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GEOCHEMICAL CHARACTERISTICS AND URANIUM-THORIUM DISTRIBUTION OF BASALTIC ROCKS FROM DOKHAN VOLCANICS, QIFT-QUESEIR ROAD, EASTERN DESERT OF EGYPT

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Abstract: the present work deals with geochemical characteristics and radioactivity of basaltic rocks from Dokhan Volcanics, qift-queseir road, Eastern Desert,Egypt.

Geochemically, the studied Dokhan Volcanics seem to have originated from calc-alkaline magmas which were developed in an island arc tectonic setting.The basaltic volcanics (~2.5km2) posses an elongate outcrop with N-S long axis. Normalized trace element patterns show enrichment in LILEs (Rb, Ba, K, Th,) relative to HFSEs (Nb, Zr, P, and Ti) and are very similar to calc-alkaline subduction-related rocks from orogenic belts. A subduction-related tectonic setting for the emplacement of the investigated rocks is indicated by the petrological and geochemical evidences.

The concentrations of U and Th in the studied Dokhan Volcanics were controlled by magmatic processes indicated by the positive relation between U and Th and U-Zr in addition to weak negative relation between U and K/Rb.

1. Introduction

The studied basaltic rocks from Dokhan Volcanics, Eastern Desert,Egypt . form elongate outcrop (~2.5km^2) with N-S long axis. (Fig. 1).

Many publications concern with the petrology and mineralogy of Dokhan Volcanics (e.g. El Gaby *et al.*, 1989, Stern and Hedge, 1985, Hassan and Hashad, 1990, El Mahallawi, 1999) confirmed that the Dokhan Volcanics of the Red Sea Mountains match the compositions of modern ocean island arcs.

El Mahallawi, (1999), inferred that the Dokhan volcanics are consistent with the derivation by partial melting of primitive mantle materials under hydrous conditions at high pressure.

This paper presents geochemical characteristics and Uranium-thorium distribution of basaltic rocks from Dokhan Volcanics, Eastern Desert, Egypt.

2. Field Aspects

The mapped area (~10km^2) represents a part of the geological map of the Saqia Zeidun district, Eastern Desert of Egypt (Akaad & Noweir,1980). The study mapped area includes such lithologic units, namely ; Atud conglomerate, serpentinite and ultramafites, metagabbros, Dokhan Volcanics, Hammamat sediments and Younger granite (Fig, 1).

The basaltic volcanics under investigation (~2.5km^2) posses an elongate outcrop with its longer axis N-S. It usually forms moderate hilly country rocks. The contacts between this basaltic Dokhan volcanics and the enveloping Hammamat sediments, serpentinites and metagabbros are in part fault contact with mild reaction of extrusive nature (serpentinites and metagabbros). Two pronounced sets of Joints of the study basaltic rocks were recognized, first; a set trending ENE and commonly dipping SE at an average 15°, secondly ; a less developed set, roughly at right angle to the first set.

