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PETROLOGICAL AND GEOCHEMICAL STUDIES OF SOME DYKES IN UMM EL HWITAT AREA, NORTH EASTERN DESERT, EGYPT.

BY

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ABSTRACT

This paper deals with the petrochemical and geochemical characters of some dykes, of rhyolite, dacite, andesite and basaltic andesite composition, dissecting the Pan African rocks of Umm El Hwitat area. New eleven chemical analysis for major and trace elements are reported and discussed using different parameters and diagrams to reveal their petrochemical and geochemical characters. The petrogenesis and tectonic setting of these dykes are also clarified.

INTRODUCTION

Umm El Hwitat area covers about 300 km^2 at the northern part of the Eastern Desert of Egypt and delineated by Latitudes 26° 28′ and 26° 38′ N. and Longitudes 33° 47′ and 33° 55′ E. (Fig. 1).

The area under investigation comprises Pan African rocks of highly schistose rocks and associated talc carbonate, metavolcanics , metagabbro quartz diorite rocks, old granites, old volcanics, molass type sediments and younger granites, (Fig. 2).

The investigated dykes are represented by rhyolite, dacite, andesite and basaltic andesite. They cut the younger granites, old granites, metagabbro – quartz diorite and old volcanics (Fig. 2). They have sharp contact with these host rocks. The dykes are vertical or steeply inclined (70° – 80°) and trend NE – SW, rarely they trend NW – SE, (Fig. 3).

Under the microscope the rhyolite dykes are composed essentially of quartz, alkali feldspare and minor plagioclase. They are fine grained with some phynocrysts. Quartz insets may reach 3mm across, plagioclase insets are highly stained with hematite and altered into saussurite. Relics of lamellar twinning may be feebly observed. Dacite and andesite dykes are composed of plagioclase with less amounts of hornblende, biotite and quartz. Quartz occurs as interstitial grains ranging from 2 to 5 mm. Hornblende occurs as brown to greenish brown, subhedral to prismatic crystals, partly altered to chlorite. Biotite occurs as irregular flakes of straw

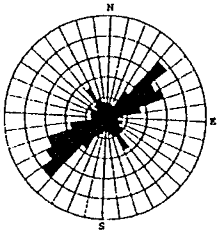


Fig.(3) Azimuth – frequency diagram of the dykes in Umm El Hwitat area.

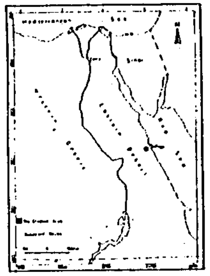


Fig.(1) Location map of the investigated area.

