Qatar Univ. Sci. Bull. (1987) 7: 281-312

PETROGENESIS AND TECTONIC SETTING OF THE VQLCANIC SUITE WEST OF WADI BAGHARID SOUTH EASTERN DESERT, EGYPT

By

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Key words : Volcanics, Egypt, Petrogenesis.

ABSTRACT

The metavolcanic belt west of Wadi Bagharid, south Eastern Desert, Egypt is geologically investigated. Petrographically, the metavolcanics are subdivided into four rock varieties namely: metaandesites, metadacite-rhyodacite, metarhyolite and metapyroclastics. Petrochemical characters based on major and trace elements data of nine analysed samples are clarified. Behaviour of major and trace elements are discussed and chemical classifications are presented based on major and trace elements composition. Petrographical and petrochemical data suggest a calc - alkaline trend for the examined rocks during island arc development at converging plate margin, but well behind the deep ocean trench.

INTRODUCTION

The present paper deals with the geology, petrochemisty, pertrogenesis and classification of a metavolcanic belt which lies in the south Eastern Desert. The belt is located between latitudes 22°32′ 00′ to 22°37′ 00″ North and longitudes 34°13′ 00″ to 34°20′ 00′ East. It covers an area of about 120 Km^2.

The first important contribution to the general geology of south Eastern Desert was developed by Hunting Geology and Geophysics Corporation Ltd. (1967) who presented a photogeological map of scale 1:500,000. According to Hunting, the area under cosideration consists mainly of the so called Seiga–Shianit Gneisses complex (psammitic gneisses,pinkish leucocratic granitic gneisses and amphibolites). These rock types are separated by a series of mica and amphibole schists associated and closely followed by the syntectonic and late tectonic granite–granodiorite complex which forms the main mass of

Gabal Kulyiet. The Hunting map does not include any occurence of metavolcanic rocks in the studied ares. Since Hunting (op. cit.) no large scale maps or detailed petrological studies of the presently considered area were published.

In the last ten years a growing awareness has been focused on the role of plate tectonics on the late Precambrian rocks of the Arabian shield (Greenwood, et al., 1976). The investigations of the Precambrian formations carried out recently on the Eastern Desert and Saudi Arabia revealed many important regularities that are typical of the Wilson cycle.

This paper is a contibution to the geology and geochemistry of the metavolcanics of Wadi Bagharid aiming to deduce the geotectonic setting of their formation.

GEOLOGIC SETTING

In general the area consist of thick series of metamorphosed volcanic rocks which are the most prominent rock units in the area. Intrusive gabbro and syntectonic and post tectonic granite and other igneous rocks mainly the whole area was cut by sets of dykes. The general geology of the area is shown on the map (Fig. 1) prepared during this work.

Morphologically, the relief of the investigated area varies from north to south as consequence of differences of rock types. The northern part of the area has a rougher physiography than the southern partbecause it contains granitic masses and different igneous rock types, whereas the latter is low level consisting of less resistant metamorphics.

A thick series of metamorphosed sedimentary rocks are considered to be the oldest rock unit in the present area. They represent old epiclastic sediments derived by weathering and reworking of older volcanic rocks which were later intensely deformed and were affected by regional metamorphism exhibited in its marked schistosity and the formation of metamorphic minerals like chlorite, epidote, hornblende and garnet. This rock unit crops out in the northern part of the area.

The metavolcanics form a belt 4–6 km wide extending approximately 10 km NE. They are interbedded with volcanogenic metasedimentary sequence and the main volcanic trend is concordant with the main structures of the area. The main lithologic types consist of intermediate to acidic metavolcanics ranging in composition from andesite, dacite to rhyolite.

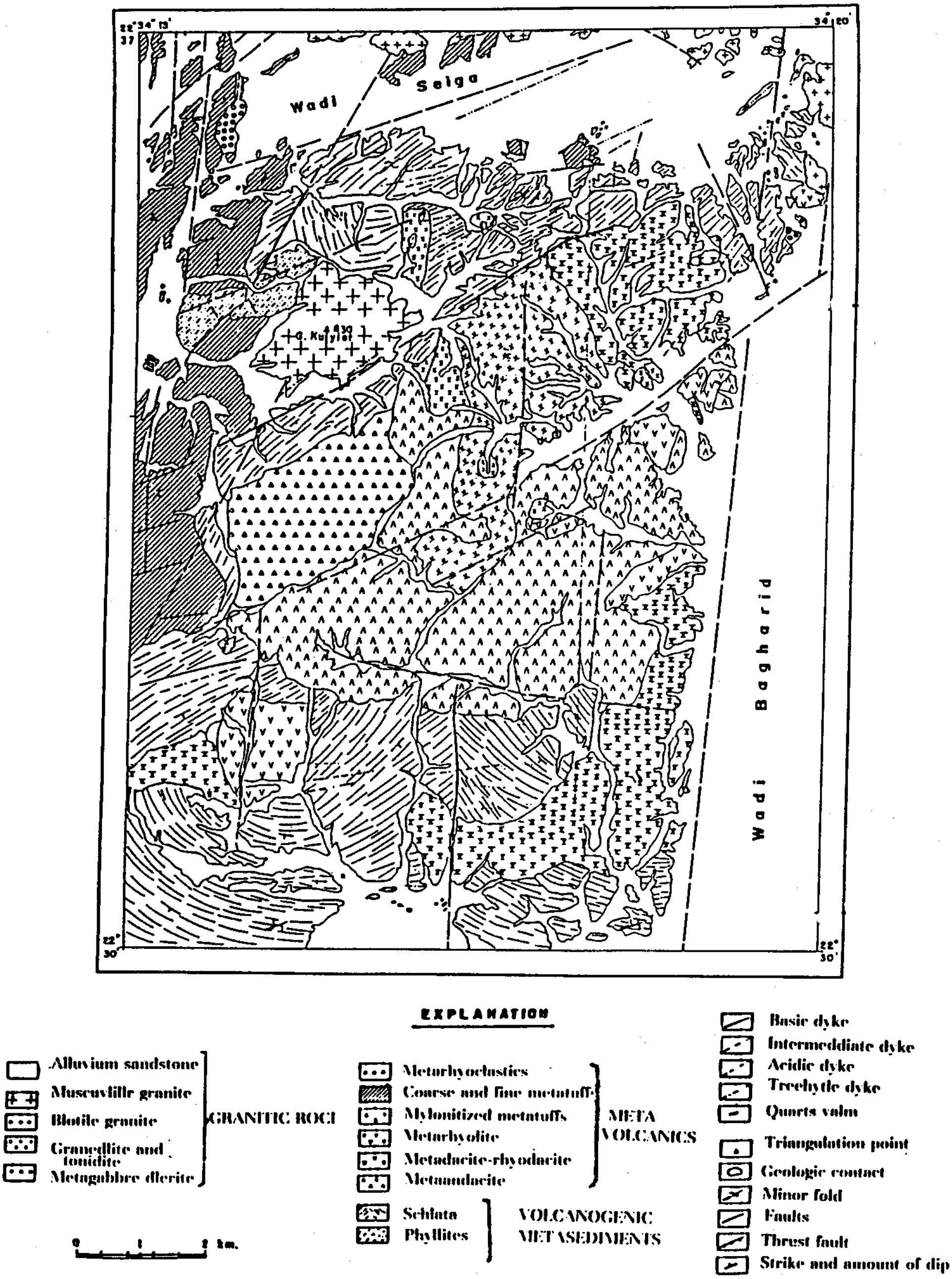


Fig. 1 : Geologic map of the area west of Wadi Bagharid, south Eastern Desert, Egypt.

The metavolcanic series are intruded by granite and granodiorite and cut by various post granitic dykes and veins in some locations. They can be differentiated into five mappable rock units:

1. Metarhyolite; 2. Metadacite–rhyodacite association; 3. Metaandesite; 4. Rhyodacite metatuffs; 5. Metapyroclastics.

The main tectonic structures in the area are represented by synclinal and anticlinal fold system grouped in an elongated belt, having an axis direction NE–SW and a group of major as well as minor faults which run in three different trends.

PETROGRAPHY

Petrographically, the metavolcanics were found to consist of four rock varieties namely: metaandesite, metadacite–rhyodacite, metarhyolite and metapyrolastics and tuffs.

Most of the metaandesite is highly porphyritic, the phenocrysts constitute about 15% of the rock and consist of tabular crystals of altered plagioclase that include small grains of epidote. Smaller phenocrysts of quartz are also encountered. The groundmass consists of the above mentioned minerals with mafic minerals including actinolitic hornblende and chlorite. Accessory minerals are iron oxides and apatite.

The metadacite–rhyodacite is composed mainly of porphyritic crystals of quartz, plagioclase, alkali feldspar embedded in a fine grained groundmass consisting mainly of quartz, alkali feldspar, sodic plagioclase, and crystals of biotite. Iron oxides, zoisite, calcite and chlorite are secondary minerals (Fig.3).

The porphyritic metarhyolite is composed of quartz as essetial mineral, where it occurs in two forms as phenocrysts and in the groundmass. The large phenocrysts consist of oriented, crushed, cracked crystals with corroded margins and show conspicuous deformation lamellae and small recrystallized quartz grains in between (Fig. 4).

The groundmass consists of sericite, quartz and kaolinitized alkali feldspar and contains pockets of fine grained calcite. Accessories include opaque iron oxides.

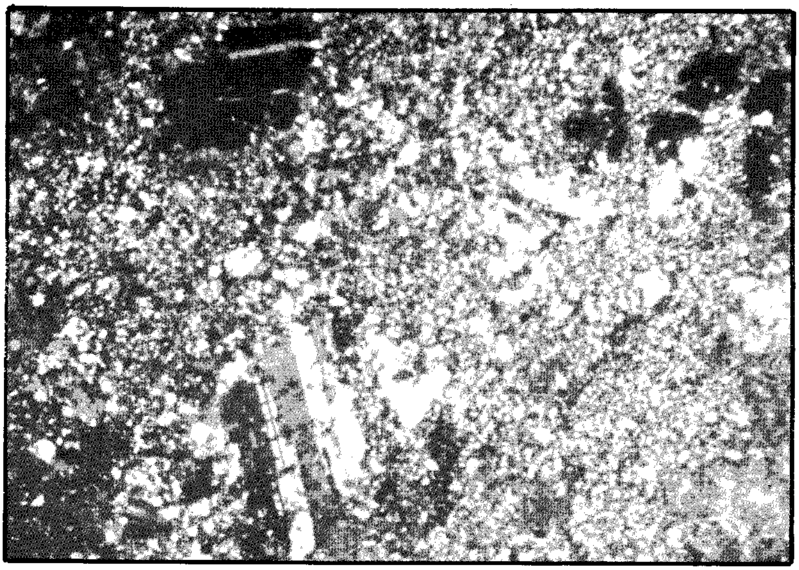


Fig. 2 : Porphyritic metaandesite showing plagioclase phenocrysts.