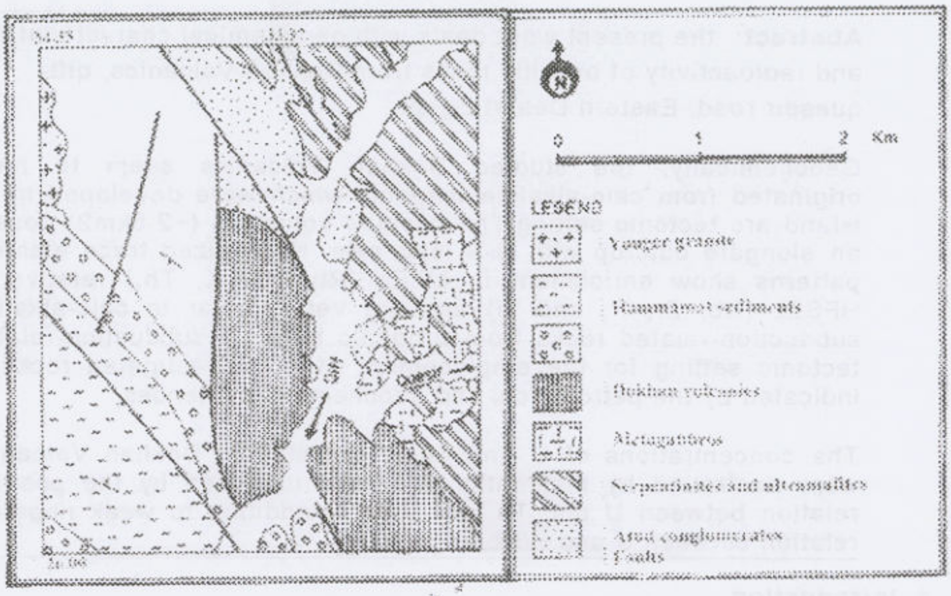


Fig. (1) Geological map of the studied area (slightly modified after Akaad and Noweir, 1980)

3.Petrographic Notes

The lava flow constitutes only by basalt which is fine grained, dark grayish green. Ophitic, subophitic, intergranular and fluidal textures are most pronounced in these rocks.

Microscopically, the basaltic rocks consist of microphenocrysts of labradorite plagioclase and diopsidic augite set within intergranular fashion and / or microcrystalline fluidal groundmass. Sometimes ovidal and irregular elongate amygdale (0.7mm long) filled with anhedral secondary quartz.

4. Geochemistry

4.1. Sample set

Whole-rock major and trace elements for selective samples are listed in table 1. The chemical analyses of the studied basaltic Dokhan Volcanics have been carried out at the Nuclear Material Authority, Cairo.

4.2. Chemical classification

According to the SiO_2 versus Na_2O+K_2O diagram recommended by the International Union of Geological Sciences (IUGS) for the classification of volcanic rocks (Le Bas *et al.*, 1986) and SiO_2 vs. K_2O (Fig. 2a) (Le Maitre, 1989) diagram (Fig. 2b),the investigated volcanic rocks have a narrow range of SiO2 (48.69–49.95%) plot in the field of basalt which related to low to medium K-calc alkaline volcanic series., (Figs. 2a,b).

Table (1) : Major oxides (%), trace elements (ppm) of the studied basaltic Dokhan volcanics of Qift-Queseir road .

S.No.	AV2	AV4	AV5	AV6	AV7	AV8	AV9	AV10
				MAJOR ELEMENTS (%)				
SiO_2	49.14	48.81	48.69	48.99	49.10	49.60	49.95	49.63
TiO_2	0.29	0.22	0.31	0.28	0.39	0.36	0.27	0.37
Al_2O_3	17.61	17.41	16.90	17.41	17.30	17.10	16.95	17.21
Fe_2O_3	3.43	3.14	3.91	3.95	3.51	3.58	3.01	3.11
FeO	5.41	5.43	7.66	8.32	6.66	6.59	6.96	6.26
MnO	0.18	0.17	0.19	0.20	0.15	0.16	0.16	0.17
MgO	5.50	5.20	6.20	6.30	5.80	5.90	5.60	6.60
CaO	8.61	8.41	7.72	7.28	6.72	7.56	872	7.84
Na_2O	4.68	4.09	4.21	3.31	3.28	2.43	2.56	2.65
K_2O	0.20	0.12	0.14	0.15	1.01	0.67	0.18	0.47
P_2O_5	0.27	0.33	0.47	0.53	0.53	0.65	0.55	0.58
L.O.I	4.28	4.39	4.68	4.43	4.21	4.81	4.65	4.69
Total	99.58	99.16	99.91	99.46	100.15	98.68	98.32	99.64
				TRACE ELEMENTS (ppm)				
Zr	24	27	35	37	29	26	25	20
Y	10	11	17	22	15	15	13	12
Sr	76	172	137	124	158	120	141	179
Rb	< 2	< 2	2	< 2	13	6	6	3
Nb	19	7	14	< 2	15	7	26	13
Ba	229	194	289	215	374	256	248	320
Cu	23	27	19	27	28	24	17	29
Ni	27	28	29	24	7	10	29	10
Co	13	13	13	12	12	10	13	13
Cr	133	131	150	116	25	47	149	37
V	21	22	27	24	22	24	23	32
Zn	67	68	63	62	64	52	65	64
Ga	7	7	7	7	8	6	8	9
Pb	38	36	39	41	42	46	38	46
U	0.45	0.23	0.37	0.42	0.33	0.47	0.35	0.39
Th	1.56	1.03	1.51	1.40	1.20	1.53	1.18	1.31
Th/U	3.47	4.47	4.80	3.33	3.64	3.26	3.37	3.36

