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RECONNAISSANCE STUDY ON ECONOMIC MINERALS OF WADI NUGRUS STREAM SEDIMENTS: RESOURCES AND DISTRIBUTION.

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ABSTRACT

Wadi Nugrus (70km southwest of Marsa Alam town) is a major tributary of Wadi Al- Gemal, which is one of the main Wadis in the south Eastern Desert of Egypt. This wadi is characterized by the famous occurrences of beryl.

Nine bulk samples of the stream sediments along Wadi Nugrus (30km long) were collected for their mineralogical study. Some of the specious minerals were separated by heavy fractions confirmed by Environmental Scanning Electron Microscope (ESEM).

Rock units exposure along Wadi Nugrus shoulders are: ophiolitic rocks (mafics-ultramafics and related rocks), ophiolitic mélange (metasedimentary matrix enclosing the ophiolitic fragments), psammitic gneisse, younger granites (biotite, muscovite and two mica granites), younger gabbros and post granite dykes and veins.

Some minerals were recorded for the first time such as gold and three varieties of corundum (ruby, sapphire and spinel), as well as columbite, coronadite, zincite, titanite, garnet, zircon and pyrite were recorded and confirmed by ESEM technique. Emerald beryl was also recorded in all studied samples along Wadi Nugrus. The reconnaissance study of these samples revealed that the stream sediments of Wadi Nugrus contain considerable amounts of these economic valuable minerals.

Absence of Ag and high content of Cu in gold grains reflect that their origin can be related to hydrothermal veins or contacts of metamorphic deposits or due to bimodal magma (acidic and basic).

The expected source of the recorded corundum derived from Hangalia mine (~5 km) west the mapped area which is characterized by higher elevation.

Key wards: Wadi Nugrus, stream sediments, mineralization, gold, corundum, beryl, zincite, columbite and radioactive minerals.

INTRODUCTION

Wadi (W.) Nugrus is a major tributary of W. Al Gemal, which is one of the main Wadis of the south Eastern Desert of Egypt. W. Nugrus (~30 km long) lies at about 70 km southwest of Marsa Alam coastal town on the Red Sea coast of Egypt. The area under investigations lies between 34°35` - 34°50`N and 24°45` - 24°35` E (Fig. 1).

This study aims to study the distribution of heavy minerals in the stream sediments of W. Nugrus as a geochemical exploration tool for mineralization. However, it should be noted that variation in heavy minerals distribution is controlled by nature and duration of weathering processes as well as by length and power of the transporting agents. This involve systematic measurement of one or more of chemical elements or compounds (referred to as indicators or pathfinders), which usually occur in very small amounts. The objective is to find some dispersion of such elements or compounds sufficiently above normal to be called anomaly in the overburden overlying or near to the concealed deposits.

METHODOLOGY

Nine bulk dry stream sediment samples from the main course of W. Nugrus with intervals (2.0 to 6.5 km) have been collected. For the orientation survey stream sediment samples were collected adjacent at outlets of major tributary of W. Nugrus i.e. W. El- Nom, W. Abu Rusheid, W. ancient Medinat Nugrus, W. Um Slimat and W. Sikait.

The friable sediment samples were collected from holes with about 70 cm diameter and about 90 cm depth. These samples were extracted from each hole, between depths of 50 cm to 90 cm from the surface level of the wadi after stripping off the surficial wind blown sand layer. Each sample weight is about 50 kg. The grains and pebbles >2 mm size were first excluded by sieving through a 2 mm size aperture sieve.

Samples were taken particularly where the flow velocity slackens as the resulting fall in transporting capacity of the stream allows the load material, especially the heavy minerals to settle such places include; a) points of abrupt valley widening; b) the concave sides of sharp bends and convex banks of meanders and c) sites upstream of obstacles in the river bed (boulders, tree stumps and trunks). The collected samples were subjected to preparation procedures in the Nuclear Materials Authority (NMA) Laboratories, Qattamyia, Cairo, Egypt.

The heavy mineral fractions separated by bromoform. The Frantz

Isodynamic separator used for magnetic fractionation of heavy fraction. This was followed by hand picking under binocular microscope in order to obtain pure mineral separates following the method described in Macdonald (1983). Identification of minerals was carried out using the Environmental Scanning Electron Microscope (ESEM) model Philips (XL30) housed in (NMA). The acquired back scattered electron images (BSE) with resolution of 3.5 nm at 25-30 kV characterize the micromorphology of the stream sediments grains under investigation. In addition, the equipped energy dispersive X-ray spectrometer (EDX) which provides semiquantiaive microanalysis is considered as an effective tool in mineralogical characterization through the enabled gross chemical composition of minerals. This technique becomes more precise through the standard (ZAF) matrix correction software.

GEOLOGIC SETTING

Regional geologic settings of the study area are divided into two major groups separated by a low angle thrust and intruded by the late granitoids. The structurally lower group comprises the Migif-Hafafit gneisses and associated rocks (El Ramly et al., 1993). This group is characterized by medium grade metamorphism and complex deformation. The second group, known here as Ghadir Group, tectonically overlies the first group and is characterized by relatively low metamorphic grade and simpler deformation (El Bayoumi, 1984). The two groups are separated by a major thrust fault, known as the Nugrus thrust, which runs along the upper part of W. Sikait in NW direction.

Focusing on Wadi Nugrus, it consists of several lithostratigraphical units affected by metamorphic events and plutonic cycles. The rocks which are exposed at W. Nugrus (Fig. 1) are classified as follows: (1) layered metagabbros, (2) ophiolitic mélange (consists of mafic-ultramafic fragments set in metasediment matrix; (3) psammitic gneisse (4) late-tectonic granites and (5) post-granite dykes and veins. The layered metagabbros are over thrusted the ophiolitic mélange and the later is over thrusted the Hafafite psammitic gneisses. The late-tectonic granites are represented by biotite-, muscovite- and two mica-granites. The post granite dykes are (unmapped) represented by sets of felsic, basic dykes and quartz veins.

MINERALOGY

The identified minerals by using microscopic investigations and ESEM-EDX techniques are summarized as follows:

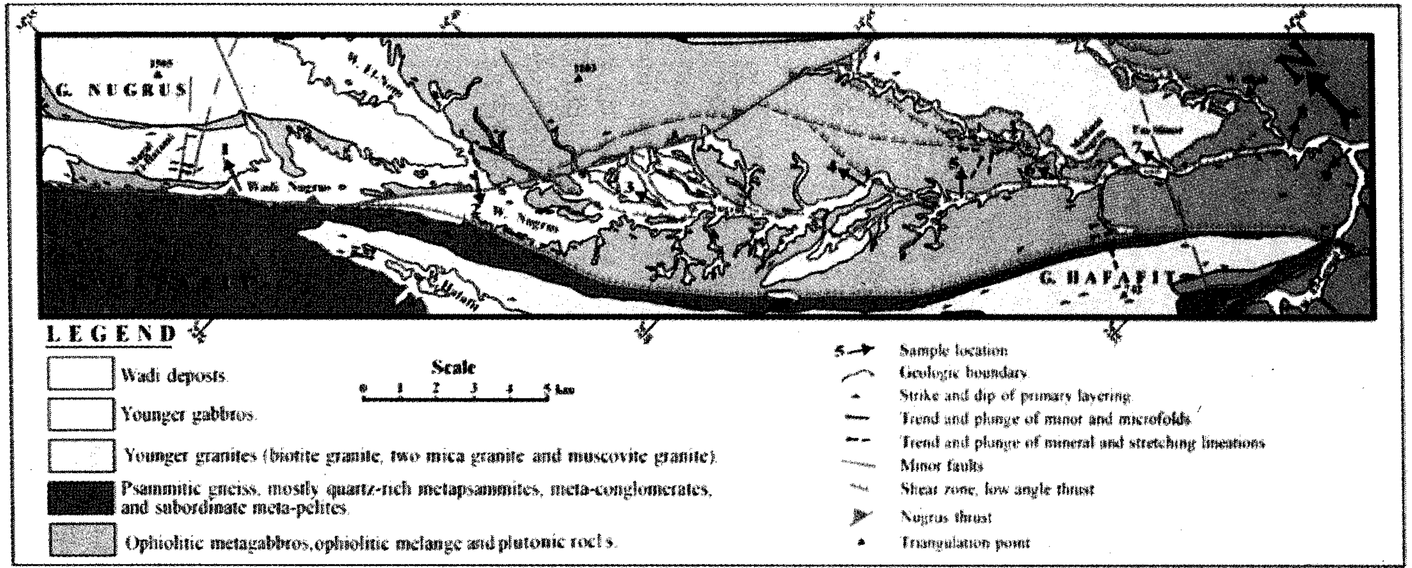
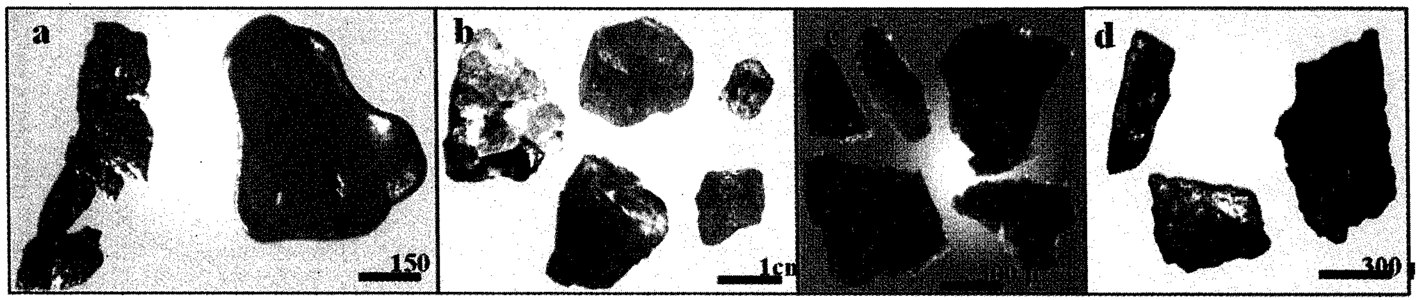


Fig. (1): Geological map of Wadi Nugrus showing sample locations (modified after Geriling and El Ramly, 1990).

