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Mineralogical Studies of the Stream Sediments in Khour Abalea Abu Rusheid area, South Eastern Desert, Egypt

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ABSTRACT

Abu Rusheid area occupies a small part of the Precambrian besement of the south Eastern Desert of Egypt. Khor Abalea is located at the middle part of the Mylonitic rocks and it is formed as a result of faults and dissected by dykes. These dykes act as a trap for mineralizations where played an important role in a heat source, which led to uranium mobilization. Khor Abalea crushed in most parts that indicate of the hydrothermal solution. Khor Abalea represents promising area for accessory minerals. The ESEM studies revealed that presence of 1) base metals includes (pyrite, chalcopyrite, arsenopyrite, sphalerite), 2) Radioactive minerals including: uranium minerals (Betafite) and thorium minerals (uranothorite) 3) NB-Ta Minerals (columbite,) and, 4) REE-bearing Minerals (monazite, xenotime and zircon).

Key words: Precambrian besement, faults, dissected, dykes, stream sediments

Introduction

Wadi Abu Rusheid area lies in the southern part of the Eastern Desert of Egypt at the boundary between Central Eastern Desert (CED) and the Southern Eastern Desert (SED) at about 90 km southwest of Marsa Alam. The works resulted in the discovery of hot cataclastic rocks (U, Th, Nb, Ta, Zr, Pb,Y, Zn, W, Sn and Ga), in Abu Rusheid area, cut by lamprophyre dykes bearing mineralization (U, REEs, Pb, Ag and Zn) along two shear zones (Ibrahim *et al*., 2004 and 2015). The area is characterized by low to medium topographic features (Fig.1a).The highest topographic feature is about 542 m above Sea level and 385 m. above Wadi level. The area is dissected by Khour Abalea, several gullies and NNW-SSE and ENE-WSW shear zones, characterized by low topography place resemble longitudinal trenched of vertical V-shape Khour Abalea (1.5 Km in length, 10-20 m in width) forming U-shaped and located at the middle part of the cataclastic rocks. It was formed as a result of deep strike-slip faults, forming shear zones in ENE-WSW, NNW-SSE, N-S and NNE-SW trends respectively (Ibrahim *et al*.,2002).The main aims of our study throw some lights on the mineralogical investigations of stream sediments in the entrance of Khour Abalea.

Geologic Setting

A detailed geologic map of Abu Rusheid area was constructed (3 km^2) on the base of a grid pattern 20 x 20 m (Fig.1b).The main rock types arranged as follows:1) Protomylonites, 2) Mylonites rocks, 3) Ultramylonites, 4) Silicified ultramylonites , 5) Granitic rocks (Ibrahim *et al*., 2004), and 6) Post granitic dykes and veins, (Fig. 1b). Abu Rusheid area is traversed by strike- slip faults trending ENE-WSW, NNW-SSE, N-S and NNE-SSW and play as good channel ways for mineralization.

The description of the tectonostratigraphic sequence of the Precambrian rock units of the studied area as following:

1- Protomylonites:

Macroscopically, the protomylonites are coarse to very coarse grained to dark greenish grey in color. The crop out eastward flank of W. Abu Rusheid covering about 12.0 in vol. % of the cataclastics (Ibrahim *et al*., 2004).They invaded by two generations of quartz veins. The oldest one is mineralized (U, Sn, W)

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and parallel to the banding planes (WNW -ESE) and dipping in NNE direction .Whereas the youngest one is barren and normal to the banding planes.

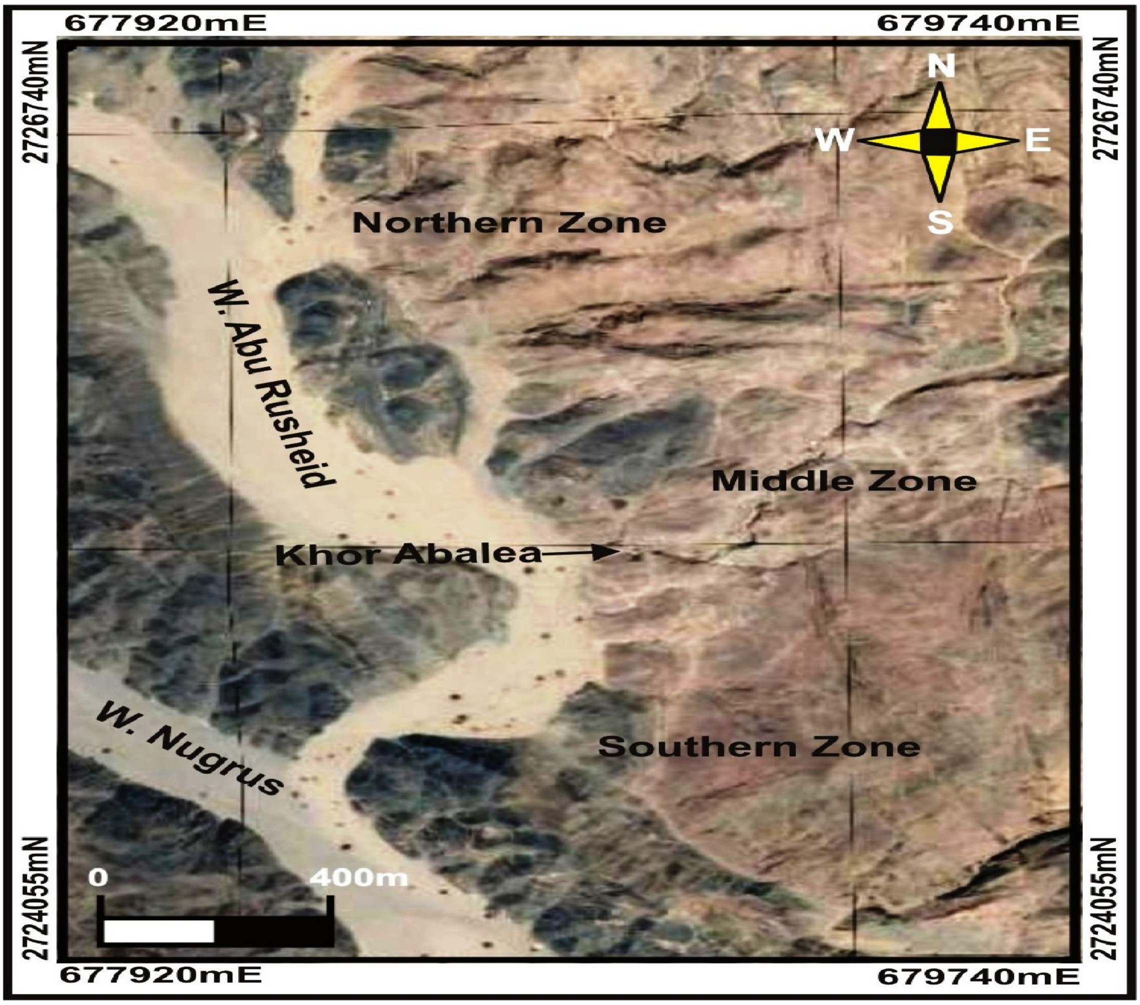


Fig. 1a: Google Earth image of the Abu Rusheid area showing the location of khour Abalea, Abu Rusheid area.

