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Petrographical and mineralogical studies of Hammamat sediments and Gattarian granite along Wadi Belih, north Eastern Desert, Egypt.

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Abstract

The Hammamat sediments at Wadi Belih area are represented by greywacke and siltstones. The greywackes are immature and are fine to coarse grained and composed of quartz, feldspar and rock fragments. The siltstones consist of quartz, feldspar and hematite. The younger granites (The Gattar granites) are composed mainly of quartz and feldspars as essential minerals and biotite, hornblende, zircon, and apatite as accessory minerals. Some secondary minerals as epidote, chlorite and sericite are found. The radioactive minerals are identified by using the Quanta FEG-250 ESEM instrument which is an environmental Scanning Electron Microscope (ESEM) attached by Energy Dispersive X-ray(EDX) in the national central research (NCR). The younger granites and Hammamat rocks at Wadi Belih area contain primary uranium mineral as Coffinite, secondary minerals as Uranophane, Kasolite, Schroeckingerite and uranium bearing minerals like Columbite.

Keywords

Radioactivity mineralogy :hammamate sediments and granites W.Balih

Introduction

The Egyptian Eastern Desert, northern Sudan, western Saudi Arabia and Yemen have collectively been termed the Arabian Nubian Shield, which is characterized by four principal rock association: i.e. (1) an older shelf sequence of ortho- and paragnesis, (2) arc assemblages, (3) ophiolitic suits and (4) granitoid intrusive (Koener et al., 1987). The Egyptian granitoid rocks have been subdivided in different ways (Greenberg, 1981 and Stern et., 1984). They can be in general classified into two main types, the older and younger granites (El-Ramly and Akaad, 1960). Gattarian granite studied by Barthoux (1922), Schürman (1966), Ghobrial and Lotfi (1967), Rasmy (1969), Salman et al. (1986 and 1990), Attawiya (1990),Mahdy et al. (1990), Roz (1994), Khalaf, (1995), Youssief (1996), Mahdy (1999), Mahdy et al (2013).Hammamat of Wadi Belih areas studied by Willis et al. (1988), Mahdyet al. (1990), Salman et al, (1986 and 1990), Sayyah and Attawiya (1990), Shalaby (1990, 1995 and 1996), Mahmoud (1995), El Kammar et al (2001), Amin (2010).

The present study deals with the Petrographical, mineralogical and radioactive minerals studies of Hammamat sediments and Gattarian granite along W. Belihby using The Quanta FEG-250.

General Geology

Gabal Gattar and Wadi Belih areas are located in the north eastern desert (NED) of Egypt between latitudes 26° 52\ to 27° 08\ N and longitudes 33° 13\ to 33° 26\ E Figure 1. It comprises the Gattar granite pluton which forms a mountainous terrain with G. Gattar (1963m), G. Umm Disi (1556 m), G. Abu El Hassan, G. Abu El Hassan El-Ahmar, G. Reddah, G. Theima and G. Abu Samyuk. The main wadis are W. Balli (Fig. 1). The Gattar ploution is oval in shape stricking NE-SW direction with the same direction of G. El Eglab (Stern and Gottfried, 1986 and Ayoub 2003), and G. Uqab El Nugum south Eastern Desert Egypt (Samaan, 2000). G. Gattar covers an area of about 455km2 with about 30km length and 20km wide. It is dissected by various faults trending mainly ENE-WSW, NNW-SSE, NW-SE and NNE-SSW (Waheeb and EL Sundoly 2016). The basement rocks in the studied area are classified according to Takla classification (2002), into:

Intra-plate Magmatism and Sediments:

- Felsic and mafic dykes (Younger)
- Younger granites (G. Gattar granites)
- Hammamat sediments
- Dokhan volcanics

Subduction-related granitoids (Arc granites):

- Granodiorites (Older)

Subduction-Related Granitoids (Arc Granitoids)

The Subduction-Related Granitoids in the studied are represented by granodiorites, Intra-plate Magmatism and Sediments, Dokhan volcanics and Hammamat sediments.

Granodiorites

The granodiorite crops out at the north east part of the studied area Figure 1. Waheeb and EL Sundoly (2016) mentioned that the granodiorites are characterized by low to moderate relief, exfoliation and boulder weathering with characteristic monumental shapes. The older granitoids are intruded by the younger granites which took xenoliths of various shapes and sizes from them.

Intra-plate Magmatism and Sediments

The Intra-plate Magmatism and Sediments in the studied area represented by Dokhan volcanic, Hammamat sediments and younger granites (Gattar granites).

Dokhan volcanics

The Dokhan volcanics are crop out as large area in the northern and central part of the area of study (Fig. 1), It is represented by a successive sequence of lava flows ranging in composition from intermediate to acidic varieties with their related pyroclastics. The Dokhan volcanics are intruded by the younger granites. The contact between Dokhan volcanic and younger granites are structural contact (Roz 1994).