Plate (1):

Photomicrograph showing; (a) flattened gold grains; b) saphir corundum; c) ruby corundum and d) emerald beryl crystals.



B. 1. Precious Minerals

1.1. Gold

Gold (Au) is almost mixed with a small amount of silver, and sometimes contains traces of copper as well as impurities of iron. A Gold nugget contains usually 70 - 90 percent gold, (Boyle, 1979).

Gold in W. Nugrus is recorded in sample No. 3 (Plate 1.a). Sample location is surrounded by younger granites and younger gabbros (bimodal magma). Gold found as flattened grains and scales (gold dust), with rich bright yellow colour due to high content of Au which ranges from 86.89 - 98.81% (Fig. 2). Some gold grains have high content of copper inclusions (9.57 - 12.79%) and traces of iron (0.32 - 1.19%). The absence of Ag and high content of Cu reflect that gold origin can be related to hydrothermal veins or contacts of metamorphic deposits or due to bimodal magma (acidic and basic) (Ibrahim, M. E., personal communication).

Botros (2001) stated that Gold mineralization associated with porphyry–copper mineralization and quartz veins at the contacts of younger gabbros and granites characterize gold mineralization associated with the orogenic stage

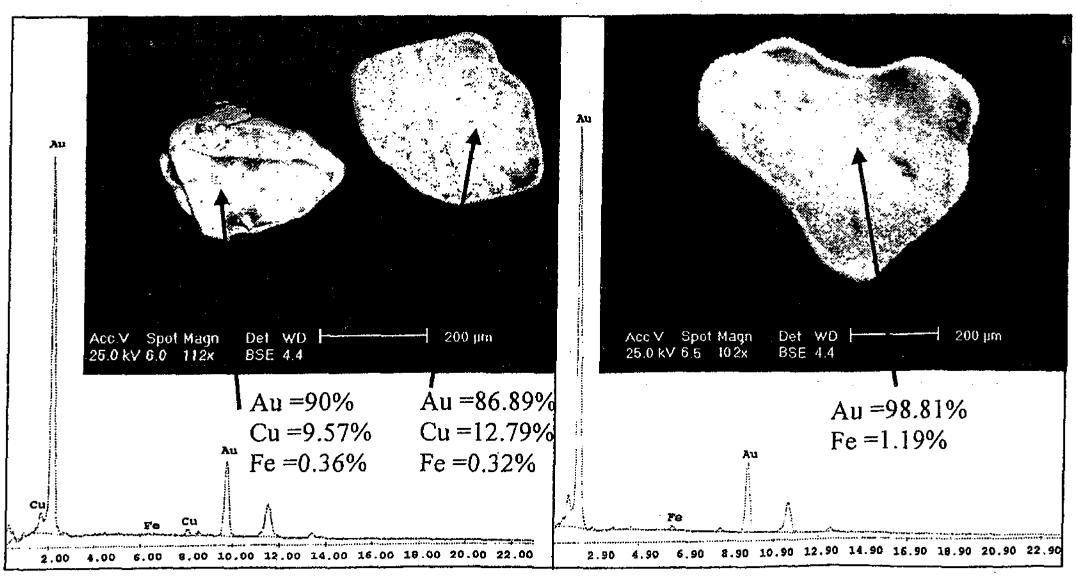


Fig. (2): EDX and Backscattered (BSE) image showing flattened gold grains, W. Nugrus, south Eastern Desert (SED), Egypt.

1.2. Beryl

The beryl mineral species include, besides the emerald (Plate 1.b) and the aquamarine, other precious stones of less importance, which are generally referred to by jewelers as beryl. The percentage composition of Beryl ($3BeO.Al_2O_3.6SiO_2$) is; silica (SiO_2) = 66.84, alumina (Al_2O_3) = 19.05, beryllia (BeO) = 14.11 (Ward, 2001). Chromic oxide exists as a trace in the emerald, which can reach up to 3% (Wise, 2001).

The ancient emerald mines are located at the contact surface between the ophiolitic mélange and cataclastic rocks, especially at Madient Nugrus and east W. Abu Rusheid (Mansour, 2005).

Aurisicchio, et al. (2006) studied the chemical composition of Roman emerald and gold necklace, dating from the first century AD found in Oplontis (Torre Annunziata, Naples, Italy) and concluded that they have an Egyptian origin, that they as derived from Sikait mines.

The occurrences and evaluation of beryl in W. Al Gemal in general were well studied by Omar (2001), Oraby et al. (2003) and Khaleal (2005). Beryl in general occurs in the south Eastern Desert of Egypt at the contact between carbonitic rocks and the schist.

Beryl (emerald) was recorded in the light fraction in all samples with more intensity in the sample No. 7 refers to Medinat Nugrus (Fig. 3).

1.3. Corundum

Corundum is pure aluminum oxide (Al_2O_3), composed of 53.2% of Al and 46.8% of O. Natural corundum is probably never chemically pure; the inclusions of foreign elements, sometimes but the merest traces, impart the colour that makes the gem (Ward, 1995). The coloured corundum varieties occur usually associating with or closed to the contacts with ophiolitic rocks (high Cr) (Hall, 2002).

Three varieties of corundum have been recorded. Ruby occurs in sample No. 5 whereas sapphire and spinel occurs in both samples No. 1 and 2. The expected source of this corundum may be due to the scattered carbonitic rocks in ophiolitic mélange of W. Nugrus as a main course and/or derived from Hangalia mine (~5 km) west the mapped area which characterized by higher elevation (Ibrahim, M. E., personal communications).

- **Ruby** is the red variety of corundum (Plate 1.c and Fig. 4a). The colour in ruby is caused by trace amounts of chromium element. It is found in a mother-rock of carbonates which altered by contact with igneous material which recrystallized the calcium carbonate as pure calcite.

- **Sapphire** is the blue variety of corundum (Plate 1.d and Fig. 4b and 4c). The blue color is due to charge transfer involving Fe-Ti (Hall, Op. Cit.). It is the most precious of blue gemstones. It is the most desirable gem due to its color, hardness, durability, and luster.
- **Spinel** usually associates ophiolitic rocks enriched in corundum. Spinel (Fig. 4d) is practically a magnesium alumina, consisting of alumina, 71.8% and magnesia, 28.2%.

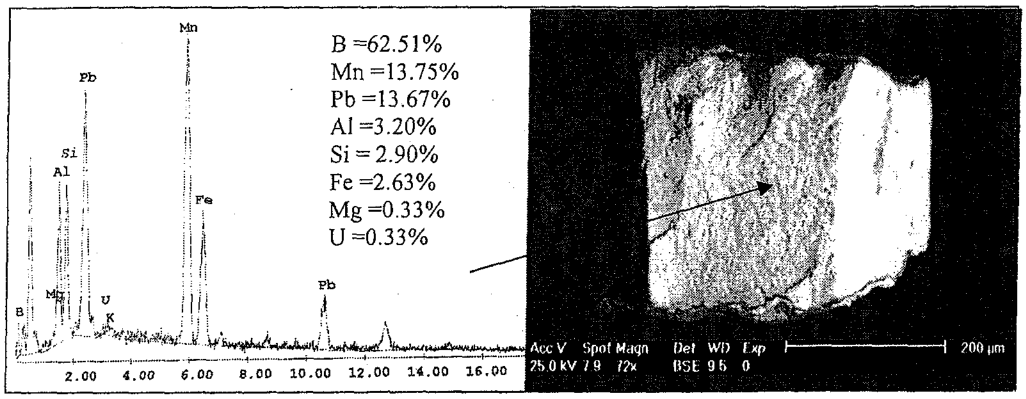


Fig. (3): EDX and BSE image showing beryl (emerald), W. Nugrus, SED, Egypt.

2. Base metals

2.1. Zincite

Zincite composed mainly of zinc oxide (Zn, Mn)O. It may contain manganese and some iron $(Zn,Mn^{2+},Fe^{2+})O$ (Palache, 1935). Zincite is recorded in lamprophyre dykes along shear zone, 1 Km close to Madinat Nugrus (Ibrahim et al. 2007a).