2- Mylonites rocks

The rocks are highly foliated (WNW - ESE), and characterized by absence of enclaves together with the frequent occurrence of greenish – microcline veinlets- like running parallel to the foliations. The mylonites are frequently dissected by pegmatite and quartz veins, which are usually concordant with the foliation planes. The altered rock acquires reddish to yellowish color due to staining with iron solutions. Some pyrite crystals were removed leaving vugs filled with quartz, carbonates and U-minerals. Columbite – tantalite occurs abundantly as disseminated minute grains or as single crystal and aggregates visible by naked eyes.in south W.Abu Rusheid at Madinat Nugrus, the intercalation between the protomylonite and mylonite rocks is common indicating the sedimentary origin.

3- Ultramylonites

They are light grey to grey in color, fine to medium grained and exhibit both banding and augen structures. The ultramylonite covers about 17 % of the cataclastic rocks (Ibrahim *et al*., 2004) .A major shear zone (NNW - SSE), highly brecciated and enriched by poly-mieralization, is cross- cutting the ultramylonite. The ultramylonite is frequently dissected by pegmatite and quartz veins, which are usually concordant with the banding planes. They are characterized by sub-horizontal and vertical major joints. The abundant joint sets are as follows: NW – SE, NE-SW, N-S, E-W trends. The altered rock acquires reddish to yellowish color due to staining with iron solutions. Some pyrite crystals were removed leaving vuge filled with quartz, carbonate and U-minerals. Columbite – tantalite occurs abundantly as disseminated minute grains or as single crystal and aggregates visible by naked eyes. (Ibrahim *et al*., 2008).

4- Silicified ultramylonites

The Silicified ultramylonites cover about 6% of the cataclastic (5-15 m) with irregular and oval in shape overlie all the previous rocks in the mapped area (Ibrahim *et al*., 2008). Sulfides are dominantly pyrite, arsenopyrite, with rare galena impregnations along fractures and cleavage planes of other minerals. Smoky quartz is the dominant minerals in the silicified ultramylonite (80 -95 in vol. %).

5- Granitic rocks

The granites are represented by two mica granites and biotite granites in the northern and southern parts of the study area respectively and a small intrusion of muscovite granite at the end of Khore Abalea. It occurs as small to moderate bodies of low hill masses and extends out of the cataclastic rocks, as large masses, with high elevation. These rocks are grey color, medium - to coarse grained, mylonitized at the contact with cataclastic and ophioltic mélange rocks, jointed and fractured. The granitic rocks carry a roof pendant of mylonitic rocks. Networks of pegmatite veins are intensively filling joints and fractures.

6- Post granitic dykes and veins

The basement rocks of Abu Rusheid area cut by various dykes and veins. They comprise the following rocks types' encountered in the cataclastic rocks:

a) Lamprophyre dykes: Abu Rsheid area is extruded by four lamprophyre dykes; these dykes are usually highly altered to clay minerals, the first two of them taking NNW – SSE direction, the third and the fourth taking ENE – WSW direction, the third lamprophyre dykes found mainly at the contact between cataclastic rocks and the two mica granitic rocks. The northern part of Abu Rushied area is extruded by a wide basic dyke (dolorite) about (8 m) in width and extend for (1200 m).

b) Pegmatite veins: Several Pegmatite veins occur within the cataclastic rocks, they consist of quartz, orthoclase, microcline and micas. The pegmatite veins are bearing cassiterite, thorite and columbite – tantalite with secondary uranium mineralization. And quartz veine are distributed among all the studied country rocks and not exceed (3m) in length and (0.5m) in thickness.

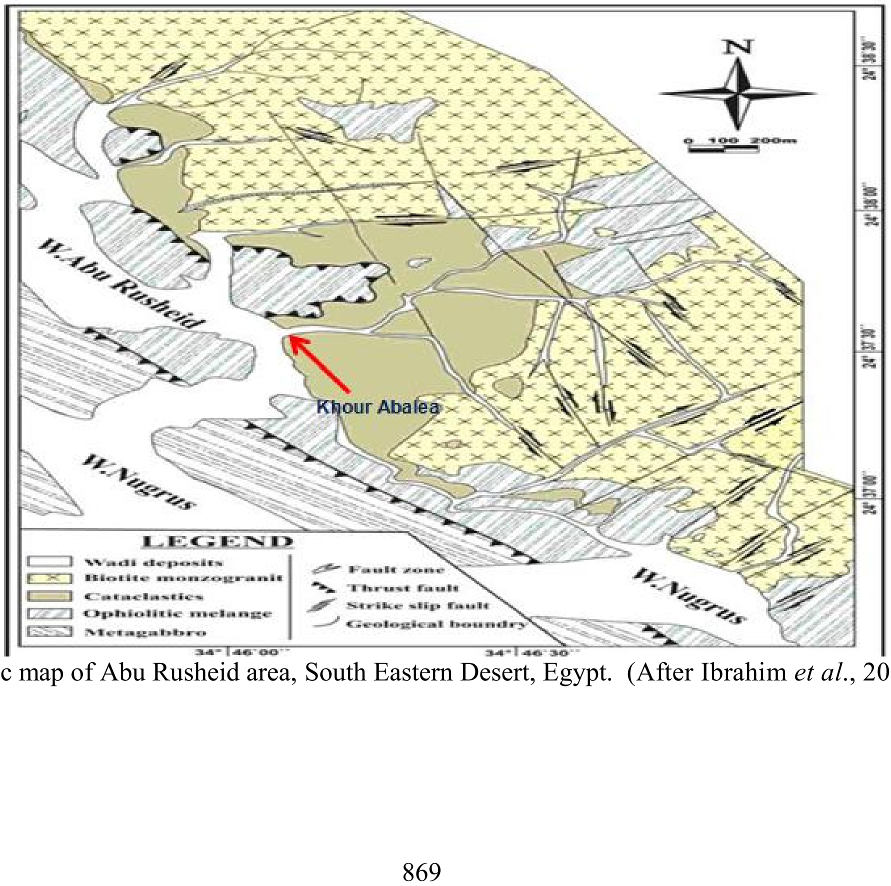


Fig. 1b: Geologic map of Abu Rusheid area, South Eastern Desert, Egypt. (After Ibrahim *et al*., 2004)