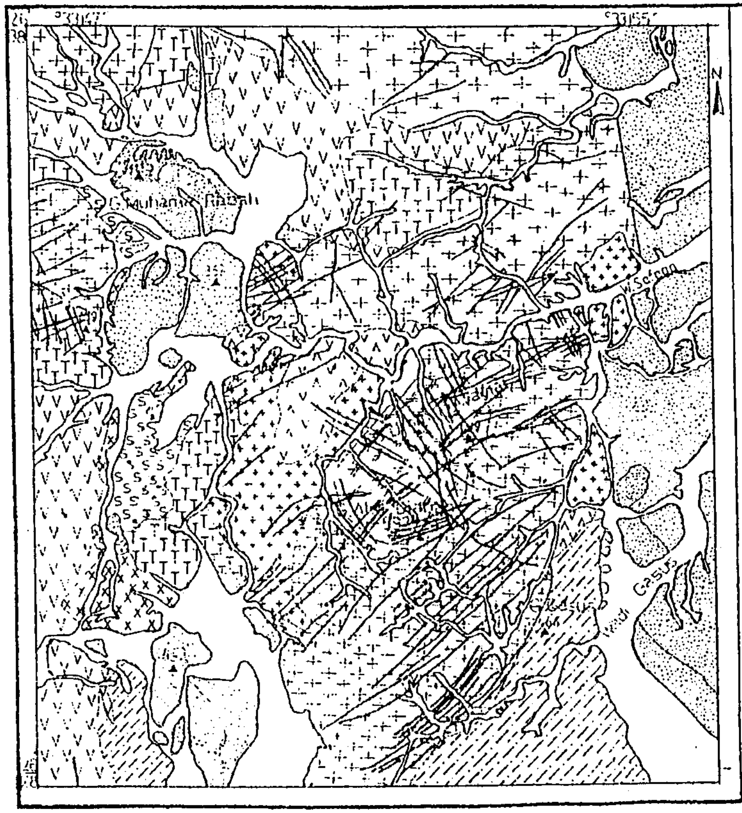


Fig.(2) Geological and distribution map of the dykes in Umm El Hwitat area.

Table (1) Chemical analyses of the examined dykes.

	Rhyolite				Dacite				Basaltic andesite			Andesite
Sam. No.	**1**	**2**	**3**	**Av.**	**4**	**5**	**6**	**Av.**	**8**	**9**	**Av.**	**7**
SiO_2	71.92	73.63	75.83	73.33	68.97	67.76	65.05	67.26	55.52	53.41	55.94	58.90
TiO_2	0.17	0.07	0.19	0.14	0.25	0.76	0.79	0.6	2.61	2.15	2.09	1.52
Al_2O_3	12.86	12.69	12.96	12.83	13.65	14.33	15.41	14.46	14.3	15.24	14.68	14.50
Fe_2O_3	0.87	0.80	0.14	0.60	1.81	1.45	1.07	1.44	3.57	7.54	6.69	8.97
FeO	0.30	0.64	0.66	0.53	0.37	3.40	4.16	2.64	5.09	3.78	3.11	0.46
MnO	0.02	0.02	0.01	0.01	0.02	0.08	0.10	0.06	0.08	0.09	0.10	0.15
MgO	0.24	0.86	0.17	0.42	0.79	2.22	2.59	1.86	3.61	2.44	2.59	1.74
CaO	1.58	1.83	0.64	1.35	2.54	3.29	2.50	2.77	3.47	3.98	4.34	5.59
Na_2O	3.73	6.17	6.63	5.51	3.07	2.40	2.18	2.55	4.19	3.96	4.14	4.29
K_2O	4.62	0.41	0.94	1.99	2.72	2.53	3.93	3.06	1.62	1.43	1.69	2.03
P_2O_5	0.08	0.02	0.03	0.04	0.07	0.17	0.17	0.13	0.58	0.85	0.61	0.41
L.O.I	2.64	2.29	0.86	1.93	4.42	1.03	1.88	2.44	4.41	4.21	3.31	1.32
Total	**99.03**	**99.43**	**99.06**	**99.17**	**98.92**	**99.92**	**99.83**	**99.5**	**99.32**	**99.08**	**99.42**	**99.88**
τ	53.70	78.90	33.30	55.3	42.30	15.70	16.80	24.93	3.90	5.30	5.2	6.50
Log τ	1.73	1.89	1.52	1.71	1.63	1.20	1.23	1.35	0.59	0.72	0.70	0.81
δ	2.40	1.33	1.75	1.82	1.26	-0.95	1.69	0.66	3.21	2.79	3.13	3.41
Log δ	0.36	0.12	0.24	0.24	0.10	-0.02	0.22	0.1	0.51	0.45	0.49	0.53
D.I.	94.76	91.94	95.67	94.12	8350	86.55	64.1	78.5	60.05	62.50	63.23	67.15

τ = $(Al_2O_3 - Na_2O) / TiO_2$
δ = $(K_2O + Na_2O)^2 / (SiO_2 - 43)$
D.I. = Differentiation index = (1/3 Si + K) – (Ca + Mg)

yellow to pale brown colour, few green biotite flakes are also recognized. The basaltic andesite dykes are mainly composed of andesine – labradorite with fresh and altered pyroxene. Fresh plagioclase phenocrysts of with lamellar twinning, and hornblende after pyroxene are observed.