Hammamat sediments

The Hammamat sediments crop in the central part of the study area. They are unconformably overly all the pre- existing older rocks (Mahdy, et al., 1990). The succession of these well-stratified molasses type sediments, in the study area, attains a thickness of about 250 meter of well-defined clastic sediments and generally forms moderate to high relief mountainous terrains with gentle slopes Shalaby (1990).

The Hammamat sediments were studied microscopically and it is shown that they are composed mainly of two rock types: greywacke and siltstone.

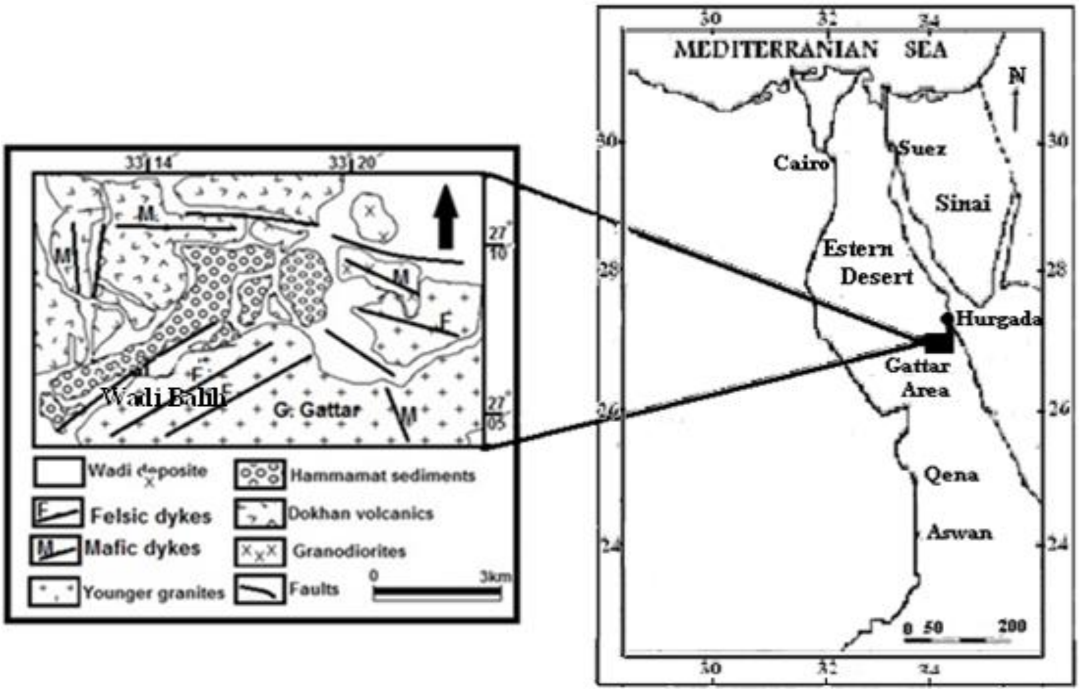

Figure 1 Geological map and location of Wadi Balih area (Aftar Waheeb and Elsundoly 2016).

Petrography

Greywacke

The greywackes in the studied Hammamat sediments are immature and are fine to coarse grained. They are dark to gray in color and consist mainly of subangular to subrounded quartz, altered feldspar, rock fragments and a matrix (20-40%) rich in sericite, chlorite, fine grained quartz and iron oxide. Some varieties are rich in calcite.

Quartz

occurs as subangular to subrounded grains up to 2 mm in diameter and mainly occurs as polycrystalline fragments Figure 2, sometimes showing mosaic texture. Monocrystalline quartz is minimal or absent.

Feldspar

Are commonly plagioclase and are mainly sussritized Figure 3, subhedral to anhedral grains

Rock fragments

Are frequent in samples. They are dominated by granitic fragments as well as other rock units such as acidic volcanic and quartzite.

Siltstones

Siltstones microscopically, consist of wide varieties of fine angular to subrounded grains of quartz, in silt size Figure 4, feldspar, microcrystalline chlorite, sericite, detrital mica Figure 5 and epidote; all are densely packed in a dark hematitic matrix. Feldspars are rounded to subrounded, Rock fragments are relatively uncommon. Carbonate veinlets and patches are absent.

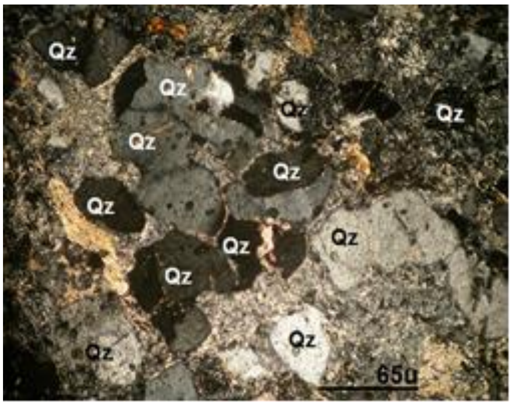

Figure 2 Polycrystalline fragments quartz (Qz) in graywake C. N.

