

COMPARATIVE STUDY BETWEEN SOME URANIFEROUS VOLCANIC ROCKS, EASTERN DESERT, EGYPT

By

I. H. Ibrahim and M. E. Ibrahim

Nuclear Materials Authority, P.O. Box: 530 El Maadi, Cairo, Egypt.

Corresponding author: ibrahim170@yahoo.com

ABSTRACT

Four volcanic areas; Um Safi rhyolite (USR) and El-Atshan bostonite sill (EBS) at the Central Eastern Desert, whereas, Um Domi trachyte (UDT) and Um Doweila bostonite (UDB) at the South Eastern Desert of Egypt were chosen for comparison on the bases of geologic setting, mineralogy, geochemistry and spectrometric investigations.

UDT and UDB are alkaline to per-alkaline in nature while USR and EBS are metaluminous to slightly peraluminous regime. USR, EBS and UDT are affected by diagenetic processes whereas hydrothermal processes is common in UDB.

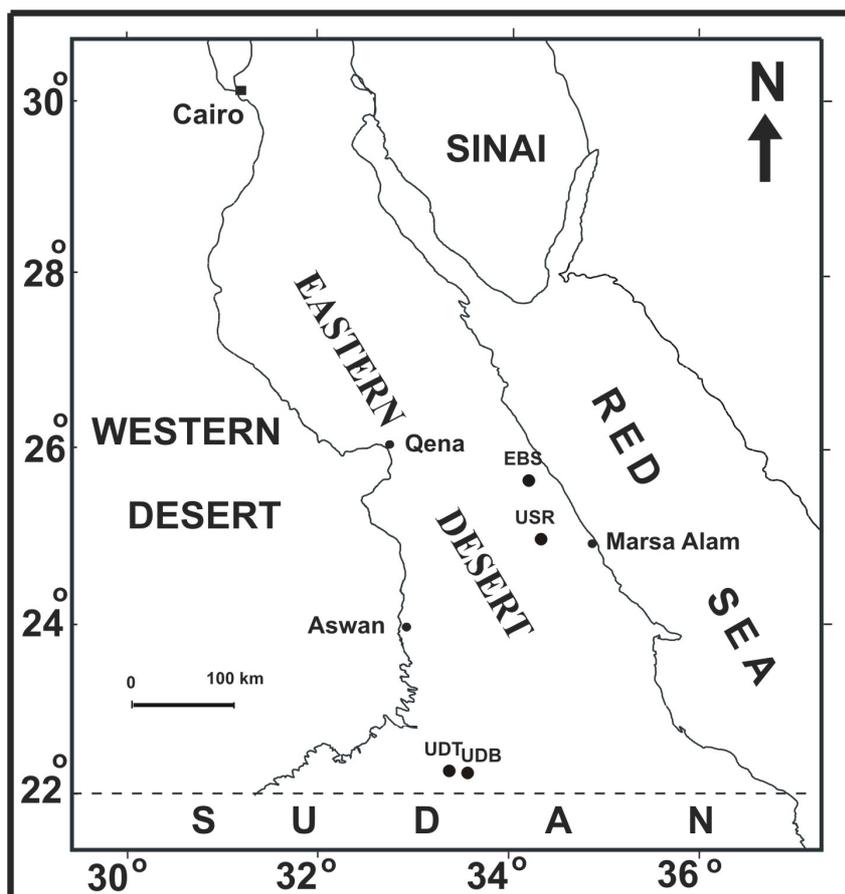
The base metals (pyrite, cassiterite, arsenopyrite, corundite, wolframite and chrysocolla) are common in USR, UDB, EBS and UDT in decreasing order. The secondary uranium minerals (uranophane, zippeite and kasolite) are common in all volcanic areas except UDT. Spectrometric results indicate that the eU/eTh ratios decreases (0.6-0.3) from EBS and UDB through USR to UDT.

Keywords: Rhyolite, Bostonite, Trachyte, Diagenetic processes.

INTRODUCTION

Volcanic activity in Egypt spanned a long period and marked a change in tectonic setting from ocean floor and subduction related volcanics in the Precambrian to intraplate volcanicity in the Phanerozoic. During the Phanerozoic continental intraplate volcanic activity in Egypt was intermittent and resulted in extrusion of volcanic rocks of wide compositional variation size and mode of eruption. Geochronological studies on these Phanerozoic volcanics (El-Shazly, 1977, Hashad et al., 1978, Ressetar et al., 1981, Stairs et al., 1991) revealed three phases of activity in Egypt. These are, Paleozoic (233-395 Ma), Mesozoic (74-191 Ma) and Tertiary (15-48 Ma). The dykes and plugs are part of the tectono-magmatic events that had affected the Eastern Desert of Egypt during the Mesozoic.

The aim of our contributions is to comparison on the bases of geologic setting, mineralization, alteration processes and spectrometry of four volcanic areas include; Um Safi rhyolite (USR), El-Atshan bostonite sill (EBS), Um Domi trachyte (UMT) and Um Doweila bostonite (UDB) (Fig. 1).



USR= Um Safi Rhyolite
EBS= El-Atshan Bostonite Sill
UDT= Um Domi Trachyte
UDB= Um Doweila Bostonite

Figure 1

METHODOLOGY

The identified minerals has been carried out by means of binocular microscope, XRD (Model PW 1830) and examined by the environmental scanning electron microscope (ESEM) supported by qualitative energy dispersive spectrometer (EDS) unit at the Nuclear materials Authority of Egypt. The gamma ray spectrometry measurements were carried out using a GS-256 spectrometer with a 7.62x7.62 cm² sodium iodide (Thalium) [NaI(Tl)] crystal detector. Major elements for 69 samples were analyzed by wet chemical in the Nuclear materials Authority (NMA), Egypt. Precision of the analytical data was monitored by international rock standards and is better than 3% for major elements.