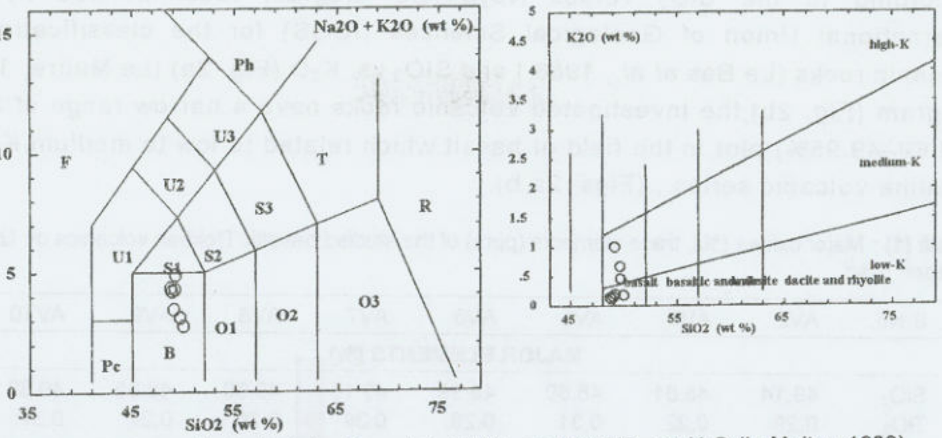


Fig. 2. (a) SiO_2 vs. Na_2O+K_2O (Le Bas *et al*, 1989) , and (b) SiO_2 vs. K_2O (LeMaitre, 1989) diagrams

4.3. Compositional variations

FeO* /MgO variation diagrams of major and trace elements are illustrated in Fig. 3.a,b. The studied basaltic Dokhan Volcanic rocks define strongly correlated and continuous variation trends. Al_2O_3, CaO, Na_2O, Rb, and Sr decrease with FeO* /MgO increasing whereas SiO_2, TiO_2, FeO (total), MgO, K_2O and Ba contents increase (Fig. 3a,b). Nb, Zr and Y abundances increase systematically with increasing FeO* /MgO.

4.4. Magma Type

On AFM diagram (Irvine and Baragar, 1971) the studied basaltic Dokhan volcanics rocks plot on the prephery between the calc-alkaline field and tholiietic field (Fig 4).

4.5. Tectonic setting

On the Zr–Ti–Sr ternary diagram (Pearce and Cann, 1973) (Fig. 5a) they show geochemical characteristics of calc-alkaline rocks emplaced in convergent plate margins but on other diagram Zr versus Ba diagrams (floyed, 1991) (Fig.5b), they are similar to island arc basalt. Accordingly, the studied basaltic Dokhan Volcanic rocks have geochemical characteristics of calc alkaline basalt and island arc basalt settings.

4.6. Normalization patterns

Spider diagrams for eight analysed samples of the the studied basaltic Dokhan Volcanics rocks, normalised to PRIM are similar (Fig. 6). Relative to normal primitive mantle (N-PRIM). The spider plots for the volcanic rocks, (Fig.6) reveal a remarkable similarity in the patterns of all of the samples, with relatively high overall concentrations of the large ion lithophile (LIL) group elements, particularly Ba, and low values of the high field-strength (HFS) elements.

the studied volcanic rocks (Fig.6) show strong enrichment in the incompatible LILE such as Rb, Ba, and K; enrichment in Th and U; strong depletion in K in some samples relative to Nb and U; which show abundances similar to those of N-PRIM.