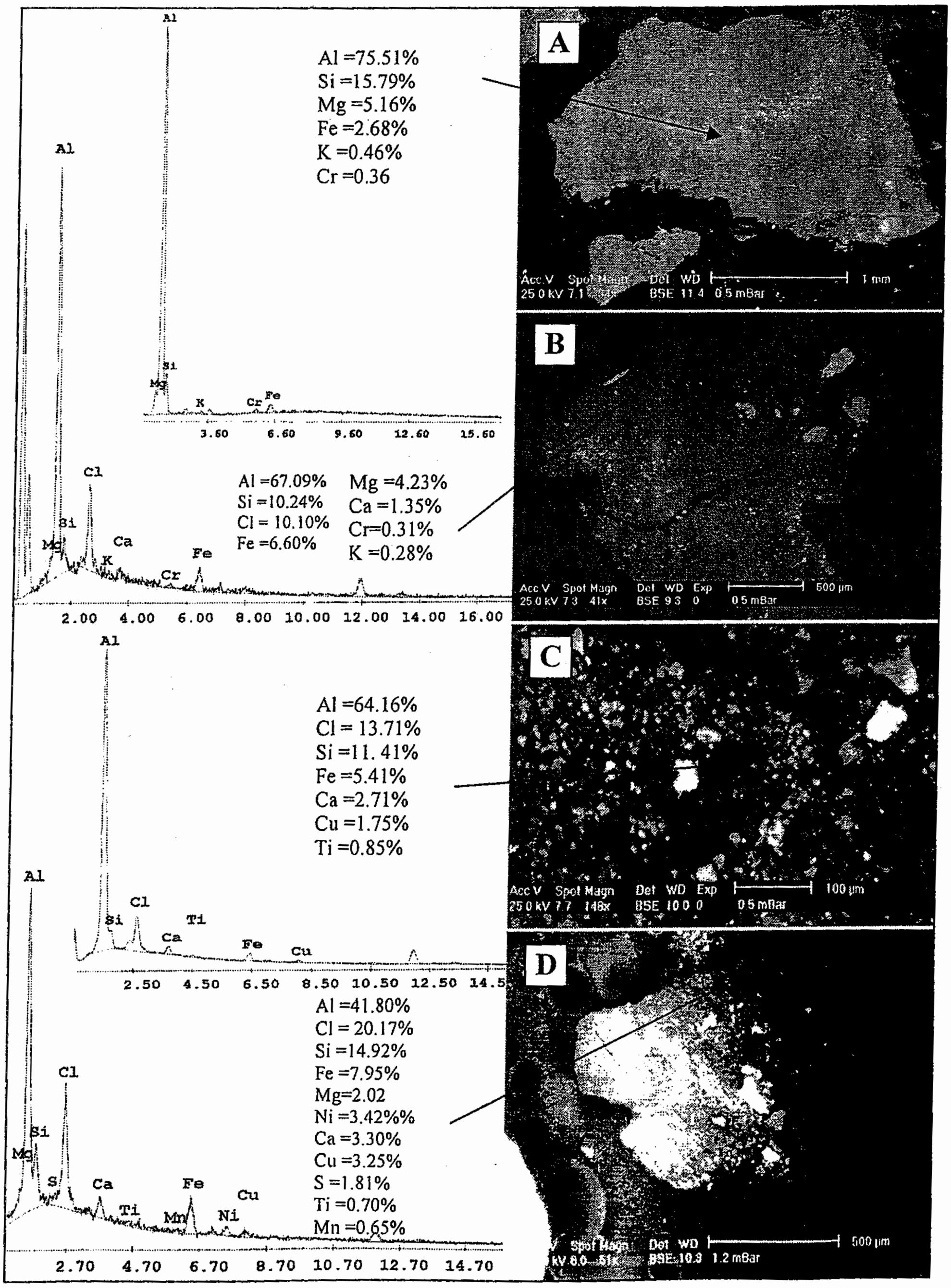


Fig. (4): EDX and BSE image showing different varieties of corundum; (a and b) ruby, (c) sapphire and (d) spinel, W. Nugrus, SED, Egypt.

The recorded pure zincite (white in color) in sample No. 6, (pigment white zinc) and containing 95.17% Zn (Fig. 5) was recorded in lamrophyre dykes which cut cataclastic rocks in Abu Rusheid area (Zn ranges from 1-7%) (Ibrahim et al., 2007b).

C. 2.2. Coronadite

D. Coronadite $Pb(Mn^{4+},Mn^{2+})_8O_{16}$ is an admixture between Mn, and Pb oxides with impurities of Fe, Al, S and Zn (Betekhtian, 1973). It has Dark grey, black colour and sub-metallic, dull luster with massive, botryoidal crusts with a fibrous structure. Coronadite is a primary mineral in hydrothermal veins, secondary origin in oxidized zones above Mn deposits and bedded sedimentary rocks. This mineral is first record in the stream sediments of W. Nugrus (sample No. 6) and suggests that it can be derived from Abu Rusheid sources (Fig. 6). Ibrahim et al. (2002 and 2004) and Mansour (2005) recorded Mn and Pb minerals (i.e. kasolite, Mn-Frankilinite and Pyrolusite) in the shear zone and Khour Abalea of Abu Rusheid area. A Suitable environment found in Abu Rusheid area to produce coronadite by alteration processes affected Mn and Pb minerals.

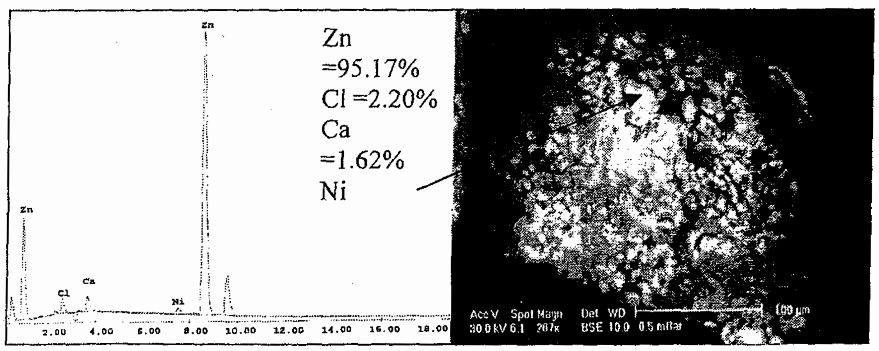


Fig. (5): EDX and BSE image showing zincite, W. Nugrus, SED, Egypt.

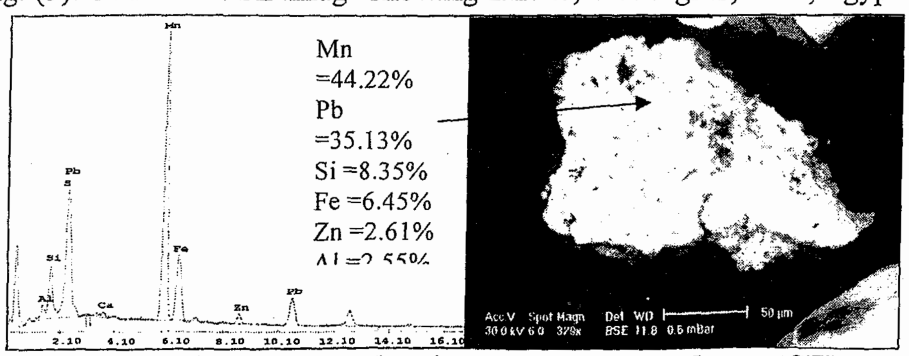


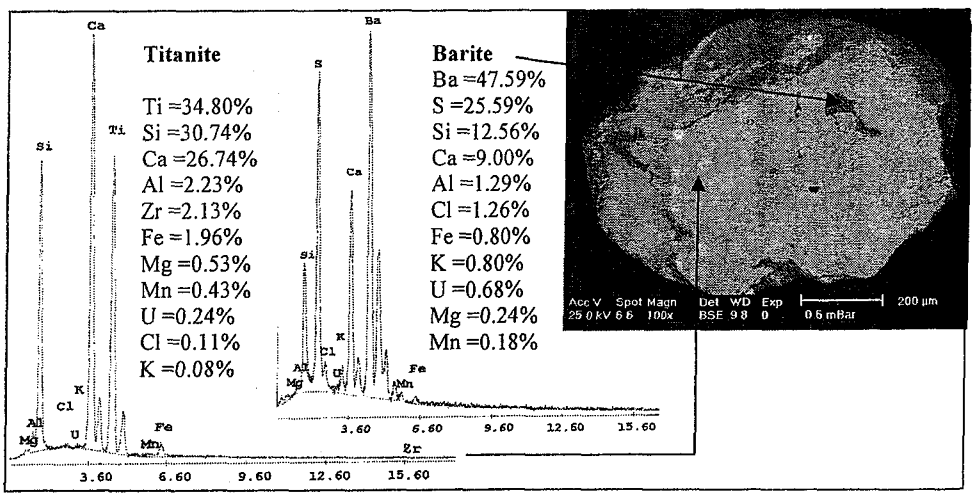
Fig. (6): EDX and BSE image showing coronadite, W. Nugrus, SED, Egypt.

E. 2.3. Titanite (sphene)

F. Titanite [Ca,Ti(SiO$_2$)(O,OH,F)] is wide spread chiefly as an accessory mineral in most of the igneous rocks. It is a dominant titanium-bearing mineral. It is characterized by rhombic or sphenoidal shape and extreme birefringence and depression. In general, the colour can be correlated with iron content. The recorded titanite from (samples Nos. 3 to 9) exhibit brown to black varieties due to their content of Fe_2O_3 (more than 1%) (see Fig. 7). Titanite has been derived from most plutonic rocks of the investigated area. It is appeared as rod and rhombic crystals.