GEOLOGIC SETTING

Um Safi rhyolite (USR) was mapped previously as felsite by Akaad and El-Ramly (1963); El-Ghawaby (1966); Akaad et al. (1996) and Abdalla (2001). USR extruded the volcano-sedimentary associations (slate, phyllite, Banded Iron Formation and schist), serpentinites and ortho-amphibolites with Knife sharp contact, forming small obladed body striking NW-SE, covering about 0.3 km² (Fig. 2). The bulk compositions is mainly rhyolite showing banded and flow structures, which may appear as coloured bands strips or lines of spherulites and spherulitic textures.

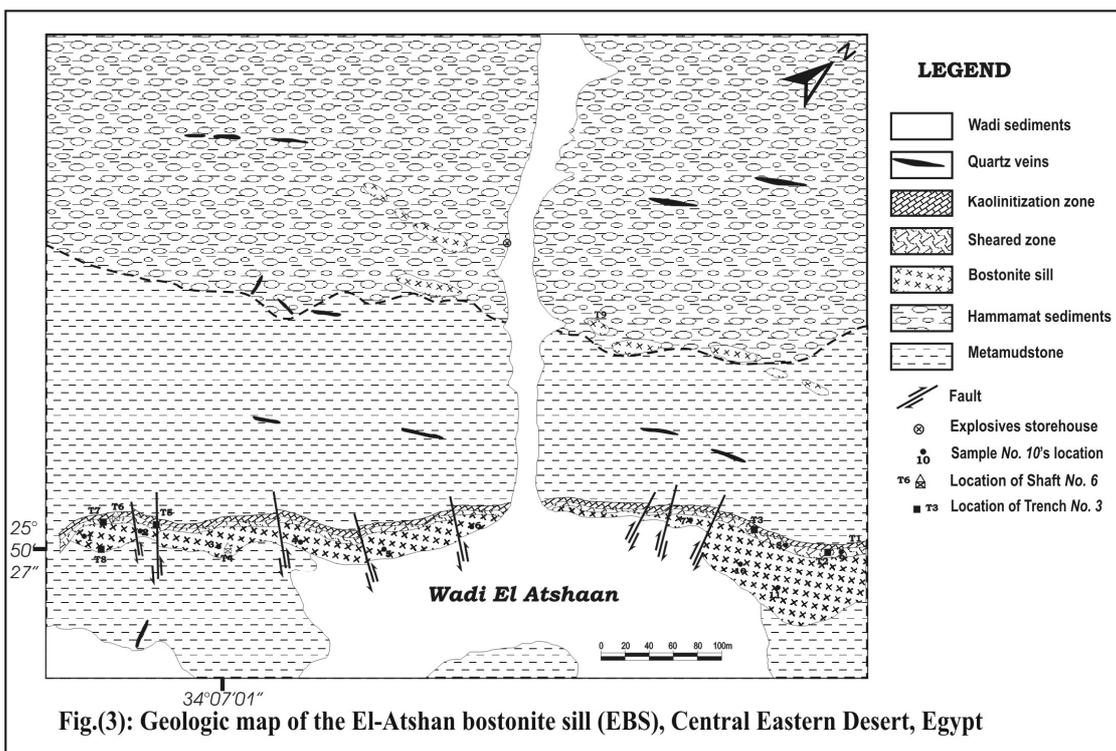
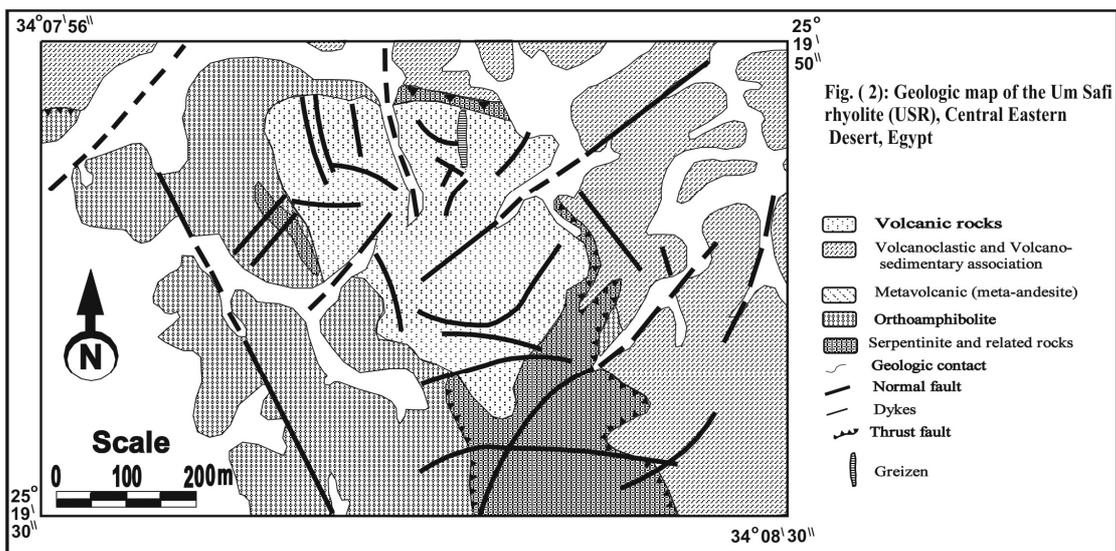
Pyroclastics are represented by breccias, tuffs and welded tuffs and composed mainly of crystals and rock fragments in fine-grained groundmass. USR show different degrees of alteration, hematitization, kaolinitization and silicification. They are invaded by N-S sub-vertically greisenized microgranite, which shows exfoliated and cavernous. The pyroclastics and greisen rocks gain importance due to their high intensities of radioactivity. Visible non-radioactive minerals are observed such as pyrite, arsenopyrite and manganese dendrites, as well as, violet fluorite and metallic black veinlets (N-S trend).