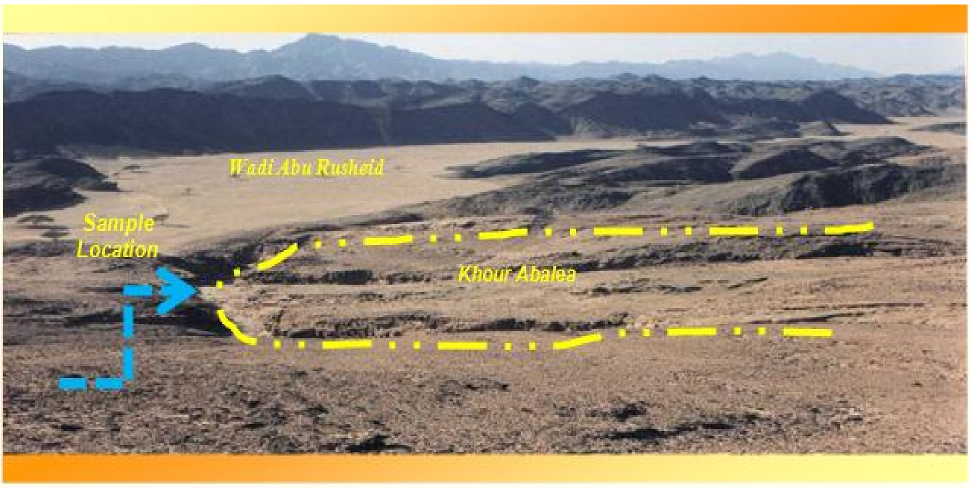


Fig. 2: Photo showing the study area (Khour Abalea) and sample location.

Methodology

The collected field samples (Three samples weighting about 50 kg were taken from Khour Abalea) (Fig.2), are composed of three wet loose sediments. Firstly, each field sample was subjected to sun drying and disaggregation process. Each dry field sample (weighing about 50 Kg.) was split into two halves using John's Splitter. One of them was kept in a bag as a reference sample and the second was subjected to splitting again using John's Splitter to obtain a representative sample weighing about 200 gram for the different analyses while the rest returned to the stored sample. Each representative sample was weighed and put in a two liter size beaker filled with tap water and using an electric stirrer for about 5 minutes to liberate the different minerals particles composing the sample. Then, the sample was left to rest for a time suitable to settle all sizes larger than fine silt size. The upper two-thirds of the water depth with its suspended materials were decanted using a siphon to avoid the escape of any sand particle during decantation. The process was repeated several times till the decanted water becomes clear. The clean samples were then dried and weighed. The difference between the first weight of each sample and its weight after cleaning represents the weight of the fines (the weight of the size fraction less than the coarse silt size and the weight of the organic matters). A representative sample weighting about 50 grams was taken by the using of rotary splitter and subjected to mechanical analysis. Each representative sample was put on the top of a set of sieves selected according to the Wentworth Grade Scale for the sand size (Wentworth, 1922). The aperture diameters for these sieves were 2.00, 1.00, 0.50, 0.25, 0.125 and 0.063 mm. The sieves were arranged in a descending order and the pan beneath them and the cover on the top sieve. The sieves with the sample on the top sieve were shacked for about 30 minutes using an automatic vibratory shaker. The retained material on each sieve and in the pan was taken and weighed and the frequency for each size was calculated. The collected samples were subjected to mineralogical investigation by the using of laboratory techniques (heavy liquid separation, magnetic fractionation and microscopic investigations). To apply Bromoform separation, each of the previously prepared representative samples weighing about 40 grams was put in a 500 milliliter separating funnel. A sufficient quantity of Bromoform, enough to make the solid/liquid ratio suitable to give complete freedom for each particle to sink or float, was added. The liquid with the sample was thoroughly stirred till the sample was completely and homogeneously mixed with the liquid and left a suitable time to free separation. After the suitable time, the sample was separated into float and sink layers with a clear liquid band between them. The float layer includes the light minerals with specific gravity less than 2.8 gm/cm^3 and called the light fraction, which mainly composed, from quartz and feldspars. While the sink layer consists of the minerals have specific gravities greater than 2.8 gm/cm^3 and called the heavy fraction which constitute all the heavy minerals. After complete separation, the heavy fraction was taken on a filter paper in a precipitating funnel and the light fraction on another filter paper in another funnel. The two fractions were left to precipitate all the Bromoform liquid. The Bromoform liquid was again used while each fraction was washed with acetone to leach the remnant Bromoform film coating the particles and that exist in the pores between the different grains. After complete washing with acetone, each fraction was dried and weighed. The obtained heavy fractions from the Bromoform separation were subjected to Clerici's solution separation in order to separate the heavy economic minerals in the sink layer or heavy sub-fraction and the colored silicates in the float sub-fractions. The sink and float sub-fractions were taken and washed with distilled water, dried and weighed. Actually, the obtained heavy sub-fractions after the Clerici's solution separation are composed mainly of magnetite, zircon, rutile, garnet and monazite beside the rare heavy economic minerals cassiterite, gold, xenotime, and uranothorite. Each of the mentioned minerals exhibits its own magnetic susceptibility, which varies from ferromagnetic to non, (Dabbour, G.A.1995).The microscopic investigation of the studied samples was carried out under the binocular stereomicroscope and transmitted polarizing light microscope.The recognition for the picked minerals by Environmental Scanning Electron Microscope (ESEM), Model Phillips XL 30 with Energy Dispersive X-ray (EDX). Finally, the picked Samples were then ground to -200 mesh size for XRD analysis using PHILIPS PW 3710/31 diffractometer with automatic sample changer PW 1775, scintillation counter; Cu-target tube and Ni filter at 40 kV and 30 mA.

Mineralogical investigations:

The study reveals that: 1) base metals includes (pyrite, chalcopyrite, arsenopyrite, sphalerite), 2) uranium - thorium minerals (Betafite and uranothorite respectively) 3) Nb-Ta minerals (columbite), 4) REE-bearing minerals (monazite , xenotime and zircon) in addition to garnet and iron oxides, (Table 1).