2.4. Barite

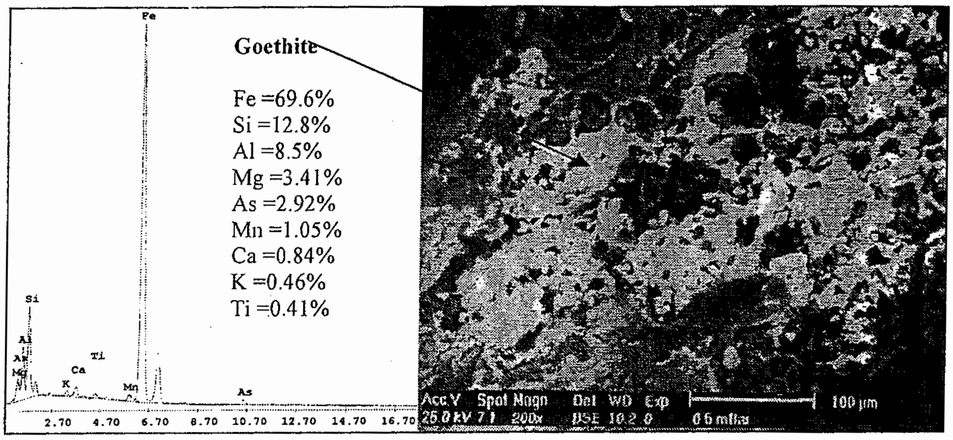
Barite (BaS) occurs chiefly in medium-to-low temperature hydrothermal vein deposits. Barite is locally recorded in sample No. 2. Sometimes forms tufacious mounds from deposition of hot, barium-rich springs and commonly occurs with calcite (Palache, 1935). This is may explain the high percentage of Ca (26.74%) recorded in the EDX of the barite (Fig. 7).



(Fig. 7): EDX and BSE image showing barite hosted in titanite, W. Nugrus, SED, Egypt.

2.5. Arsenopyrite (FeAsS)

Arsenopyrite (FeAsS) constitutes disseminated crystals in galena-chalcopyrite-rich massive deposits. Arsenopyrite crystals are fine-grained (10 – 400mm and recorded in sample No. 6, and altered to goethite (Fig.8).



(Fig. 8): EDX and BSE image showing sulpher release alteration of arsenopyrite to goethite (light), W. Nugrus, SED, Egypt.

2.6. Pyrite (FeS_2)

Slightly large pyrite crystals commonly show corroded outlines and include grains of matrix sulphides or gangue (Fig. 9) recorded in samples No. 2, 6 and 7. The trapped base metal sulphide grains (galena, sphalerite and chalcopyrite) usually define growth zones in pyrite. The outer part of the porphyroblasts is almost devoid of inclusions whereas in the interior, the inclusions are commonly arranged along crystallographic directions. This feature is attributed to recrystallisation of pyrite during metamorphism (Craig and Vokes 1992).

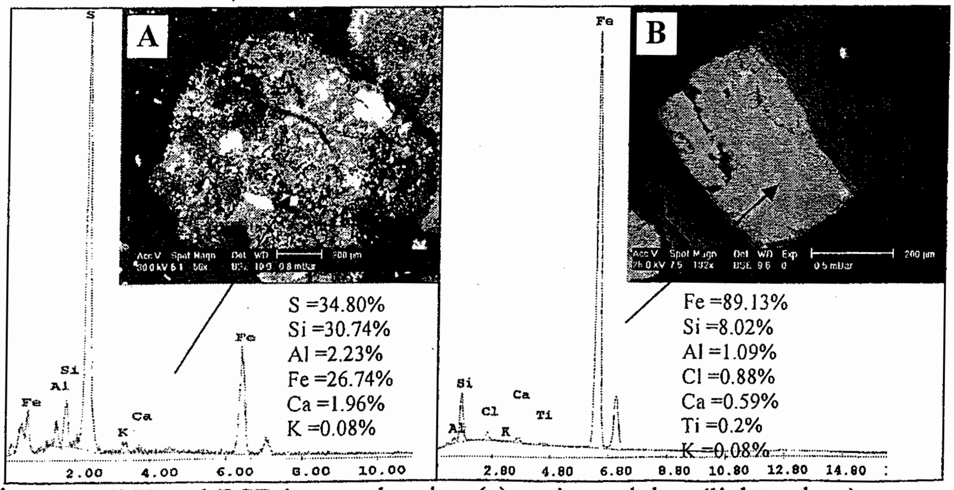


Fig. (9): EDX and BSE image showing (a) native sulpher (light colour) surrounded by pyrite, (b) psedomorph of pyrite replaced by hematite, W. Nugrus, SED, Egypt.

2.7. Marcasite (FeS_2)

Marcasite, sometimes called white iron pyrite, and is often mistakenly confused with pyrite. It is found in the low-temperature hydrothermal veins. Though marcasite has the same chemical formula as pyrite, it crystallizes in a different crystal system, thereby making it a separate mineral. In jewelry, pyrite used as a gem is improperly termed "marcasite". True marcasite is never used as a gem, due to its brittle and chemically unstable structure (Wise, 2001). Marcasite is locally recorded in samples 2, 3 and 6 (Fig. 10).

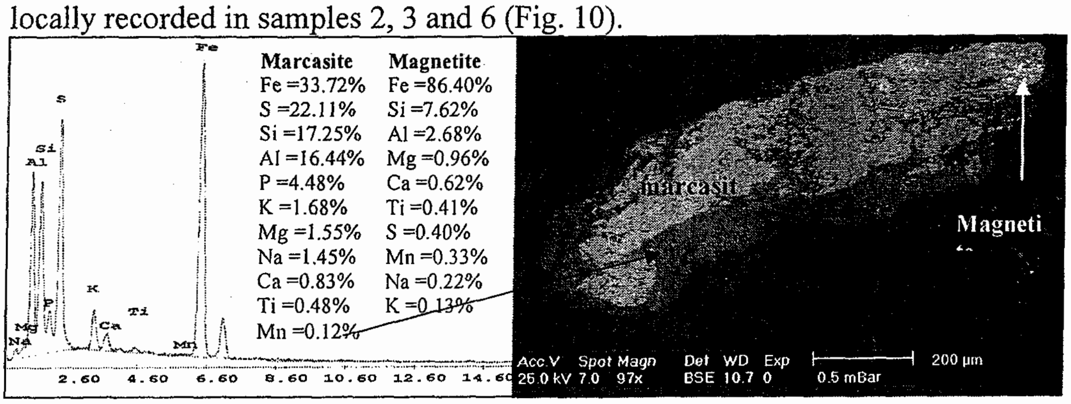


Fig. (10): EDX and BSE image showing marcasite (white iron pyrite), W. Nugrus, SED, Egypt.

2.8. Cassiterite

Cassiterite (SnO_2) is a brown to black tetragonal mineral. The crystals of cassiterite show the prismatic form, that are massive or compact with concentric structure. They occur as inclusions in some essential minerals or as secondary minerals filling cleavage planes and/or coating the silicate minerals (Fig. 11).

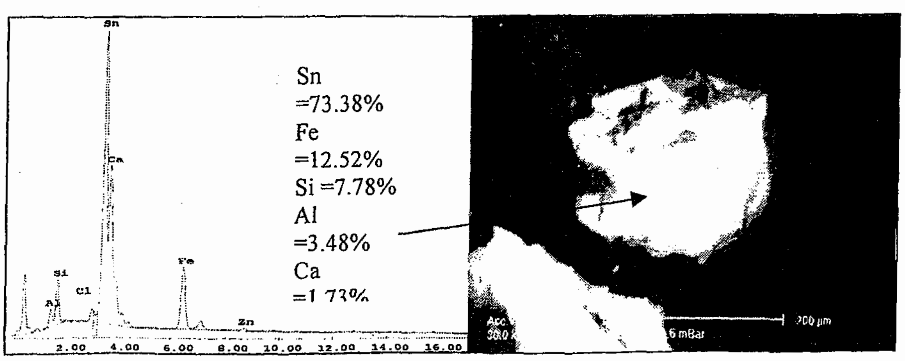


Fig. (11): EDX and BSE image showing cassiterite, W. Nugrus, SED, Egypt.

Cassiterite is continually crystallized from the postmagmatic hydrothermal stage in the paragenetic sequence of Wadi Nugrus granites in which the cassiterite is usually associated with albitization and tourmalinization. The recorded cassiterite is usually free of columbite-tantalite inclusions. It is also associated with albite and tourmaline-bearing assemblages. In this respect, it is somewhat comparable to the cassiterite derived from Um Slimat granites (sample No. 7).

2.9. Nb-Ta minerals

Black columbite-tantalite [(Fe,Mn)(Nb,Ta)2O6] has been recorded locally in the samples No. 6 and 7. Columbite is crystallized in the orthorhombic system. It occurs as black short prisms. It is characterized by the dominance of Nb over Ta content. Columbite shows Nb/Ta ratio = 5.38, indicates slightly removal of Ta. The recorded columbite has Fe-rich content (Ferro-columbite) reach up to 15.13%. Similar columbite was recorded by Ibrahim et al., (2002 and 2004), Rashed (2005) and Mansour (2005) in Abu Rusheid area. In addition, the shape of the elongated crystals of columbite (Fig. 12) reflect that their source is close to Abu Rushied and/or Medinat Nugrus mineralized rocks.

