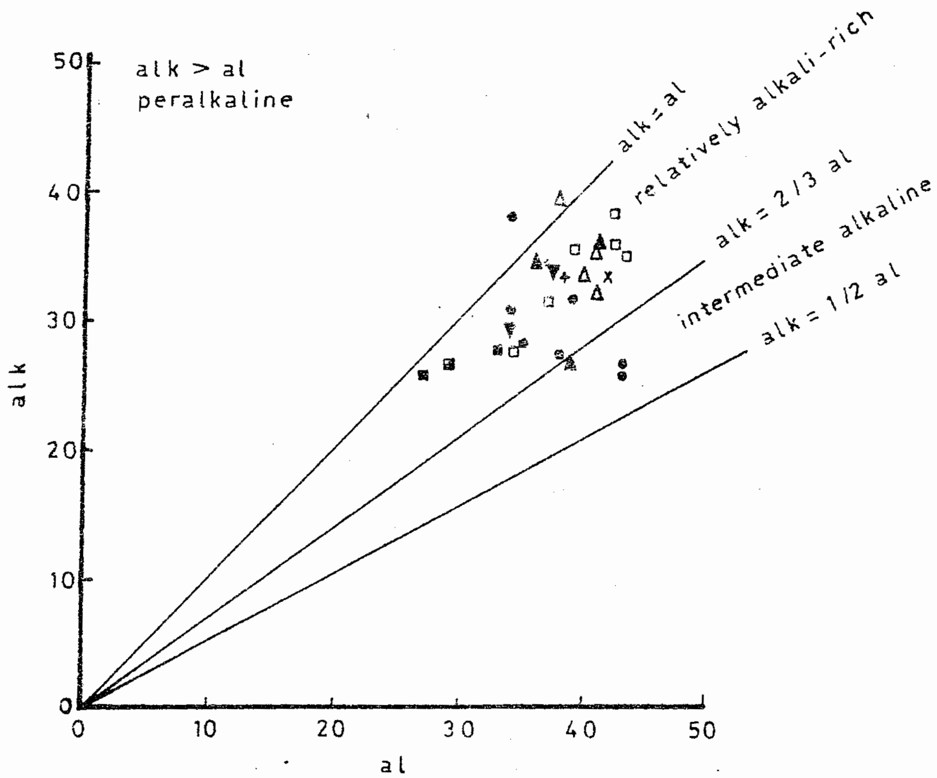


Fig. 11. Plot of Niggli values al vs alk for Gabal Hadayib and Gabal Um Risha.

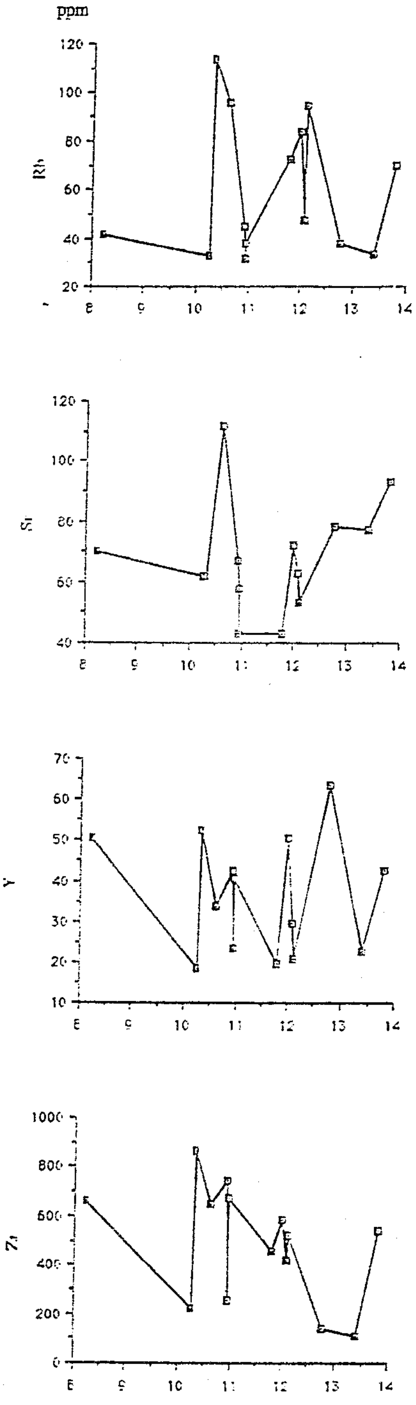


Fig. (12) : Variation of the minor elements Zr, Y, Sr and Rb with the D.I. for the rocks of Gabal Hadayib and Gabal Um Risha.