Table 1: Showing the result of mineralogical study for the entrance of Khor Abalea.

Mineral groups	Minerals
Base metals	Pyrite (Fe S_2) - chalcopyrite ($CuFeS_2$) - arsenopyrite (FeAsS) - sphalerite (ZnS).
Nb-Ta Minerals	Columbite (Fe, Mn) (Nb,Ta)O4
Uranium Mineral	Betafite (Ca(UO2)2(SiO3)2
Thorium Mineral	uranothorite (U, Th) SiO_4
REE- bearing Minerals	Monazite (Ce, La, Th) PO_4 - xenotime (HREE,Y,PO_4) - zircon($ZrSiO_4$)

1- Base metals

- Pyrite (Fe S_2)

Pyrite is the most widespread and abundant sulfide minerals in the Earth's surficial rocks, commonly constitutes the primary opaque phase in ore deposits. Pyrite forms large bodies in moderate- to high-temperature hydrothermal deposits and in contact metamorphic ore deposits. In the study area, The EDAX analysis indicates that cubic pyrite (Fig.3) composed of S (43.19%), Fe (40.8%) and O (10%).

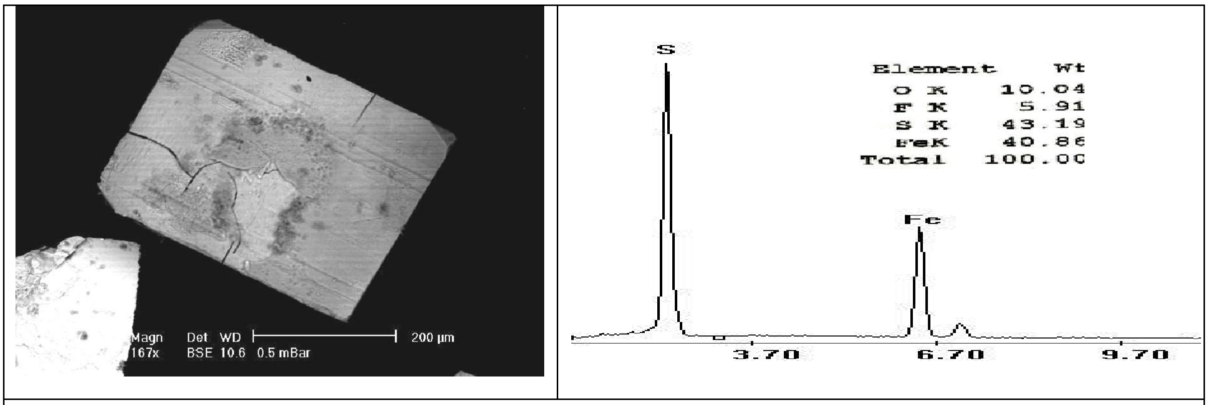


Fig. 3: EDX and BSE image showing cubic pyrite grain.

- Chalcopyrite ($CuFeS_2$)

Chalcopyrite occurs as subhedral to euhedral crystals ranging in size from 50 to 200 m. The EDAX analyses of the chalcopyrite reflect its chemical composition and gave S (18.82 %), Fe (11.38 %), Cu (38.64 %), and Zn (28.54), together with minor Al, Si and Ca (Fig.4).

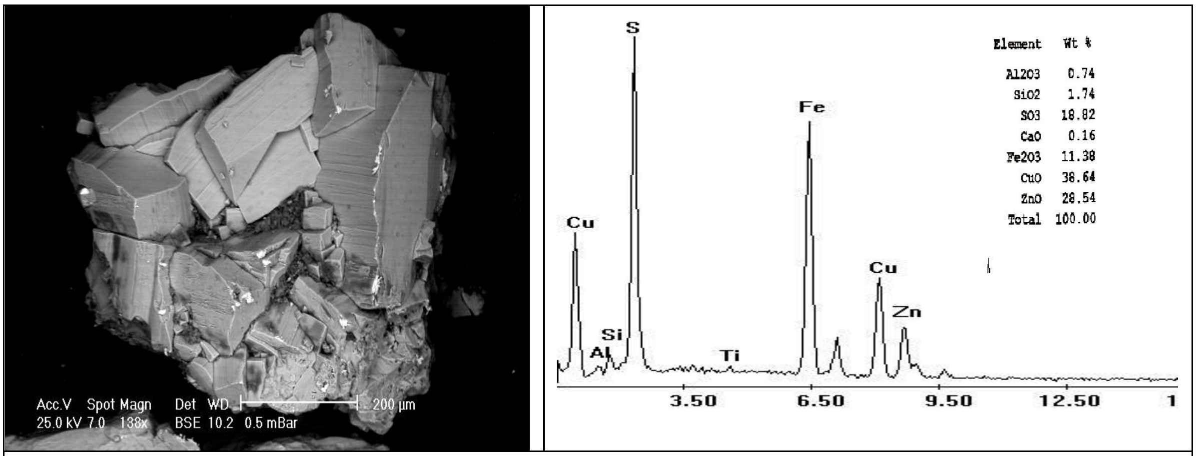


Fig. 4: EDX and BSE image showing cubic chalcopyrite grain.

- Arsenopyrite (FeAsS)

Arsenopyrite is the most common ore of arsenic commonly found in ore veins that were formed at high temperatures. Arsenopyrite present as a dark or light grey and forms monoclinic or triclinic crystals with an orthorhombic shape, (Fig.5).

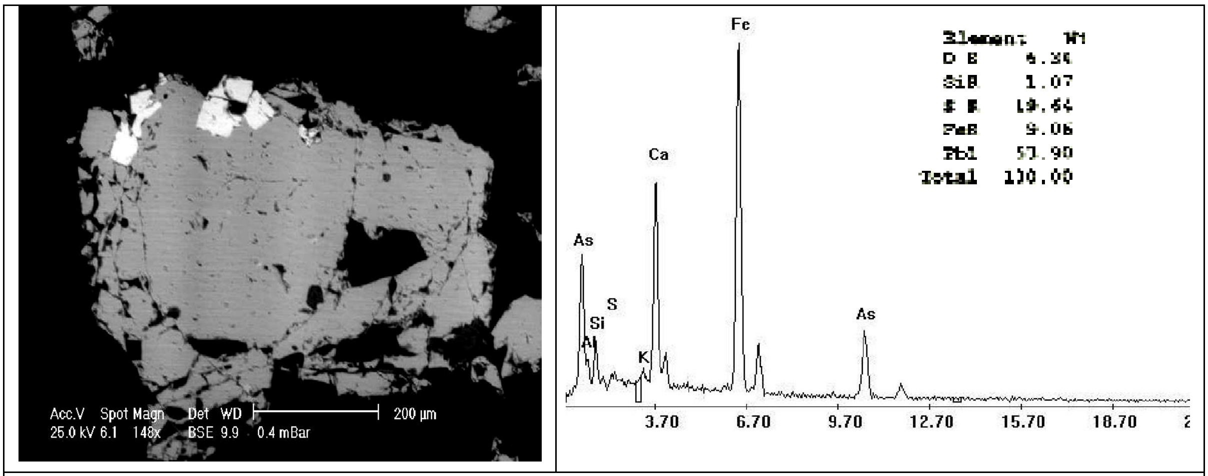


Fig. 5: EDX and BSE image showing euhedral arsenopyrite crystal.