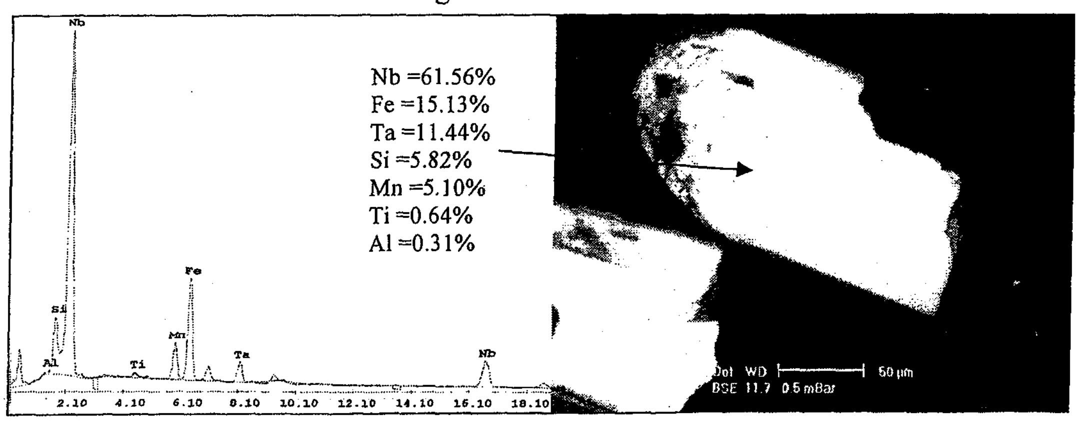


Fig. (12): EDX and BSE image showing ferro-columbite, W. Nugrus, SED, Egypt.

3. Radioactive minerals:

3.1. Kasolite

Kasolite [$Pb(UO_2)SiO_4.H_2O$] shows yellowish brown colour and occurs as a component of "gummite" pseudomorphs after uraninite. Monoclinic, minute cleavable prismatic crystals characterize it. Kasolite is confirmed by ESEM (Fig. 13) and recorded in samples No. 6 and No. 7. It contains 47.43% U, 44.71% Pb, 3.13% Si and 2.61% K, typically compared with that recorded by Mansour (2005) in Wadi

Abalea (Abu Rusheid area). Kasolite broken crystals with sharp edges means that they may be shortly driven from Abu Rusheid and/or Medinat Nugrus mineralized rocks. Kasolite is previously recorded in Abu Rusheid area by Ibrahim et al (2002, and 2004), El Afandy et al. (2002), Rashed (2005), Mansour (2005) and Osman (2008).

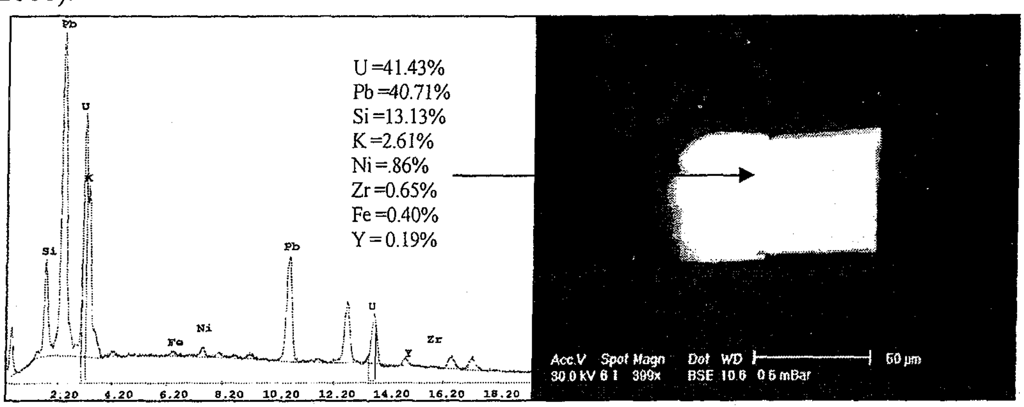


Fig. (13): EDX and BSE image showing kasolite, W. Nugrus, SED, Egypt.

3.2. Thorite

Thorite (Th SiO_4) forms brownish discrete to black grains, varies in size from less than 60 µm up to 350 µm in diameter. It is slightly pleochroic from yellow to brown color. Thorite recorded in sample No. 6; contains 84.68% thorium and showing staining rims due to alteration process, this explains the associated amounts of U (3.54%), S (1.27%), Ni (1.16%) (see Fig. 14). It is clear that the source mineral was Abu Rushied and/or Medinat Nugrus mineralized rocks. Thorite had been recoded in Abu Rusheid area by Ibrahim et al. (2002 and 2004), Rashed (2005) Mansour (2005) and Osman (2008).

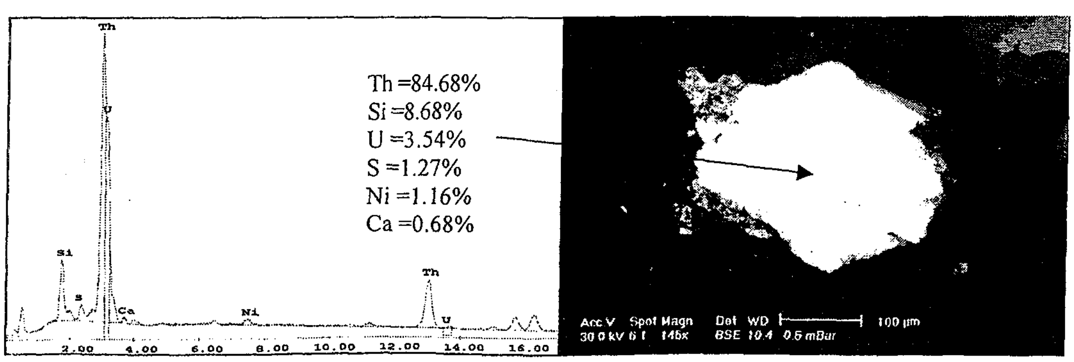


Fig. (14): EDX and BSE image showing thorite, W. Nugrus, SED, Egypt.

3.3. Thorianite

Thorianite (ThO_2) shows yellowish brown colour grains stained with iron oxides due to hydrothermal solutions effect (Fig. 15). It is confirmed by ESEM and recorded in sample No. 6. Thorianite was also recorded in Khour Abalea in Abu Rusheid by Mansour (2005) and the shear zone of Abu Rhusheid by Ibrahim et al. (2002, and 2004) and Rashed (2005). High contents of U, Y, Yb and Si in the recorded thorianite (Fig. 15) and the well rounded forms and thick staining rim, show that alteration process had took place after crushing and movement of the original soft mineral and/or the original mineral edges affected by corrosion of hydrothermal solutions. The later idea is more acceptable because of the thorianite is driven from Abu Rusheid breciated shear zone. The presence of Mg, Al, Cl and Ca elements shows that the hydrothermal solution was rich in garnet (Fig. 15). The source of this garnet may be derived from ophiolitic mélange of Abu Rusheid area.

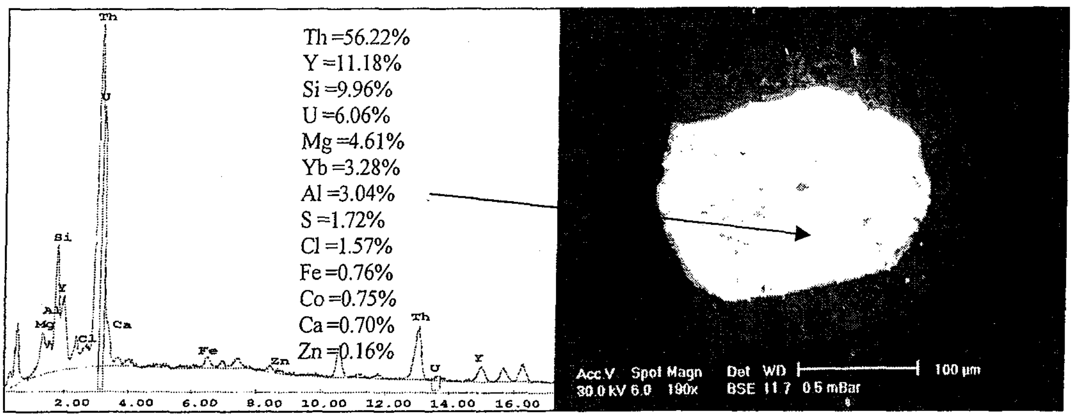


Fig. (15): EDX and BSE image showing thorianite, W. Nugrus, SED, Egypt.

4. Associated accessory minerals

4.1. Zircon

Zircon ($ZrSiO_4$) is a common accessory mineral in the igneous rocks, particularly the Na-rich plutonic rocks. Metamictization in minerals is generally considered to be the effect of radiation damage produced by radioactive decay of thorium and uranium. The studied zircon varies from short prismatic crystals to euhedral blunted edges, varies in size from less than 20 µm up to 200 µm in diameter. Gradational zoning from brownish cores to yellowish rims is common. Sharp euhedral oscillatory zoned bands were observed in few grains. In some granite, the zircon is partially altered to amorphous uranothorite (Fig. 16) and/or xenotime, probably due to the effects of radioactivity of U and Th in its (Deer et al. 1992).

Irber (1999) indicated that the Zr/Hf ratios for peraluminous granites of Mideastern Germany varies between (9–39) and granites with lower ratios (<20) are affected by strong magmatic hydrothermal alteration. The Zr/Hf ratio in common granites is about 39 (Erlank et al., 1978) and are mostly close to the chondritic ratio of 38 (Anders and Greversse, 1989). The average for pegmatites is at about 25, (Erlank et al., 1978) and the Zr/Hf ratios shifts toward smaller ratio with increase evolution of the silicate melt. Weyer et al. (2002) recorded that the most precise chondritic ratio for Zr/Hf = 34 ± 0.3. On the other hand, Zr/Hf ratios of the recorded zircon of Wadi Nugrus ranges between 42 (Fig. 17A) and 9.98 (Fig. 17B). Zircon grain of figure (17b) was recorded from sample No. (6) i.e. derived from Abu Rusheid area which affected by hydrothermal alteration previously studied by Rashed (2005). Meanwhile, zircon grain of figure (17a) was recorded from sample No. (4) is close to that of chondritic ratio.