El-Atshan bostonite sill (EBS) have been studies by El-Ghawaby (1973), Assaf (1973) and El-Shazly (1977). Most workers considered the Hammamat sediments in El-Atshan as post-orogenic deposits accumulated in disconnected intermountain basins. The rocks of El-Atshan area can be classified into metasediments (metamudstones, chlorite schists and muscovite schists), Hammamat sediments (siltstones, sandstones and conglomerates), bostonite sill and quartz veins (Fig. 3).

EBS extends for about 660 m with a thickness ranging between 3 to 30m with general strike of N30°E and moderately dipping (25-40°) to NW. They cut by some faults in various direction but the most predominant are striking in the NW-SE and NE-SW directions. EBS is buff in colour, highly jointed, fine- to medium-grained, knife peaks with high resistant and the weathered parts are pale cream yellow with pitted surface. Two disturbed points along the EBS (shaft-1 and shaft-2 from one side and cliff on the northern part from the other side) are characterized by a lot of occurrences of uranium mineralization.

Um Domi trachyte (UDT) and **Um Doweila Bostonite (UDB)** are essentially limited to work by El-Manharawy (1972); Hashad and Mahfouz, (1976); Hashad et al., (1981); Akaad (1996); Kamel et al. (1985); Ibrahim et al. (2002); Heikal (2003); Saleh et al. (2004). They crops out in the southeastern Desert of Egypt.

UDT is semi-rounded in shape (0.5 Km²) and elevate 364 m above sea level (Fig. 4). It is located between two conjugate wrench faults (right-hand) trending N-S and NW-SE. The area is dissected by strike-slip faults (NE-SW, NW-SE and N-S) with obvious displacement along the main Wadis. UDT is hard, fractured, fine- to medium-grained and highly sheared at their contact with volcanogenic sediments. The grain size decreases toward the western side of the trachyte plug. Visible sulphide is common by naked eye. Hematitization, kaolinitization and albitization are the alteration processes. The volcanogenic sedimentary sequence can be divided into lower unit, consisting mainly of clast and matrix supported conglomerates, being interbedded by minor bedded greywacke and chlorite-epidote schist. The upper unite is composed mainly of grey to greenish slates and interbedded with thin beds of mudstone.



UDB extends in the NE-SW direction for about 14 km with 1-10 m width crosscutting three country rocks; volcanogenic meta-sediments, meta-andesite and marble with sharp contacts (Fig. 5). The northeastern and southwestern parts of the UDB (8 Km long) are characterized by fine- to medium-grained, equigranular, whereas the middle part of UDB (3 km long) is characterized by porphyritic texture and low intensity of radioactivity compared with the other parts. Silicification ferrugination, fluoritization and kaolinization processes are predominating features due to hydrothermal solutions.

The fracture framework of Um Doweila area is characterized by two semi-perpendicular dominant trends (NE-SW and NW-SE) resulting from an extensional phase of deformation prior in age to the emplacement of bostonite within the NE-SW main fracture trend. These two main fracture trends are associated with two minor NNW-SSE to N-S and ENE-WSW to E-W trends. In fact, these fracture systems are recorded cutting among the country rocks (volcanogenic metasediments, meta-andesite and marble), whereas the Nubian sandstones are deposited later these trends.

Table 1: Comparison in geologic setting between the four volcanic areas.

	USR	EBS	UDT	UDB
Location	Central Eastern Desert		Southern Eastern Desert	
Country Rocks	Volcano-sedimentary associations + serpentine + ortho-amphibolite	Metasediments	Volcanogenic sediments	Volcanogenic meta-sediments + meta-andesite + marble
Area	0.3 km ²	Extends 660 m with 3 to 30 m width	0.5 Km ²	Extends 14 km with 1-10 m width
Shape	Oblated body striking NW-SE	Sill	Semi-rounded in shape	Dyke
Essential minerals	Quartz + sanidine + secondary muscovite	Sodic feldspar + orthoclase + quartz.	Quartz + plagioclase + alkali amphiboles + alkali feldspars + alkali pyroxene	Quartz + microperthite + riebeckite + rare arfvedsonite
Accessories	Zircon + apatite fluorite+ pyrite + opaques	Zircon + pyrite + apatite + fluorite + opaques	Zircon+ apatite+ fluorite+ pyrite + opaques	Zircon + apatite + fluorite + opaques
Tectonics	Extend in NW-SE direction	Extend in N30°E direction	Extend in NNW-SSE direction	Extend in NE-SW direction

USR= Um Safi Rhyolite

UDT= Um Domi Trchyte

EBS= El-Atshan Bostonite Sill

UDB= Um Doweila Bostonite

DISTRIBUTION of eU and eTh

The eU-content in fresh USR ranges from 17 to 34 ppm with an average 26 ppm, and the eTh-content ranges from 32 to 75 ppm with an average 50 ppm, while the average eTh/eU ratio

is equal 1.9 (Table 2). The eU and eTh values of USR are indicate to uranium enrichment rather than thorium. The field radiometric measurements localized three radioactive anomalies, two within pyroclastics and one within greisenized microgranite.

Table 2: Average of eU (ppm), eTh (ppm), K (%), eU/eTh and eTh/eU ratios of the four volcanic rocks.

