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PETROLOGY AND OPAQUE MINERALOGY OF UM ARTA VOLCANICS, NORTHERN EASTERN DESERT, EGYPT.

Takla, M. A.[1] *Khalaf, I. M.*[2] *Hathout, M. H.*[2] *and Eliwa, H. A.*[2]

1- Department of Geology, Cairo University.
2- Department of Geology, Menoufia University.

ABSTRACT

The present paper deals with the petrology and opaque mineralogy of the Dokhan Volcanics at Wadi Um Arta (Lat. 28° 35` and 28° 41` 48`` N & Long. 32° 25` and 32° 32` 6`` E) in the extreme northern Eastern Desert of Egypt.

Field relations indicate that these volcanics are older than the surrounding younger granites and younger than the enclosed metamorphic rocks. These volcanics are represented by laminated lapilli andesite tuff, andesite (dominant rock type), quartz andesite, dacite and rhyodacite. The opaque minerals are titanomagnetite, magnetite, ilmenite and sulphides. The quartz andesite, dacite and rhyodacite are poor in opaques (0.4 - 0.5 %) and their ilmenite/ (ilmenit + magnetite) ratio varies from 0.2 to 0.6. The laminated lapilli andesitic tuff and andesite are relatively rich in opaques (2-2.7%) and their ilmenite/(ilment + magnetite) ratio varies from 0.1 to 0.2. They are calcalkaline and probably generated in an island arc with a well developed thin continental crust (active continental margin). The data presented indicates that the volcanic suite is comparable to the Dokhan Volcanics of the Eastern Desert.

INTRODUCTION

The Dokhan Volcanics cover about 10% of the basement outcroup in the Eastern Desert of Egypt. These volcanics attracted the attention of many workers (Barron and Hume, 1902; Barthaux, 1922; Hume, 1934; Andrew, 1938; El-Ramly and Akaad, 1960; Akaad and El-Ramly, 1960; Schürmann, 1966; Ghobrial and Lotfi, 1967; Akaad, 1972; Ghanem, 1972; Akaad and Noweir, 1980; Basta *et al.* 1980; Himly *et al.*, 1980; Dardir *et al.*, 1982; El-Gaby, 1983; Ressetar and Monrad, 1983; Abu Zeid, 1984; El-Gaby *et al.*, 1984 & 1988; Furness *et al.*, 1985; Stern and Hedge, 1985; Ragab, 1987; El-Gaby *et al.*, 1989 & 1990).

The Dokhan Volcanics under consideration are exposed at Wadi Um Arta in the extreme northern Eastern Desert between Latitudes 28° 35` and 28° 41` 48`` N and Longitudes 32° 35` and 32° 32` 6`` E. It is located 80 km northwest of Ras Gharib. Although many workers have studied the Dokhan Volcanics in the Eastern Desert, no detailed studies have been done on the volcanics of the present area.

Fifty rock samples were collected from the exposed volcanics of the area. Out of these samples, 30 thin sections and 20 polished sections were prepared. In addition, fourteen repersentative rock samples were subjected to complete chemical analysis for major and some minor elements using gravimetric, compleximetric, flame photometric and atomic absorption methods. Thirteen trace elements for ten samples were determined using XRF technique.

The objective of the present work is to study the field relationships of the Dokhan Volcanics at Wadi Um Arta and the surrounding rock units as well as to give the petrography, opaque mineralogy and geochemistry of these volcanics and discuss its magma nature and tectonic setting.

GEOLOGICAL SETTING

The studied Dokhan Volcanics (Fig.1) cover an area of 54.3 Km^2 in the form of two masses. The first one is small (1.8 km^2) forming an oval outcrop of moderate relief up to 826 m (a.s.l.). It is greyish green, fine grained and consists mainly of rhyodacite and dacite. It is intruded from the east and south by graphic granites. From the west, sedimentary Nubia Sandstone is unconformably overlying it. The second exposure (52.5 Km^2) is the main body

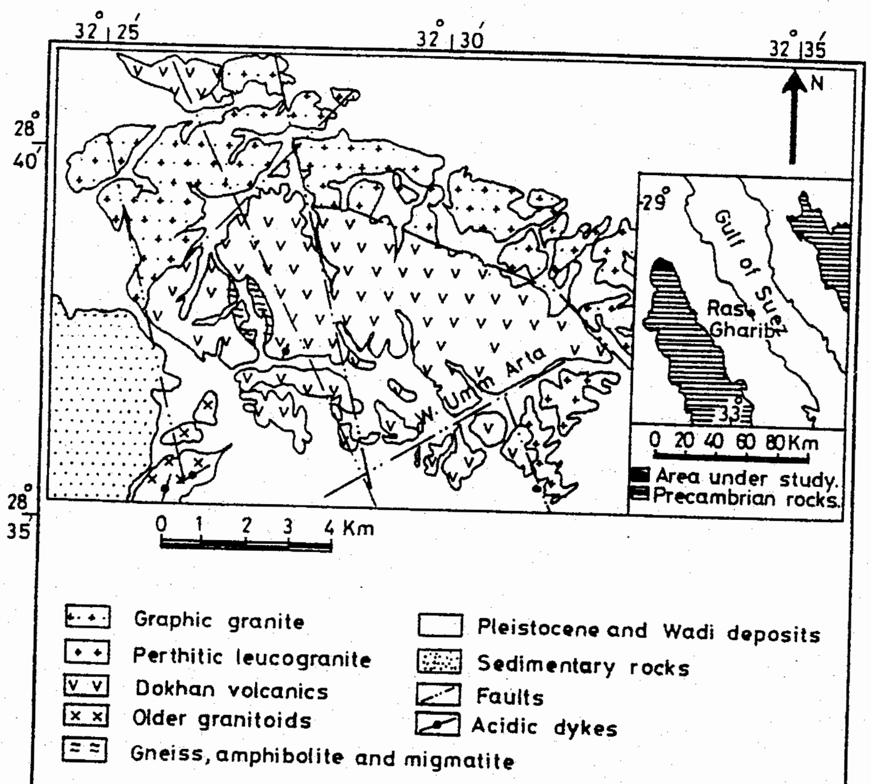


Fig.1 : Geological map of Um. Arta Volcanics.