PETROCHEMICAL CHARACTERS

New eleven representative samples of the examined dykes have been analyzed for the major and trace elements at the Central Laboratories of Geological Survey of Egypt by using XRF technique, (Table 1).

Different chemical parameters and CIPW norms are calculated for the studied rocks, to through more light on their petrochemical and geochemical behavior, the magma type and tectonic setting. Generally, most of the varieties have normative corundum, except the rhyolite samples which contain normative wollastonite only (1.4 and 0.08 respectively), indicating a slight alumina deficiency. The occurrence of normative hematite in some samples indicates high Fe_2O_3 /FeO ratio.

The differentiation index (D.I.) of Thornton and Tuttle (1960) for the analyzed samples (Table, 1), ranges from 60.05 (for basaltic andesite) to 95.67 (for rhyolite), indicating that the latter were formed from highly differentiated magma. Also it is clear that SiO_2, Na_2O and K_2O increase with increase of the differentiation index (Fig.4). On the contrary TiO_2, Al_2O_3, MnO, FeO, Fe_2O_3, MgO and CaO decrease with increase of D.I.

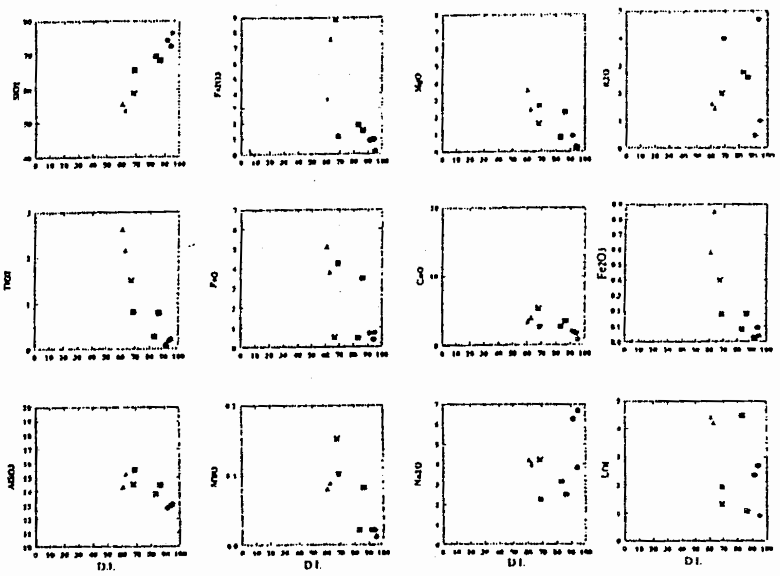
CHEMICAL CLASSIFICATION

The chemical nomenclature of the examined dykes is adopted according to the TAS diagram (total alkali - silica diagram in wt.%) (Fig. 5) suggested by Le Maitre (1984). According to this classification, the investigated dykes are plotted in the field of basaltic andesite, andesite, dacite and rhyolite.

TRACE ELEMENTS

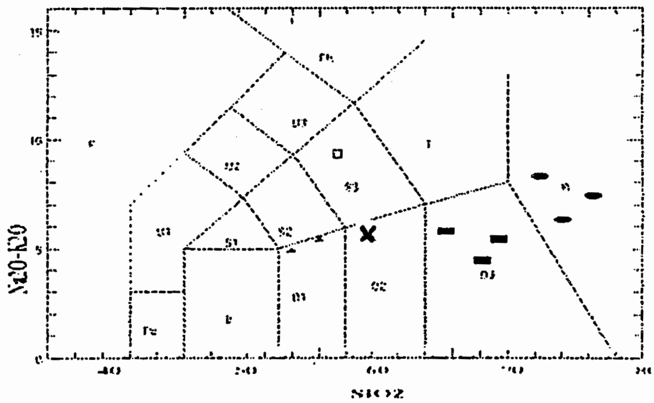
The results of the trace elements of the examined dykes are shown in Table (3). Variations of some trace elements against the calculated differentiation indices (Fig. 6), reveal that Ni shows a gentle decrease as compared with the other elements. On the other hand, Sr and Y increase with decreasing differentiation from rhyolites to andesites. The distribution of Zr in the rhyolite and andesite dykes decreases with decreasing differentiation.