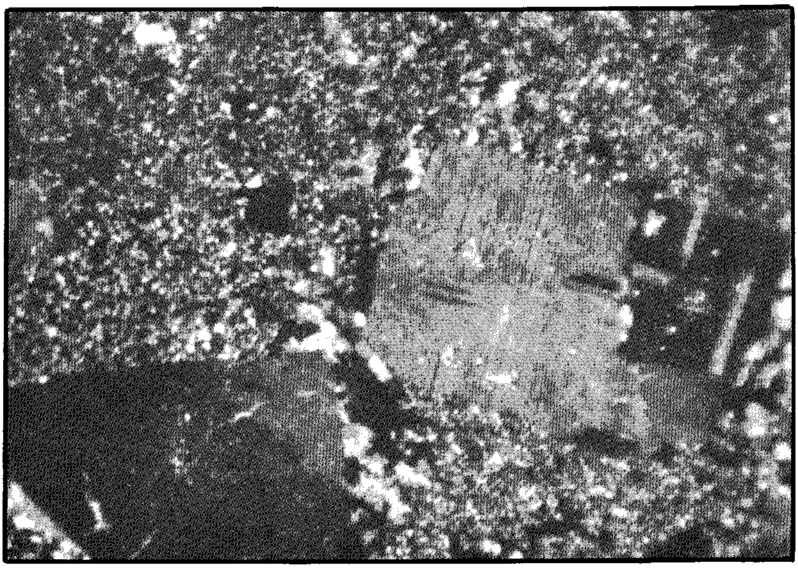


Fig. 3 : Porphyritic metadacite.

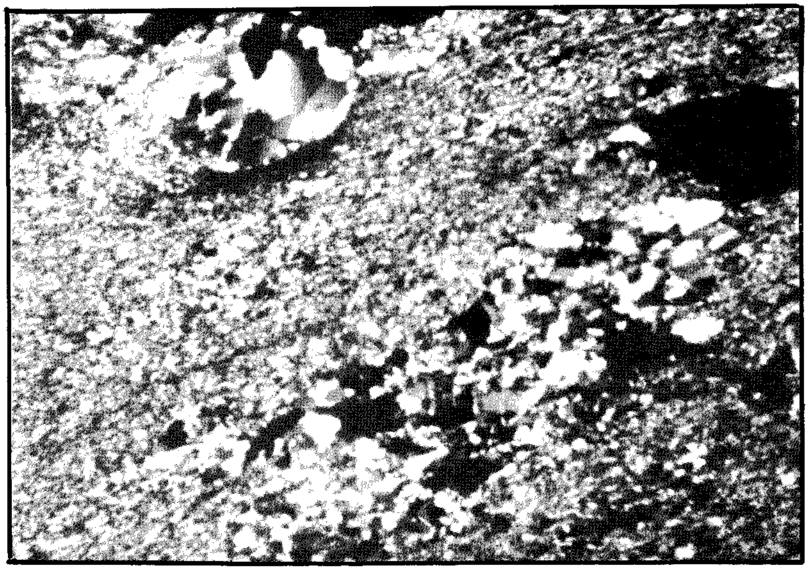


Fig. 4 : Showing segregation of deformed quartz and muscovite rich layers.

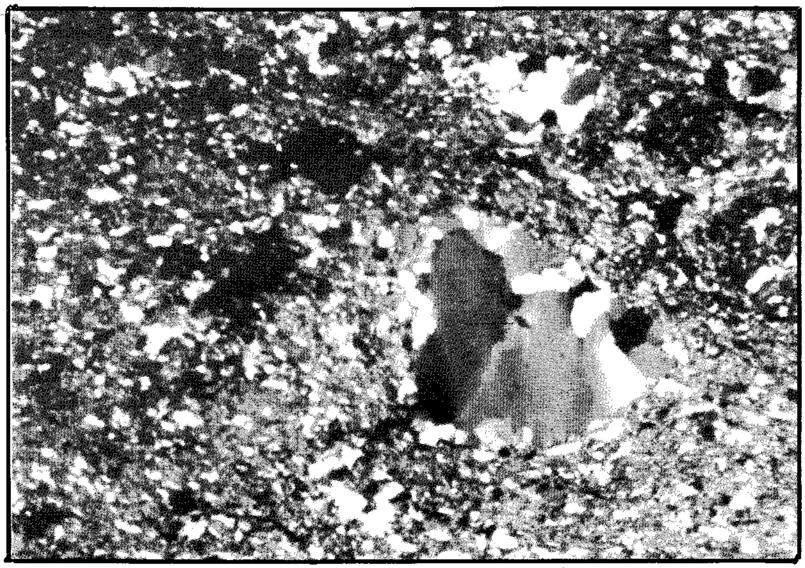


Fig. 5 : Quartz augen porphyroclast in fine grained matrix of quartz and muscovite.

The mylonitized metarhyolite forms the major part of the rhyolites. The rock is strongly foliated, with phenocrysts that are elongated and show signs of cataclastic effects (Fig. 5). Mineralogically, is composed of quartz as fine grained, elongated subhedral to anhedral crystals representing about 80% of the rock. It shows conspicuous deformation lamellae and contains minor dust inclusions. Sericite is the second mineral in abundance. It is present in the groundmass as fine fibers. It shows aggregates in some parts of the groundmass, which may be alteration product of alkali feldspar crystals. Biotite present as relic of elongated flakes, pale brown colour, shows weak pleochroism and pink bands. It is weathered at the margin as well as along cleavage planes. Numerous black granules of iron oxides are present and muscovite present as small flakes associated with quartz and in the groundmass.

The rock has a more intense red colour due to the oxidation of the iron minerals to secondary hematitic material.

Layers of coarse grained and fine metatuffs are common west of the area being characterized by fairly well banded and laminated textures. The rocks are made of lithic and crystal fragments generally found in a fine grained matrix (Fig. 6 a,b). The metatuff is dacitic to rhyolitic.

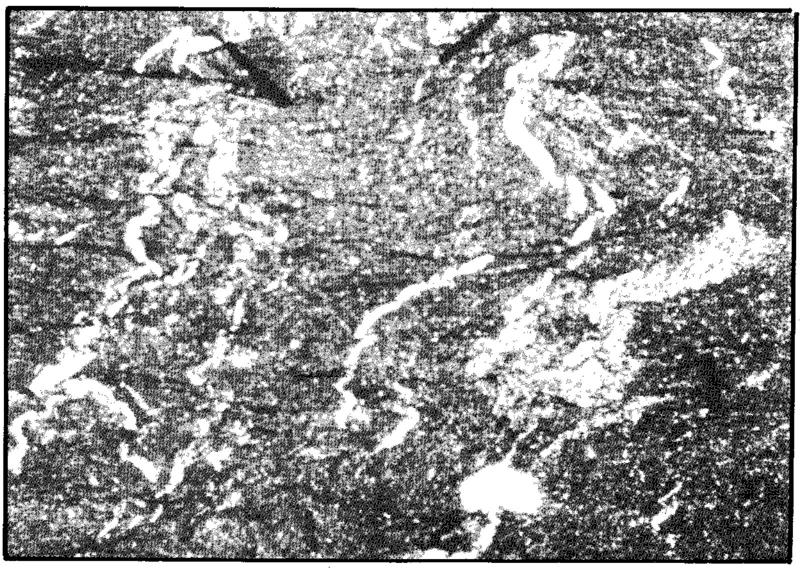


Fig. 6-a : Fine grained metatuffs with intervening quartz laminae.

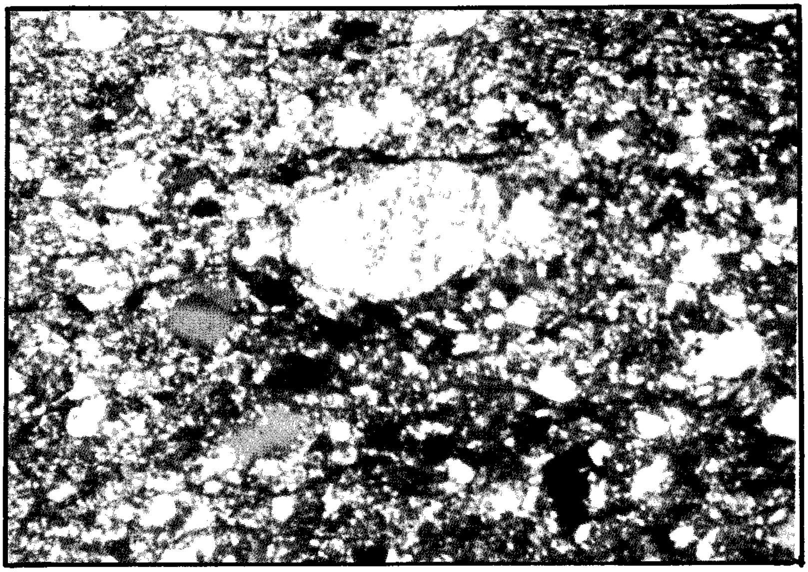


Fig. 6–b : Lithic metatuffs.

PETROCHEMISTRY

The chemical character of the metavolcanics in the area has not previously been treated. For this purpose nine selected samples were chemically analysed.

Tables 1 & 2 report the major elements data and CIPW norm for the analysed metavolcanics, where analyses are arranged in increasing order of SiO_2 content. Some indication of alteration of the samples is given by their H_2O, CO_2 content, since in general hydration has been an essential part of the alteration processes. The Fe_2O_3/FeO ratios (Table 1) are generally low to moderate which reflect slight weathering in some samples.