forming an elongated outcrop (10.2 km x 4.6 km) in nearly E-W direction. The northern boundary of this volcanic exposure is relatively higher in relief with respect to the surrounding granites whereas the southern part forming isolated scattered hills that are relatively low in relief and crossed by Wadi Um Arta. It is dark greyish green, fine grained and consist of andesitic tuff, andesite, dacite and rhyodacite. This arrangement is recorded from the eastern side to the western side where it is unconformably overlain by Nubia Sandstone. These volcanics are intruded and cut by the surrounding graphic granites (Fig. 2a) and perthitic leucogranites with sharp contacts. They are also capping and cutting the enclosed metamorphic rocks (gneisses, migmatites and amphibolites) with sharp contact. At the southwest boundary of these volcanics, a set of acidic dykes are injected in a NE-SW direction.

PETROGRAPHY

Detailed microscopic examination of the investigated Dokhan Volcanic rocks revealed the following rock types :

a- Laminated lapilli andesitic tuffs.
b- Andesites.
c- Quartz andesites.
d- Dacites.
e- Rhyodacites.

The andesites are the predominant rock type, while the other types are of relatively limited occurrence. The Dokhan Volcanics under study consist mainly of plagioclase, quartz, potash feldspar, hornblende and biotite phenocrysts embedded in a fine grained groundmass.

The description of the phenocrysts in the Dokhan Volcanic varieties can be summarized as follows :

Plagioclase is the most common phase. Its composition ranges from andesine (An 32) in the laminated lapilli andesitic tuff to oligoclase (An 14) in the dacite. Generally, the plagioclase phenocrysts are zoned (Fig. 2b) and twinned (Fig. 2c). Two generations are occasionally observed in andesites (Fig. 2d). In dacites, few phenocrysts are randomly segregated in clusters forming a glomerophyric texture. The plagioclase phenocrysts are variably altered to sericite, kaolinite, carbonate and epidote. The margin of most plagioclase crystals are cloudy and sometimes stained by hematitic material.

Quartz is a common constituent in the studied rock types, except andesites. It exists as phenocrysts and in the groundmass. It usually exhibits undulatory extinction (Fig. 2e) and rarely encloses fine dusty inclusions of biotite, chlorite, hornblende and plagioclase. Apatite needles are common inclusions. In rhyodacites, the quartz phenocrysts are euhedral (Fig. 2f) and occasionally encloses amygdules that are composed of fibrous and radial aggregates of K-feldspar and carbonate (Fig. 2g).

Potash feldspar is only detected in the laminated lapilli andesitic tuffs and rhyodacites where it is represented by microcline-microperthite in the former and microperthite in the latter. Occasionally the phenocrysts are simply twinned (Fig. 2h) and commonly altered to kaolinite. Few phenocrysts contain plagioclase and xenomorphic quartz grains.

Hornblende is a common constituent in quartz andesites and dacites. It occurs either as phenocrysts or in the groundmass. Occasionally the phenocrysts are simply twinned (Fig. 2i). They enclose fine plagioclase laths, irregular sphene grains and apatite needles. In dacites, it shows partial alteration to biotite and chlorite.

Biotite phenocrysts are only present in quartz andesites, dacites and rhyodacites. They commonly show partial to complete chloritization.

Fig. (2) :

a) Dokhan volcanics intruded by graphic granites with sharp contact, at Wadi Um Arta.

b) Plagioclase phenocryst showing normal zoning; quartz andesite, C.N.

c) Plagioclase phenocryst showing albite, combined albite-carlsbad and pericline twinning; dacite. C.N.

d) Two generations of plagioclase phenocrysts; andesite, C.N.