4.7.-Geochemistry of U and Th.

Uranium and thorium contents were determined chemically in 8 samples.

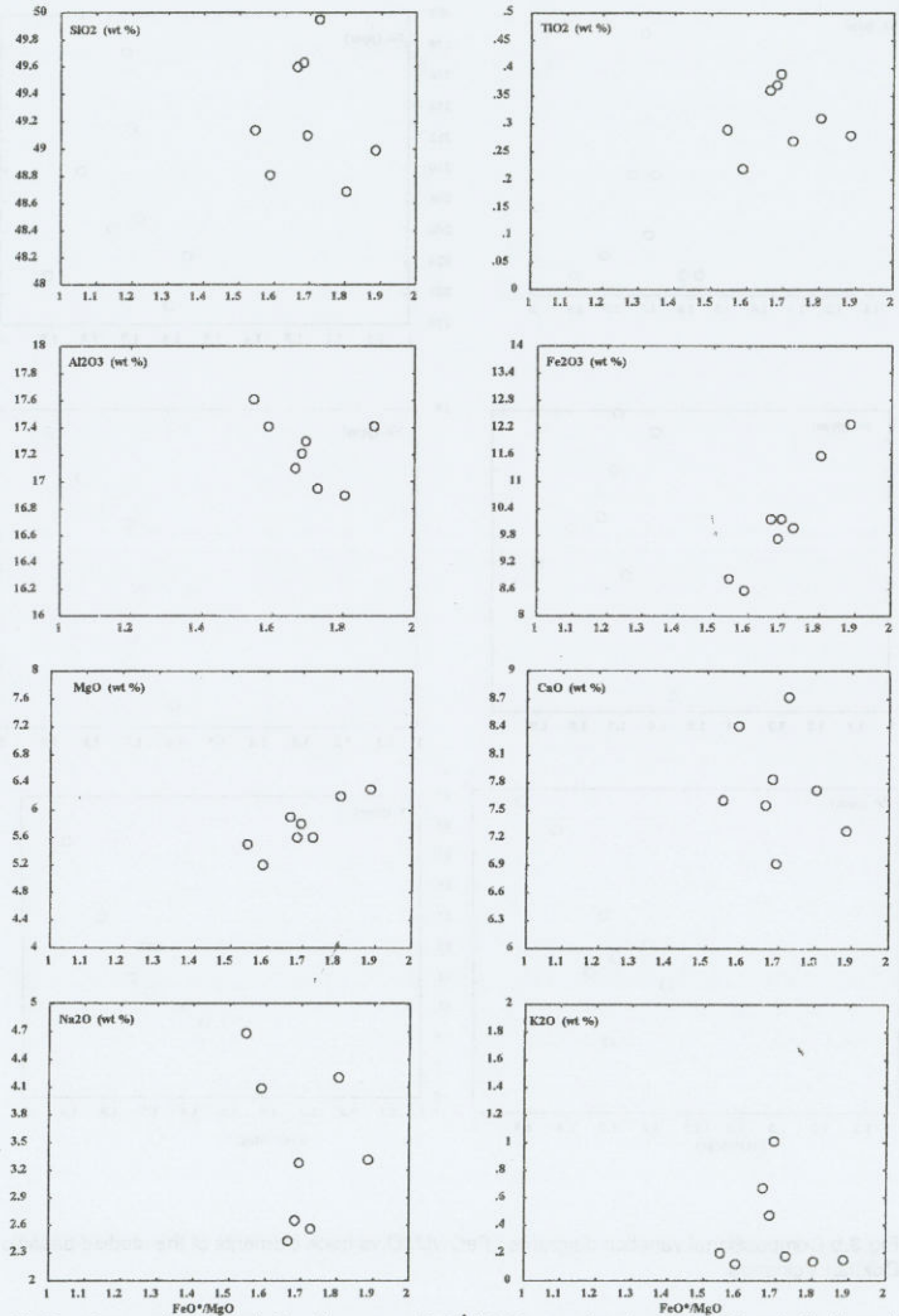


Fig.3.a. Compositional variation diagrams ; FeO* /MgO vs major elements of the studied basaltic Dokhan Volcanics.