For the purpose of comparison, eight additional analysis of volcanic rocks are included in Tables 1 and 2 representing the world average of volcanic andesite, dacite, rhyodacsite and rhyolite calculated by Le Maitre (1976) and the average of Egyptian andesite, dacite, rhyodacite and rhyolite given by Aly and Mostafa (1984) respectively.

Table 1

Major element contents of the analysed metavolcanics.

Sample / Number / Oxides	METAANDESITE						METADACITE–RHYODACITE							METARHYOLITE				
	121	187	165	155	Egypt	World	140	37	175	Egypt	Egypt	World	World	100	153	30	Egypt	World
SiO_2	54.52	57.20	60.25	61.45	57.57	57.94	63.68	65.07	66.30	65.08	67.43	65.01	65.55	68.58	72.50	74.23	69.75	72.82
TiO_2	0.55	0.66	0.50	0.63	1.01	0.87	0.42	0.29	0.45	0.68	0.19	0.58	0.60	0.55	0.37	0.42	0.38	0.28
Al_2O_3	16.97	16.82	17.00	16.65	16.45	17.02	17.00	17.10	16.77	15.02	13.94	15.91	15.04	16.93	15.88	15.60	13.99	13.37
Fe_2O_3	5.04	4.30	4.20	4.08	3.51	3.27	4.40	3.36	3.37	2.93	11.52	2.43	2.13	2.38	1.80	1.60	2.26	1.48
FeO	2.80	2.52	2.95	1.97	4.58	4.04	2.75	2.40	1.68	2.32	2.58	2.30	2.03	1.91	0.90	1.14	1.51	1.11
MnO	0.09	0.07	0.11	0.08	0.17	0.14	0.08	0.13	0.08	0.09	0.08	0.01	0.09	0.03	0.03	0.04	0.07	0.06
MgO	4.82	6.16	4.05	3.63	3.44	3.33	1.47	2.80	1.76	2.35	2.43	1.78	2.09	0.93	0.40	0.39	0.99	0.39
CaO	6.85	4.14	3.56	4.68	5.90	6.79	4.03	2.12	3.36	4.03	3.45	4.32	3.62	1.86	0.90	1.43	1.58	1.14
Na_2O	3.05	3.45	3.23	2.96	3.56	3.48	3.07	1.94	2.45	4.20	3.74	3.79	3.67	0.97	0.95	1.02	4.17	3.55
K_2O	1.68	1.80	1.96	2.26	1.48	1.62	2.10	1.98	2.84	1.91	3.98	2.17	3.00	3.88	3.90	3.71	4.14	4.30
H_2O	0.09	0.31	0.59	0.91	—	1.17	0.61	1.92	0.56	—	—	1.19	1.51	0.37	1.17	0.47	—	1.41
P_2O_5	0.17	0.16	0.17	0.20	0.26	0.21	0.14	0.15	0.15	0.30	0.13	0.15	0.25	0.14	0.14	0.15	0.09	0.07
CO_2	3.26	2.21	1.59	0.33	—	0.05	0.46	0.42	0.58	—	—	0.06	0.21	1.21	1.07	0.26	0.37	—
Total	99.89	99.80	100.16	99.83	—	99.93	100.21	99.68	100.35	—	—	99.78	99.79	99.60	99.20	100.56	—	99.96
FeO^t	7.33	6.38	6.73	5.64	7.73	—	6.70	5.42	4.71	4.95	—	—	—	4.35	6.29	6.62	—	—
Fe_2O_3/FeO	1.80	1.71	1.42	2.07	—	—	1.60	1.40	2.01	—	—	—	—	1.25	2.00	1.40	—	—
FeO^t/MgO	1.52	1.04	1.66	1.55	2.25	—	4.56	1.93	2.67	2.11	—	—	—	4.35	6.29	6.62	—	—

Table 2

CIPW Normative Minerals and the differentiation index of the analysed Metavolcanics

Sample Number / Normative Mineral	METAANDESITE						METADACITE–RHYODACITE							METARHYOLITE				
	121	187	165	155	Egypt	World	140	37	175	Egypt	Egypt	World	World	100	153	30	Egypt	World
Q	16.35	17.21	22.62	19.38	—	12.37	26.62	37.08	31.47	20.71	18.44	22.73	22.73	43.91	49.24	49.57	23.42	32.87
C	6.00	7.73	7.67	1.97	—	—	4.07	10.36	5.79	—	—	—	0.25	11.93	10.74	9.58	—	1.02
Or	10.00	10.50	11.75	13.60	9.01	9.60	12.0	12.15	17.00	11.47	23.70	12.82	17.72	23.79	24.30	22.65	24.87	25.44
Ab	27.20	30.65	29.10	28.29	32.93	29.44	28.15	18.15	22.40	38.35	33.84	32.07	31.05	9.02	9.05	9.44	38.08	30.07
An12.45	5.55	6.95	20.11	25.28	26.02	16.70	7.50	12.45	16.77	9.57	20.01	15.04	1.16	1.95	3.90	7.35	4.76	
					En 8.87					En 6.04	4.84						En 2.77	
Di	—	—	—	—		4.84	—	—	—			0.11	—	—	—	—		—
					Fs 3.28					Fs 0.69	2.02						Fs 0.35	
Hy	13.48	17.12	12.48	10.42		9.49	4.96	9.26	5.10			5.73	6.19	3.27	1.30	1.25		1.34
					Di 2.50					Di 1.25	5.46						Di 0.02	
Ap	0.29	0.29	0.29	0.45	0.56	0.50	0.29	0.29	0.29	0.64	0.27	0.34	0.59	0.29	0.32	0.32	0.19	0.17
Cc	8.20	5.60	4.02	0.90	—	0.11	1.14	1.04	1.46	—	—	0.14	0.47	2.79	0.70	0.97	—	0.17
Il	0.78	0.88	0.66	0.90	1.45	1.65	0.56	0.46	0.68	0.96	0.27	1.09	1.14	0.80	0.58	0.60	0.54	0.54
Mt	5.25	4.47	4.44	3.24	3.78	4.74	4.29	3.64	2.88	3.11	1.60	3.53	3.08	2.58	1.43	1.72	2.40	2.14
Hm	—	—	—	0.07	—	—	—	—	0.46	—	—	—	—	—	0.39	—	—	—
Total	99.98	100	99.98	99.98	—	—	99.98	99.93	99.98	—	—	—	—	99.99	100	100	—	—
D.I.	53.54	58.36	63.47	61.27	—	—	67.57	67.38	70.87	70.53	75.98	67.62	71.44	76.68	82.59	81.66	86.37	88.38

Table 3 reports the trace element data for the analysed samples. Ten trace elements were selected to be determined in order to throw light on the magma type and tectonic setup. The selected elements are Co, Ni, Cr, Va, Sr, Cu, Zn, Y and Zr. For comparison, analogous rocks of the Egyptian Dokhan volcanics (Basta et al., 1980) and those of Taylor (1969), Jakes and White (1972) calc-alkaline association of andesite and dacite and Coats (1968) rhyolites are also included.

The analysed metavolcanics are characterised by an absence of rocks with SiO_2 less than 54%. They range from 54% to 75% SiO_2 and show moderate potash/soda ratios (Table 1).

Sodium content is slightly higher than potassium content, but the predominance of K over Na is more marked only in the rhyolites for higher content of K-feldspar phenocrysts in it.

The analysed volcanic rocks show a large variation of major elements composition with the SiO_2 content. The percentage AL_2O_3 are similar to the percentage listed by Le Maitre (1976) for the average world andesite and slightly higher than the percentage of dacite, rhyodacite and rhyolite of similar SiO_2 content. They have also higher Fe_2O_3 content than the world and Egyptian volcanics presented recently by Aly and Mostafa (1984) with slight difference in Al_2O_3, MnO, TiO_2 and P_2O_5.

Jakes and White (1972) divided the volcanic arc rocks into three rock series: the low K-tholeiite series, the calc- alkaline series and the shoshonitic series. This reflects gradation both in time (in which the tholeiites are typical of the earliest eruptions) and in space (in which that island arcs are generally high in Al_2O_3 irrespective of SiO_2 content. They contain 26% to 17.5% range of Al_2O_3 cover most of the SiO_2 range. The Al_2O_3 percent in the studied area is in the range of 16-17%.

Jakes and White (op. cit) differentiate also between high K-andesites, especially occuring in continental margin from low K-andesites of island arcs. However, the metavolcanics in the studied area could be considered of moderate K affinities.

The Al_2O_3 percentage of volcanics in the area is higher than that of iron and magnesium as shown by the ternary FeO^t, MgO, Al_2O_3 diagram (Fig. 7) indicating slight enrichment in Al_2O_3 while poor in MgO. This confirms an island arc origin for these rocks.

The studied rocks are all saturated with respect to silica, hypersthene, quartz and corundum is absent in both the Egyptian and world andesite, dacite and rhyolite and appears only in the world average rhyodacite. They show neither normative nepheline nor leucite reflecting the non–alkaline character of these rocks.

The studied rocks show similar values of normative Or, Ab and low average of normative An compared with the corresponding values of both the Egyptian and world andesite – dacite – rhyolite. The average normative hypersthene is considered high compared with the average Egyptian and world samples.