Rock types	Radiometric measurements					
		eU (ppm)	eTh (ppm)	K(%)	eU/eTh	eTh/eU
USR (n=86)	min.	17	32	1.75	0.4	1.7
	max.	34	75	4.29	0.6	2.2
	average	26	50	2.99	0.5	1.9
EBS (n=204)	min.	2	4	1.20	0.1	0.4
	max.	115	70	8.10	2.7	15
	average	10	18	3.34	0.6	2.6
UDT (n=94)	min.	6	23	2.90	0.10	2.2
	max.	37	112	7.10	0.45	9.7
	average	23	77	5.31	0.3	3.6
UDB (n=123)	min.	3	5	0.20	0.1	0.2
	max.	570	245	6.60	5.5	20
	average	50	77	2.58	0.6	2.7

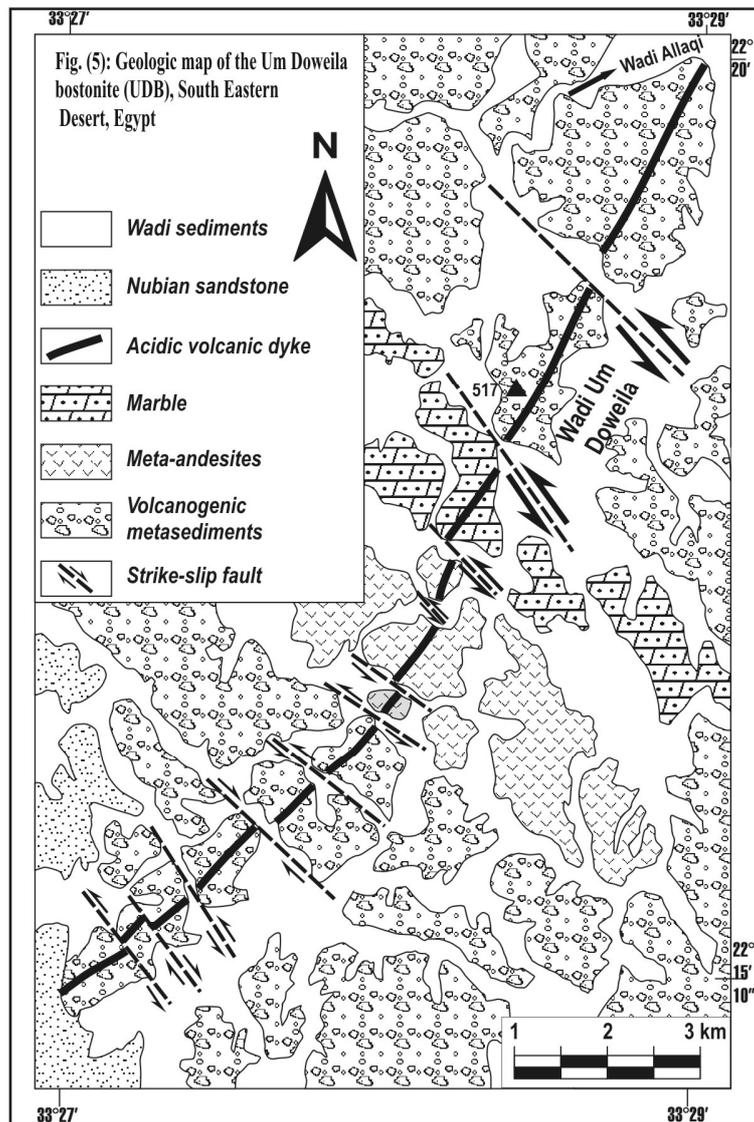
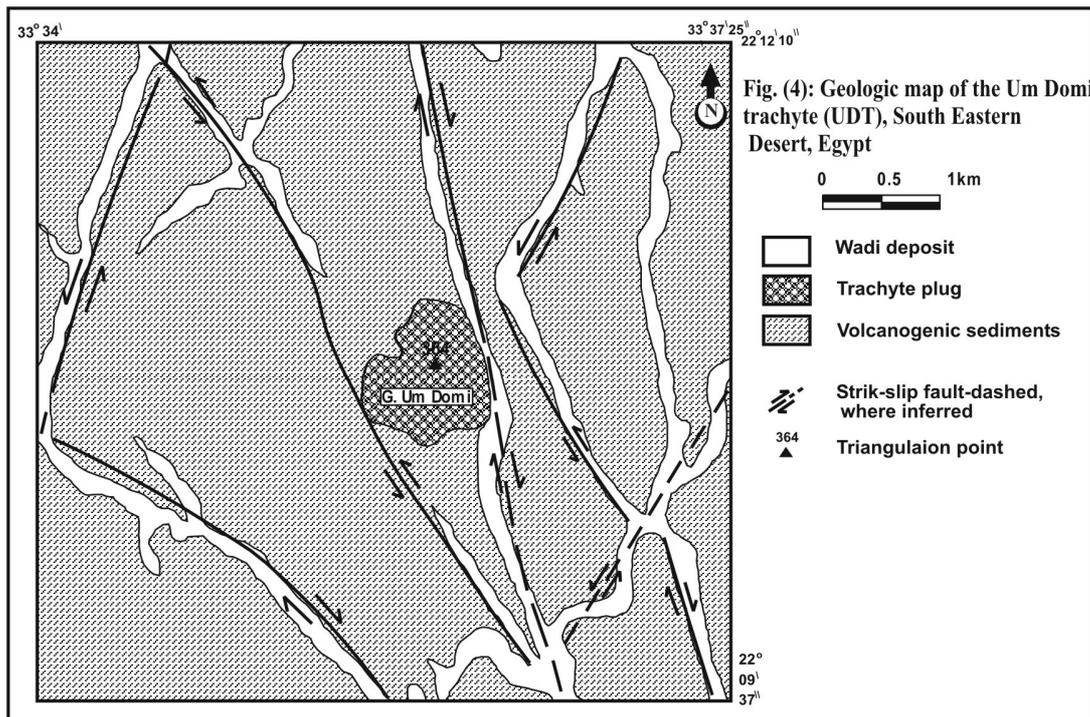
n= Number of analyzed samples

USR= Um Safi Rhyolite.

EBS= El-Atshan Bostonite Sill.

UDT= Um Domi Trchyte.

UDB= Um Doweila Bostonite dyke.



Results of the gamma-ray spectrometric survey of the EBS show the eU-content ranges from 2 to 115 ppm with an average 10 ppm, and the eTh-content ranges from 4 to 70 ppm with an average 18 ppm, while the eTh/eU ratio is equal 2.61 (Table 2). The eU and eTh values of EBS are indicate to uranium slightly enrichment rather than thorium. The high eU-contents are restricted mainly in site shaft No-1 and shaft No-2.