The distribution of trace elements in the basaltic andesite and andesitic dykes indicates that these rocks are characterized by high content



■ Dacite ●Rhyolite ▲ Basaltic Andesite x Andesite

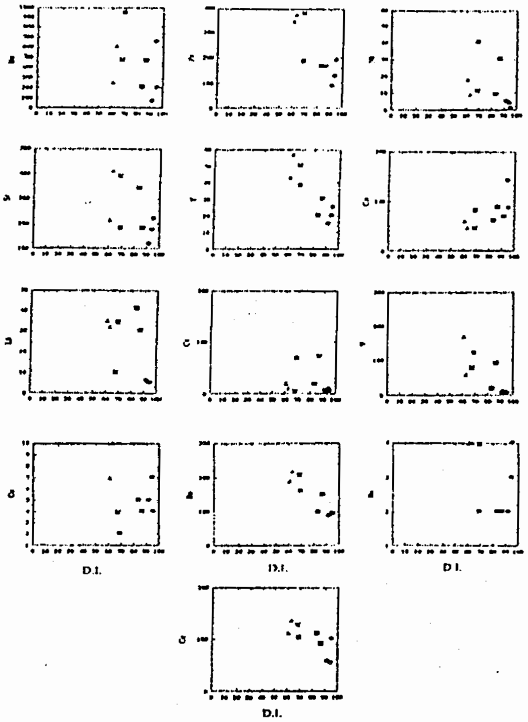
Fig. (4) Major oxides variations plotted against differentiation index for the examined dykes.



■ Dacite ●Rhyolite ▲ Basaltic Andesite x Andesite

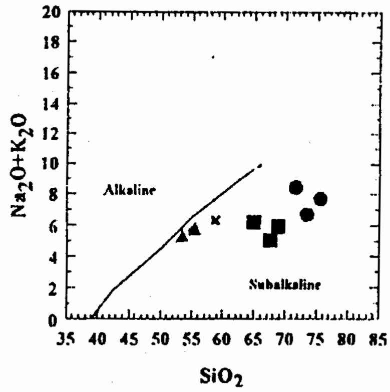
Fig. (5) Classification of the examined dykes in the TAS diagram, after Le Maitre (1984).

(F) foidite (Pc) picrobasalt (B) basalt (01) basaltic andesite (02) andesite (03) dacite (S1) trachybasalt (S2) basaltic trachyandesite (S3) trachyandesite (T) trachyte (R) rhyolite (U1) tephrite (U2) phonotephrite (U3) tephriphonolite (ph) phonolite



■ Dacite ●Rhyolite ▲ Basaltic Andesite x Andesite

Fig. (6) Variations diagram of trace elements plotted against the differentiation index.



■ Dacite ●Rhyolite ▲ Basaltic Andesite x Andesite

Fig. (7) Alkali – silica diagram for the analyzed samples (Irvine and Baragar, 1971).

Table (2) CIPW Norm of the examined dykes.

	Rhyolite				Dacite				Basaltic andesite			Andesite
Sam. No.	**1**	**2**	**3**	**Av.**	**4**	**5**	**6**	**Av.**	**8**	**9**	**Av.**	**7**
Q	30.95	32.51	32.44	31.97	36.36	32.93	26.52	31.94	13.31	15.71	14.51	15.27
Or	28.35	2.5	5.66	12.17	17.07	15.21	23.73	18.67	10.12	8.92	9.52	12.18
Ab	32.71	53.68	57.06	47.82	27.53	20.62	18.81	22.32	37.42	35.28	36.35	36.79
An	4.84	5.88	2.87	4.53	12.94	15.58	11.65	13.39	14.6	15.56	15.08	14.49
C	0	0	0	0	1.24	2.04	3.44	2.24	0.61	1.85	1.23	0
wo	0.72	1.4	0.08	0.73	0	0	0	0	0	0	0	4.68
en	0.62	2.22	0.43	1.09	2.1	5.64	6.61	4.78	9.54	6.43	7.99	0.38
fs	0	0.45	0.81	0.42	0	4	5.74	3.25	2.35	0	1.17	0
Mt	0.56	1.19	0.21	0.65	0.57	2.14	1.58	1.43	5.47	6.58	6.03	2
He	0.52	0	0	0.17	1.53	0	0	0.51	0	3.41	1.7	7.72
Il	0.34	0.14	0.37	0.28	0.5	1.47	1.53	1.17	5.24	4.31	4.78	0
Ap	0.18	0.04	0.07	0.09	0.16	0.38	0.38	0.49	1.34	1.96	1.65	0.91
Total	99.78	100	100	99.93	100	100	100	100	100	100	100	98.46

