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GEOCHEMISTRY OF KAB EL-RAKAB BIMODAL METAVOLCANIC ROCKS, CENTRAL EASTERN DESERT, EGYPT

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ABSTRACT

The Kab El-Rakab metavolcanic rocks occur in the Egyptian portion of the Arabo-Nubian Shield and are Late Proterozoic in age. These metavolcanics are typically bimodal with basic and acidic products characterizing their lithostratigraphic zone. Activity in their zone was more variable with a high proportion of calc-alkaline/ tholeiitic systematic chemical changes throughout the basic and acidic products have been recognized with both major and trace elements ratios increasing with time. These features may related to introduction of large-ion lithophile elements-enriched fluids derived by dehydration of subducted lithosphere that caused progressive metasomatism of the overlying mantle wedge. Also, the differences may reflect variation in the degree of alteration of such overlying mantle wedge and could be interpreted in terms of variable fractional crystallization, partial melting and mantle heterogenity. The examined metavolcanics are most probably broadly similar in terms of their lithology, mineralogy, major and trace element composition and geochemical feature to the metavolcnic rocks which have been formed at ancient plate margin either convergent (orogenic setting) or diverting (tensional setting).

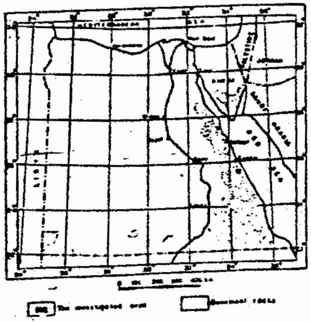
Chemical discrimination of tectonic setting demonstrates that the basic metvolcanics were generated from a mantle source in an island arc environment. The relatively low K-tholeiites may suggest the immature phase of such arc with rather high Ti-content. With the progressive of subduction, tholeiites with higher K (or calc-alkaline magma) could be lead to the formation of mature arc, not from the same source of mantle, but from the nearly formed arc crust. Hence, the suggestion aciquired to assume a gentle dip for the Bennioff zone (El-Ramly et al., 1982). This may provide a possible explanation for the spatial and temporal variation in Kab-El-Rakab metavolcanics.

INTRODUCTION

Throughout Arabia, N.E Sudan and Egypt, the dominant host rocks to the abundant granitic plutons are Volcanic products of calc-alkaline affinity and immature volcaniclastic sediments derived therefrom; all have been metamorphosed usually to the greenschist facies (Gass, 1955 and 1979; Nasseef, 1971; Akaad and Noweir, 1972; Jackmann, 1972, Bakor, 1973; Greenwood et al. 1976, Garson and Shalaby, 1976, Al-Shanti and Mitchell, 1976; Bakor et al., 1976). These metavolcanic rocks are widely distributed in the Eastern Desert representing the so-called Shadli metavolcanic terrians mostly as a volcanosedimentary complexes that have been previously known as early geosynclinal filling (Akaad and El-Ramly, 1960). More recently, these rocks have been interpreted as formed in ensimatic island arc or continental margin Volcanic arc setting (Hashad and Hassan, 1977 and Engel et al. 1980) and also occur as members of ultramafic-mafic complexes as ophiolites or tectonically emplaced remnants of oceanic crust (Stern, 1979; Dixon, 1979; and Nasseef et al. 1980).

In general, as most of the metavolcanic rocks of Shadli type (Fig.I) it is difficult to establish the original geotectonic environments of these metavolcanics especially

MAP SHOWING LOCATION OF KAB EL RAKAB METAVOLCANICS



Map shows the distribution of the metavolcanics of the Egyptian basement complex.
(Map after El Kamly,(1972)).