The obtained results of the uranium and thorium analyses are indicated by ppm as well as Th/U are shown in table (1). From this table, the Uranium content ranges from 00.23 to 00.47 ppm with an average 00.38ppm and thorium ranges from 01.03 to 01.56ppm with an average 01.34ppm.

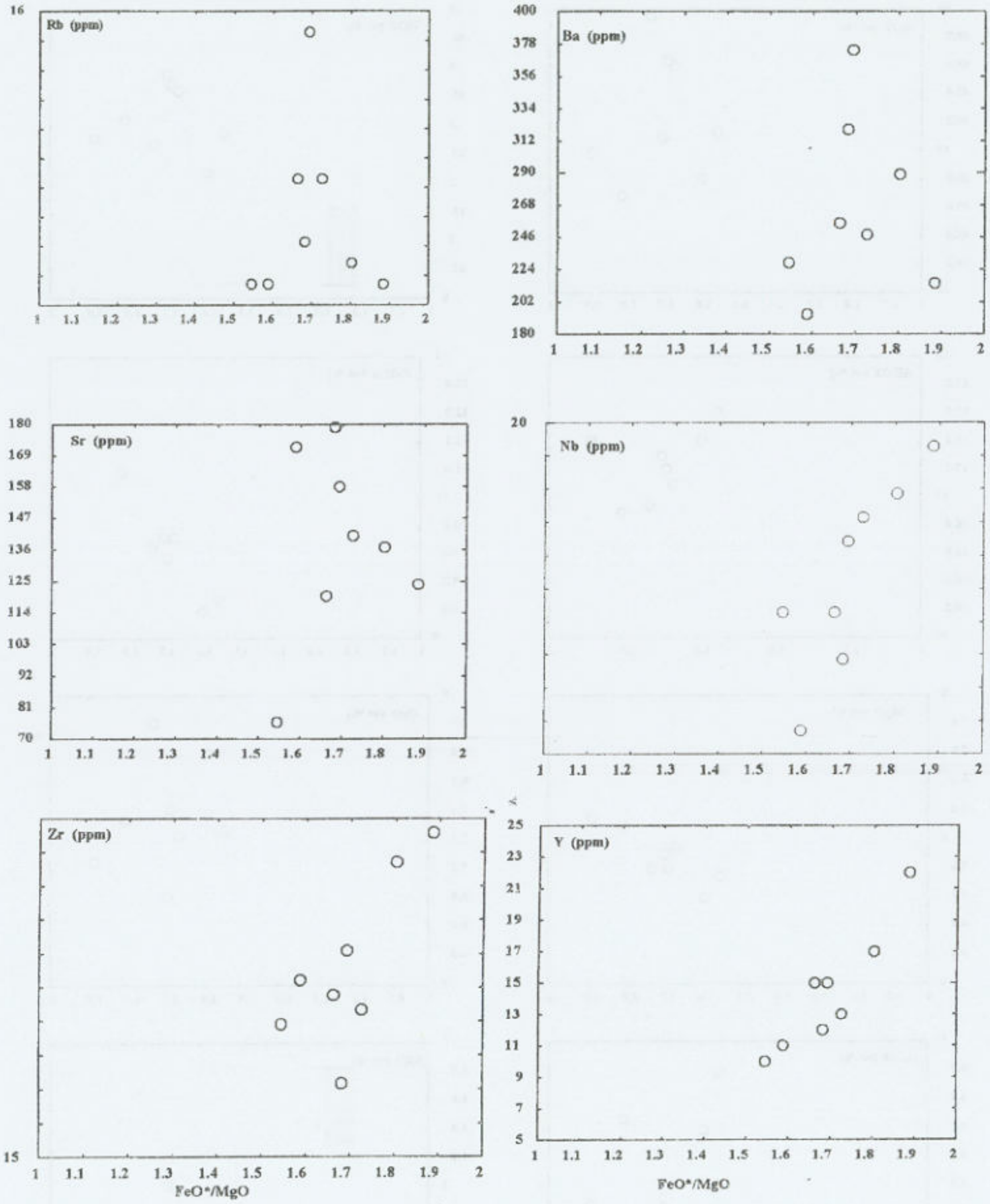
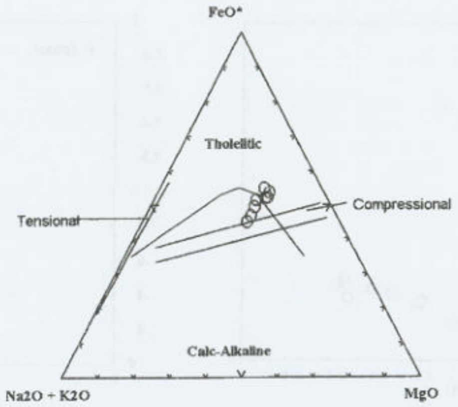