Table (3) Trace elements abundances (in ppm) for the examined dykes.

	Rhyolite				Dacite				Basaltic andesite			Andesite
Sam. No.	**1**	**2**	**3**	**Av.**	**4**	**5**	**6**	**Av.**	**8**	**9**	**Av.**	**7**
Cr	8	6	5	6.3	17	70	67	51.3	20	10	15	6
Ni	4	5	1	3.3	9	30	40	26.3	18	9	13.5	12
Co	140	68	85	97.7	60	87	80	75.7	60	45	50.25	46
Cu	7	5	4	5.3	5	4	2	3.6	7	10	8.5	4
V	9	9	7	8.3	18	90	120	76	170	60	115	79
Ba	650	70	200	306.7	200	460	937	532.3	250	610	430	478
Zn	95	88	94	92.3	98	150	160	136	190	219	204.5	212
Zr	127	87	189	134.3	166	165	185	172	345	376	360.5	390
Sr	175	118	220	171	341	180	180	233.6	215	412	313.5	390
Li	5	6	5	5.3	41	30	34	35	35	32	33.5	10
Be	3	2	4	3	2	2	2	2	4	4	4	4
Y	20	15	25	20	20	30	38	29.3	43	57	50	50
Ce	54	56	100	70	110	90	102	100.7	112	136	124	130

andesitic dykes indicates that these rocks are characterized by high content of Sr, Zn, Zr, Y, Cu and Ce contents. The average value of Sr in the investigated andesite dykes is 390 ppm which is much less than the value mentioned by Taylor et. al (1969) for Bougainville andesites (700 ppm). The average content of V in the examined basaltic andesite and andesite dykes is 96.84 ppm, in accordance with the average value (97 ppm) of the Egyptian andesite dykes given by Kabesh et. al (1977). This value is much lesser than the value given by Turkian and Wedepohl (1961) for the average andesites (175 ppm). On the other hand, the low content of Ni and Cr for the examined andesite dykes have suggests the derivation of andesites by simple mixing of basalitic magma and acidic material.

It is also observed that Ba content increases with increase of differentiation index (Fig. 6).

The rhyolite dykes have normal contents of Ba and Sr and are depleted in V, Zr, Ni and Cr. It is worthy to notice that almost all the examined trace elements (with exception of Co, Ba, Ni and Cr) decrease in the abundance from andesitic basalt towards rhyolite (Table 3).

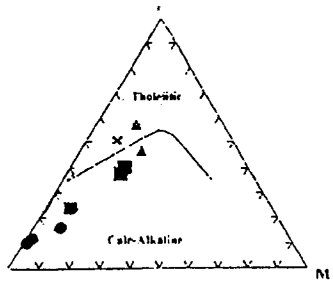
MAGMA TYPE

To show magma type of the investigated dykes of Umm El Hwitat area, the analyzed samples of different varieties are plotted on alkali – silica diagram of Irvine and Baragar (1971) and AFM diagram, as well as SiO_2 – FeO^*/MgO digram of Miyshiro and Shido (1975), SiO_2 – Cr diagram, and Log τ - Log δ of Gottini and Rittman (1970).