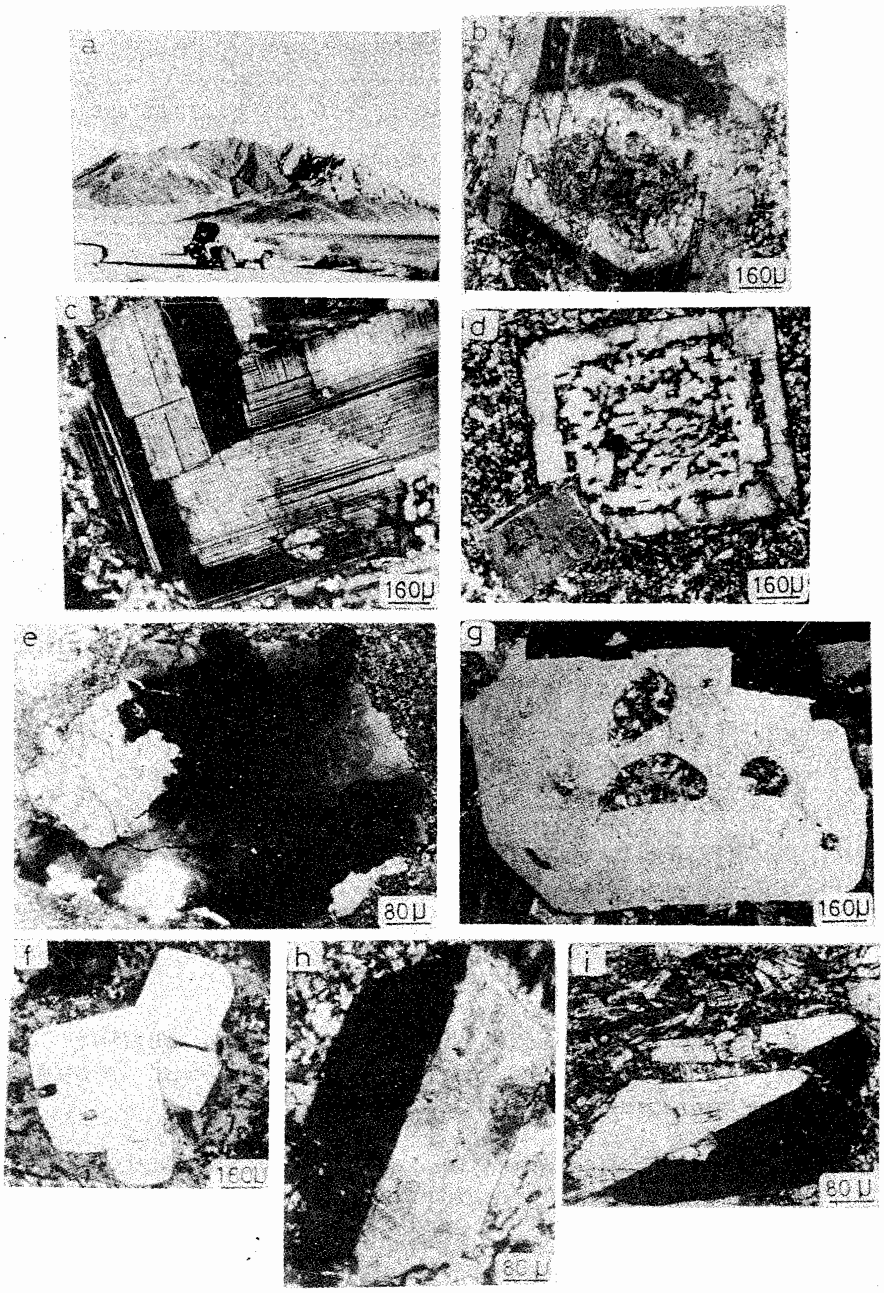
e) Quartz phenocryst showing wavy extinction; laminated lapilli andesitic tuff, C.N.

f) Rhyodacite showing quartz phenocrysts, C.N.

g) Large quartz crystal enclosing amygdules filled with k-feldspar, quartz and calcite; rhyodacite, C.N.

h) Potash feldspar phenocryst with well developed simple twinning; rhyodacite, C.N.

i) Hornblende phenocryst showing simple twinning; quartz andesite, C.N.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The groundmass of the different varieties of the Dokhan Volcanics has the following features :

a- In laminated lapilli andesitic tuff, the groundmass exhibits a well developed flow and laminated textures (Fig. 3a). It contains rounded to elongated amygdules composed of quartz, rarely chlorite and biotite (Fig. 3b).

b- In andesite, the groundmass is characterized by orthophyric texture (Fig. 3c) composed of plagioclase laths, green chlorite and quartz. The plagioclase laths are usually more sodic than the associating phenocrysts.

Fig. (3) :

a) Groundmass with banded texture, showing felsic layers alternating with mafic layers; laminated lapilli andesitic tuff, C.N.

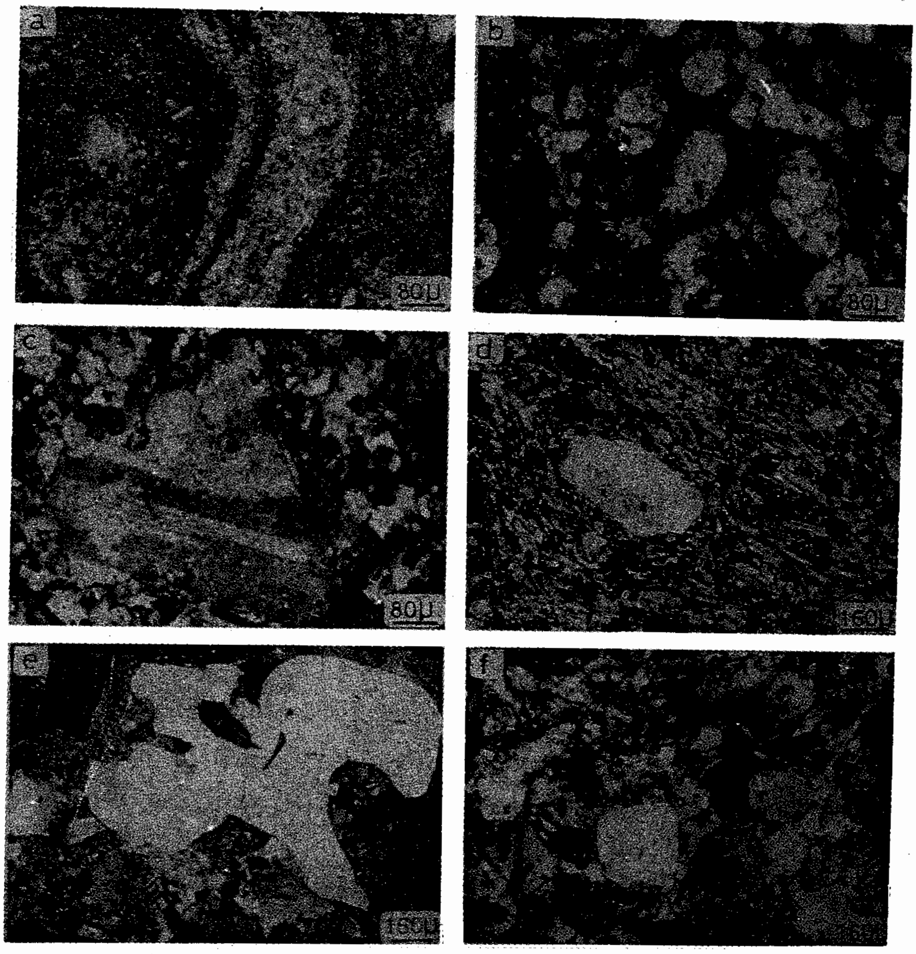
b) Laminated lapilli andesitic tuff showing amygdules of quartz enclosed within groundmass, C.N.