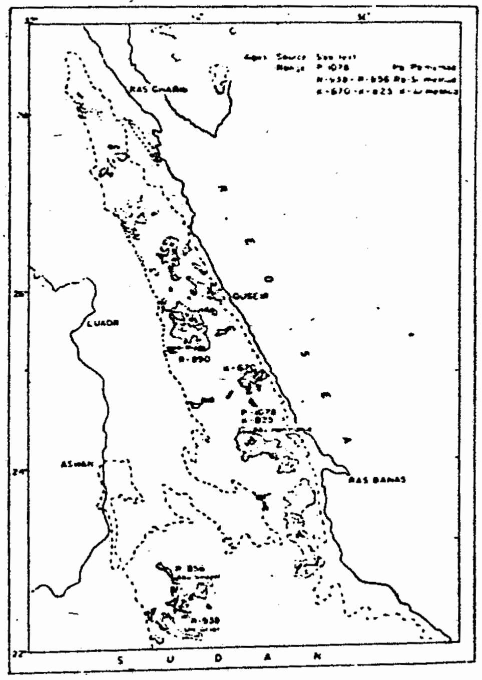


PHOTO-GEOLOGICAL MAP OF WADI KAB EL RAKAB AREA

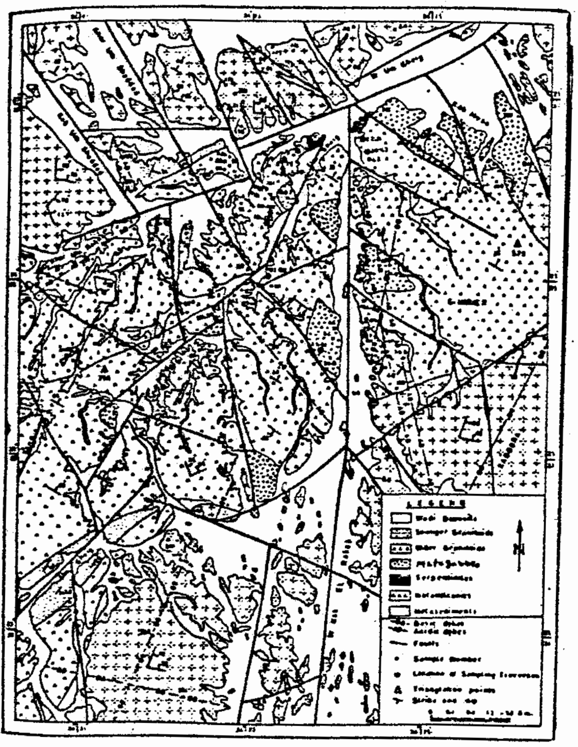


Fig.1. Maps show the distribution of the metavolcanics of the Egyptian basement complex; and a photogeological map of Kab El-Rakab area.

Table (1) : Chemical analyses (weight percent) of Kab El Rakab - metavolcanics.

S.No. Field No.	1* 84	2 1	3 38	4 83	5 117	6 31	7 32	8 81	9 30	10 110	11 2	12 115	13 196	14 89	15 76	16 70	17 71	18 85	19 320	20 335	21 321	22 202
SiO_2	75,58	74.36	66.50	66.30	66.21	66.01	66.30	65.93	63.70	64.18	53.08	52,95	51.77	50.27	47.81	48.31	47.36	46.98	47.92	46.78	46.17	46.82
TiO_2	0.23	0. 25	0.60	0.50	0.42	0.57	0.50	0.57	0.37	0.23	0.75	0.33	0.82	1.05	1.00	0.87	1.33	0.42	0.87	1.40	1.12	0.39
Al_2O_3	10.46	11.24	14.62	14.81	13.71	15.14	15.19	14.71	15.14	14.03	14.38	15.56	15.79	11.78	14.67	12.92	13.29	15.88	14.03	13.19	15.39	12.12
Fe_2O_3	1.30	2.03	2.38	2.36	1.71	2.41	2.29	2.32	2.45	0.92	2.89	2.67	4.04	2.36	2.43	2.54	1.90	2.51	4.13	3.26	3.19	4.41
FeO	2.66	2.85	2.46	2.58	1.95	2.46	2.44	2.61	2.30	2.66	3.98	4.03	3.35	7.42	6.94	7.31	7.56	5.44	5.62	7.33	5.69	8.20
MnO	0.01	0.01	0.2	0.02	0.03	0.03	0.02	0.02	0.02	0.04	0.11	0.09	0.12	0.09	0.10	0.10	0.19	0.14	0.18	0.14	0.55	0.17
MgO	1.84	1.69	1.71	1.38	3.96	1.80	1.84	1.11	1.71	2.86	8.32	8.94	6.92	10.52	9.06	9.38	9.17	10.89	9.41	10.47	8.39	8.77
CaO	1.68	1.54	3.55	4.19	4.11	3.48	3.42	4.26	3.61	6.39	8.97	7.06	10.65	6.55	12.26	13.49	14.26	11.17	10.66	11.68	13.22	11.81
Na_2O	0.83	0.92	5.18	4.84	4.78	4.80	4.72	4.61	5.34	6.25	3.86	3.17	3.91	5.25	1.67	1.21	0.65	1.41	3.17	2.16	2.16	2.76
K_2O	2.68	3.43	1.37	1.47	1.69	1.74	1.86	1.21	1.62	0.34	1.99	2.14	1.08	0.93	0.75	0.27	0.22	1.48	0.90	0.60	0.60	0.66
P_2O_5	0.09	0.10	0.16	0.16	0.14	1.19	0.19	0.17	0.16	0.16	0.22	0.17	0.33	0.23	0.21	00.17	0.19	0.09	0.14	0.11	0.17	2.10
Loss on ignition	2.28	0.63	0.97	0.97	1.21	1.05	1.06	2.18	1.28	1.58	0.78	2.63	0.64	3.35	2.78	3.00	3.47	3.29	2.72	2.40	3.19	1.47
H_2O	0.76	0.72	0.39	0.47	0.06	0.53	0.56	0.51	0.57	0.18	0.46	0.28	0.28	0.57	0.65	0.70	0.55	0.31	0.38	0.18	0.28	0.17
Total	100.40	100.33	99.91	100.05	99.98	100.21	100 19	100.11	100.27	100.02	99.79	100.03	99.50	100.37	100.33	100.18	100.14	100.01	100.13	99.90	100.11	99.85