- Sphalerite (ZnS)

Sphalerite is tetrahedral sulfides group minerals and is recognized by its luster, density and may be confined with galena but yield a brown streak. Sphalerite is found in different kinds of deposits, associated with galena, chalcopyrite, pyrite, fluorite, carbonates and quartz in voids and fracture fillings of carbonate hosts. It is found in hydrothermal veins with pyrite and magnetite. In the study area, it is colorless to pale brown or yellow in thin section. The EDAX shows it contain Zn (50.29%), S (33.05%), U (3.59%), with minor amounts of Al (0.88%), Si (2.70%) and Fe (9.49%), (Fig.6).

2- Radioactive minerals

a- Uranium mineral

- Betafite $Ca(UO_2)2(SiO_3)2$

Betafite is the common uranyl mineral. It is formed in a neutral to alkaline environment. They also added, betafite gets unstable in acidic, low carbonate environments, where it alters to soddyite, but in alkaline environment it alters to beta-uranophane and kasolite (Fig.7).

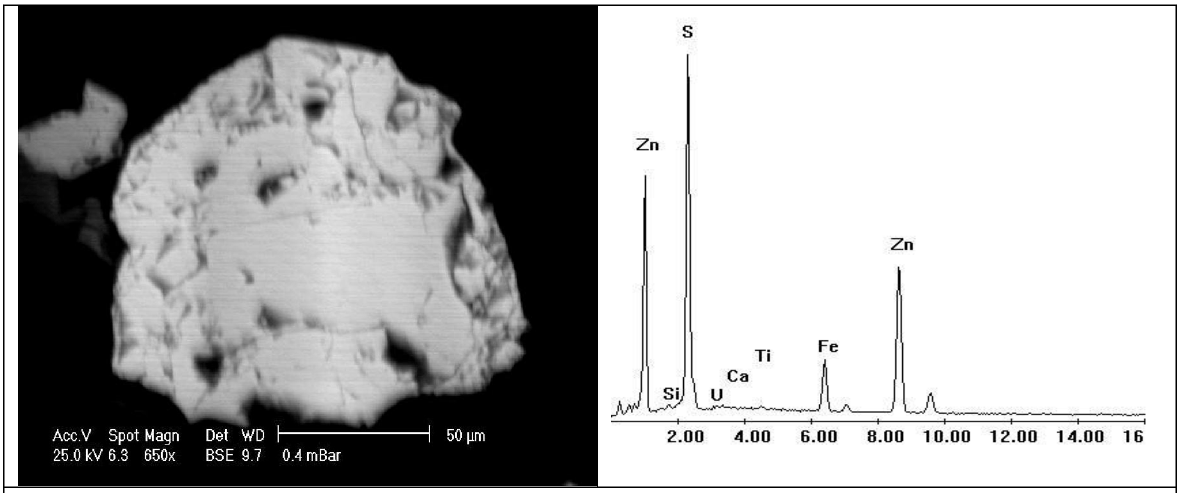


Fig. 6: EDX and BSE image showing sphalerite.

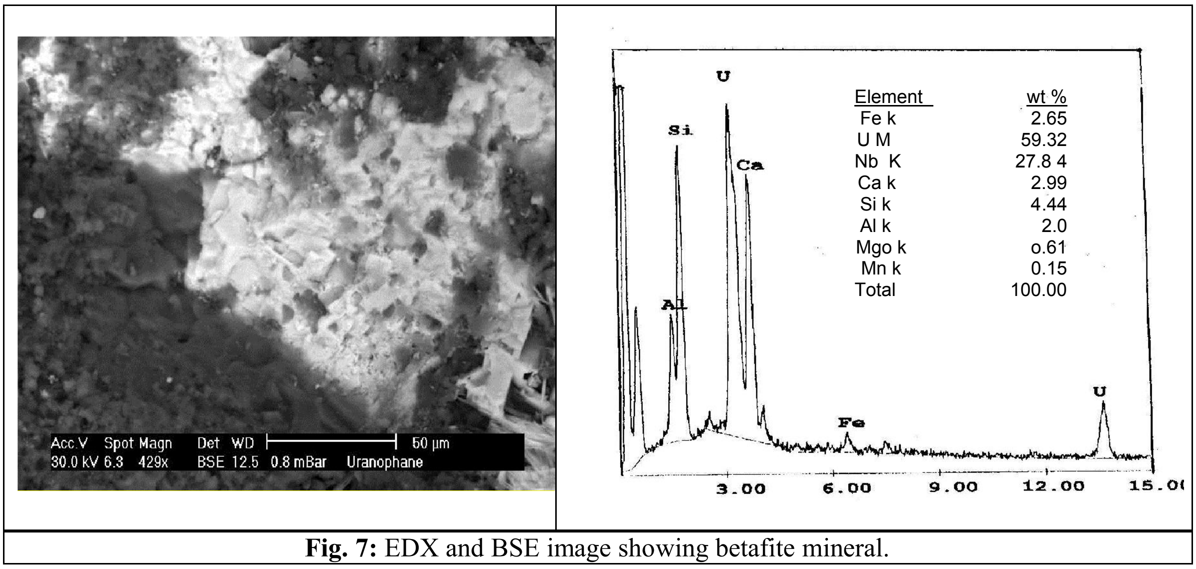


Fig. 7: EDX and BSE image showing betafite mineral.

b - Thorium mineral

- Uranothorite (U, Th) SiO_4

Uranothorite is considered as one of the radioactive minerals that are derived from the magma differentiation. Uranothorite may carry by the substitution for Th by U .The obtained EDAX spectrum for these inclusions reflects the chemical composition of uranothorite. These results indicate that the major elements in uranothorite are Th (56.14 wt %), Si (12.88 wt %) and U (14.49 wt %). Also, minor amounts of Fe, Ca, Al, Zr, S and Ta were reported as substitutions in uranothorite (Fig.8).