c) Andesite showing groundmass with orthophyric texture and plagioclase phenocryst, C.N.

d) Quartz andesite showing pilotaxitic groundmass, C.N.

e) Quartz crystal shows embayed outlines and micrographic intergrowths confined along its peripheries; rhyodacite, C.N.

f) Rhyodacite showing a well developed rounded spherulitic groundmass, C.N.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c- The groundmass of quartz andesite shows a pilotaxitic texture (Fig. 3d) which consists of plagioclase, hornblende and rarely chlorite.

d- In dacites, the groundmass includes quartz as dominant constituent and subordinate amounts of plagioclase, perthite and biotite.

e- The rhyodacite groundmass is composed essentially of quartz and potash feldspar with subordinate amounts of plagioclase and chlorite. Quartz is either completely intergrowth with K-feldspar forming a micrographic texture (Fig. 3e) or grouped with radial and fibrous K-feldspar forming rounded spherulites (FIg. 3f).

The main accessory minerals in the concerned rocks include opaques, apatite, zircon and sphene whereas the most predominant secondary minerals are sericite, kaolinite, chlorite, muscovite and carbonates.

Finally, the petrographic data suggest that the studied Dokhan Volcanics are generally fresh, may show slight alteration but not metamorphism (Ries *et al.*, 1983 and Stern *et al.*, 1984).

OPAQUE MINERALOGY

The distribution of the opaque minerals and their intergrowths in the Dokhan Volcanics of Egypt is given here for the first time.

The opaque mineralogical characteristics of the studied Volcanics reveal the following :

a- Laminated lapilli andesitic tuff contains opaques (2%) that are represented by titanomagnetite with traces of pyrite. The ilmenite/(ilemenite + magnetite) ratio varies from 0.1 to 0.15. Titanomagnetite is cracked and martitized. It is partly replaced by sphene along cracks (Fig. 4a) and periphery (Fig. 4b). The titanomagnetite shows sandwich intergrowth with ilmenite and myrmekite intergrowth with silicates.

b- Andesite contains the highest opaque percentage (2.7%) compared with other volcanic types. The opaques consist mainly of titanomagnetite and subordinate amounts of ilmenite and fresh pyrite. The ilmenite/(ilemenite + magnetite) ratio = 0.2. Few titanomagnetite crystals are completely intergrown with silicates and ilmentite forming myrmekitic (Fig. 4c), trellis (Fig. 4d) and internal granule intergrowths. Ilmenite is commonly replaced by sphene along (0001) planes (Fig. 4e).

c- Quartz andesite is very poor in opaques (0.5%) that consist of ilmenite and magnetite with traces of sulphides. The ilmenite / (ilmenite + magnetite) ratio = 0.6. Ilmentite occurs as discrete homogenous crystals that are extensively replaced by sphene. Magnetite is slightly altered to martite. Sulphides are represented by chalcopyrite and pyrite. The latter shows hydration to colloform goethite "limonite".

d- Dacite is much poor in opaques (0.4%) that are represented by fresh ilmenite and minor pyrite. The ilmenite/(ilmenite + magnetite) ratio = 1.

e- Rhyodacite is very poor in opaques (0.5%) mainly of magnetite and pyrite with very subordinate amount of ilmenite. The ilmenite/(ilmenite + magnetite) ratio = 0.2. Magnetite occurs as titanomagentite phenocrysts extensively replaced by sphene and normal fresh magnetite grains scattered through the groundmass. The pyrite is commonly replaced by goethite with well developed colloform texture (Fig. 4f). The replacement of pyrite is extensive forming a net-like fashion (Fig. 4g).

Fig. (4) :

a) Large cracked titanomagnetite crystal partly replaced by sphene along the cracks. Laminated lapilli andesitic tuff, Reflected Light.

b) Titanomagnetite phenocryst with corroded peripheries and showing replacement by thin rim of sphene along its outer periphery. Laminated lapilli andesitic tuff, Reflected Light.