Detailed spectrometric studies of UDT show the eU-content ranges from 6 to 37 ppm with an average 23 ppm, and the eTh-content ranges from 23 to 112 ppm with an average 77 ppm, while the average eTh/eU ratio is equal 3.9 (Table 2).

Detailed spectrometric studies were carried out along NW-SE profiles at a grid pattern of 10x10m for UDB. Generally the eU-content along UDB ranges from 3 to 570 ppm with an average 50 ppm, and the eTh-content ranges from 5 to 245 ppm with an average 77 ppm, while the average eTh/eU ratio is equal 2.7 (Table 2).

MINEROLOGY

The volcanic rocks of USR seem to host uranium are more than sub-alkaline and calc-alkaline varieties (Leroy and Aniel, 1991). Columbite, uranothorite and zircon minerals were recorded as fracture filling in the sheared parts of this felsite rocks (El-Ghawaby, 1966). The uranium occurrence of El-Atshan was subjected to geologic and exploratory works since its discovery in 1962 by Nuclear Materials Authority. Primary mineral (Atshanite), secondary minerals (uranophane, bequerelite, schoepite, kasolite, soddyite and zippeite) and manganese iron minerals (psilomelane, pyrolusite, titanomagnetite, pyrite, hematite, goethite and limonite) have been identified by Abd el Gawad (1964). The mineralogical studies of UDT (Saleh et al., 2004) revealed the presence of rare earth silicates, tantalite, ilmenorutile, chrysocalla, zircon and fayalite minerals. The mineralogical study of the UDB (Ibrahim et al., 2005) reveal the presence of uranophane, beta-uranophane, wolframite (hueberite) monazite, zircon, rutile and opaques whereas, pyrite is a common in volcanogenic metasediments.

Table 3: Minerals identification in the four volcanic rocks.

	USR	EBS	UDT	UDB
Primary U-minerals	-	Atshanite	-	-
Secondary U-minerals	Kasolite	Uranophane + Kasolite +	-	Uranophane + β -uranophane
Uranium bearing-minerals	Yttrialite + Betafite + Plumbobetafite	-	Rare earth silicates	
Thorium minerals	Uranothorite	-	-	-
Tantalum and Niobium metals	Columbite	-	Tantalite + Ilmenorutile	-
Base metal minerals	Pyrite + Cassiterite + Arsenopyrite + Coronadite	Pyrite	Chrysocolla	Pyrite + Wolframite
Manganese + iron minerals	Pyrolusite + Hematite + Goethite + Limonite	Psilomelane + Pyrolusite + Titanomagnetite + Hematite + Goethite + Limonite	Fayalite	-
Accessories	Allanite + Fluorite + Zircon	Zircon	Zircon	Monazite + Zircon + Rutile

USR= Um Safi Rhyolite.

EBS= El-Atshan Bostonite Sill.

UDT= Um Domi Trachyte.

UDB= Um Doweila Bostonite.

RESULTS OF CHEMICAL ANALYSES

Average of major chemical composition for 69 samples are listed in Table 4. The alteration box plot is used to discriminate between geochemical trends of diagenetic alteration from those hydrothermal one. This index (Ishikawa alteration index: $[100 (MgO + K_2O) / (MgO + K_2O + CaO + Na_2O)]$) relates to the replacement of plagioclase by sericite and chlorite during hydrothermal alteration (Ishikawa et al., 1976; large et al., 2001). The index is superior to using Na_2O alone because of its ability to distinguish alkali depletion related to hydrothermal alteration. The chlorite-carbonate-pyrite index $[100 (FeO + MgO) / (FeO + MgO + K_2O + Na_2O)]$ measures the degree of chlorite, (Fe, Mg) carbonate, and or pyrite alteration.

The geochemical data for USR, UDT and EBS are illustrated in an alteration box of diagenetic trend. USR and UDT lies in trend No.9, indicate the common digenetic minerals albite, K-feldspar early digenetic trend of K-feldspar replacing albite and least altered box (Gifkins and Allen, 2001) (K-metasomatized and albitization alteration). The average EBS samples lies in

trend No. 7. indicate the common diagenetic minerals (albite & chlorite) are typical of seawater interaction at low temperature. The reactions that describe these alteration processes include: The first reaction is typical of sericite replacement of albite in volcanic rocks in the outer parts of the alteration system (Date et al., 1979 and Eastoe et al., 1987). The second reaction is important close to massive sulphide mineralization where chlorite rich assemblages become dominant over sericite rich assemblages (Lentz, 1999, Schardt et al., 2001). The average UDB data is plotted in common proximal hydrothermal minerals; sericite, chlorite, pyrite, dolomite and ankerite which lies on the right hand CCPI axis and the upper AI axis (Fig. 6). The samples are plotted between in trends 3, 4 and 5 which represented by chlorite + sericite + pyrite and carbonate.

SUMMARY AND CONCLUSIONS

A- In USR, the average of eTh/eU ratios are increased from greisenized microgranite through fresh rhyolite to pyroclastic samples (kaolinized and argillite). The lowering of the eTh/eU ratio indicates redistribution and localization of secondary uranium mineral (kasolite). The enrichment of U and Th in pyroclastics may indicate the stabilization of them in late- to post-magmatic fluids. In the pyroclastics samples. Kaolinitization, ferrugenation, and argillation represent the hydrothermal alteration processes. The widespread sericitization through the rhyolite rocks provides additional evidence of large-scale movement of solutions through these rocks. The hexavalent U is readily leached from rhyolites by dilute acid solutions so some U may have been transported as $UO_2(OH)^+$ and UO_2^- complex.