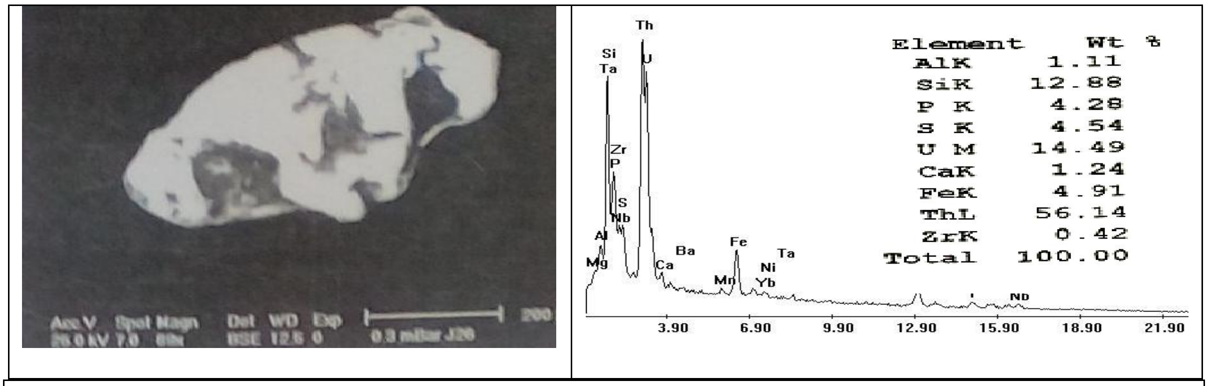


Fig. 8: EDX and BSE image showing uranothorite.

3- Nb – Ta Minerals

- Columbite (Fe, Mn) (Nb,Ta)O4

Columbite is iron-black, grayish and brownish black, opaque, rarely reddish brown and translucent. The columbite group of minerals comprises a large number of structurally related orthorhombic AB_2O_6 compounds (B= Ta, Nb). The columbite subgroup is Nb-dominant, and the tantalite subgroup is Ta-dominant. They contain U and Th in various amounts and are commonly metamict but none has been described with U as essential constituent. The relatively small octahedral A-site is commonly occupied by Mg2+ (magnesio columbite) and transition-metal cations such as Fe2+ (ferrocolumbite) and Mn2+ (manganocolumbite), while U and Th substitutions are relatively minor. The obtained results indicate that the chemical composition of the studied columbite crystals is ferrocolumbite (Fig.9). The major elements are Nb, Fe, Ta and Mn. The U bearing columbite is Ta poor and lesser amount of U could be accompanied in the columbite structure with decreasing temperature of crystallization (Heinrich, 1962). This indicates the role of hydrothermal solution in accumulation of the mineralization.

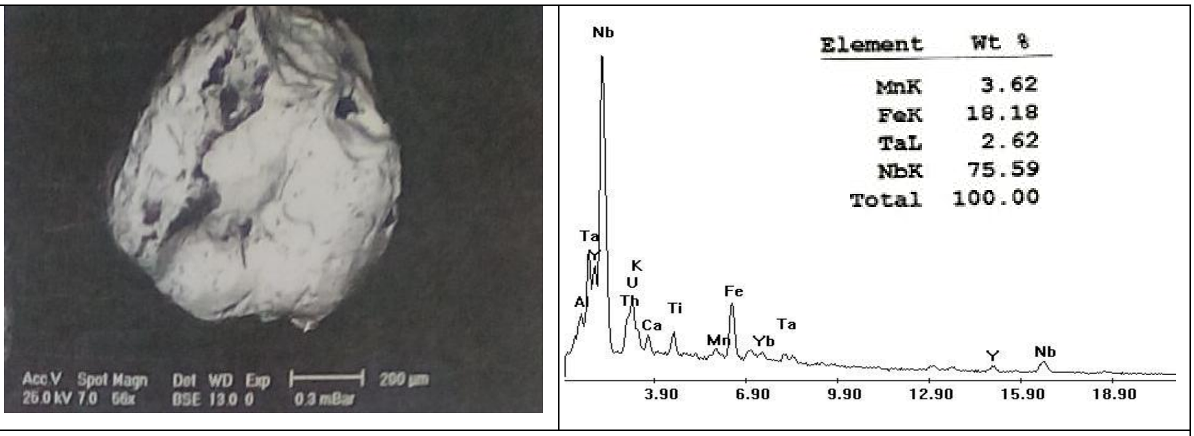


Fig. 9: EDX and BSE image showing ferro -columbite.

4- REE -bearing minerals:

- *Monazite (Ce, La, Th) PO_4*

Monazite is phosphate mineral which attains special importance of rare elements such as thorium and REE, especially lanthanum and cerium while uranium is present in small amounts (Bee, 1996). Monazite occurs as a rare earth accessory mineral in granitic rocks, syenites and is found as relatively large crystals in pegmatites (Deer *et al.*, 1992). It is the most common, REE-bearing mineral, which has preferential selectivity towards the LREE and is also known as ultra- stable mineral during weathering. The early crystallization of monazite would lead to U enrichment in the residual fluids (Pagel, 1982).

In the study area, monazite is transparent and vitreous luster, pale yellow, honey yellow, greenish yellow and reddish yellow grain**.** In some cases monazite is contact with pyrite. The EDAX spectrum for these crystals reflects the chemical composition of monazite (Fig.10). Uranium may also occupy some of the REE sites in monazite. The EDAX data shows that Ce is dominant and so monazite can be referred as monazite-Ce .Th is higher than U in the studied grains.

- Xenotime (HREE, Y, PO4)

Xenotime is a rare mineral which occurs, like monazite, as an accessory constituent in granite, gneiss and pegmatite veins and crystalline metamorphic rocks. It is also found as a heavy residual mineral in the sands of streams. It is an orthophosphate of Y belong to large cations zircon ($ZrSO_4$) group. Xenotime is considered another source for HREEs, besides Y, U and Th. In the present study it occurs as euhedral crystal, brown to greenish brown colors and occurs as granular aggregates. The existence of xenotime may be related to abundance of main component as yattrium (El Balakassy *et al.,* 2012). Xenotime may have formed from coffinite due to substitution of Y and P for U and Si respectively (Evins and Jensen, 2010**).**

The EDAX data shows that xenotime is associated with U (7.83%), Th (2.25%), Y (30.97%), S (23.17%) and Fe (15.89%). xenotime known as autogenic xenotime (Ibrahim *et al.,* 2008) (Fig.11).