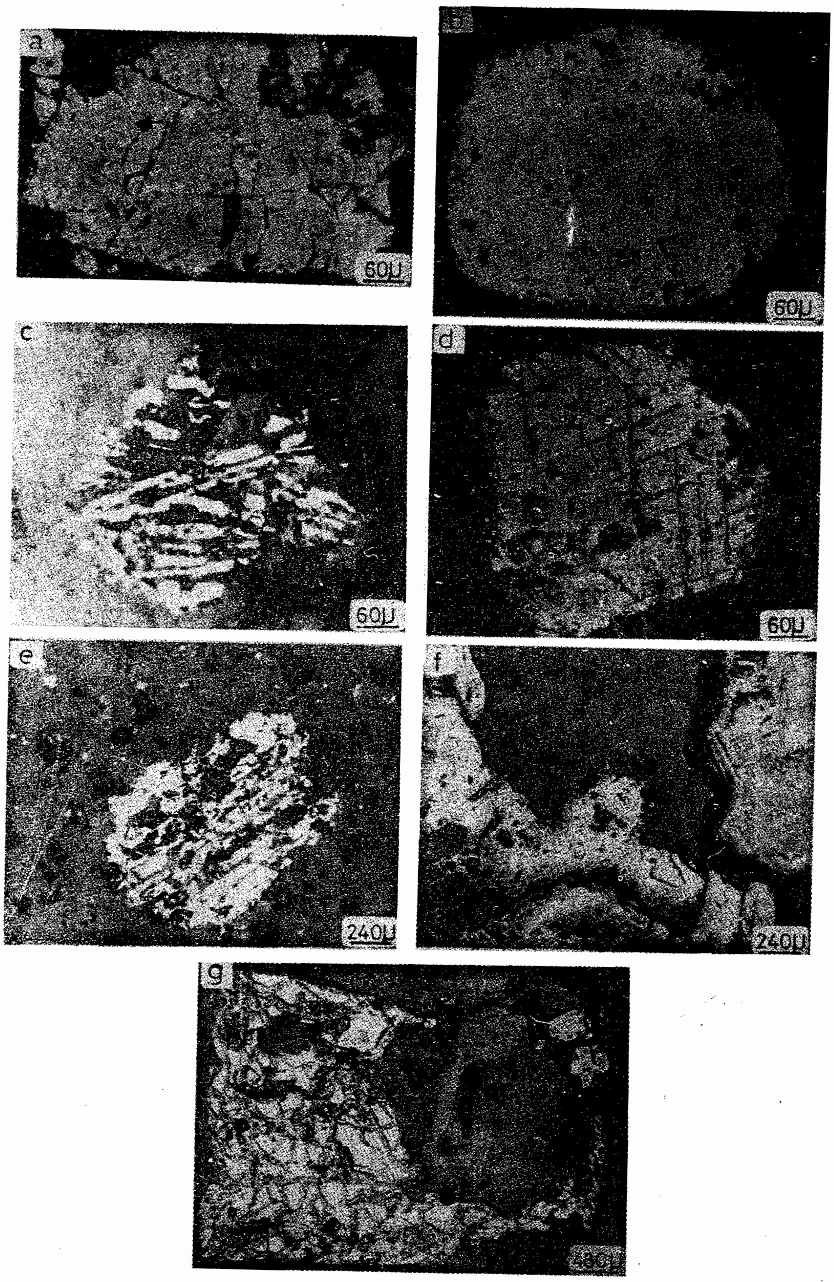
c) Titanomagnetite-Silicate mymekitic intergrowths. Andesite, Reflected Light.

d) Titanomagnetite grain with ilmentie forming trellis intergrowth. Andesite, Reflected Light.

e) Ilmenite crystal partly replaced by sphene along (0001) planes. Andesite, Reflected Light.

f) Rhyodacite showing a complete replacement of pyrite by well developed colloform goethite and limonite. Reflected Light.

g) A cracked pyrite crystal with well developed colloform texture of goethite-limonite in net like fashion. Rhyodacite, Reflected Light.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60µ
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The distribution of the opaque minerals and their intergrowths in the studied Dokhan volcanics is summarized in Table 1. The table shows the possibility of distinguishing the various petrographic varieties on basis of their opaque mineral contents and intergrowths.

GEOCHEMISTRY

Tables 2 & 3 give a comparison of the obtained chemical data with data of Dokhan Volcanics (Basta *et al.*, 1980).

The data presented indicates that the examined volcanic rocks are comparable with the Dokhan Volcanics at type locality, rocks of active continental margin and are very similar to the Dokhan Volcanics at Qena-Safaga road (Ressetar and Monrad, 1983).

Chemical Classification :

Figures 5a, 5b and 5c show that the studied volcanic rocks show a compositional range from andesite to rhyodacite which support the petrographic nomenclature.

Magma Type :

All plots of the studied samples on different variation diagrams (Figs. 6a to 6d) indicate that the present Dokhan Volcanics are typical calc-alkaline.

Tectonic Setting :

The tectonic environment of Um Arta volcanics is deduced from the following relationships :

Table (1): Distribution of the opaque minerals and their intergrowth in the studied Dokhan Volcanics.

Petrographic nomenclature	Opaques %	I / (I + M)	Magnetite					Ilmenite		Sulphides	
			Homogeneous	Trellis	Comp. grains	Sandwich	Granule	Homogeneous	Sphene replac.	Chalcopyrite	Pyrite
Laminated lapilli andesite tuff	2	0.1-0.15	++++	-	-	+	-	-	-	-	+
Andesite	2.7	0.2	++++	++	-	-	+	++	++	-	+
Quartz andesite	0.5	0.6	++	-	-	-	-	+++	++	+	+
Dacite	0.4	1	-	-	-	-	-	+++	++	+	+
Rhyodacite	0.5	0.2	++	-	-	-	-	+		-	++

++++ Dominant +++ Common ++ Fair + Rare - Absent

I Ilmenite M Magnetite

a- The plots of the studied volcanics (Fig. 7a) on Gottini-Rittmann diagram indicate that these volcanics are situated in orogenic belts and generated in island arc.

b- Figures 7b, 7c and 7d show that all the plotted analyses of andesites and dacites fall mainly in the field of island arc and active continental margins.

c- The remarkably high content of K2O (2.06-3.9%) in the studied volcanics provides an evidence that they most probably represented a well developed island arc with thick contiental crust or active continental margin. They are also characterized by medium rate of plate convergence (Miyashiro, 1975).

d- Figure 7e indicates that the studied andesites were generated in an island arc environment.

e- The high and variable Zr / Y ratios (Fig. 7f) for the studied andesites are characteristic for calc-alkaline volcanics formed in a continental margin environment (Pearce, 1983; Capan and Floyd, 1985).