Fig.3.b.Compositional variation diagrams ; FeO* /MgO vs trace elements of the studied basaltic Dokhan Volcanics



Fig(4): AFM diagram of the studied rocks.(after Irvine and Baragar, 1971)

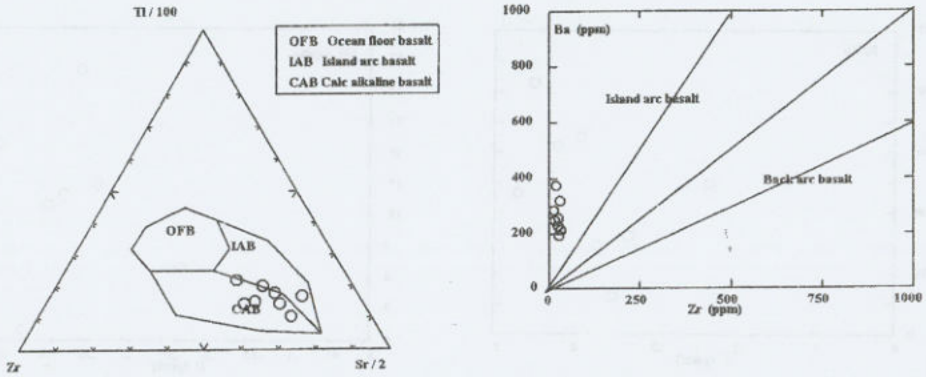


Fig. 5: Tectonic discrimination diagrams for the studied basaltic Dokhan volcanics: (a) Zr–Ti–Sr diagram (Pearce and Cann, 1973), (b) Zr–Ba diagram of (floyed, 1991),. Symbols as in Fig. 2.

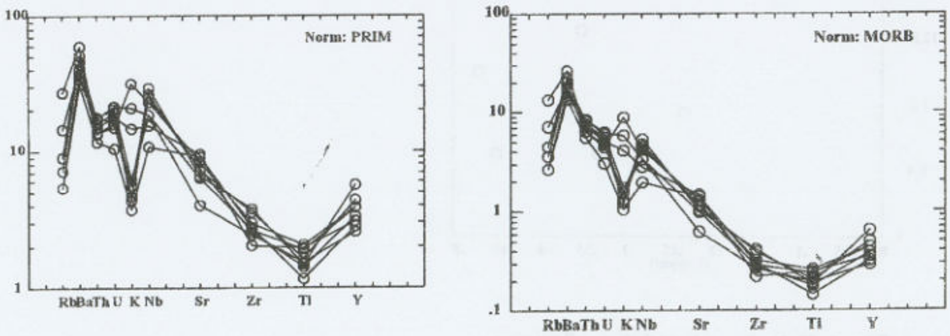


Fig. 6: N-PRIM-normalized trace element plots for the the studied basaltic Dokhan Volcanic rocks. Normalization values are from Sun and McDonough (1989).