UM Safi Rhyolite pyroclastics appears to have provided less-welded layers and lenses. This is coincidence with the similar observation (Smellie, 1982) described from Duobblon rhyolitic ignimbrites. The leached U from solutions percolating through fractures, fissures and permeable bands were re-deposited and sink. The pyroclastics were erupted with explosive violence as a turbulent mixture of hot, expanding gases and gas-emitting lava fragments at relatively low pressures. The base metal minerals (pyrite, arsenopyrite and corondite) are formed in the deeper part in the epithermal zone. In the next zone to the top where ascending solutions rise further towards the surface and mingled with the descending meteoric water, precipitation of secondary uranium mineral (kasolite) and U-bearing minerals (plumbobetafite, columbite, yttrialite, betafite and uranothorite) occur as a function of oxidation and failing temperature.

Table 4: Average of major chemical composition of the four volcanic rocks.

Major Oxides		USR n= 11	EBS n= 20	UDT n= 17	UDB n= 21
SiO ₂	Min.	57.44	59.60	69.49	42.20
	Max.	65.94	69.00	81.50	72.20
	Average	61.91	64.27	72.73	59.85
TiO ₂	Min.	0.17	0.10	0.10	0.15
	Max.	0.69	1.91	0.13	1.51
	Average	0.32	0.51	0.12	0.52
Al ₂ O ₃	Min.	12.66	11.50	8.94	7.40
	Max.	15.69	15.98	14.62	18.40
	Average	14.58	13.73	12.41	11.14
Fe ₂ O ₃	Min.	2.77	2.19	0.81	6.00
	Max.	7.17	7.10	4.39	11.5
	Average	5.35	4.23	2.41	9.58
FeO	Min.	0.2	1.00	0.20	2.18
	Max.	0.66	3.20	0.76	4.10
	Average	0.41	1.92	0.46	3.01
MnO	Min.	0.08	0.03	0.06	0.04
	Max.	0.26	0.22	0.18	0.23
	Average	0.15	0.13	0.10	0.17
MgO	Min.	0.08	0.80	0.80	1.16
	Max.	1.60	3.96	2.80	7.26
	Average	0.91	1.61	1.24	2.36
CaO	Min.	0.84	0.68	1.12	0.39
	Max.	3.92	2.24	2.80	8.70
	Average	1.72	1.52	1.80	2.39
Na ₂ O	Min.	0.21	4.00	0.34	0.41
	Max.	6.61	7.62	4.63	6.10
	Average	5.99	5.92	3.08	1.79
K ₂ O	Min.	2.61	2.08	0.83	0.47
	Max.	3.48	5.40	4.55	4.40
	Average	2.87	4.22	2.72	3.09
P ₂ O ₅	Min.	0.01	0.01	0.07	0.05
	Max.	4.54	1.00	0.13	1.11
	Average	2.95	0.28	0.09	0.86

n= Number of analyzed samples

USR= Um Safi Rhyolite.

UDT= Um Domi Trachyte.

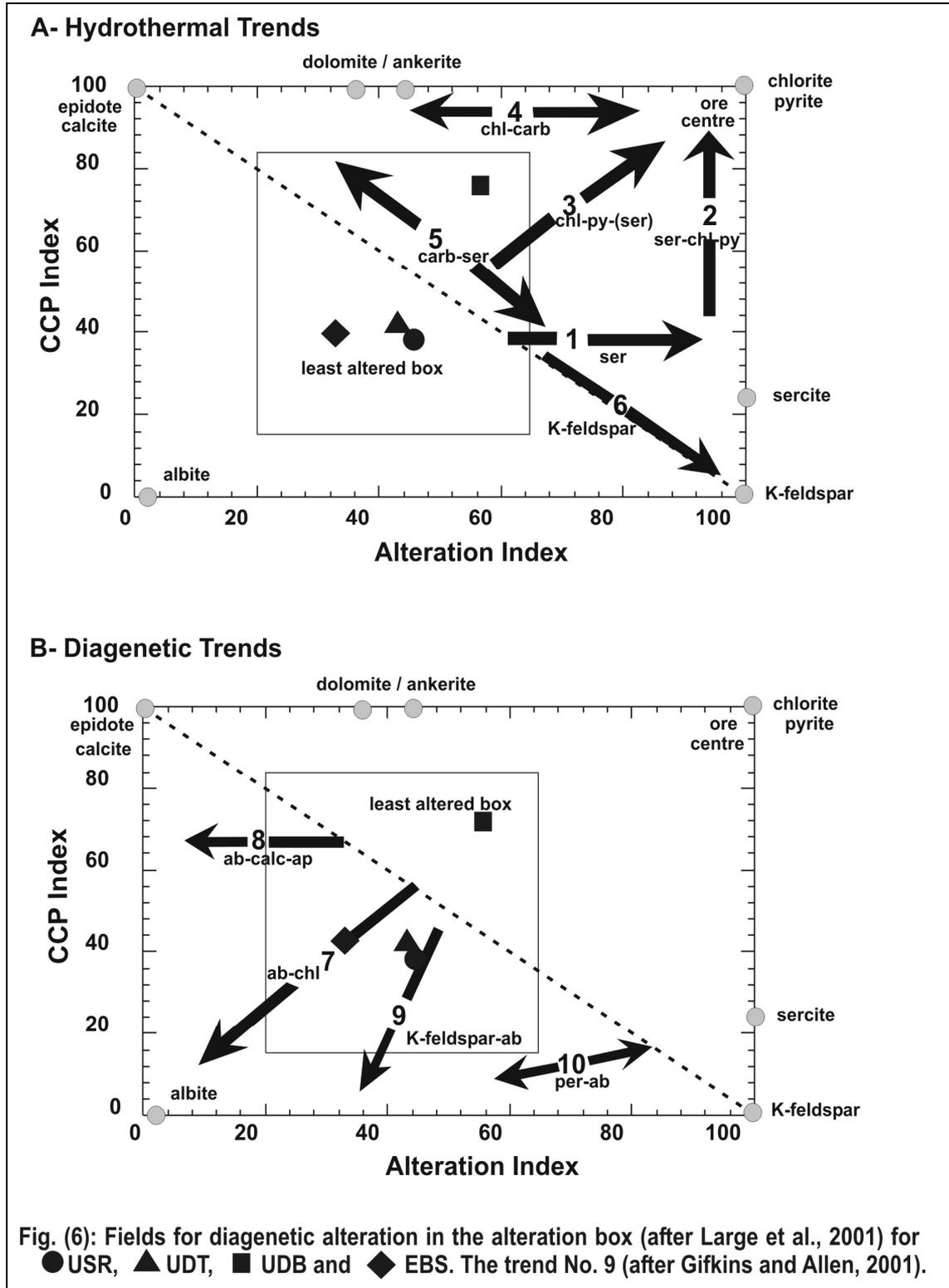
EBS= El-Atshan Bostonite Sill.