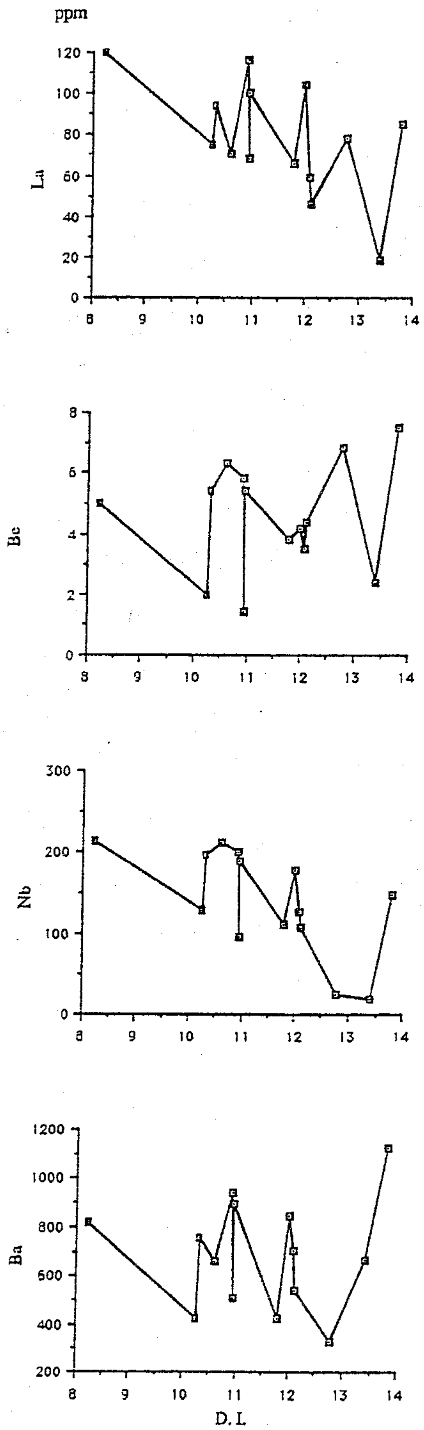


fig. (12) cont. : Variation of the minor elements Ba, Nb, Be and La with the D.I. for the rocks of Gabal Hadayib and Gabal Um Risha.

إضافات إلى جيولوجية المعقدات الحلقية لجبل حدايب وجبل أم ريشه الصحراء الشرقية الجنوبية - مصر

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يشتمل جبل حدايب على تركيبين حلقيين يعلو أحدهما الآخر ويتكونان أساسا من السيانيت الألكيلى وسيانيت الكوارتز الألكيلي متداخلا فى كتل التراكيت الألكيلى التى تمثل بقايا مخروط بركانى أصلى . ويتكون جبل أم ريشه أساسا من أنواع عديدة من السيانيت الألكيلى إلا أن الجرانيت الألكيلى يشكل حلقة خارجية غير مكتملة تحيط بالسيانيت . وتمثل التراكيت الأجزاء المرفوعه من مخروط بركانى قديم .

تتركب السيانيت من أرثوكليز برثيتى ، البيت ، أنتيبرثيت ، كوارتز ، وسلسلة التغير ايجيرين – أرفدسونيت – ريبيكيت وبدرجة أقل البيوتيت والأكميت . أما فى الجرانيت الألكيلى فتزداد نسبة الكوارتز والأرثوكليز وتشكل معادن الأرثوكليز والميكروكلين مكونات أساسية .

يكشف التماثل فى كميائية العناصر الشائعة وتوزيع العناصر الشحيحة فى المتراكبين أصلها المشترك . والتشبع بالسليكا والخاصية الألكيلية وتظهر بوضوح الميل الصوبى وتتابع التفارق العام للصخور يوجد موازيا لمنهج تكونها فى الحقل والذى يبدأ بالتراكيت الألكيلى متبوعا بالسيانيت الألكيلى وفى النهاية الجرانيت الألكيلى .

وتتكون صخور المتراكبين خلال عمليات تفارق من صهير سائل ويعتقد أن له مصدرا عميقا فى القشرة الأرضية مختلطا بمواد من الوشاح .