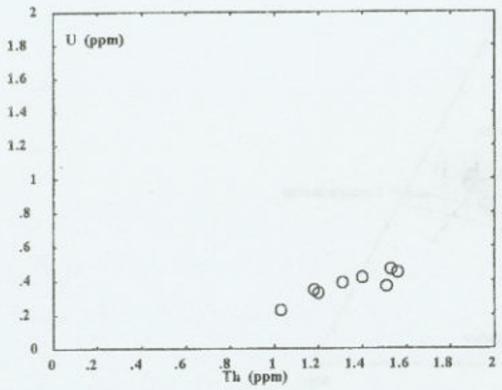


Fig. (7a) : Th-U variation diagram .

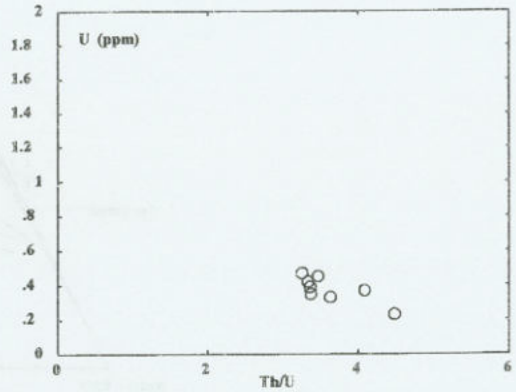


Fig. (7b) : Th/U-U variation diagram .

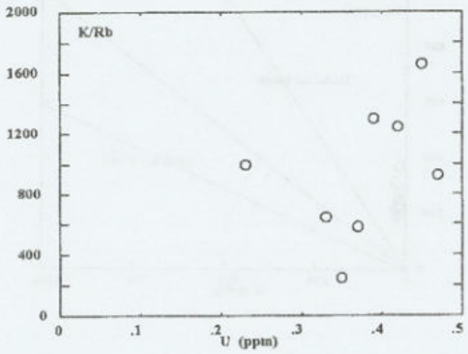


Fig. (7c) : U - K/Rb variation diagram .

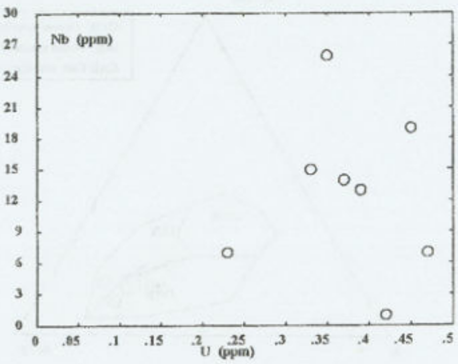


Fig. (7d) : U - Nb variation diagram .

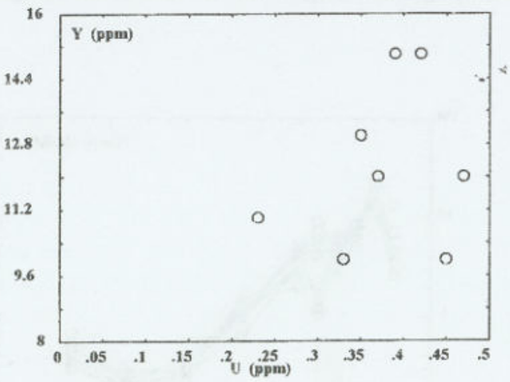


Fig. (7e) : U - Y variation diagram .

The geochemical behaviour of U and Th in the studied area can be examined as follows:

The U-Th variation diagram for the studied basaltic Dokhan Volcanics rocks indicates positive relations between the two elements as shown in (Fig. 7a). This indicate magmatic origin.