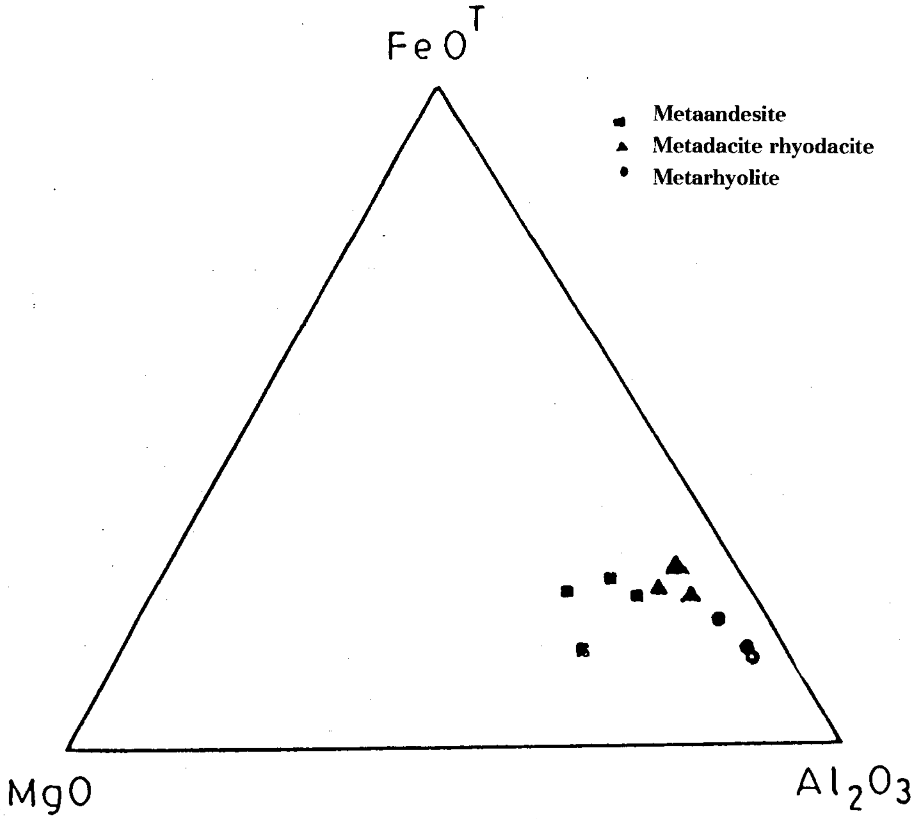


Fig. 7 : FeO^tMgO and Al_2O_3 ternary diagram for the studied metavolcanic rocks, indicating an island arc origin.

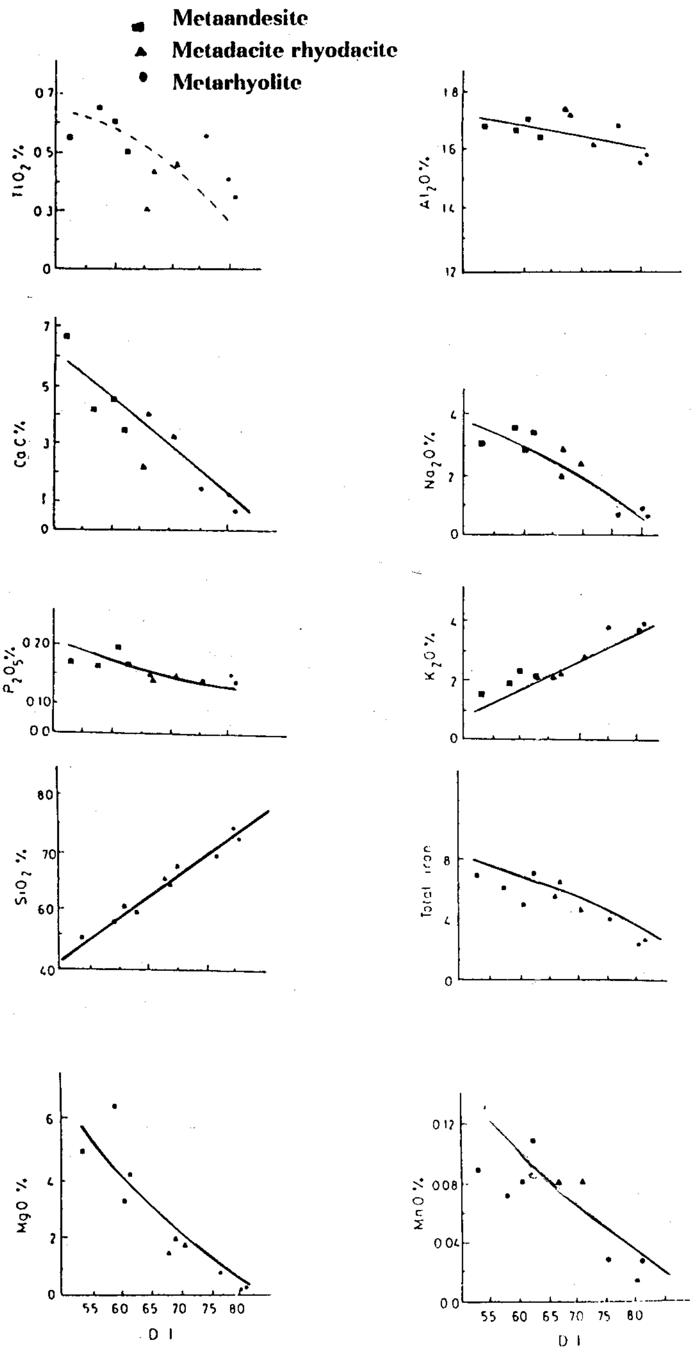


Fig. 8 : Major elements variation diagrams versus differentiation index of Thornton & Tuttle (1960) for the metavolcanics of the area.

Variation in Chemical Composition

Several variation and correlation diagrams have been constructed for the chemical components to clarify the petrochemical character of the rocks in the area, and to elucidate the petrogenesis and tectonic setting of these rocks.

The major elements variations are expressed in Fig 8 with reference to the differentiation index of Thorton and Tuttle (1960). The trend closely resembles those of other orogenic series (Wilkinson, 1971) with marked increase in SiO_2 and decrease of total iron, CaO, MgO, MnO and TiO_2 with increasing D.I. Al_2O_3 and P_2O_5 show marked scattering. The K_2O with increasing D.I. in contrast to Na_2O which shows decrease in content with increasing D.I.

The alkalies versus silica variation diagrams are widely used by several authors (e.g. Miyashiro, 1975) to distinguish between the alkalic rock series and non alkalic (subalkalic rock series). The latter may be subdivided into two differentiation trends namely: tholeiitic (Th) and calc–alkaline (CA) series corresponding to iron enrichment and iron depletion respectively (Miyashiro, 1974). Plotting the present data onto the alkali–silica diagram (Fig. 9) it is evident that mostly all the samples fall in the field of non alkalic series.

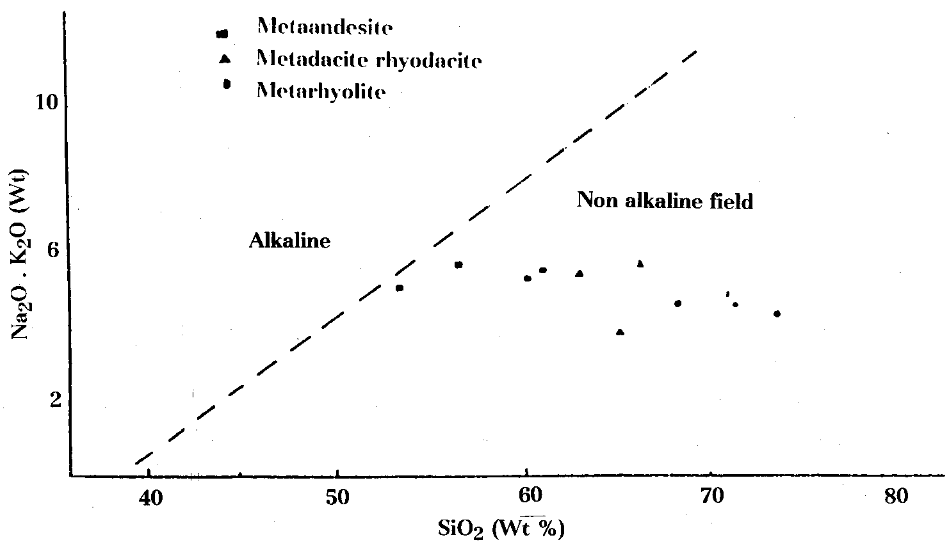


Fig. 9 : Alkali+silica diagram for the studied metavolcanic rocks the dashed line is Macdonald's (1968) dividing line for Hawaiian theoleiitic and alkaline rocks.

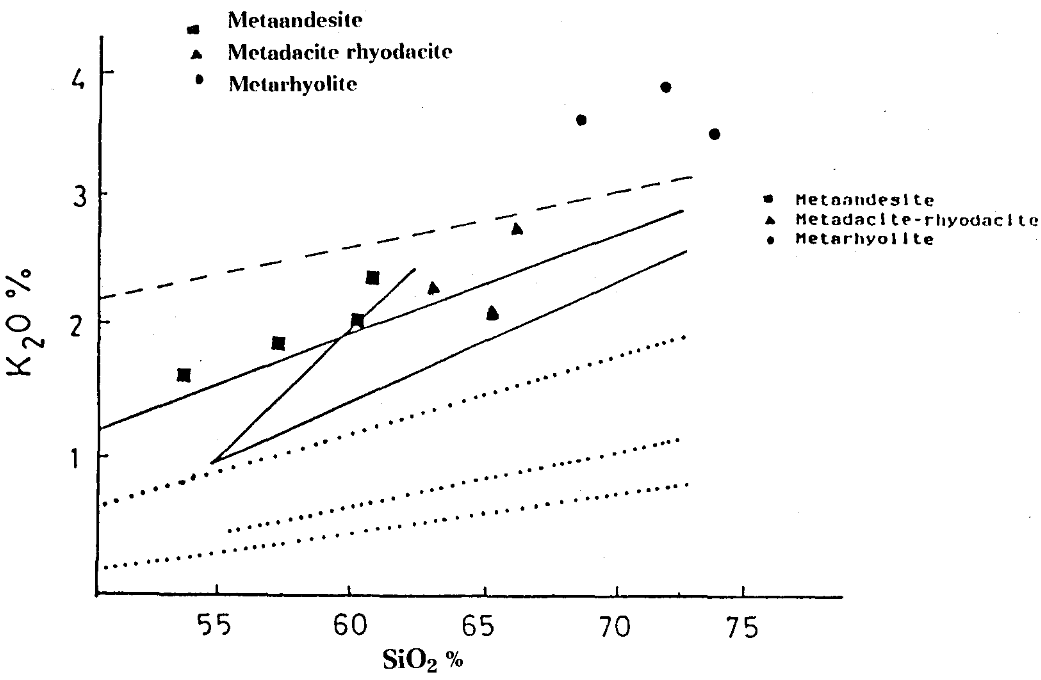


Fig. 10 : K_2O% versus SiO_2% in volcanic rocks of island arcs (Jakes and White, 1971). Dotted lines : Theoleiitic association; Full lines : Calc–alkaline; Dashed lines : Shoshonitic association

The K_2O versus SiO_2 relation, and total alkali contents, K_2O/Na_2O ratio are used for the division of island arc volcanics into different types. Gill (1970), and Jakes and White (1972) observed that the slope of K_2O versus SiO_2 plot increase across an island arc toward the continent. Na_2O does not change as much as K_2O in sections across island arcs with a given SiO_2 content and consequently the K_2O/Na_2O ratio increases with increasing K_2O from approximately 0.1 in the low K rocks on the oceanic side to 1.0 in high K rocks (shoshonite) on the continental side (Jake and White, 1972). This permits the subdivision of the island arcs into tholeiitic, calc alkaline and shoshonitic varieties. Taking this fact into account and by plotting the metavolcanics analysis of the area on the K_2O versus SiO_2 (Fig. 10), the resultant association is markedly calc alkaline with average K_2O/Na_2O range between 0.5 to 1.0 with the exception of the metarhyolite samples which have higher K_2O/Na_2O ratio K_2O/Na_2O and may reach 3 to 4.