* 1 = Metarhyolite.
2 = Metarhyolitic tuff.
3 - 6 Metadacites.
7 - 10 Metadacitic tuffs.
11 - 12 Metaandesitic basalts.
13 - 20 Metabasalts and metadolerites.
21 - 22 Schistose amphibolitic metabasalts.

in the field. Also, it is not easy to solve their space and time relationships for the complexity of the structural relationship came as a result to the younger plutonic events and their rapid lithofacies changes as well.

In the course of the present study, field and geochemical features are used in an attempt to identify the tectonic enironment in which the Kab El-Rakab bimodal metavolcanics were formed. On those given by Garcia (1978) field criteria of the examined metavolcanics are based. The chemical discrimination parameters proposed by recent workers are also valid. This is the second record to be described in the Egyptian Shield resemble Kolet Umm El-Kharit (El-Ramly et al. 1982).

Chemical discrimination parameters using major and trace elements showed that the present Shadli type of Kab El-Rakab metavolcanics were formed of bimodal volcanicity from seperate partial melts of common source (El-Rahmany et al., this volume). This bimodality is clearly obivous in Tables I & 2 which show the identification of Kab El-Rakab metavolcanics according to their silica and potassium content (Peccerillo and Taylor, 1979).

Table (2): Trace elements concentration for Kab El Rakab matavolcanics.

	*84	1	38	83	117	31	32	81	30	110	2	115	196	89	76	70	71	85	320	335	371	202
V			30	20	30	40	40	30	40	20	50	50	60	40	40	40	40	30	80	80	50	60
Zr	80	80	40	50	40	30	20	40	40	20	20	30	10	20	20	10	40	30	20	60	20	30
Cr	60	50	60	60	60	100	100	80	100	60	100	100	100	100	300	300	600	300	100	500	200	300
Ni	20	20	20	20	20	60	40	20	40	20	60	80	40	40	100	80	200	20	100	200	80	300
Co						4			3		4	6	3	3	6	8	30	10	20	50	3	40
Cu	10	10	10	8	8	10	10	10	10		10	10	10		10	10	10		30	30	8	10
Ba	300	300	200	200	300	200	200	200	200	100	300	300	100	100	300	100	200	200	200	200	400	300
Sr	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300
Sn	3	4	—	3	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Mo	4		3		3	6	4	3	6	—	—	—	—	—	—	—	3	—	4	4	—	—
Y	30	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Yb	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Be	4	6	2	2	1	3	2	2	3	1	1	1	1	1	—	—	1	—	—	1	1	3

* Numbers refer to Table (1)

- = not detected

Table (3) Comparison of major element chemistry of contimental tholeiite,abyssal tholeiite, behined arc tholeiite, island arc tholeiite and island arc calc-alkahine volconic rocks with kabel Rakab metavolcanics.

	Contimental* tholeiite	Abyssal* tholeiite	Behind the* arc tholeiite	Island-arc* tholeiitic series	island - arc* calc-alkali series	Kab El Rakab metavolcanics basic rock. types		acidic rock types	
						Range	Av.	Range	Av.
SiO_2	51.5	47.62	48.50	45.70	50.66	46.17-46.82	48.02	64.18-75.85	67.83
TiO_2	1.2	1-2	1-2	0.5-1	0.2-1	0.39- 1.12	0.93	0.23- 0.75	0.49
Al_2O_3	16.3	14.15	14.17	14-17.5	16.18	11.03-15.83	13.60	10.46-15.14	13.91
Na_2O	2.5	2.5-3	1-3.5	2-3	2.9-5	0.66-5.25	2.72	0.83 - 6.25	3.84
K_2O	0.88	0.1-0.2	0.2-0.6	0.5	1-2.7	0.22-1.48	0.75	0.50 - 1.86	1.44
Na_2O/K_2O	3	10-15	6-10	4-6	1.3	0.95-5.65	3.48	0.27-3.78	3.45

* Compiled by Greenwood et al. 1980, after Coats, 1968 ; Manson, 1968 ; Jakes and White. 1972 ; Amhaeusser. 1973 and Rogers et al. 1974.