The plots of the analyzed samples on the alkali silica diagram of Irvine and Baragar (1971), reveal that the investigated dykes have subalkaline affinity (Fig. 7). However on the AFM diagram they have calc – alkaline affinity (Fig.8). Actually the samples of rhyolite are enriched in alkaline rather than other varieties. However, the basaltic andesite and andesite are situated nearby the tholeiitic field (Fig.8). On the other hand the andesite dykes show tholeiitic affinity on SiO_2 – FeO^*/MgO digram of Miyshiro and Shido (1975) and SiO_2 – Cr diagram of Miyshiro (1974) (Fig. 9&10 respectively).

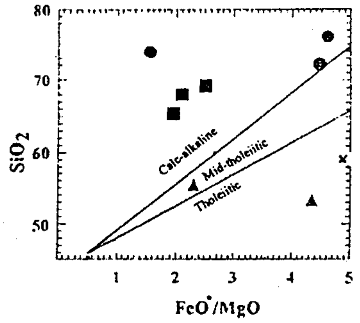
TECTONIC SETTING

According TiO_2 - Zr discriminant diagram (Fig. 11) of Pearce (1980) the majority of rhyolite and dacite samples plot in the field of arc lavas, whereas the basaltic andesite and andesite samples plot in the field of within plate lava. On the other hand, Miyashiro and Shido (1975) proposed the FeO^*/MgO-Ni discrimination diagram for tholeiitic and clac-



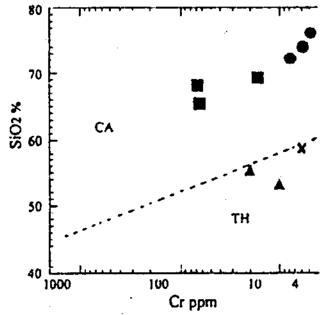
■ Dacite ●Rhyolite ▲ Basaltic Andesite x Andesite

Fig. (8) Ternary plot of A ($K_2O + Na_2O$) Vs. F($FeO + 0.889\ Fe_2O_3$) M (MgO). For the investiGaled dykes.



■ Dacite ●Rhyolite ▲ Basaltic Andesite x Andesite

Fig. (9) Variation of SiO_2 versus FeO*/MgO of the examined dykes after Miyashiro and Shido (1975).



■ Dacite ●Rhyolite ▲ Basaltic Andesite x Andesite

Fig. (10) SiO_2 Vs. log Cr diagram for calc – alkaline (CA) and tholeiitic rock series (TH) of the examined dykes.

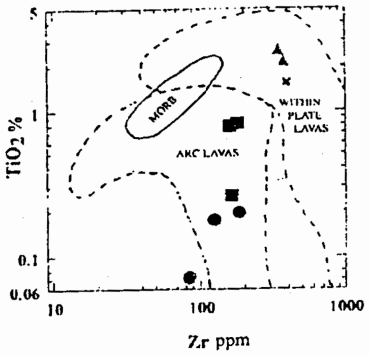


Fig. (11) TiO_2 – Zr discriminate diagram for the examined dykes showing the fields of mid-ocean basalts (MORB), arc lavas and within plate lavas (after Pearce,1980).

■ Dacite ●Rhyolite ▲ Basaltic Andesite x Andesite

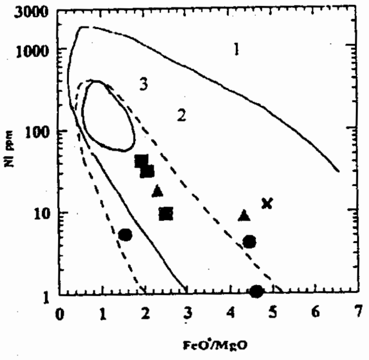


Fig. (12) Ni – FeO/MgO diagram for the examined dykes showing fields of nickel contents of abyssal tholeiites (field 3), volcanic and related intrusive rocks in island arcs and active continental margins (field 2) and non-orogenic regions (stable continents and oceanic islands) (field 1), after Miyashiro and shido (1975)

■ Dacite ●Rhyolite ▲ Basaltic Andesite x Andesite

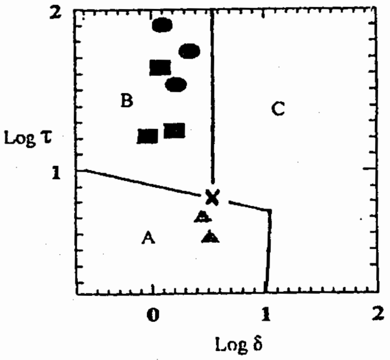


Fig. (13) Log τ - Log δ diagram by Gottini and Rittmann (1970) of the analyzed volcanic dykes.