Miyashiro (1974) has shown that the relationship between the ferromagnesian elements during fractionation may persist through low grade metamorphism and be diagnostic of tholeiitic (Th) and calc–alkaline (CA) volcanic suites. Thus, the FeO^t/MgO ratio may be used as quantitative parameter representing the degree of fractionation crystallisation. He used FeO^t/MgO versus SiO_2, TiO_2 and FeO^t to identify volcanic arc complexes. Figs. 11, 12. and 13 show these relations. On such plots it is evident that the main trend of the metavolcanics in the area is calc–alkaline with slight tendency towards the tholeiitic trend. They show marked decrease in TiO_2 with increase of FeO^t/MgO ratio during fractional crystallisation, a trend consistent with that of calc–alkaline series.

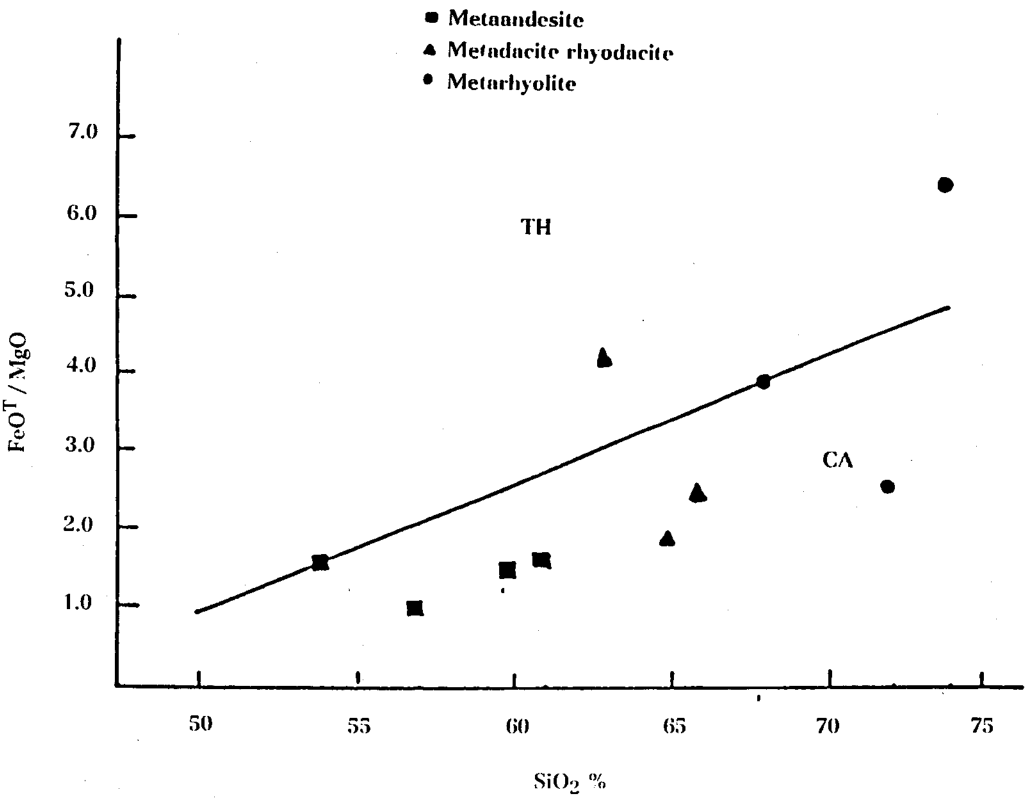


Fig. 11 : FeO^t/MgO versus SiO_2 wt% (Miyashiro, 1974) plot for samples from the studied area. TH : Tholeiitic; CA : Calc–alkaline.

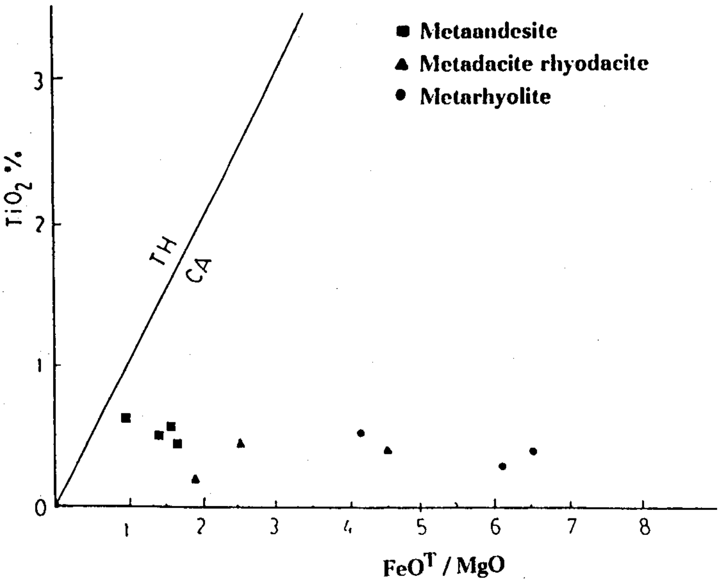


Fig. 12 : TiO_2 versus FeO^t/MgO ratio for the \studied metavolcanics (Boundary after Miyashiro, 1974).

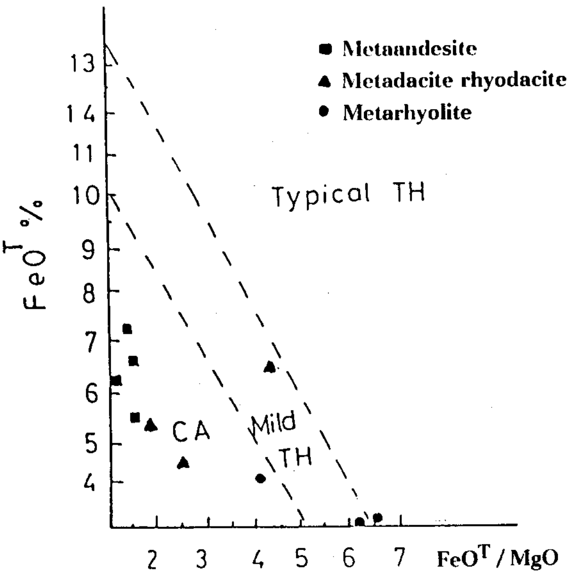


Fig. 13 : FeO^t versus FeO^t/MgO ratio for the studied metavolcanics (Field designated by Miyashiro, 1974).

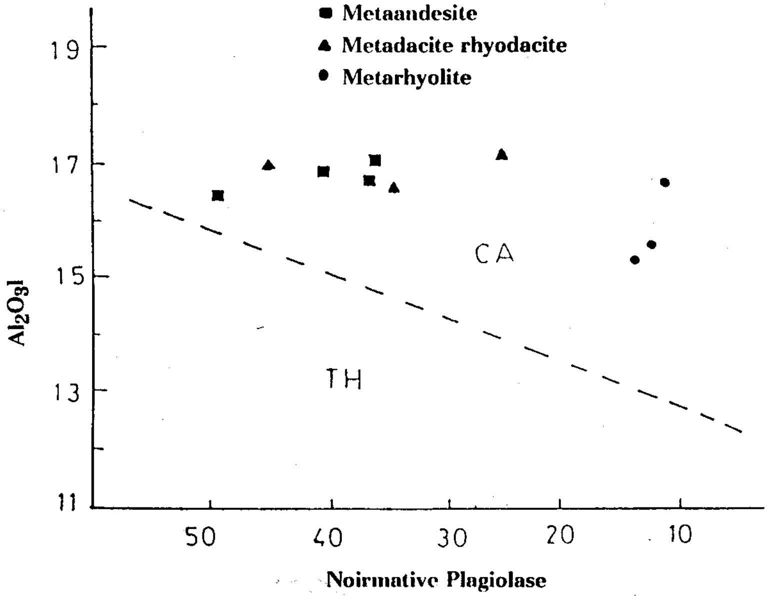


Fig. 14 : Alumina versus normative plagioclase for the studied metavolcanics (Boundary after Irvine and Baragar, 1971).