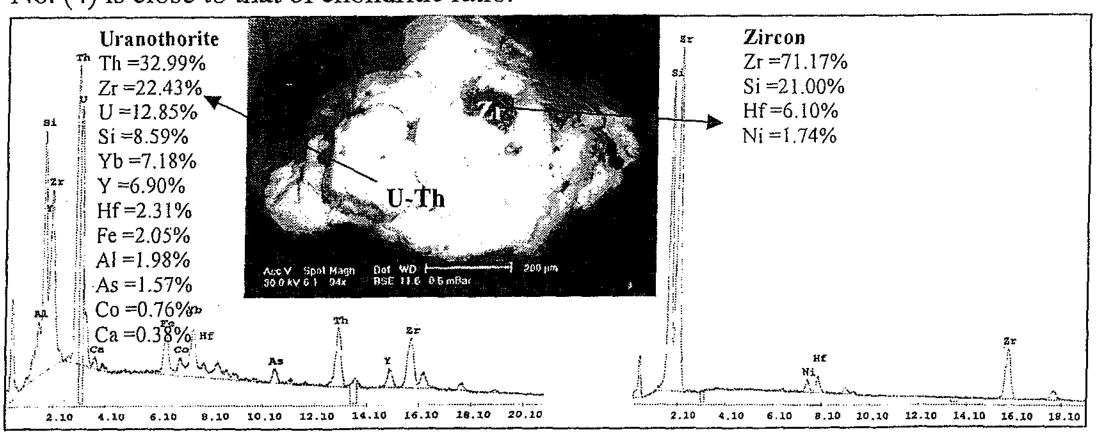


Fig. (16): EDX and BSE image showing admixture between zircon (Zr) and uranothorite (U-Th), W. Nugrus, SED, Egypt.

Recorded zircon in Wadi Nugrus varied in shape from grown elongated crystals (Fig. 17a from sample No. 4) to rounded muddy ones (samples No. 6 and 7, Fig. 17b). The later reflect metamication effects on their crystal faces characterized zircon of Abu Rusheid rocks. While fine-grained zircon (Fig. 17c) and anhedral zircon filling fractures (Fig. 16d) were also recorded in samples (1 and 3 to 9). More detailed studies on the heavy minerals and zircon of Wadi Nugrus area had been carried out by El Gemmizi (1979 and 1984).

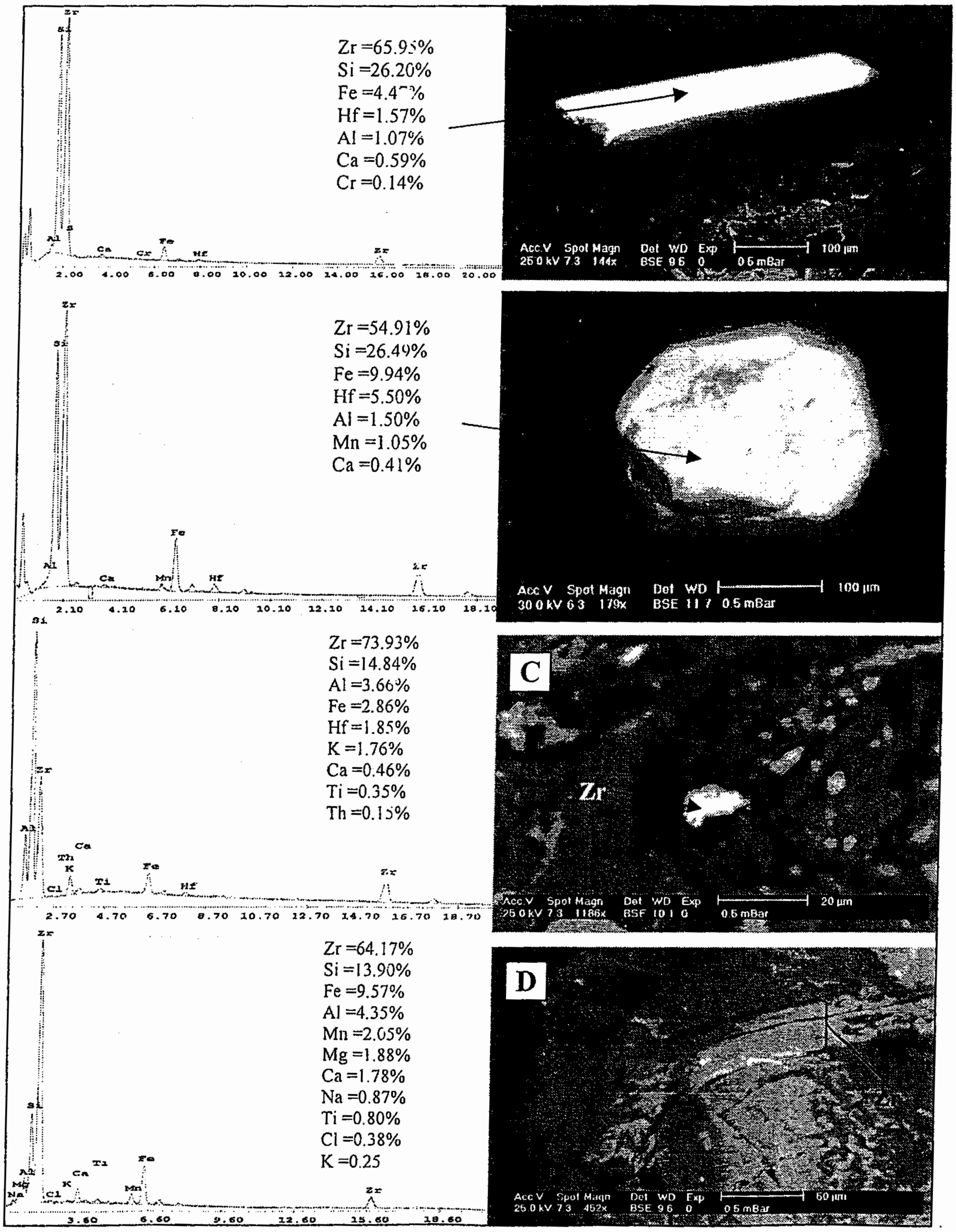


Fig. (17): EDX and BSE image showing (a) elongated euhedral zircon crystal, (b) Euhrdeal mud zircon (c) fine eubhedral zircon crystals associated with hematite and (d) Zircon filling fracture between garnet (alamandine) crystals, W. Nugrus, SED, Egypt.

4.2. Leucoxene

Leucoxene is the transitional phase during the alteration of ilmenite to secondary rutile. Colors of leucoxene range from yellowish brown to white. Most of the leucoxene grains have smooth waxy surface, however some of them show pitted surfaces and light creamy color with Ti-rich content (Fig. 18). Leucoxene is locally recorded in samples No. 4 and 5.

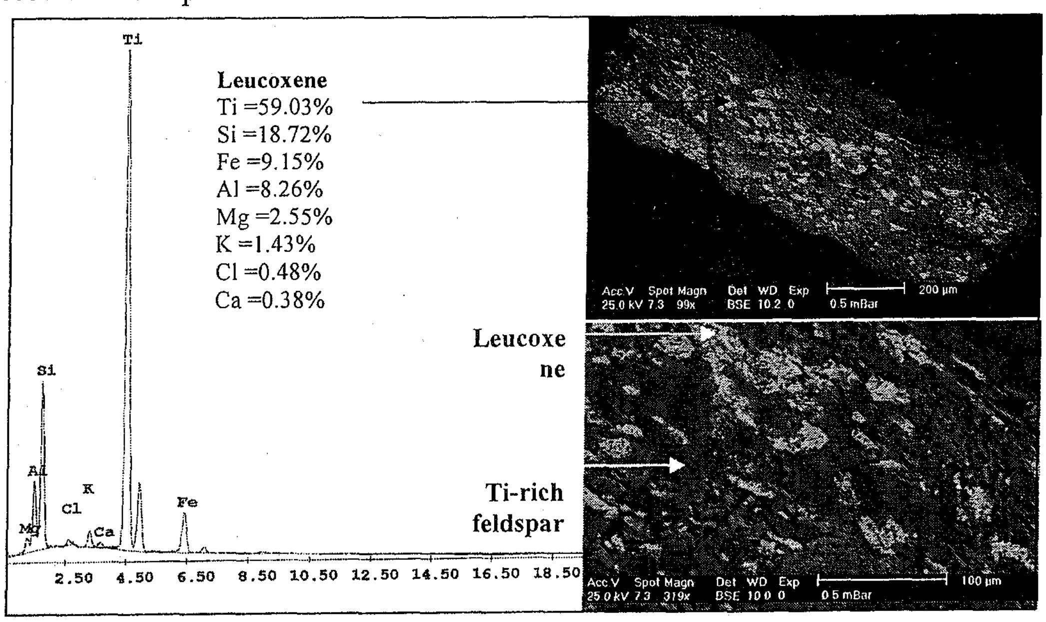


Fig. (18): EDX and BSE image showing fine-grained leucoxene crystals grown in Ti-rich feldspar, W. Nugrus, SED, Egypt.

4.3. Monazite

Monazite (Ce,La,Nd,Th)(PO_4SiO_4) is wide spread in different igneous and metamorphic rocks (Ziemann et al., 2005). Ce-monazite is predominant in the stream sediments of Wadi Nugrus. The studied monazite crystals are found in appreciable amount, characterized by their relative coarse size and brownish red and reddish in color, mostly due to staining with iron oxides and sometimes associated with metamict zircon (Fig. 19). Monazite was recorded in samples 6, 7 and 8.