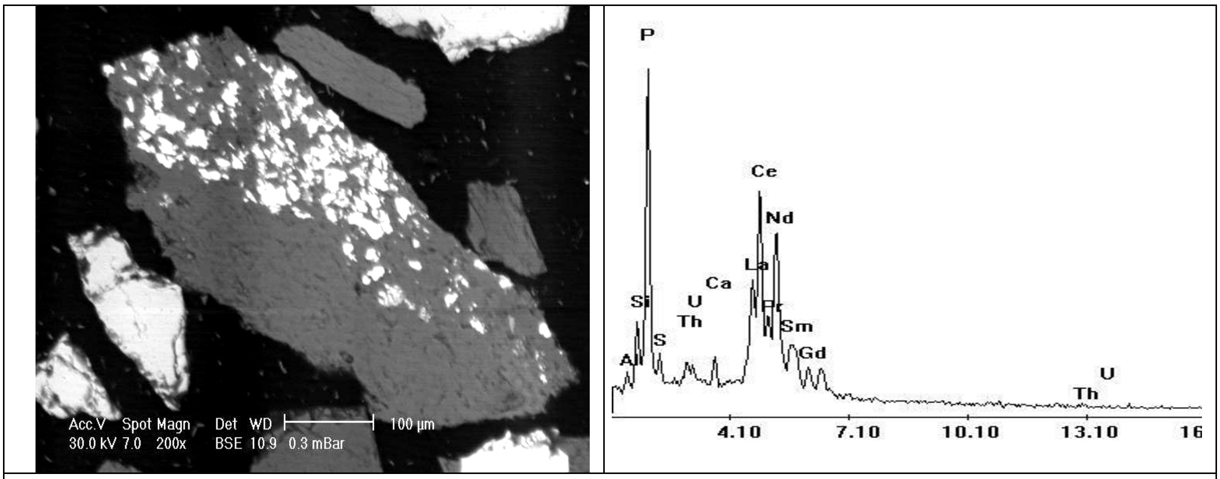
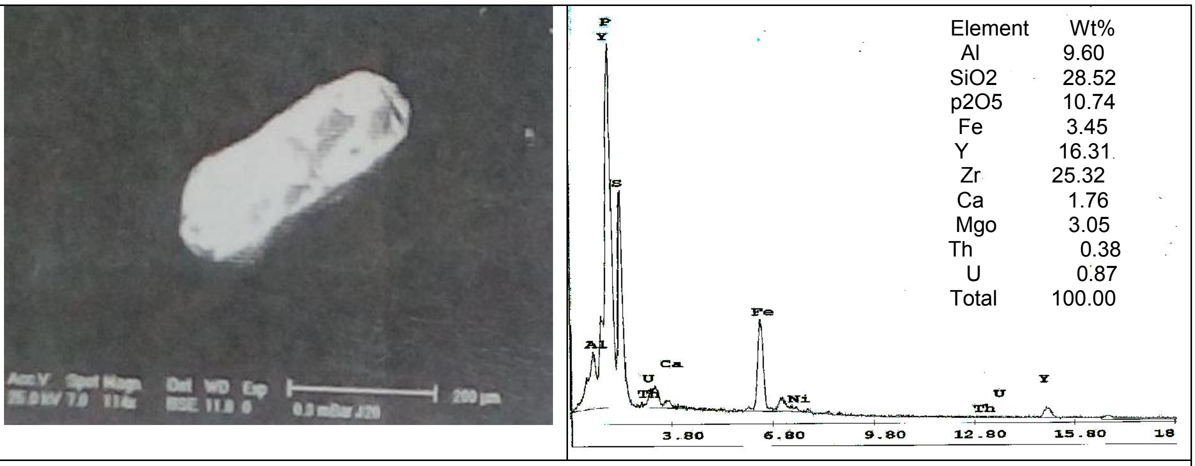


Fig. 10: BSE image showing pyrite inclusion in monazite grain.



Element	Wt%
Al	9.60
SiO2	28.52
p2O5	10.74
Fe	3.45
Y	16.31
Zr	25.32
Ca	1.76
Mgo	3.05
Th	0.38
U	0.87
Total	100.00

Fig. 11: EDX and BSE image showing xenotime grain.

- Zircon ($ZrSiO_4$)

Zircon occurs as short and long euhedral prismatic and/ or bipyramidal crystals, possessing various colors (pale yellow, reddish brown, reddish orange and colorless). The euhedral shape of the zircon suggests its magmatic origin. Occasionally, zircons show slight to moderate roundness at one or both ends and terminations of the pyramidal and/ or prismal faces (Armstrong, 1922), most probably as a result of late magmatic corrosion or late hydrothermal effect.

Speer *et al.* (1981) suggested that uranium is the most important trace element in zircon. The presence of high contents of U in zircon leads to the breakdown of the structure of zircon (metamict state), which causes radial and concentric fractures that are good pathways for uranium addition in presence of iron oxy-hydroxides (Speer *et al*., 1981). Zircon is fairly resistant to normal chemical attack (Surour *et al*., 2003). Altered varieties are, therefore, not common. The metamict state (breakdown of the structure) in zircon may be due, at least in part, to the presence of radioactive atoms. Recently, zircon is used as a guide for U mineralization (Dardier, 1999, Abdel Warith, 2001).

In the present study, the separated zircons are coloured, euhedral to subhedral prismatic and with thick width, some grains are rounded, and with zoned core and usually contain brownis- black radioactive inclusions and have relatively large sizes (Fig.12 a and b).