An important criterion of the analyses (Table I) is the dominance of either basic or extremely acidic varieties as well as the scaricity or lack of pure intermediate type reflecting the bimodality of their volcanicity. Also, the combined water and loss on ignition in basic varieties is high due to the alteration of pyroxene to hornblende and chlorite. The high ferric/ferrous ratio associated with dehydration is an important criterion taken in consideration.

Another feature of particular importance is the wide range in the K_2O/Na_2O ratio varies between 0.27 and 5.65; an odd sample reach 11.57 and the exceptional high value being revealed by only one sample. This may represents the wide variation in feldspar proportions as in many worldwide orogenic settings and could be reflects the low grade of metamorphism and the greater mobility, during alteration by the alkalies. Also, such variation could interpreted in terms of fractional crystallization and mantle heterogenity.

FIELD CRITERIA:

Continental and island arc volcanics, particularly those of orogenic belts, are normally much more explosive than oceanic volcanoes. According to Williams and Mc Birney (1979) the continental and island arc volcanics have contributed 95% or more of all pyroclastic deposits laid down during historic times. Rittmann (1962), and Rittmann and

Rittmann (1976) have estimated the percentage of tephra among the total erupted material in various volcanic fields. according to these authors, pyroclastics are more abundant in volcanic rocks of island arcs and continental arcs than those from oceanic and ocean basins. Garcia (1978) suggested that the important controlling factor for the predominance of pyroclastics within a volcanic sequence is their tectonic setting without regard of magma type. Volcanic arcs are the site of explosive activity, while volcanism in mid oceanic ridge and oceanic island is mainly effusive with only fragmental deposits (Garcia, op. cit,p.150).

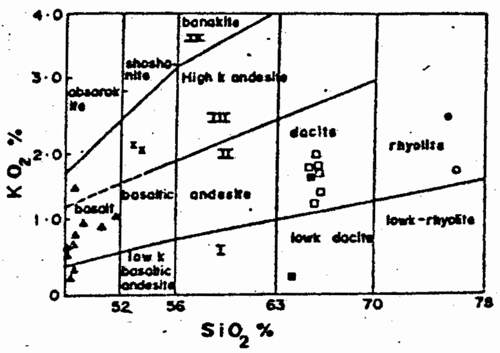
In Kab El Rakab metavolcanics, pyroclastics (dacitic and rhyolitic tuffs) are predominant similar in character in the modern volcanic arcs. Also, the studied metavolcanics succession is interbedded, specially the upper parts, with volcaniclastic rocks. Garcia (1978) has reported that pyroclastic rocks in island arcs are interbedded with volcaniclastic sedimentary rocks derived from such arcs.

GEOCHEMICAL CRITERIA :

The following diagrams and discussion reveal the geochemical character of kab El-Rakab metavolcanics and the tectonic environment is clarified based on major and the immobile trace elements behaviour.

EXPLANATION

○ Metarhyolite.
● Metarhyolitic tuff.
□ Metadacite.
■ Metadacitic tuff.
X Meta-andesitic basalt.
▲ Metabasalt.△ Metadolerite.
▲ Schistose amphibolitic metabasalt.



Relation between SiO_2 and K_2O content.

after Peccerillo and Taylor (1976)

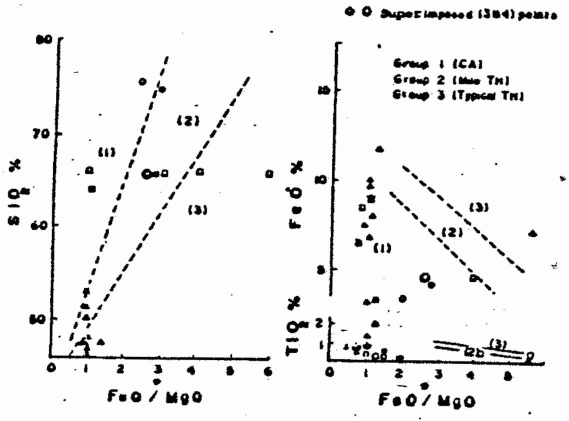


Fig.3. Changes of SiO_2, FeO^* and TiO_2 contents with FeO^*/MgO ratio in Kab El Rakab volcanics lines dividing typical calc-alkalic rocks (1) from mildly calc-alkalic rocks (2) and tholeiitic rocks (3) are from Miyashiro (1973) FeO^*: total iron as FeO