UDB= Um Doweila Bostonite dyke.

B- EBS was extruded into the tilted strata of the metasediments parallel to the foliation planes.

During the cooling of the bostonite sill, shrinkage and cracking took place parallel to the foliation planes giving rise to the formation of the major NE-SW set of fractures especially at the contact with the host rocks. Upon the final cooling and consolidation sill the shrinkage and cracking process is continued leaving the bostonite with radial group of joint. Later on, the fractures of this trend has been reopened and refilled with quartz during a NW-SE

trending extensional phase of deformation. Moreover, the NE-SW fracture set is recorded as major new formed normal faults along W. El Atshan parallel to the bostonite sill indicating an other NW-SE trending extensional phase of deformation.



It could be concluded that the major NE-SW trending fracture sets were acted as the principal channel ways for the mineralized solution while the re-deposition took place within almost all the minor fracture trends with no preferred orientation. This could suggest meteoric water origin for the mineralized solution rather than the hydrothermal origin. This conclusion is in agreement with the results obtained from the geochemical analyses (diagenesis effect).

El-Atshan bostonite sill is considered to be low grade uranium mineralization that related to alkaline volcanic rocks. This area seems to have been affected by many groundwater activities. The area is also characterized by the absence of post magmatic activities (chemical traps for U mineralization).

The U mineralization is restricted only to local spots concentrated at the small alteration parts of the metamorphic belt in close contact with the bostonite sill. Although the visible uranium mineralization in both the metamorphic belts and Hammamat sediments is absent, their eU/eTh ratio (>1) confirm the mobilization idea of the U towards the bostonite sill.

C- UDT occurs as semi-rounded (0.5 Km²) form of highly sheared at their contact with volcanogenic sediments and located between two conjugate wrench faults trending N-S and NW-SE and parallel to the extensional direction (NNW-SSE). Geochemically, the UDT plug has an alkaline affinity and silica-oversaturated and may be attributed to extensive alkali feldspar fractionation. It is affected by both K- and Na-metasomatism related to diagenetic process.

The accessories of UDT plug are composed of tantalite, REE silicate, chrysocolla, ilmenorutile, zircon, apatite and pyrite. Although the nature and distribution of such minerals are controlled by magma features, they may be significantly affected by diagenetic process.

The absences of post-magmatic activity (i.e. chemical trap for uranium) and any significant shear zones in UDT incorporated with the low uranium content (37 ppm). Finally, UDT plug could be considered as a good target for exploration on tantalite and REEs silicate.

D- UDB could be considered the longest U-bearing dyke in the Eastern Desert of Egypt. It extends in the NE-SW direction for about 11 km and ranges from 1-10 m in width and emplaced across three country rocks; volcanogenic meta-sediments, meta-andesite and marble with sharp contacts.

The NE-SW and NW-SE tensional fractures have been reactivated as strike-slip faults (sinistral and dextral respectively) under N-S (semi-meridional) followed by a ENE-WSW trending regional compressional stresses creating zones of ductile deformation characterizing coupling tectonic environment. The metamorphism in the country rocks is a weak to very weak type that occurred under moderate pressure with depletion in silica and enrichment in CaO and MgO restricted to marble zone.

The mineralogical study of the UDB samples reveal the presence of uranophane, beta-uranophane, wolframite, monazite, zircon, rutile and opaques whereas pyrite is a common in volcanogenic metasediments .

UDB is affected by a common proximal hydrothermal minerals; sericite, chlorite, pyrite and

ankerite. The detailed spectrometric survey revealed coincidence of eU/K and eU ratios along the country volcanogenic metasediments rocks (reduced regime). The U migrated from the central zones of UDB close to fault zones (channel-ways) inward to outward the peripheries and concentrated at the NE and SW upper and lower corner.