Table (2) : Chemical composition of the studied Dokhan volcanics compared with those of Basta *et al.* (1980)

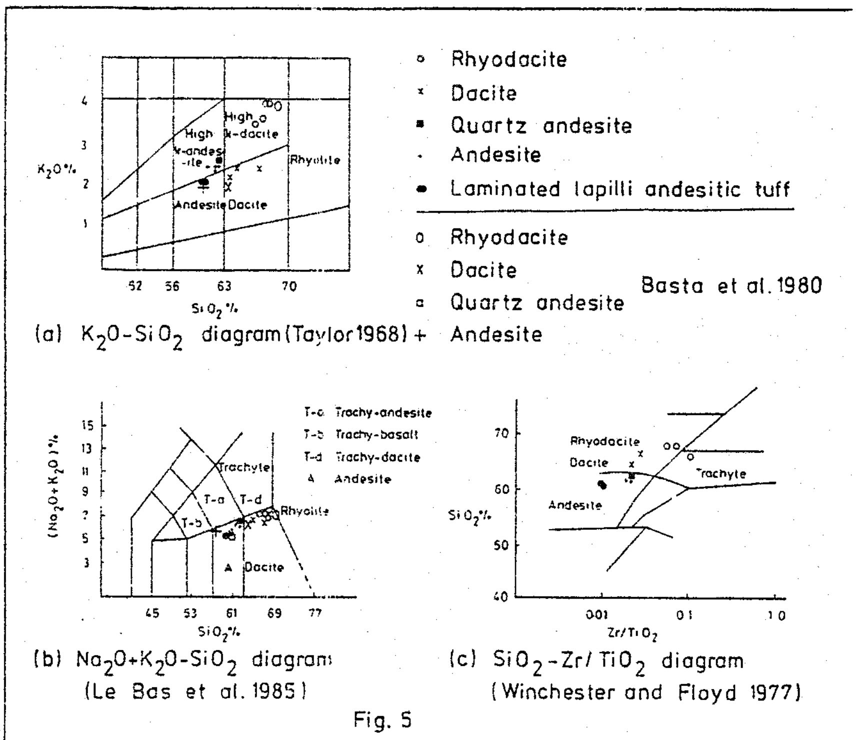
	Studied Dokhan volcanics																		Dokhan volcanics of the type locality (Basta *et al*, 1980)			
Rock type	Laminated lapilli andesitic tuffs (2)			Andesites (4)					Quartz andesites (1)	Dacites (3)				Rhyodacites (4)					Andesites (9)	Quartz andesites (16)	Dacites (3)	Rhyodacites (1)
Sample No	35	42	Av.	31	31A	33	34	Av.	30	22	49	89	Av.	27	44	25	59	Av.				
Wt %																						
SiO_2	60.66	60.06	60.36	61.80	60.80	62.16	62.05	61.70	62.80	66.78	64.30	64.10	65.06	57.57	66.40	67.71	67.77	68.61	57.44	60.63	63.61	69.69
TiO_2	0.81	0.92	0.86	0.42	0.46	0.37	0.46	0.43	0.39	0.40	0.47	0.4	0.44	0.38	0.40	0.53	0.44	0.45	1.10	0.94	0.89	0.30
Al_2O_3	16.76	16.91	16.83	16.90	17.50	15.59	15.90	16.47	16.49	16.17	17.08	16.97	16.74	15.15	15.91	14.24	13.82	14.78	16.04	15.53	14.57	12.95
Fe_2O_3	4.72	5.03	4.87	2.86	2.86	2.76	3.39	2.97	2.86	1.91	2.07	2.00	1.99	2.33	1.94	1.94	2.60	2.20	3.74	3.84	3.55	1.16
FeO	3.28	3.99	3.64	3.89	4.04	4.31	3.99	4.06	3.73	3.08	2.71	2.99	2.93	2.74	2.76	2.18	2.00	2.42	4.49	3.16	3.09	3.78
MnO	0.13	0.14	0.13	0.24	0.25	0.23	0.26	0.25	0.11	0.08	0.11	0.12	0.10	0.08	0.11	0.04	0.05	0.07	0.13	0.12	0.10	0.08
MgO	1.93	2.58	2.26	1.91	1.71	2.09	1.97	1.92	1.70	1.41	1.37	1.59	1.46	1.08	1.15	0.86	0.99	1.01	3.60	2.83	2.34	1.12
CaO	3.90	3.94	3.80	4.30	4.09	4.33	4.20	4.23	3.30	2.36	2.12	2.21	2.23	2.09	2.11	1.76	2.09	2.01	6.11	5.16	3.87	2.58
Na_2O	3.61	3.39	3.50	3.65	3.55	3.77	3.65	3.66	3.88	4.21	4.17	4.23	4.20	3.39	3.50	3.90	3.80	3.65	3.37	3.42	4.47	3.24
K_2O	2.06	2.08	2.07	2.40	2.28	2.43	2.35	2.36	2.63	2.30	2.43	2.20	2.31	3.42	3.54	3.94	3.89	3.70	1.93	1.92	1.87	3.79
P_2O_5	0.23	0.20	0.21	0.20	0.18	0.13	0.10	0.15	0.15	0.14	0.30	0.10	0.18	0.40	0.17	0.16	0.21	0.21	0.29	0.26	0.19	0.06
L.O.I.	0.44	0.42	0.43	1.36	1.92	1.19	1.09	1.39	1.72	0.99	1.93	2.52	1.81	1.31	1.50	1.62	1.71	1.53	n.a	n.a.	n.a.	n.a.