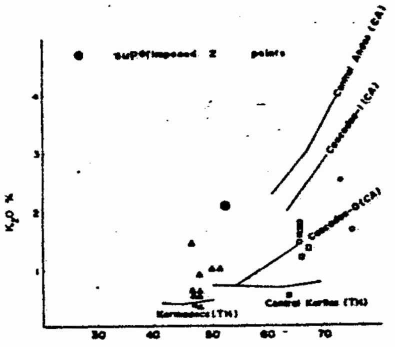


Fig. 4 SiO_2 versus K_2O diagram for the examined metavolcanics trend lines with names show average values for volcanic rocks in three volcanic arcs (Miyashiro 1974)
TH: Tholeiitic rocks CA: Calc-alkaline rocks
o : outer volcanic rocks I: inner volcanic rocks

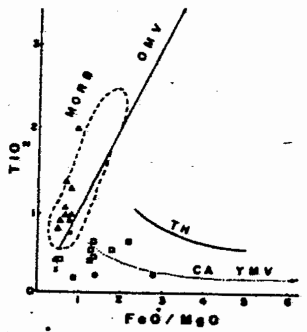


Fig. 5 TiO_2- FeO/MgO diagram for the Metavolcanic series of Wadi Kab El Rakab (OMV) old metavolcanics (YMV) younger metavolcanics from Stern (1979)

Ramsay, et al (1981) Diagrams :

Ewart (1979 & 1981) has reviewed the lava analyses from various modern geotectonic settings and gave the average abundances of 30 minor and trace elements from the main volcanic environments. Such data was used by Ramsay, et al. (1981), and plot the most inportant of these elements against SiO_2 for the following geotectonic environs;

1- Active continental margins (Western USA and Andean South America) .

2- Anorogenic environments (Iceland, S.E. Queensland, and the Western Scotland-Northern Foreland Province).

3- Oceanic islands (Galapagoa Hawaii, Canaries, and the Zephyr Shoal).

4- Primitive ensimatic island-arcs (Tonga-Kermadec and Lesser Antilles).

The plots of Kab El-Rakab metavolcanics are shown in (Fig.9) they fall mainly (except those of Cu) in the field defined by Ramsay et al. (1981) after Ewart (1979 & 1981) for immature island arcs. Although a few individual analyses may incorrectly allocated the main bulk of population lie in the island arc field. It is worthy to mention that Ramsay et al . (op. cit.) stated that the defined fields "arc" the fields of average values. For defined SiO_2 ranges, and therefore indicate only typical concentrations of the relevant elements. The actual fields of individual points are, of course, larger.

A comparison of the chemical data of Kab El-Rakab metavlcanics and those of different tectonic settings is presented in Table 3. From the table, it is obvious that the chemical data of Kab El-Rakab metavolcanics-in general-resemble data of island arc calc-alkaline setting for the acidic rock types and island arc tholeiitic for the basic rock varieties. This may aain assure their bimodality.

General Criteria:

Kab El Rakab metavolcanics represent one of the widely distributed metavolcanic rock units of Shedli type in the Easten Desert of Egypt. They are of Late Proterozoic age represented by four belts around Wadi Kab El Rakab. These belts appear with their outer peripheries suggesting that they may be resemble the continuation of one belt extends, generally, in a NE-SW direction. They occur in the form of successive sheets, plug and dikes of greyish-black colour changing into brown to browrish black on the weathed surface. The rocks are represented mainly by lavas and pyroclastics. The bulk composition of lava is mainly

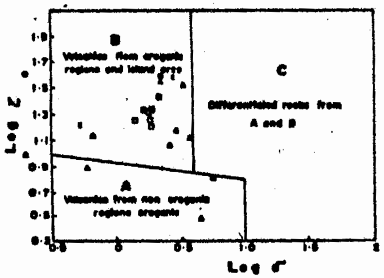


Fig.6 Log σ - log τ diagram for Metavolcanic series in Wadi Rab El Rakab (after Rittmann 1973 and Gottini 1971)

Field A Tholeiites plateaubasalts , alkali basalts, tholeiites

Field B: [illegible] basalts, andesites, dacite, rhyodacites

Field C : [illegible], [illegible], trachytes, [illegible]

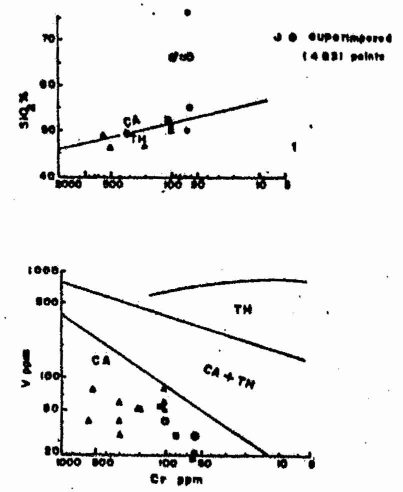


Fig. 7 , log V-log Cr and SiO_2- log Cr to discriminate between tholeiitic and calc-alkaline volcanic rocks of Rab El Rakab (Miyashiro and Shido,1975).