Fig. (7b) show that the variation of Th/U ratios versus U in the studied rocks . It is clear that from the figure the decreasing of Th/U accompanied with enrichment in U.

Figure (7c) shows that U concentration tends to weak increase with the weak decreasing of K/Rb ratio for the studied basaltic Dokhan Volcanics. This weak negative correlation is a good evidence for magmatic control of U concentration.

The relations between U and Zr which indicate weak positive correlations and regular relation for the studied basaltic Dokhan Volcanics which may indicate magmatic origin and also that their magma differentiation at shallow depth (Briquieu *et al.*,1984). (Fig. 7d).

The U-Y variation diagram for the studied rocks indicate positive relations between the two elements in the studied basaltic Dokhan Volcanics due to magmatic origin as shown in (Fig. 7e).

5 Summary and conclusions

The volcanic history of the Neoproterozoic belt in the Eastern Desert of Egypt encompasses two major magmatic episodes. An earlier episode (950-750 Ma) produced the Shadli metavolcanic assemblages, and a younger episode (680-550 Ma) produced the Dokhan Volcanic rocks.The most consistantly observed geochemical difference between arc and nonarc magmas is the depletion in HFS elements especially Zr, Nb,Y relative to LIL elements. The behavior of these elements during island arc magma generation processes is controversial. The separation of different groups of trace elements during subduction-related enrichment processes or magma genesis is generally attributed to one of two mechanisms. The frist mechanism involves preferential enrichment in LIL elements by an aqueous phase relative to the HFS elements, controls the trace elements fractionation (Saunders *et al.*, 1991; Mc Culloch and Bennett, 1994; Hawkesworth *et al.*, 1994). In the second mechanism, petition of the HFS elements into a titanite phase in the mantle wedge and/or in the felsic melt residue during melting in the upper most part of the subducted slab effectively fractionates the trace elements groups, (Foley and Wheller, 1990; Stadler *et al.*, 1998; Klemme *et al.*, 2005). Therefore, the abundance of the LIL and HFS elements in the subduction-related magmatic rocks can be used as indicators of magma generation processes and/or characterizing the upper mantle source regions where such magmas were generated.

The trace elements data of the study basaltiic rocks are plotted on a series of tectonic discrimination diagram Zr-Ti-Sr ternary diagram (Fig. 5a) show geochemical characteristics of calc-alkaline basalt, similar to calc-alkaline basalts and island arc basalt.

The low-K calc-alkaline affinity as well as the LILE-enrichment and HFSE-depletion of the studied basaltic rocks, are attributed to partial melting of metasomatized lithospheric mantle source.

The present data are consistent with the work of El Mahallawi (1999) which inferred that the Dokhan Volcanics described here form a continuum in composition from basalt to rhyolite.

The concentrations of U and Th in the granitoid rocks were controlled by magmatic processes as indicated by the positive relation between U and Th and U-Zr. In addition, a weak negative relation between U and K/Rb were obtained.

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خصائص جيوكيميائية وأشعاعية لصخور بازلتية من بركانيات الدخان , طريق قفط – القصير, الصحراء الشرقية ، مصر

عاطف عبد العزيز النحاس
هيئة المواد النووية

هذا البحث بدراسة موقع لصخور بازلتية من بركانيات الدخان الواقع على طريق قفط- القصير- الصحراء الشرقية – مصر. ومن الدراسة الجيوكيميائية نجد أن تلك الصخور تتميز بأنها غنية بالعناصر الشحيحة الخفيفة وفقيرة بالعناصر الشحيحة الثقيلة وقد نتجت من صهير مجماتى له خاصية كلس قلوية وقد تدفقت فى بيئة أقواس الجزر التكتونية. يرجع تركيز وتوزيع عنصرى اليورانيوم والثوريوم فى تلك الصخور ألى العمليات التفاضلية فى المجما وتعتبر من لعمليات الأولية.