Table (3) : Trace element ccontents of the studied Dokhan volcanics compared with those of Basta *et al.* (1980)

	Studied Dokhan volcanics																		Dokhan volcanics of the type locality (Basta *et al*, 1980)			
Rock type	Laminated lapilli andesitic tuffs (2)			Andesites (4)					Quartz andesites (1)	Dacites (3)				Rhyodacites (4)					Andesites (9)	Quartz andesites (16)	Dacites (3)	Rhyodacites (1)
Sample No	38	42	Av.	31	31A	33	34	Av.	30	22	49	89	Av.	27	44	25	59	Av.				
Zr	95	98	96.5	107	n.a.	n.a.	97	102	101	109	n.a.	101	105	n.a.	263	250	247	253.3	n.a.	n.a.	n.a.	n.a.
V	70	80	75	31	n.a.	n.a.	38	34.5	40	45	n.a.	49	47	n.a.	20	27	25	24	71	48	19	6
Cr	87	85	86	45	n.a.	n.a.	52	48.5	54	59	n.a.	66	62.5	n.a.	27	20	23	23.3	54	61	65	58
Sr	404	430	417	290	n.a.	n.a.	283	286	210	173	n.a.	171	172	n.a.	132	110	151	131	n.a.	n.a.	n.a.	n.a.
Rb	38	45	41.5	88	n.a.	n.a.	101	94.5	90	90	n.a.	76	83	n.a.	75	67	74	72	n.a.	n.a.	n.a.	n.a.
Y	15	19	17	15	n.a.	n.a.	14	14.9	14	12	n.a.	13	12.5	n.a.	35	30	23	29.3	n.a.	n.a.	n.a.	n.a.
Co	21	27	24	19	n.a.	n.a.	18	18.5	21	2.5	n.a.	2.2	2.35	n.a.	5.8	6.2	5.3	5.8	19	18	10	5
Ni	30	22	26	11	n.a.	n.a.	13	12	11	17	n.a.	15	16	n.a.	19	20	17	19	80	45	35	40
Li	20	25	22.5	33	n.a.	n.a.	35	34	34	30	n.a.	29	29.5	n.a.	55	51	61	55.7	n.a.	n.a.	n.a.	n.a.
Ba	190	175	182.5	270	n.a.	n.a.	243	256.5	235	235	n.a.	293	264	n.a.	243	235	395	291	n.a.	n.a.	n.a.	n.a.
Nb	2	3	2.5	3.5	n.a.	n.a.	4.1	3.8	4.1	4.4	n.a.	3.8	4.1	n.a.	8.4	9.2	10.1	9.2	n.a.	n.a.	n.a.	n.a.
Ta	0.5	0.5	0.45	0.9	n.a.	n.a.	1.1	1.0	1.0	1.1	n.a.	1.2	1.15	n.a.	2.2	2.1	2.0	2.10	n.a.	n.a.	n.a.	n.a.
Yb	1.2	1.4	1.3	1.9	n.a.	n.a.	1.9	1.9	1.7	2.1	n.a.	1.8	1.95	n.a.	2.3	2.2	2.2	2.2	n.a.	n.a.	n.a.	n.a.

Numbers between brackets are numbers of analyzed samples.

n.a. not analyzed.

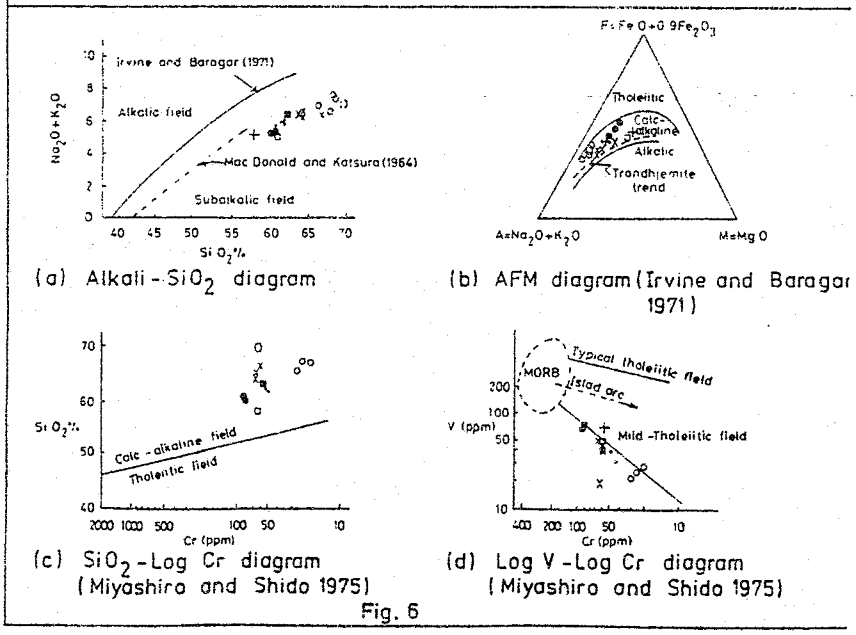


(a) K_2O-SiO_2 diagram (Taylor 1968)

(b) Na_2O+K_2O-SiO_2 diagram (Le Bas et al. 1985)

(c) SiO_2-Zr/TiO_2 diagram (Winchester and Floyd 1977)

Fig. 5



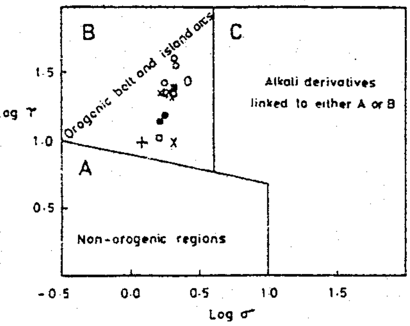
(a) Alkali-SiO_2 diagram

(b) AFM diagram (Irvine and Baragar 1971)