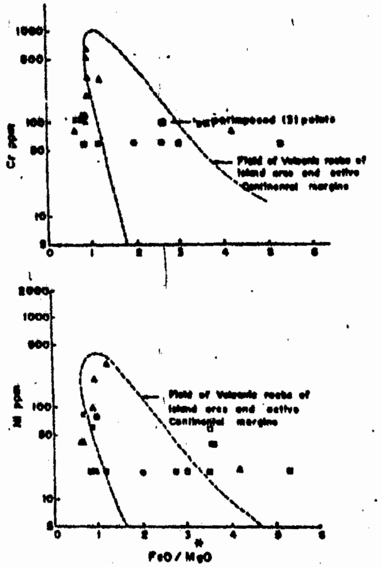


Fig. 8 Variation of Cr and Ni with FeO*/MgO for Rab El Rakab metavolcanics.
(Myashiro and Shido, 1975).

Miyashiro (1974) has pointed out that volcanic rocks of island arcs and active continental margins consist of three main rock series : calc-alkalic, tholeiitic, and alkalic. The alkalic series form only a very small part of these volcanic rocks. Neverthless, the distinction has the merit of permitting comparison with published data on modern examples where the temporal and spatial variation in island arcs and continental margins is defined in terms of the two volcanic rock series (Jakes and Gill, 1970 ; Jakes and white, 1972; Miyashiro, 1974 and Stillman and Williams, 1974).

He proposed that the tholeiitic series could be defined by as lower rate of increase of SiO_2 content and higher enrichment of FeO* (total iron as FeO) and Ti than the calc-alkaline series, with the advance in fractional crystallization. Fig.3. shows the Kab El-Rakab metavolcanics plotted on such diagram and it is evident that the main trend of evolution is calc-alkaline for the acidic types with a higher tendency towards the tholeiitic trend for the basic varieties.

Also, the trend of evolution of Kab El Rakab metavolcanics is shown in Fig.(4), by using SiO_2-K_2O diagram of Miyashiro (1974). It is appear-in general-to be partially similar to the calc-alkaline rocks of Cascades-O (for the metadacitic rocks) and similar to those Keramadecs tholeiitic rocks (for the metabasaltic rocks).

FeO*/MgO-TiO_2 -DIAGRAMS-:

Fig, (5) shows the plots of metavolcanic rocks on the Ti-FeO*/MgO diagram of Miyashiro (1974) ; modified by Stern (1979). It is clear that the metabasaltic rocks show tendency towards Fe-and Ti-enrichment with advancing fractionation. This trend mimics that of modern Mid-Ocean Ridge Basalts (MORB)Engle et al. (1965) as well as the trend of the older metavolcanics (OMV), (Stern 1979) . In contrast, the metadacitic rocks show a general tendency towards iron and titanium depletion with advancing fractionation. Analyses of the metadacitic rocks plot in the field defined by modern calc-alkaline lavas, following the trend of younger metavolcanics (YMV) of Stern, (1979). Accordingly both younger and older metavolcanics could be represented in Kab El-Rakab erea and assure their bimodal criterion of volcanicity.

Cottini-Rittmann Diagram :

Rittmann (1973) has concluded that all the active volcanoes can be divided into two well separated groups which reflect the tectonic situation of the volcanoes. This appears clearly in a diagram the coordinates of which are the value Z (Gottini, 1968) and the value (serial index of Rittmann, 1957) being :

$$= (Al_2O_3 - Na_2O/TiO_2 \text{ (Weight\%)}$$

$$= (K_2O + Na_2O)^2/SiO_2 -43 \text{ (Weight\%)}.$$

Fig. (6) shows Gottini-Rittmann diagram on which the examined metavolcanics are plotted mostly in the field "B" orogentic belts and island arcs.