4.4. Garnete

Garnete is a group of isomorphous minerals of different composition and colour. Almandine is of a deep velvety red and the most widely used in jewelry making. The stream sediments of Wadi Nugrus are alamandine $Fe_3Al_2(SiO_4)_3$ and spessartine $Mn_3Al_2(SiO_4)_3$ rich especially those derived from ophiolitic mélange. Garnet was recorded in all of the studied samples except (Nos. 2, 6 and 9). The EDX analyses indicate the elevated concentration of MnO that ranges between 1.84 to 18.85%, which may be due to almandine-spessartine solid solution series (Fig. 20). The recorded garents show irregular fractured subhedral colorless to pale pink, of which spessartine and alamandine garnets (Fig. 20) are the most common in the studied stream sediment samples.

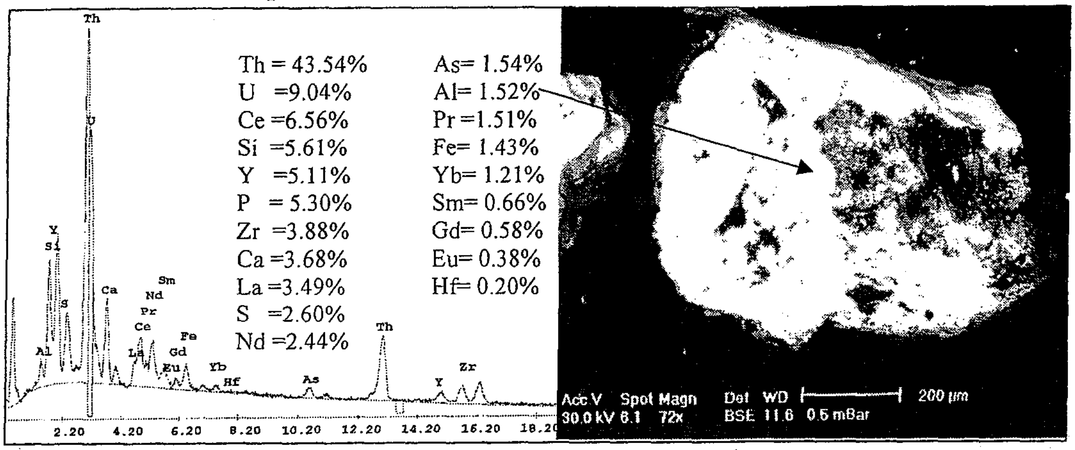


Fig. (19): EDX and BSE image showing Th rich monazite, W. Nugrus, SED, Egypt.

4.5. Tourmaline

Tourmaline was easily identified by naked eyes in the stream sediments of sample No. 8. It occurs as grown broken elongated crystals reach up to few centimeters, with black colour (Fig. 21). Harraz and El Sharkawy (2001) recognized four types in tourmaline occurrences.

The recorded tourmaline in sample (No. 8) at Um Slimate area may be derived from tourmaline-rich rocks, associated with the metapelitic and amphibolitic closely to Nugrus thrust zones. Early diagenetic reactions of biotite-pelitic sediments with B-rich hydrothermal fluids or colloids, and subsequent recrystallisation during late regional deformation and metamorphism to give tourmaline-rich rocks.

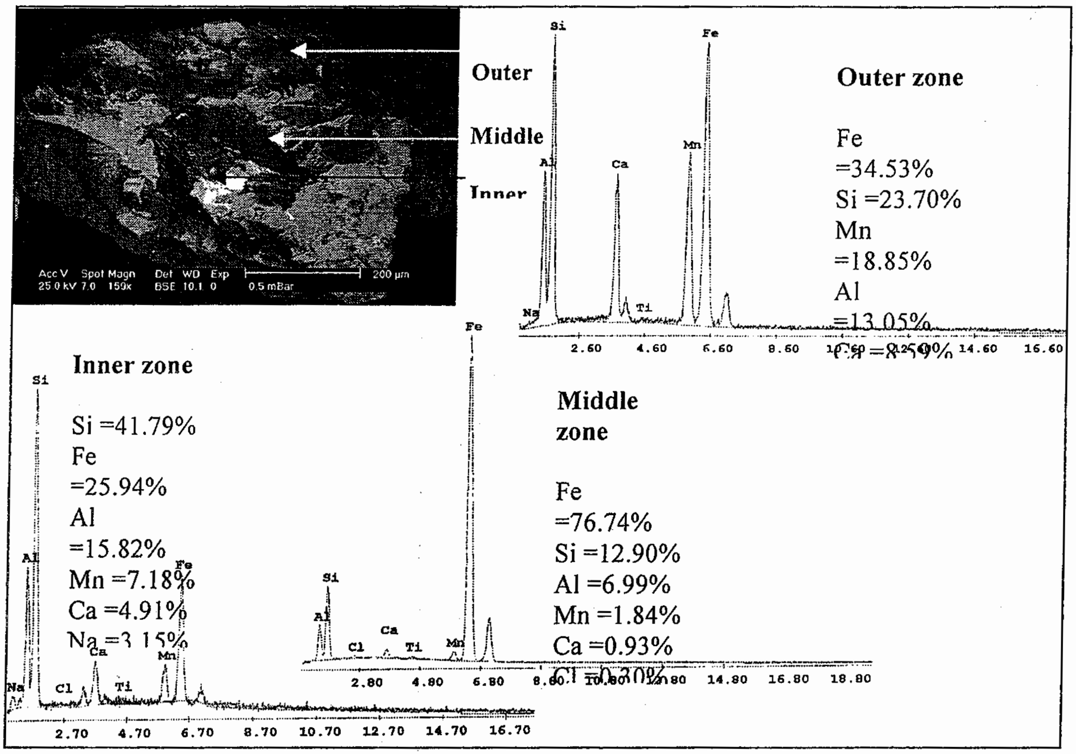


Fig. (20): EDX and BSE image showing garnet; almandine-spessartine-andradite solid solution, W. Nugrus, SED, Egypt.

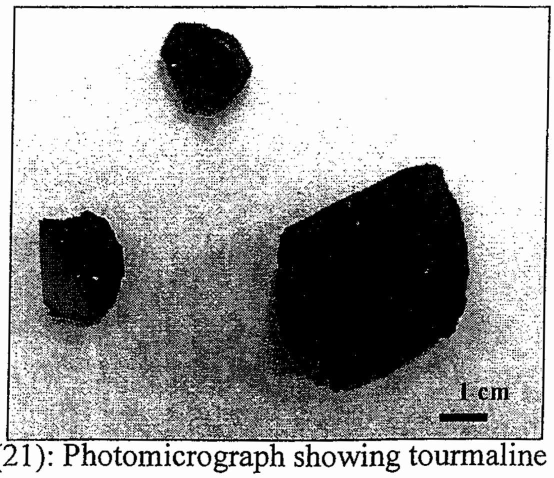


Fig. (21): Photomicrograph showing tourmaline crystals.

5. Gangue minerals

Iron oxide minerals are the most dominant minerals in all of the studied samples. They are found as inclusions in the essential minerals or as secondary minerals filling cracks and cleavage planes and coating the silicate minerals yellow and red brown coloured. Iron oxide minerals include ilmenite, hematite, goethite and magnetite. Ilmenite is the most dominant mineral followed by hematite and magnetite.

5.1. Ilmenite

Ilmenite ($FeO\text{-}TiO_2$) is present as accessory mineral associated with hematite and magnetite. Ilmenite grains are iron black or asphaltic in color (Fig. 22) with metallic and dull luster. The hematite and ilmenite intergrowth can be formed due to the unmixing of the crystals forming hematite-rich type of ilmenite.

5.2. Hematite

Hematite($\alpha\text{-}Fe_2O_3$) is the most widespread iron mineral in the studied area, it is often formed by the decomposition of iron-bearing minerals, particularly silicate. Hematite grains are reddish brown or blood red color (Fig. 23). It is of metallic or dull luster. Sometimes it is found in association with secondary uranium minerals.

5.3. Magnetite

Magnetite (Fe_3O_4) is well common in black colour form with some striations. It is metallic to submetallic luster. The magnetite is converted into secondary hematite (martite), through martitization particularly along grain boundaries, cracks and cleavage. This is representing the first stage in the oxidation of the mineral (see Fig. 10).

DISCUSSION

Mineralogical study of the present work showed that the minerals distribution in Wadi Nugrus (Table 1) is controlled by its outlet major tributaries; i.e. W. El Nom, W. Abu Rusheid, Khour Medinat Nurgus, Khour Um Slimat, W. Sikait. The radioactive mineralization were recorded along W. Nugrus may belong to W. Abu Rusheid and Khour Medinat Nugrus and some of them were related to shear zone environment. The radioactive minerals recorded in the stream sediments are kasolite, thorinanite, thorite and uranothorite; also other recorded minerals such as zincite and coronadite. Nb-

Ta minerals and cassiterite may be related to the cataclastic rocks of Abu Rusheid and Medinat Nugrus areas. The recorded coronadite is a first record in this area.