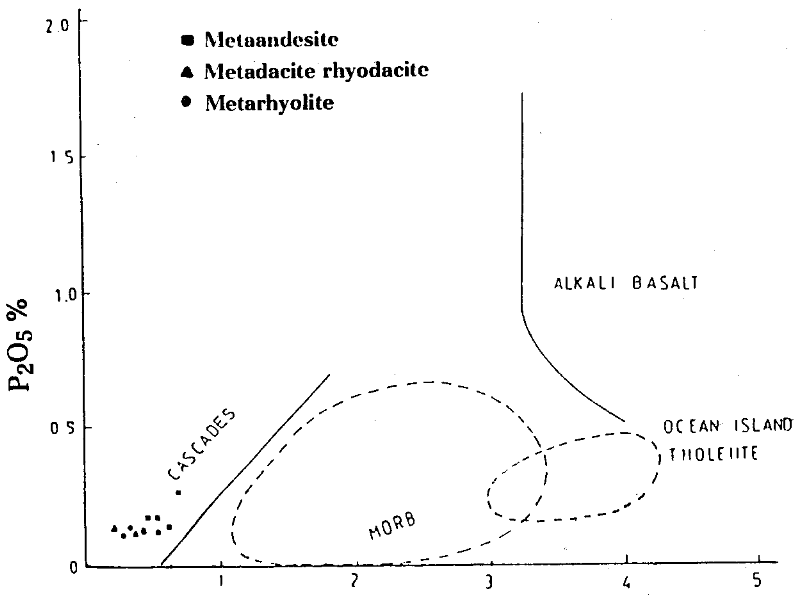


Fig. 15 : Variation of P_2O_5 versus TiO_2% for the studied metavolcanics.

Another prominent chemical difference between typical calc–alkaline and tholeiitic rocks is their alumina content. This difference is well illustated by plotting Al_2O_3 versus normative plagioclase composition as suggested by Irvine and Baragar (1971). According to Fig. 14 the examined metavolcanics are classified as calc–alkaline.

The variation of P_2O_5 versus $TiO_2$was used by Bass et al., (1973) to differentiate between the different types of magmas. In Fig. 15 the metavolcanics of the area exhibit calc–alkaline trend (the Cascades).

Some of the salient differences in major element chemistry between the island arc tholeiites and calc–alkaline series are well illustrated on an A(Na_2O + K_2O) – F(FeO^t) – M(MgO) diagram which was constructed by Wager and Deer (1939) to distinguish the different series on the basis of iron enrichment. Typical island arc tholeiites series show a characteristic trend toward FeO enrichent during differentiation. In contrast the calc–alkaline series show a less pronounced Fe enrichment and characteristically form a broad band which extends towards the A–apex of the diagram. These differences were quantified in terms of this diagram by Irvine and Baragar (1971).

The AFM values for the samples in the studied area are plotted in Fig. 16. The samples are predominantly calc–alkaline and define less Fe enrichment trend with minor occurence of tholeiite. A trend of enrichment in alkalines and depletion of Fe and Mg contents from andesites through rhyodacites and rhyolites is clear.

The Or, Ab, An diagram shows the composition of the normative feldspars (Fig. 17). The analysis for most of the metavolcanic rocks plot near the Or–Ab line, at the boundery between potassic and sodic series, far from the An corner. The metarhyolite of the area have considerably higher percentage of normative orthoclase than the other samples.

The difference in composition is particularly well shown by the Q–Or–Ab ternary diagram (Fig. 18). The analysis of metavolcanics plots halfway between the Ab and Q and on the negative Or side indicate some deficiency in orthoclase combined with higher albite content.

In the Q–F–M diagram all the samples plot close to quartz feldspar line indicating low content in mafic constituents (Fig. 19). The andesite being richer in mafics and the rhyolite is the richest in quartz. The dacite is richer in feldspar relative to rhyolites. In this diagram the trend of the investigated rocks are similar to the calc–alkaline trend.

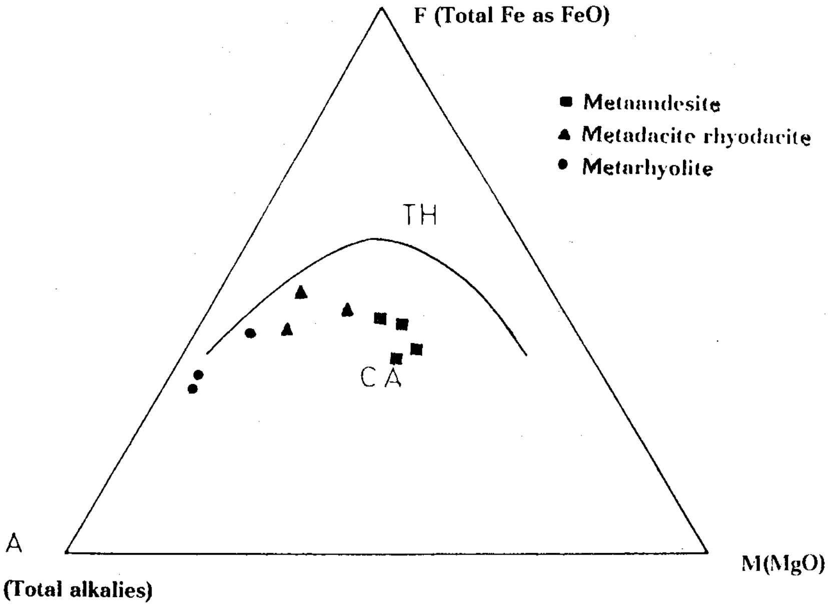


Fig. 16 : Variation diagram for the studied metavolcanics. The dotted line distinguishes between theoleiitic and calc–alkali rock types following Irvine and Baragar (1971).

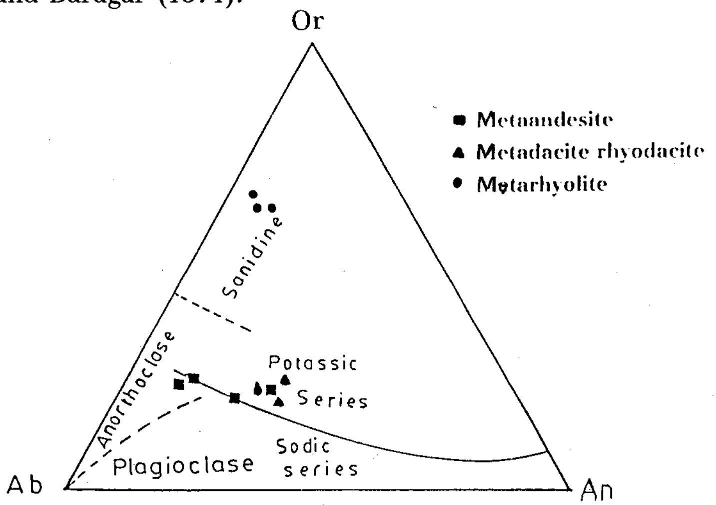


Fig. 17 : Normative molecular Or, Ab, An ratio in metavolcanic rocks of the studied area. Albite (Ab), Orthoclase (Or) and Andesite (An). Mineral phase fields and feldspar composition are deliniated from Girod and Le Fevre (1972) and from Irvine and Baragar (1971).

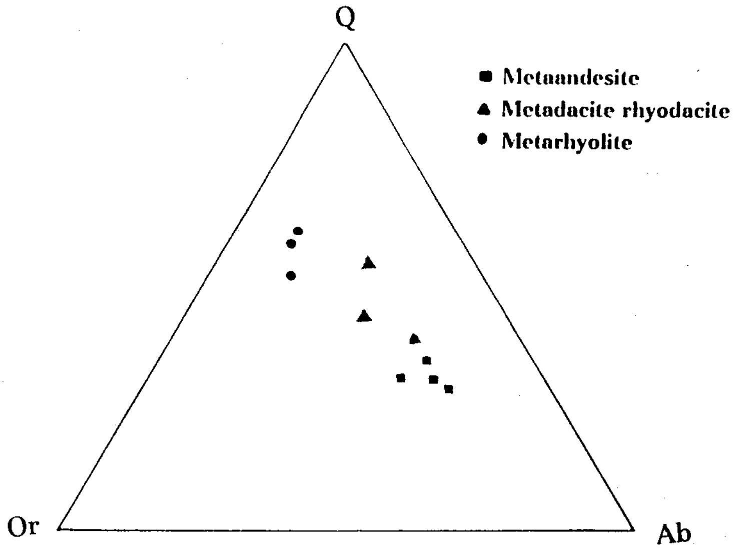


Fig. 18 : Normative Q, Or, Ab in metavolcanic rocks of the studied area. Quartz (Q), Orthoclase (Or) and Albite (Ab).

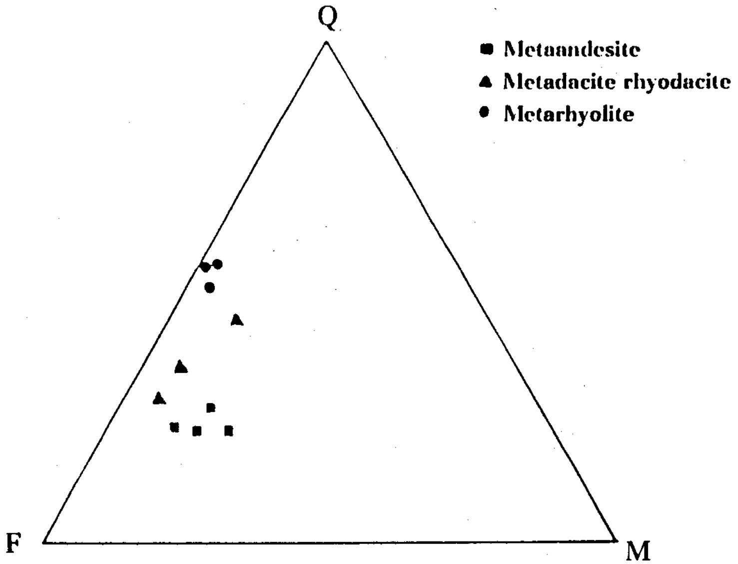


Fig. 19 : Variation in composition of metavolcanic rocks. Normative Quartz (Q), Feldspar (F) and mafic minerals (M)

Trace Elements

Since major elements are usually susceptible to modification during low grade metamorphism, use of some immobile trace elements which are fairly less resistant to chemical changes during the alteration and metamorphism to confirm the previously obtained results.

Table 3 shows that the andesites of the area show relatively higher concentration of Ni (38ppm), Sr (539 ppm) and Ba (366 ppm) than the Ni (18 ppm), Sr (385 ppm) and Ba (270 ppm) typical of orogenic andesites (Taylor, 1969). They contain also average 137 ppm Zr which is slightly higher than the value 110 ppm recorded by Jakes & White (1972). In metaandesites v ranges from 94–196 ppm averaging 143 ppm which is similar to the value recorded for calc–alkaline andesite given by Jake & White (op. cit.) but higher than the average 71 ppm obtained for Dokhan andesites (Basta et al., 1980).