REFERENCES

1. Abdalla, H.M., (2001): Geochemistry and origin of rare metal mineralization of Um Safi felsite, central Eastern Desert, Egypt. *Egyptian J. Geol.*, p. 131-149.
2. Abdel Gawad, A.M. (1964): Uranium mineralization of Atshan prospect, Eastern Desert. A laboratory study. Unpublished report. U.A.R. Atomic Energy Establishment, Cairo.
3. Akaad, M. K., (1996): Rock succession of the basement on autobiography and assessment, Egypt. Geological Survey Mining Authority, 71, 87 P.
4. Akaad, M.K. and El Ramly, M.F., (1963): Geology and structure of Um Lassaf - Um Nar iron belt, Eastern Desert of Egypt. *Geol. Surv. Egypt*, No. 17, 23 p.
5. Akaad, M.K., Noweir, A.M. and Abu El Ela, A.M., (1996): Geology of Pan-African basement rocks of the Gabal Al Hadid – Wadi Mubarak District, E.D., Egypt. *Geol. Surv.*, Egypt. No.73, 78 p.
6. Assaf, H.S., (1973): Structure and radioactive mineralization of Wadi Arak area, Eastern Desert, Egypt. Ph.D. Thesis, Ain Shams Univ., Cairo.
7. Date, J., Watanabe, Y., Iwaya, S. and Horiuchi, M., (1979): A consideration of the alteration of the dacites below the Fukazawa ore deposit. *Fukazawa mine, Akita, Mining Geology*, 29, 187-196.
8. Eastoe, C.J., Solomon, M. and Walshe, J.L., (1987): District-scale alteration associated with massive sulfide deposits in the Mount Read Volcanics, Western Tasmania, *Economic Geology*, 82,1239-1258.
9. El-Ghawaby, M.A., (1966): Structural and lithologic controls of localization of radioactive mineralization in a south Qusier area. M.Sc. Thesis, Ain Shams Univ., Cairo, 100 p.
10. El-Ghawaby, M.A., (1973): Structural geology and radioactive mineralization of Wadi Zeidun area, Eastern Desert of Egypt. Ph.D thesis, Ain Shams Univ., Cairo.
11. El-Manharawy, M.S., (1972): Isotopic ages and origin of some uranium bearing volcanic rocks in Egypt. M. Sc. Thesis, Cairo Univ.
12. El-Shazly, E.M., (1977): The geology of the Egyptian region. In : *The ocean basins and margins*, V. 4A (Edited by Nairn A.E., Kanesh, W. H., and Stehli, F.G.), P. 379-444, New York.
13. Gifkins, C.C., and Allen, R.L., (2001): Textural and chemical characteristics of diagenetic and hydrothermal alteration in volcanic rocks: Examples from the Mount Read volcanics, Tasmania, *Economic Geology*, 96, 973-1002.
14. Hashad, A.H., Hassan, M.A. and Aboul Gadayel, A.A. (1978): Trace element variations in the alkaline volcanics of Wadi Natash, Egypt. *Bulletin Faculty Earth Science King Abdulaziz Univ., Jeddah* 2, 195-204. Hashad, A.H., and Mahfouz, S., 1976, On the geochemistry of W. Kareim volcanics, Egypt. *Chemi. Erde (Geochemistry)*, 35, 317-326.

15. Hashad, A.H., and Mahfouz, S., (1976): On the geochemistry of W. Kareim volcanics, Egypt. *Chem. Erde (Geochemistry)*, 35, 317-326.
16. Hashad, A.H., Sayyah, T.R., and El-Manharawy, M.S., (1981): Isotopic composition of strontium and origin of W. Kareim, Eastern Desert, Egypt. *Journal Geology*, 25(1-2), 141-147.
17. Heikal, M.T., (2003): Model for the origin of the Um Shaghir-Um Khors alkaline trachyte plugs, Central Eastern Desert, Egypt. *The Third International Conference on the Geology of Africa*, 1, 233-253.
18. Ibrahim, M.E., Attawiya, M.Y., Osman, A.M., and Ibrahim, I.H. (2002): Occurrence of uranium bearing minerals in Um Safi pyroclastics, Central Eastern Desert, Egypt. *Egyptian Journal of Geology*, 46-1, 39-54.
19. Ibrahim, M.E., Saleh, G.M., Ibrahim, I.H., Mostafa, M.S., Azab, M.S., Darwish, M.E., Asran, H.M. and Lasheen, T.A., (2005): Spectrometric and Geochemical Characteristics of Um Doweila Bostonite, Southeastern Desert, Egypt. *The 9th inter. Min., petrol., Metall. Engin. Conf., Cairo Univ.*
20. Ishikawa Y., Sowaguch., T., Lwaya, S., and Horiuchi, M., (1976): Delineation of prospecting targets for kuroko deposits based on modes of volcanism of underlying dacites and alteration halos. *Mining Geology*, 26, 105-117.
21. Kamel, A.F., Mansour, S.I., and Ibrahim M.E., (1985): The study of the radioactive dyke at Um Domi area, Southeastern Desert, Egypt. (Internal Report). 14 p.
22. Large, R.R., Allen, R.L., Blacke, M.D., and Herrmann, W., (2001): Hydrothermal alteration and volatile element halos for the Rosebery klens volcanic-hosted massive sulfide deposit, Western Tasmania, *Economic Geology*, 96, 1055-1072
23. Lentz, D.R., (1999): Petrology geochemistry and oxygen isotope interpretation of felsic volcanic and related rocks hosting the massive sulfide deposits, New Brunswick, Canada, *Economic Geology*, 94, 57-86.
24. Leroy, J. L. and Aniel, B.G., (1991): Uranium behavior in volcanic environments: source-rocks and concentration mechanisms. *Transport and Deposition of Metals*, Balkema, Rotterdam, 321-324.
25. Resselars, R., Nairn, A. E. M. and Monrad, J.R., (1981): Two phases of Cretaceous-Tertiary magmatism in the Eastern Desert of Egypt: paleomagnetic, chemical and K-Ar evidence. *Tectonophysics* 73, 169-193.
26. Saleh, G.S., Ibrahim, I.H., Azab, M.S., Abdel Wahed, A.A. Ragab, A.A. and Ibrahim, M.E., (2004): Geologic and Spectrometric Studies on Um Domi Phanerozoic Trachyte Plug, South Eastern Desert, Egypt. *The 6th intern. Conf. On Geochemistry, Alex. Univ., Egypt.*
27. Schardt, C., Cooke, D.R., Gemmel, J.B., and Large, R.R., (2001): Geochemical modeling of the zoned footwall alteration pipe. Hellyes volcanic-hosted massive sulfide deposit, Australia, *Economic Geology*, 96, 1037-1054.
28. Smellie, J.A.T., (1982): The mineralogy and genesis of uranium in rhyolitic ignimbrites of Precambrian age from Duobblon, Sweden. *Min. Mag.*, v. 46, p. 187-199.
29. Stairs, M., Morteani, G., Fuganti, A. and Drach, V., (1991): K-Ar ages, Sr-isotopic composition and chemistry of Late Cretaceous-Tertiary basalts from the Nubian Desert (Northern Sudan). *European J. Min.*, 3, 943-955.