Field (A) are falling mainly lavas of volcanoes situated in non – orogenic regians.

Field (B) Those of volcanoes in orogenic belts and island arcs.

Field (C) The alkaline derivatives of both.

■ Dacite ●Rhyolite ▲ Basaltic Andesite x Andesite alkaline rocks of various tectonic setting. Plotting the examined dykes on this diagram (Fig.12), shows that the rhyolite and dacite dykes fall within the field of volcanic rocks of island arc and active continental margins. In practice, lava do not always fall neatly into one or other of magma types, due to the existence of transitional tectonic environments (Pearce and Gale, 1977). On the same diagram, the basaltic andesite and andesite dykes (except sample No. 7) fall in the field of volcanic and related intrusive rocks in stable continents and oceanic islands of non-orogenic regions. This setting is compatible with the result derived from the foregoing log δ - log t diagram (Fig. 13).

It is evident from the calculated data on log τ – log δ diagram (Fig. 10) of Gottini and Rittmann (1970), that the rhyolitic and dacitic dykes fall in field of orogenic belts and island arcs related rocks, whereas the basaltic andesite and andesitic dykes plott in field of non-orogenic reigion. It is clear that the increase of Rittmann's index δ is accompanied by a strong decrease of t-value (Table 1). It is unequivocal that the supply of soda and titanium to an alkali rholyitic magma causes a decrease of t-value and an increase of value of δ (Gottini, 1971). Also t-value consider a solid indicator for the distinction between simatic and sialic materials (Sima: t= 3-8), (sial: t>10), and this relation is very high for the continental ones (Pichler and Zeil, 1969). The oceanic volcanic rocks of the Hawaiian and other Midpacific islands have t-value lower than 6 and the continental andesites are characterized by higher t-value (generally above 9). From the above discussion, it is clear that samples No.7,8,9,10 and 11 have t-values ranging from 3.9 to 7.02 i.e. they are of simatic character. Moreover, Rittmann (1971) mentioned that all magmas falling in field of non orogenic regems were derived from the upper mantle.

CONCLUSIONS

It is evident from the examined dykes that these dykes are derived from tholeiitic and calc-alkakine magma with differentiation indeix ranging from 60.05 to 95.67. It is argued that the basaltic andesite and andesitic dykes were possibly derived from the upper mantle as indicated by the t-value and the diagram suggested by Gottini and Rittmann (1970), and possess features of within plate magmatism. Whereas the rhyolite and dacite dykes were erupted over an active continental margin or an old island arc with a continental type crust.

It is suggested that the rhyolite and dacite dykes are most probably related to the magmatic arcs that developed the basement of the Eastern Desert, while andesite and basaltic andesite dykes could be related to the

Mesozoic volcanism, that associated the formation of Red Sea rifting.

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دراسات صخرية وجيوكيميائية لبعض القواطع في منطقة أم الحويطات شمال الصحراء الشرقية

احمد عرابي

كلية العلوم جامعة الأزهر

البحث الريوليت والداسيت والانديزايت والانديزايت البازلتي والتي تقطع صخور منطقة ام الحويطات . تم تسجيل عدد احدى عشر تحليل كميائى من العناصر الشحيحة والعناصر الساسية وتم مناقشة توقيع هذه البيانات يوضح دراسة جوكمياء بعض القواطع من على الرسومات والتى توضح كميائية الصخور . ايضا تم توضيح نشاة الصخر والموقع التكنونى لهذه القواطع.