The metadacite–rhyodacite association is in the range of 74 to 98 ppm V averaging 68 ppm given by Jakes & White (1972) and much higher than the average 19 ppm recorded for Dokhan dacite.

Cr^{+3} content in metaandesites averaging 23 ppm. Such average is lower than those recorded for world calc– alkaline andesite and similar to the Egyptian Dokhan andesites. The studied metadacites have values (average 154 ppm) similar to the average Cr for world calc–alkaline dacite (13 ppm) but lower than the Egyptian Dokhan dacite.

The samples of rhyolite are rich in Ni, V and Sr and poor in Y, Zr and Ba. They differ mainly from the other Egyptian rhyolites by their higher concentration of Sr and V and lower concentration of Zr and Y.

As in typical calc alkaline suite Ba in the analysed samples increases while Sr decreases with an increase of the SiO_2 content. Although the abundance of transition elements (V, Cr, Ni, Co, Cu and Zn) decrease from andesite to rhyolite.

Fig. 20 illustrates the variation of the analysed trace element concentration in ppm versus the D.I. of Thornton and Tuttle (1960) for the studied metavolcanics. The diagrams show that the progressive increase of D.I. values is accompanied by a general decrease of Ni, Cr, Co, Sr, Cu, Zn, Y and Zr concentrations. V shows no definite trend. Meanwhile Ba concentration increases with increase of D.I.

Table 3

Trace element contents (ppm) of the analysed metavolcanics.

Trace Element \ Sample Number	METAANDESITES						METADACITES – RHYODACITES						METARHYOLITES			
	121	187	165	155	Egypt Ande	World Ande	140	37	175	Egypt Dacite	Egypt Rhyodacite	World Dacite	100	153	30	Circle Greek Rhyoda
Ca	56	26	20	16	19	24	17	11	13	10	5	—	12	11	12	2
Ni	49	32	42	28	80	18	20	18	15	35	40	5	35	22	30	2
Cr	30	25	21	14	54	56	17	19	12	65	58	13	14	15	18	5
V	196	175	110	94	71	175	74	98	78	19	6	68	126	112	105	8
Ba	283	404	340	435	—	270	490	510	387	—	—	520	397	485	490	820
Sr	710	465	489	495	—	385	460	320	336	—	—	460	411	360	320	40
Cu	49	55	45	21	—	54	18	16	17	—	—	—	30	18	16	10
Zn	57	67	—	—	—	—	50	49	—	—	—	—	44	45	44	—
Y	36	39	28	22	—	21	31	25	26	—	—	20	26	21	22	70
Zr	161	158	120	108	—	110	100	132	123	—	—	100	98	89	87	400

Thompson (1973) and Hart et al., (1974) have shown that Cr is immobile during low grade metamorphism and alteration reactions. Cann (1970) in a study of the effect of increasing ocean floor metamorphism on bulk composition showed that Ti abundance varies little with progressive metamophism. Thus, Pearce (1975) plotted Cr against Ti to discriminate between island arc tholeiites (IAT) and ocean floor basalt (OFB).

Rocks with low Ti are of volcanic arc affinity (either CAB or IAT). The Cr abundance is generally low in calc–alkaline rocks. Application of these distinctive chemical characteristics to the studied volcanics indicates an island arc origin for the studied samples with low Cr content (Fig. 21). The diagram did not differentiate between tholeiitic field and calc–alkaline field, but the low Cr content may indicate calc–alkaline character.

Miyashiro and Shido (1975) used the V–Cr and V–FeO ^{t}/MgO relation to differentiate between the different types of volcanics arcs. Fig. 22 shows that all the volcanics of the studied area plot in the field of calc–alkaline.

Pearce & Cann (1973) and Winchester & Floyd (1976) have pointed out that the concentration of certain minor elements such as Ti, P, Zr and Y does not change during metamorphism. Furthermore, the incompatible elements Ti, Zr and Y are characterized by their field strength and so they can be used to interpret the petrogenesis of volcanic rocks especially which suffered from metamorphism (e.g. Pearce & Norry, 1979). The relation between the concentration of these elements in the metamorphosed rocks should therefore reflect the possible tectonic setting of the extrusion.

In Fig. 23 Pearce and Cann (1973) employed a plot of Ti versus Zr to separate calc–alkaline (CAB) from tholeiitic basalts (IAT and OFB). The plot of the metaandesites – metarhyolites are in calc–alkaline field. The relation between titanium, zirconium and yittrium is shown in a ternary diagrams (Fig. 24). The metavolcanics in the area have a similar tectonic setting of extrusion. They fall in the calc–alkaline field.

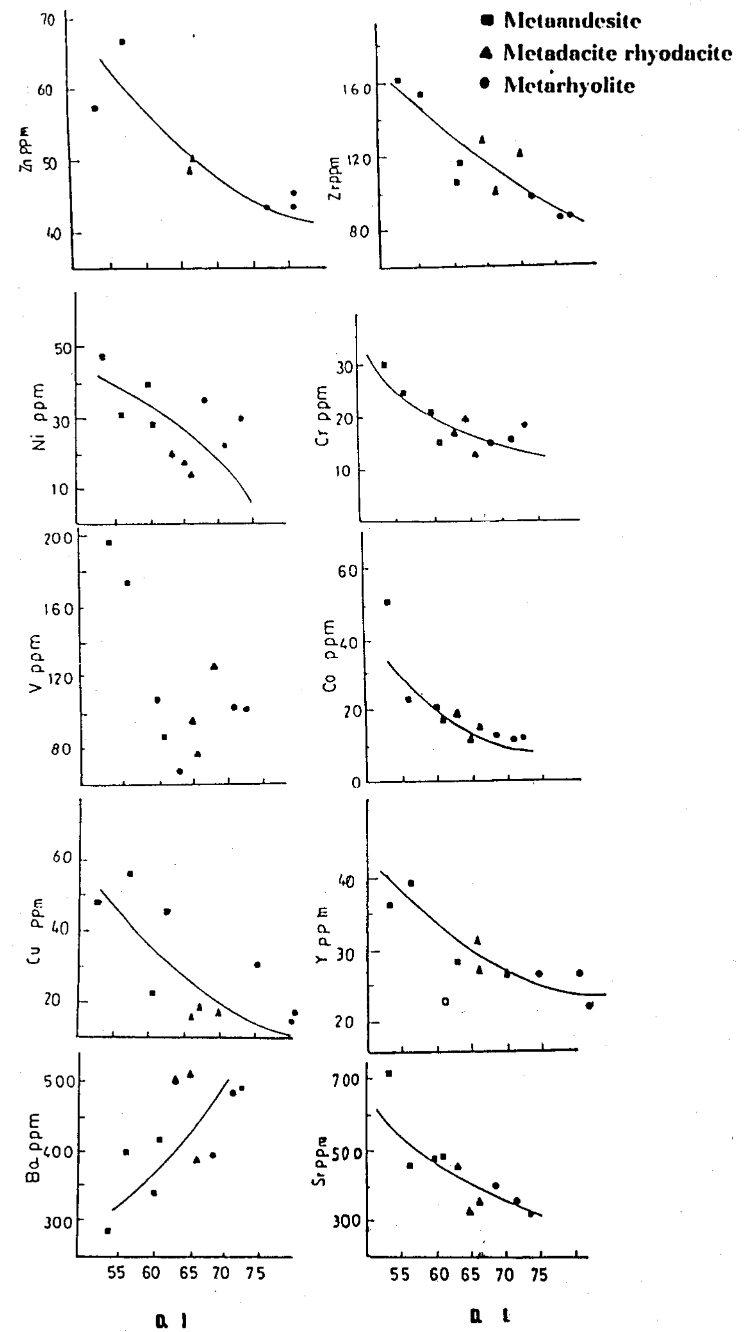
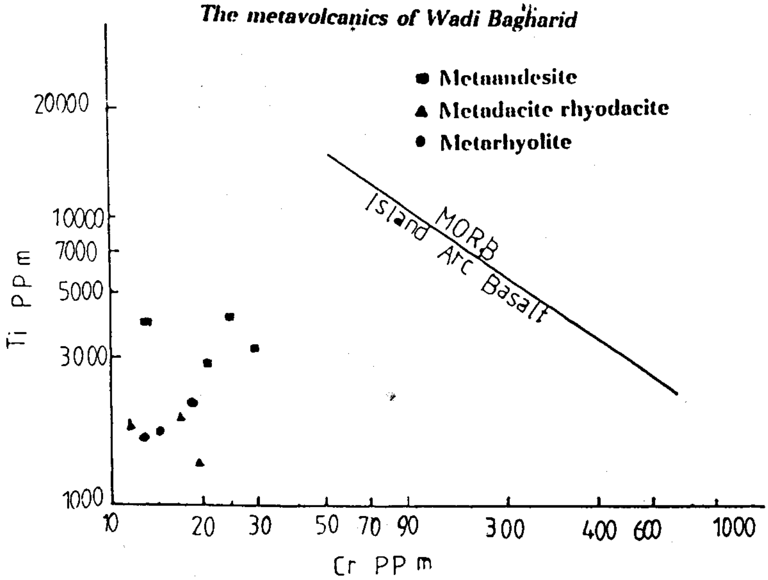


Fig. 20 : Variation of trace elements content (ppm) with the D.I. (Thornton & Tuttle, 1960).



Cr ppm

Fig. 21 : Variation of the Ti content with Cr of the studied metavolcanics (Boundary after Pearce & Gale, 1977).