Miyashiro and Shido's (1975) Diagrams :

Miyashiro and Shido (1975) have designated various diagrams using the trace element data for rocks in typical tectonic setting, that to asses and determine the relationship between the trace element contents and tectonic environment. Fig. (7) shows the discrimination between the tholeiitic and calc-alkaline volcanic rocks; on a log V-log Cr and SiO_2 -log Cr diagrams. Kab El Rakab metavolcanics plot in the calc-alkaline fields. It is worthy to mention that the metabasaltic samples plot on the tholeiitic field of SiO_2 -log Cr diagram. Fig. (8) shows the FeO*/MgO ratio and its relation with the V variation of Cr and Ni content to discriminate between calc-alkaline and tholeiitic series in various tectonic settings. The examined metavolcanics plot within the field of the volcanics of island arcs and active continental margin.

basaltic-dacitic comprising minor flows of metaandesitic basalts or metarhyolitic in composition, pure andesitic flows are rare or absent. The pyoclastics are represented by ash-fall tuffs relatively predominate.

Discussion:

The basement complex of Egypt formas a part of the U-shaped non cratonic belt of rocks (including the Arabian Nubian shield) covering a considerable portion encircling Africa. The Arabo-Nubian shield is, in turn, being includes the crystalline basement of Western Saudi Arabia, the Egyptian Eastern Desert and northeastern Sudan. This belt was strongly affected by extensive volcanism and plutonism and considered to be developed during the Pan-African orogeny (Kennedy, 1964) as a result to the tectono-thermal event (Gass, 1979). It has an age ranges of 1200-450 Ma (Gass, 1977; Kroner, 1979; International Geological Correlation Program (IGCP) Project 164, Saudi Arabia, 1979).

The origin of the Pan-African orogeny of the Arabian Nubian Shield is controversal. Some workers had supposed that this part of Pan-African Shield was developed from an Archean crust which in turn was remobilized during the Pan-African orogeny. Accordingly, this hypothesis requires the presence of older sialic material (Hume, 1934 Akaad and El Ramly, 1960; Sabet, 1961 and El shazly, 1964, Clifford, 1968; Akaad and Noweir, 1980).

On other hand. Some authors suggest that the Arabo-Nubian Shield is not ensialic, but has evolved in an oceanic environment during the Late Proterozoic. Subduction between converging oceanic plates was occurred some 1200 Ma age (Gass, 1981). Hence a consumption for the oceanic Crust of back arc basin or marginal seas along the predominantly westerly-inclined Benioff zones may have been now found either as well preserved or partly dismembered ophiolite complexes in Western Arabian and from northern Ethiopia to Egypt (Fig. 10) (Bakor et al., 1976; Garson and Shalaby, 1976; Neary et al., 1976; Gass, 1977; Frisch and Al-Shanti, 1977; Engle, 1978; El Sharkawy and El Bayomi, 1979; and Shanti and Roobol, 1979). Lately, when the subduction ceased, the oceanic Crust has evolved from the welding together of a series of island arcs, i.e. the whole region had developed a continental character (cratonization processes), (Greenwood, 1973; Gass, 1977 & 1981). The final stages of cratonization are marked by chang from calc-alkaline to peralkaline magmatism which occurred in some than in others. The line seperates 500-600 Ma Arabian peralkaline to the east from calc-alkaline products to the West (Fig. 10) is that of stoesser and Elliot, 1979.

In general. the precambrian crust of Saudi Arabia, the eastern Sudan and Egypt consists of abundant granites and granodiorites, arc-type volcanics, and well authenticated ophiolites. The metamorphic grade is generally low and Archean remnant are absent (Shakelton, 1980). Metavolcanics occur generally as volcano-sedimentary complexes that have been formed either in ensimatic island arc or continental margin volcanic are settings (Garson and Shalaby, 1976; Gass, 1977; Hashed ahd Hassan, 1979 and Engle et al., 1980) or occur as members of Ultramafic-mafic complexes as dismembered ophiolites or tectonically emplaced members (Nassef et al., 1980; Stern, 1979 and Dixon, 1979). Consequently, these metavolcanics have been most probably been formed at ancient active plate margins either converting (orogwnic setting) or diverting (tensional setting), (El Ramly et al., 1982).

In conclusion, the geological and geochemical features of Kab El Rakab metavolcanics showed that they have mixed tholeiitic/calc-alkaline character for their basic varieties and calc-alkaline for their acidic rock types.