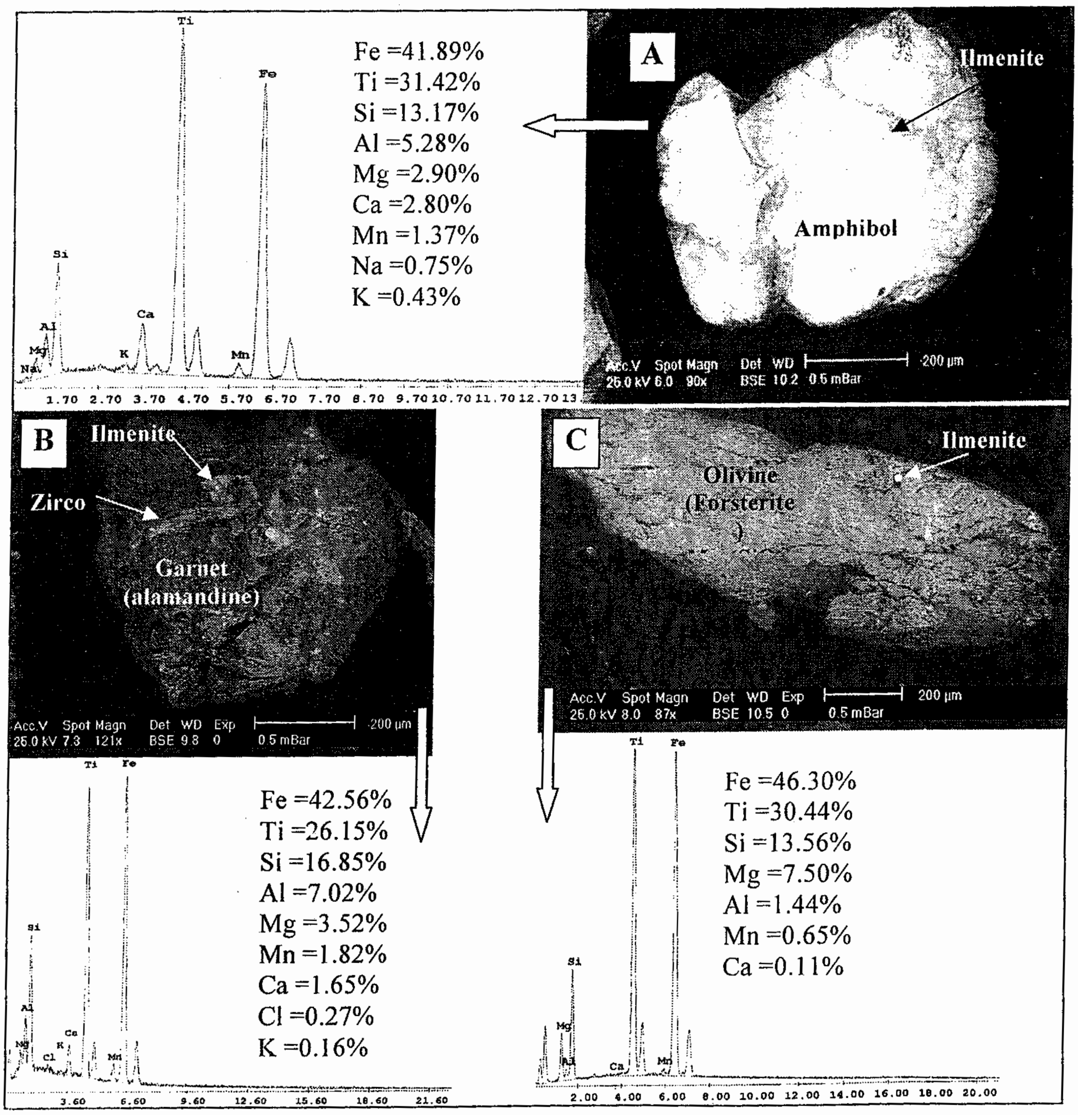


Fig. (22): EDX and BSE image showing fine-grained ilmenite crystals grown in between (a) amphibole, (b) garnet (alamandine) intergrowth with zircon (c) Olivine (Forsterite) at W. Nugrus, SED, Egypt.

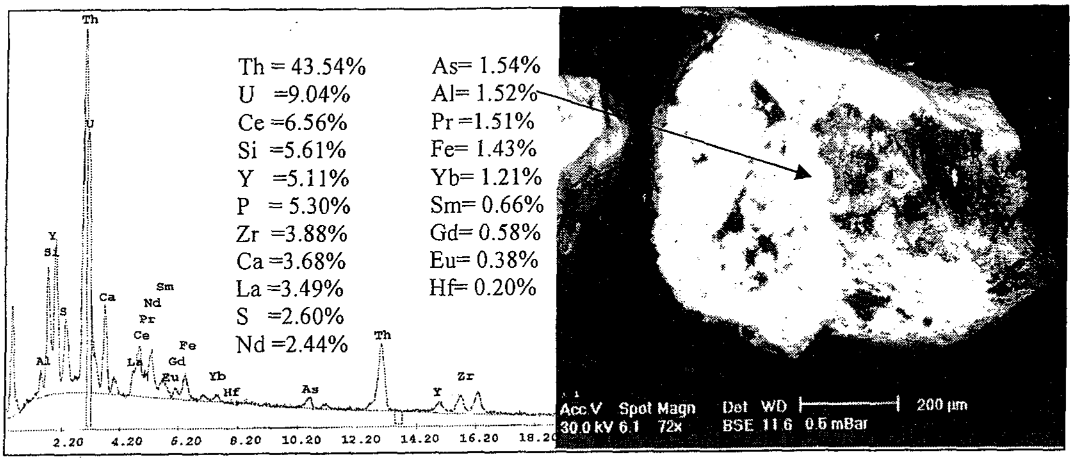


Fig. (23): EDX and BSE image showing hematite, W. Nugrus, SED, Egypt.

The preliminary evaluation of this study revealed that the stream sediments of W. Nugrus have considerable amounts of economic valuable minerals most of them base metals such gold, different varieties of corundum, emerald beryl. The gold and corundum may be related to the metagabbros and ophiolitic mélange that present in most of W. Nugurs course especially El Gizera area and its surrounding (between location of sample 2 to 5).

Also, a relative high amounts of associated minerals such as zircon, leucoxene, monazite, garnet and tourmaline. Some of them are locally distributed at Khour Um Slimat outlet, and other such as garnet was more abundant due to its relation with ophiolitic mélange along the W. Nugrus main course. Zircon was abundant in most of samples and also small amount of elongated zircon was recorded.

Gangue minerals are widely distributed in all samples; this is a logic distribution due to Fe-enrichment content of metagabbro and ophiolitic mélange and also hydrothermal activities recorded at Abu Rusheid area

Table (1): Lateral distribution and classification of the recorded minerals along W. Nugrus, south Eastern Desert, Egypt.

Class	Samples / Minerals	1	2	3	4	5	6	7	8	9
Precious minerals	Gold			●						
	Beryl (emerald)	●	●	●	●	●	●	●	●	●
	Ruby courundum					●				
	Saphire courundum	●	●							
	Spinel courundum	●	●							
Base metals	Corondite						●			
	Zincite						●			
	Titanite			●	●	●	●	●	●	●
	Barite		●							
	Arsenopyrite						●			
	Pyrite		●				●	●		
	Marcasite		●	●			●			
	Cassiterite							●		
	Nb-Ta minerals						●	●		
Radioactive minerals	Kasolite						●	●		
	Thorite						●			
	Thorianite						●			
	Uranothorite						●	●		
Associated accessory minerals	Zircon	●		●	●		●	●		●
	Leucoxene				●	●				
	Monazite						●	●	●	
	Garnet	●		●	●	●		●	●	
	Tourmaline								●	
Gangue minerals	Ilmenite	●	●	●	●	●	●	●	●	●
	Hematite	●	●	●	●	●	●	●	●	●
	Magntite	●	●	●	●	●	●	●	●	●

CONCLUSIONS

1- This study revealed that the stream sediments of W. Nugrus have considerable amounts of economic valuable minerals.

2- Appreciable amounts of native gold, and gemstones include; beryl (emerald) and corundum (ruby, sapphire and spinel) were recorded.

3- Recorded radioactive minerals founded in outlet of W. Abu Rusheid in W. Nugrus and ancient Medinat Nugrus considered as additive to their reserve of Abu Rusheid project which lunched by NMA at 2002 to development resources of uranium and its associated mineralization.

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دراسة استكشافية على المعادن الاقتصادية لروسب وادي نجرس؛ المصادروالتوزيع.

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الملخص العربي

يهدف هذا البحث إلي دراسة معدنية لرواسب وادي نجرس بجنوب الصحراء الشرقية، ولتحقيق هذا الهدف تم دراسة تسعة عينات أخذت بطول الوادي والذي يبلغ ٣٠كم تقريبا. إن الصخور المنكشفة عبر وادي نجرس هي صخور الأوفيوليت والميلانج الأوفيلايتي والنايس ذو الأصل الرسوبي والجرانيتات الحديثة والجابرو الحديث بعض الجدد والعروق. كشفت الدراسة عن وجود معادن تسجل لأول مرة مثل الذهب والكوراندوم ومصدرها صخور الميتاجابرو الأوفيوليتي و صخور الميلانج الأوفيليتي علي جانبي وادي نجرس. كما كشفت الدراسة وجود معادن أخري هامة و هي معادن أساسية مثل الكولمبيت والزنكيت والتيتانيت والجارنت والزيركون والبيريت ومصدرها منطقة أبو رشيد ومدينة نجرس ومعادن أخري مشعة مثل الكازوليت والثوريت واليورانوثوريت و مصدرها منطقة أبورشيد. معادن البريل والتورمالين مصدرها مناطق أبو رشيد و مدينة نجرس و أم سليمات ووادي سكيت.