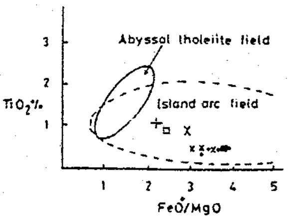
(c) SiO_2-Log Cr diagram (Miyashiro and Shido 1975)

(d) Log V-Log Cr diagram (Miyashiro and Shido 1975)

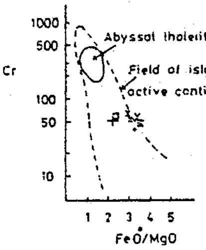
Fig. 6



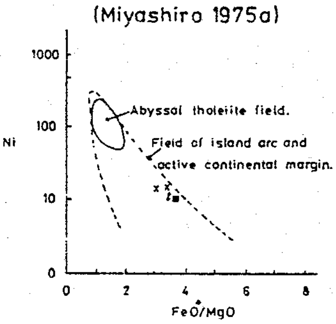
(a) Gottini-Rittmann diagram (Rittmann 1973)



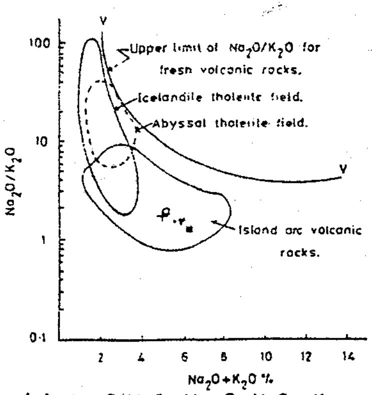
(b) TiO_2-FeO/MgO diagram (Miyashiro 1975a)



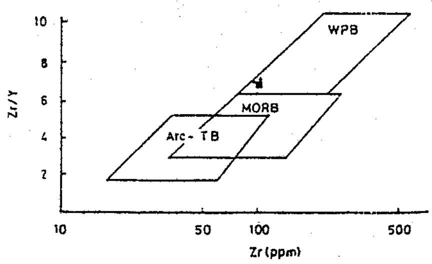
(c) Cr-FeO/MgO diagram (Miyashiro and Shido 1975)



(d) Ni-FeO/MgO diagram (Miyashiro and Shido 1975)



(e) Na_2O/K_2O - Na_2O+K_2O diagram (Miyashiro 1975)



(f) Zr/Y -Zr diagram (Pearce and Norry 1979)

Fig. 7

CONCLUSIONS

The present volcanics, which are exposed in the northern extremity of the Red Sea Hills of the Eastern Desert, are intruded by graphic and perthitic leucogranites with sharp contacts. They enclose enclaves of metamorphic rocks. These volcanics are represented by laminated lapilli andesite tuff, andesite (dominant rock type), quartz andesite, dacite and rhyodacite.

The major opaque minerals in all studied varieties are magnetite and ilmenite, however some significant differences are still observed (Table 1). In case of the laminated lapilli andesite tuff and andesite, the I / (I + M) is very low (0.1 - 0.2) while this ratio is much higher in the quartz andesite and dacite (0.6 - 1). Despite of the low I / (I + M) ratio of rhyodacite (0.2), no trellis and sandwich intergrowths are recorded contrary to the lapilli tuff and andesite. Also, the rhyodacite contains more sulphides than the other volcanic elements. Comparison between the opaque mineralogy of the studied andesite and the meta-andesite pertaining to the metavolcanics of the central Eastern Desert (Shazly *et al.*, 1976), indicates significant differences. This supports the grouping of the studied volcanics as belonging to the Dokhan Volcanics.

The chemical composition of the studied volcanics indicate that they are calc-alkaline in nature and have the characteristics which point out to their development in an island arc with well developed thin continental crust (active continental margin). They are comparable with the Dokhan Volcanics of the type locality (Basta *et al.*, 1980) and very similar to the Dokhan Volcanics at Qena-Safaga road (Ressetar and Monraad, 1983).

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بترولوجية والمعادن المعتمة لبركانيات أم أرتا ، شمال الصحراء الشرقية ، مصر

ماهر عزمى تكلا[١] ، ابراهيم محمد خلف[٢] ، محمد حامد حتحوت[٢]

وحسن على عليوه[٢]

١ – قسم الجيولوجيا – كلية العلوم – جامعة القاهرة

٢ – قسم الجيولوجيا – كلية العلوم – جامعة المنوفية

يشتمل البحث على دراسات حقلية ، بتروجرافية ، معدنية وجيوكيميائية لصخور بركانيات الدخان بوادى أم أرتا بشمال الصحراء الشرقية المصرية بين خطى عرض ٣٥َ ٢٨ْ ، ٤١َ ٢٨ْ شمالا ، خطى طول ٢٥َ ٣٢ْ ، ٦ً ٣٢َ ٣٢ْ شرقا.

وقد أظهرت الدراسة الحقلية أن هذه البركانيات أقدم من الصخور الجرانيتية وأحدث من الصخور المتحولة المحيطة بها . وأمكن تقسيم هذه الصخور بتروجرافيا إلى طف أندسيتى لابلى صفائحى ، أندسايت ، أندسايت كوارتزى ، داسايت ، ريوداسيت . وقد أمكن التمييز بين هذه الأنواع على أساس المعادن المعتمة بها. وقد تبين من الدراسة الجيوكيميائية أن هذه البركانيات لها صفات كلسى – قلوية وأنها تكونت فى بيئة أقواس الجزر ذات الخاصية القارية الرفيعة .