The present study is strongly suggest the island arc environment. However this suggestion is not absolute and their paleotectonic settings is not easy to be evalute for more than one reason:

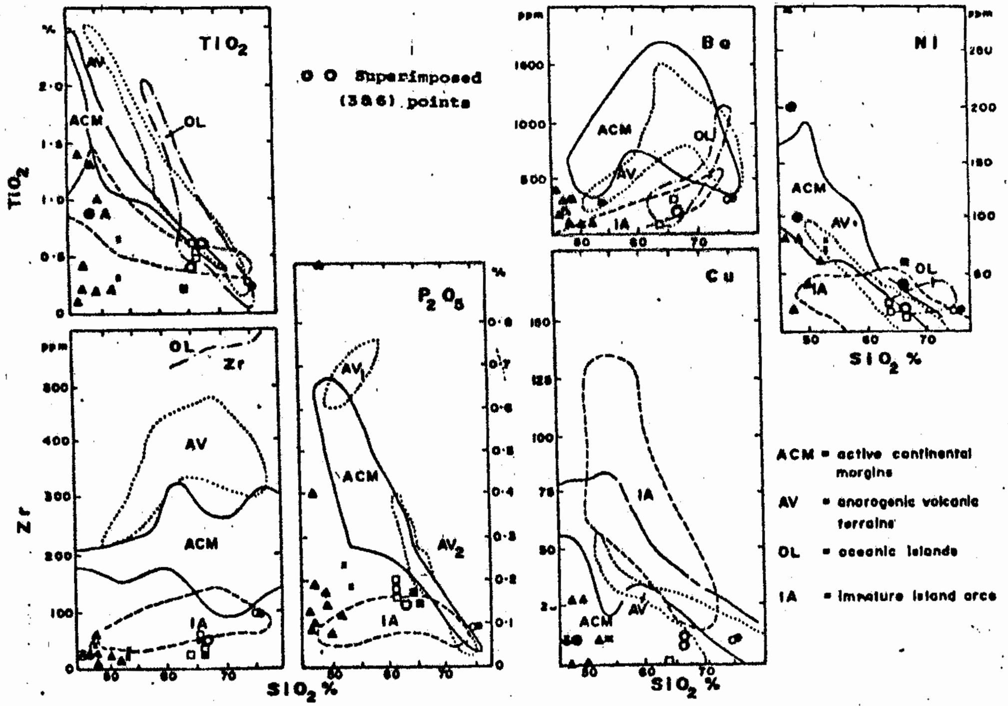


Fig. 9. Abundances of TiO_2, P_2O_5, Ba, Ni, Zr, and Cu of Kab El-Rakab metavolcanics, compared with average fields of magmas from various modern geotectonic environments. Defined by Ramsay, et al.(1981) after Ewart (1971&1981).

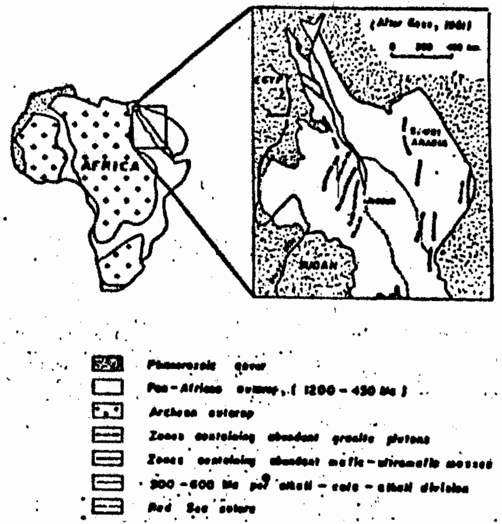


Fig. 10 Regional sketch map of the Arabian—Nubian Shield showing the disposition of ma ultramafic complexes (marking the approximate position of arc sutures) and linear gra zones (possible arc axes). The Red Sea has been closed to a pre-Miocene position. The m of Africa shows outcrop areas of dominantly Pan-African age rocks which tend to suck older cratonic rocks of Africa.

The lack of the internediate rock types (andesite) and the fairly high K content will deni the volceinc arc or the so called Andean setting model for their formation. Also, the absence of pillow lavas, the high abundance of TiO_2 and the calc-alkaline acid volcanics and pyroclastics are against the island arc model for their formation.

Generally, for the basic metavolcanices, it could be suggest that they were generated from a mantle source in an immature island arc settings (of low K-Lholeiites) with high Ti content. Tholeiite with higher K (or calc-alkaline magma) could lead to the formation of a more mature arc, during the progress of subduction with time. This feature may led to introduction of large-ion lithophile elements enriched fluids derived by dehydration of subducted lithosphere that caused progressive metasomatism of the overlying mentle wedge. It is suggested that these mature arc rocks not formed from the same (mantle) but from the nearly formed arc crust, hence a very high heat source should be acquired to cause partial melting or anatexis process. Hence, the source heat may exist if the Bennioff zone had had a gentle dip. This openion is in harmony with that suggested by El Ramly et al. (1982) for Kolet Umm Kharit metavolcanic rocks.

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