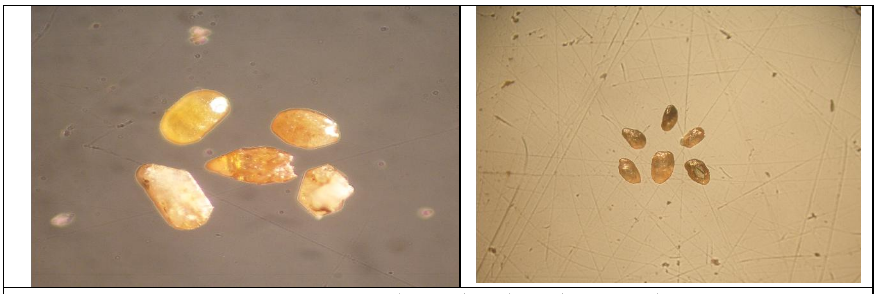
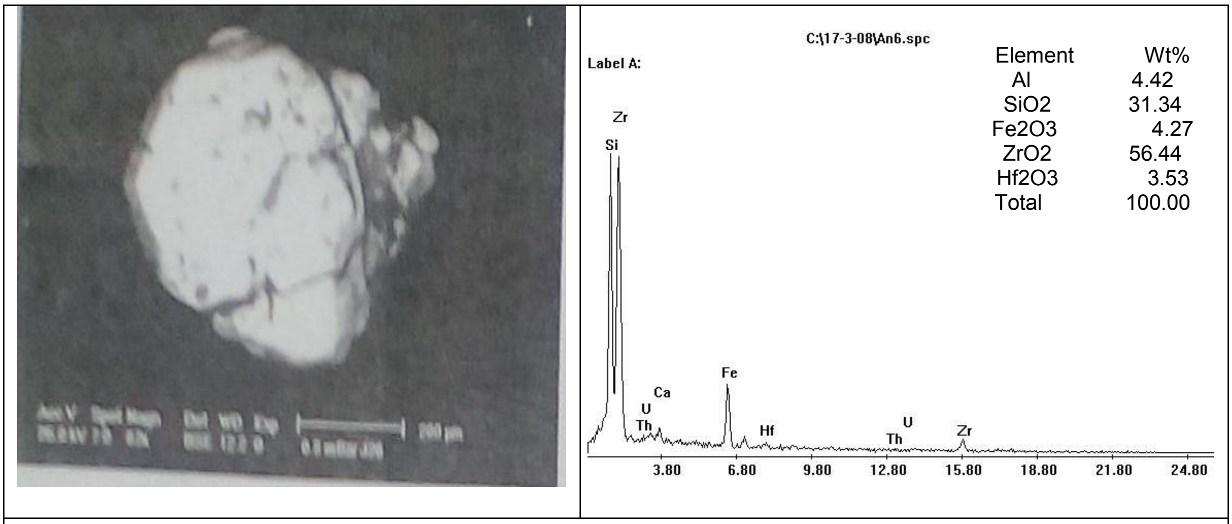


Fig. 12a: Photo showing zircon grain



Element	Wt%
Al	4.42
SiO2	31.34
Fe2O3	4.27
ZrO2	56.44
Hf2O3	3.53
Total	100.00

Fig. 12 b: EDX and BSE image showing zircon grain

Conclusion

The study reveals that the most important Base metals includes (pyrite, chalcopyrite, arsenopyrite, and sphalerite), radioactive minerals include (Bitafite and uranothorite), NB-Ta minerals (columbite) and REE-bearing minerals (monazite, xenotime and zircon). The mineralogy study indicates the present high U and Th in the radioactive minerals include (Bitafite and uranothorite) and in xenotime make it is known as uraniferous xenotime, this may be due to some supergene processes that affected the area and the columbite is (Ta) poor and lesser amount of U may be due to the role of hydrothermal solution in accumulation of the mineralization.

References

Abdel Warith, A.M., M.F. Raslan and M.A. Ali, 2007. Mineralogy and Radioactivity of Pegmatite Bodies from the Granitic Pluton of Gabal Um Taghir El-Tahatani Area, Central Eastern Desert, Egypt [C]. pp: 24–41. The 10th Int. Min. Petrol & Metallurg. Eng. Conf. Mining.

Armstrong, P., 1922. Zircon as ceriterian of igneous or sedimentary and metamorphic. Amer., 5(4): 381-395.

Bee, F., 1996. Residence of REE Y ,Th and U in granites and crustal protholiths; implications for the chemistry of crustal malts. J. petrol., 37: 521-552.

Dabbour, G.A., 1995. Estimation of the economic minerals reserves in Rosetta beach sands, Egypt. Mineral., 7: 1532-166.

Dear, A.O., 1992. An introduction to the rock forming minerals. The English Language Society and Longman, London.

Dardier, A.M., 1999. Morphology and geochemistry of zircon associated with uranium mineralaization in Gattar granitic pluton, North Eastern Desert, Egypt. Egyptian J. Geol., 42(1): 75-103.

Ibrahim, M.A., H.S. Assaf and G.H. Saleh, 2000. Geochemical alteration and spectrometrice analysis in Abu Rushied altered uraniferous gneissose granites, South Eastern Desert, Egypt. Chem., Erde, 60: 173-188.

Ibrahim, M.E., G.M. Saleh, I.H. Ibrahim, T. Amer, F.O. Mahmoud, A.A. Abu Al Hassan, M.A. Aly, M.S. Azab, M.A. Rashad, F.M. Khaleal and M.A. Mahmoud, 2004. Uanium and associated rare metals potentialities of Abu Rusheid brecciated shear zone II, south Eastern Desert, Egypt.(Internal report) Nuclear Materials Authority.

Ibrahim, M.E., G.M. Saleh, H.H. Abd El Naby, T. Amer, F.O. Mahmoud, A.A. Abu El Hassan, I.H. Ibrahim, M.A. Aly, M.S. Azab, M.A. Rashcd, F.M. Khalel and M.A. Mahmoud, 2002. Uranium and associated rare earth potentialities of Abu Rusheid brecciated shear zone I, south Eastern Desert, Egypt. (Internal report).

Ibrahim, M., G. Saleh, M. Rashed and K. Watanabe, 2007c. Base Metal Mineralization in Lamprophyre Dykes at Abu Rusheid Area, South Eastern Desert, Egypt [C]. P.31– 40. The 10th Inter. Min. Petrol., and Metall. Eng. Conf., Assuit Univ.

Ibrahim, M., G. Saleh, M. Rashed and K. Watanabe, 2008. Uranium and associated rare earth potentialities of Abu Rusheid brecciated shear zone I, south Eastern Desert, Egypt. (Internal report) Nuclear Materials Authority.

Pagel, M., 1982. The mineralogy and geochemistry of uranium, thorium and rare-earth elements in two radioactive granites of the Vosges, France [J]. Mineral. Mag., 46: 149-161.

Speer, J.A., T.N. Solberg and S.W. Becker, 1981. Petrography of the Uranium- bearing minerals of the Liberty Hill pluton. South Carolina: phase assemblages and migration of uranium in granitoid rocks. Economic Geol., 76: 2175-2175.

Surour, A.A., A.A. El-Kammar, E.H. Arafa and H.M. Korany, 2003. Dahab stream sediments, South Eastern Sinai, Egypt: a potential source of gold, magnetite and zircon. Journal of Geochemical Exploration, 77: 25-43.

Wentworth, C.K., 1922. A scale of grade and class terms for clastic sediments. J. Geol., 30: 377-392.