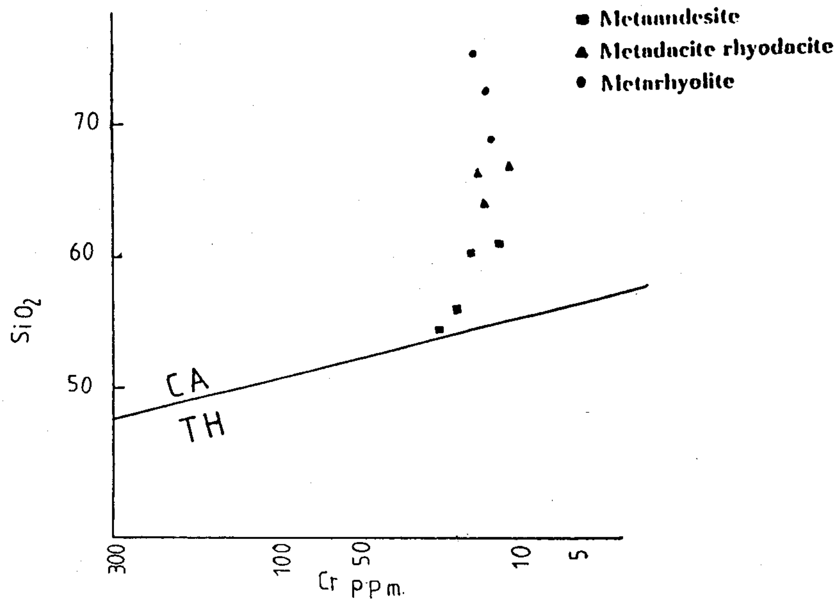


Fig. 22 : SiO^2 – log Cr discrimination diagram for the studied metavolcanics (Boundary after Miyashiro & Shido, 1975).

CLASSIFICATION OF METAVOLCANICS

Different classifications were made to outline the chemical identification between different rock units. The classification adopted by Middlemost (1980) makes use of silica and total alkalies contents (Fig. 25). It is found that the studied samples fall in the fields of basaltic andesite, andesite, andesitic dacite, dacite, rhyolite which are in accordance with their petrographic classification. No sample lies in the field of basalt, trachyandesite or trachyte.

Winchester & Floyd (1977) advanced a classification of different volcanic rocks according to the relation between Zr/TiO_2 ratio and SiO_2. Fig. 26 shows that the examined metavolcanics plotted on this diagram fall within the fields of andesites, rhyodacites and rhyolites.

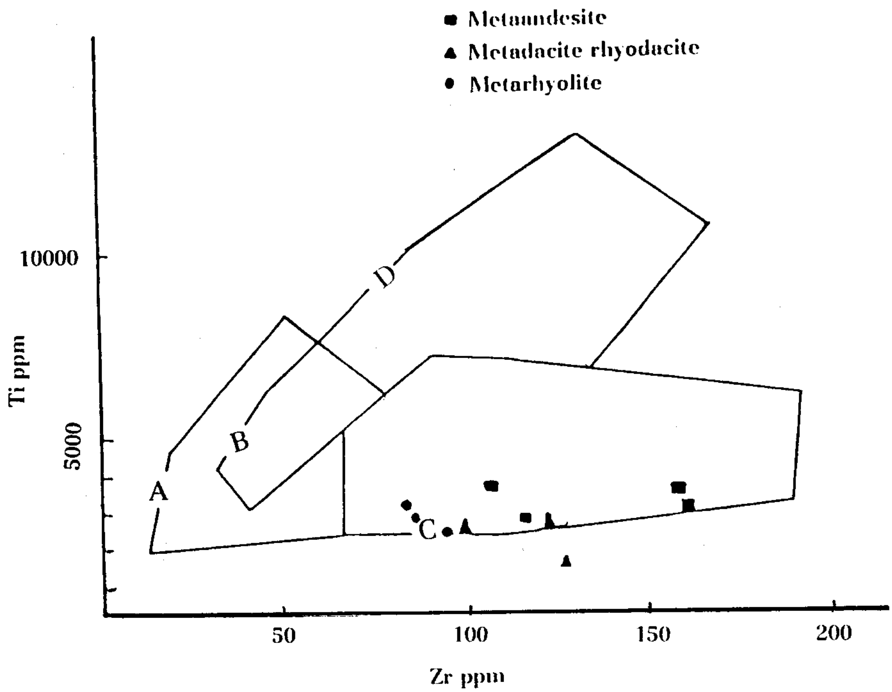


Fig. 23 : Concentration of zirconium (Zr) and titanium (Ti) in metavolcanic rocks in the studied area. A+B : Low potassium theleiites; B+C : Calc alkali basalts; B+D : Ocean floor basɾlts.

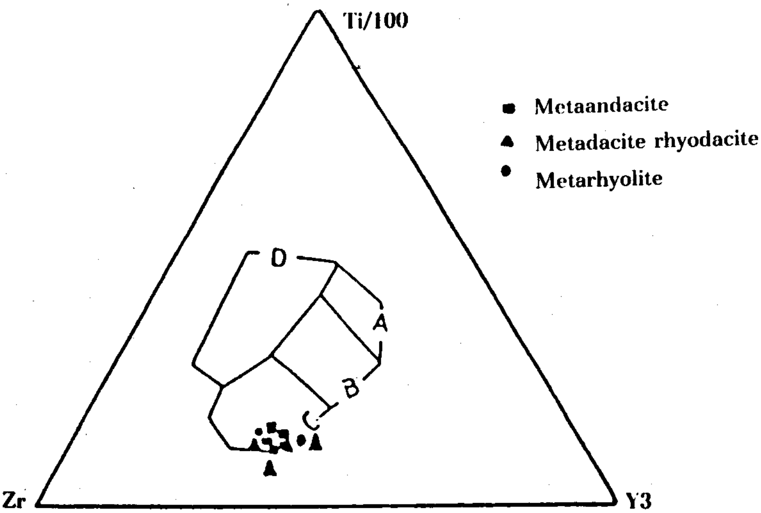


Fig. 24 : Relative content of zirconium (Zr), Yittrium (Y) and Titanium (Ti) in metavolcanic rocks of the studied area.

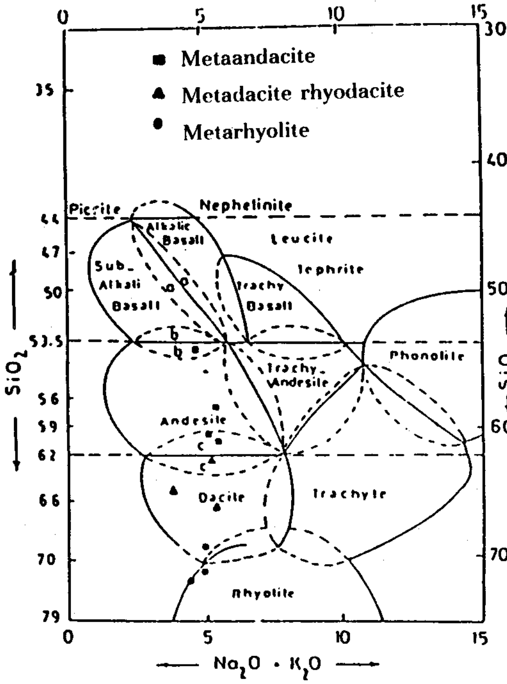


Fig. 25 : Silica–alkali diagram for the studied metavolcanics (Boundaries after Middlemost, 1980). a– transitional basalts; b– Basaltic andesite; c– Andesitic dacite.

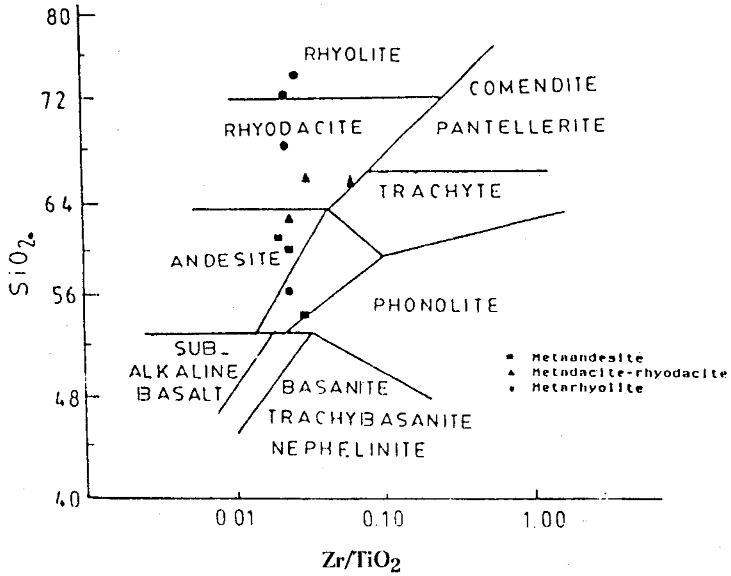


Fig. 26 : SiO_2-Zr/TiO_2 diagram for the studied metavolcanic rocks (Boundaries after Winchester & Floyd, 1977).

CONCLUSION

The present study presents a new detailed geologic map of the area west of Wadi Bagharid. Most of the area is covered by calc-alkaline intermediate to acidic metavolcanics. They consist of metaandesites to metarhyolite series and their pyroclastic equivalents. Tuffaceous layers are distinctly bedded and foliated. The metavolcanic rocks are interbedded with volcanoclastic sedimentary rocks. The sequence has experienced greenschist facies of metamorphism. The metavolcanics in the area have chemical characteristics and trace element contents which indicate that the first magmas were generated in an island arc environment.

ACKNOWLEDGEMENT

Chemical analysis was carried out at the Institute of Mineralogy and Petrology, Mainz University, West Germany, for which the writers are grateful.

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النشأة والوضع التكتوني
لحزام البركانيات غرب وادي بغاريد
بجنوب الصحراء الشرقية - مصر

باهر عبدالحميد القليوبي و زينهم سيد الألفي

يتضمن هذا البحث دراسة جيولوجية لحزام البركانيات المتحولة غرب وادي بغاريد بجنوب الصحراء الشرقية . . قسمت هذه الصخور بتروجرافيا إلى أربعة أنواع رئيسية هي : صخور الأنديزيت - الداسيت - الرايوليت وصحبتها من الطفوح والتوفا. وأجريت دراسة بتروكيميائية كما تم أيضا دراسة للعناصر الشحيحة - اتضح منها أن هذه الصخور تقع في مجموعة الكلسى - قلّيه ويمكن استنباط نموذج التكوين التكتوني لها على أنها تمثل أقواس الجزر وتكونت بعيدا نسبيا عن المحيط أثناء انزلاق اللوح المحيطي تحت اللوح القاري .