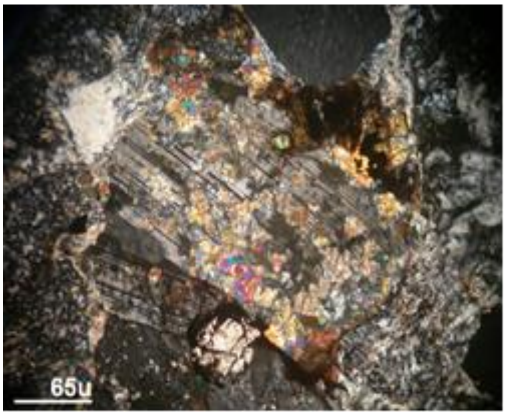

Figure 3 Saussuritized plagioclase in graywake.

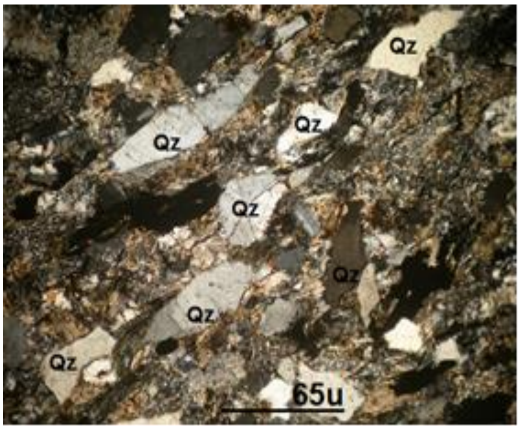

Figure 4 Angular to sub-rounded quartz grains (Qz) in siltsrone C. N.

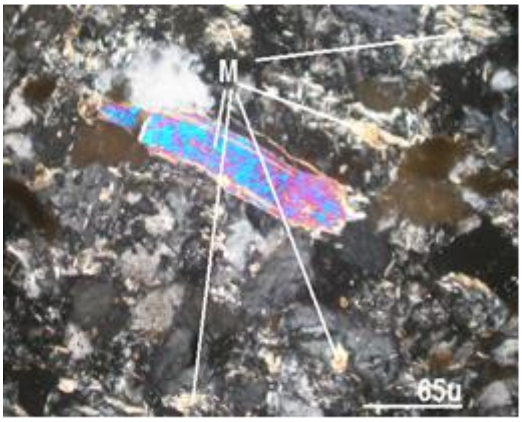

Figure 5 Detrital mica (M) in Siltstones C. N.

Younger granites (G. Gattar granites)

Gabal Gattar granites are light pink in color, hard, generally forms high relief mountainous. Holocrystalline and coars grained, pink to red in color (Ghobrial and Lotfi 1967). Microscopically, it is composed mainly of quartz, potash feldspars and plagioclase as essential minerals, biotite, hornblende, zircon, apatite, opaque and sphene as accessory minerals, epidote, chlorite and sericite are secondary minerals

Quartz

Occurs as the predominant minerals constituting about 40% of the rock. It forms coarse anhedral crystals, showing wavy extinction Figure 6 and enclosing zircon, perthite, plagioclase and biotite.

Feldspars

Occurs as perthite, microcline and plagioclase, the perthite occur as orthoclase perthite, it build simply twinned, flame type Figure 7, Microcline occurs as euhedral crystals cross hatching Figure 8. Plagioclases are subhedral to anhedral crystal, lamellar twining Figure 9. Some plagioclases show saussuritization Figure 10 and others are zoned. The plagioclase crystals enclose zircon Figure 11.

Biotite

Occurs as euhedral flaky crystals, pleochoric from dark brown to yellow, and partially altered to chlorite Figure 12. Some biotite crystals enclosed zircon.

Hornblende occurs as coarse prismatic crystals, green in color, pleochoric from dark green to light green. Some hornblende crystals enclose opaque Figure 13 and zircon, it partially altered to chlorite.

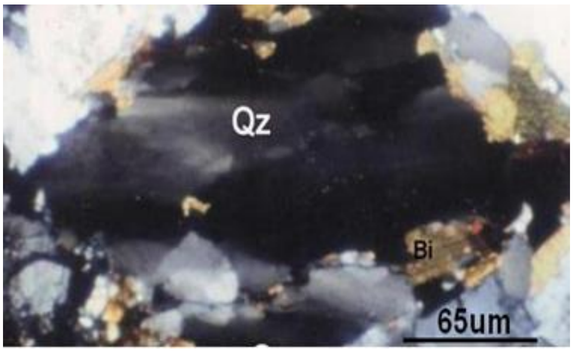

Figure 6 Wavy extinction in quartz (Qz), Biotite (Bi) C.N.

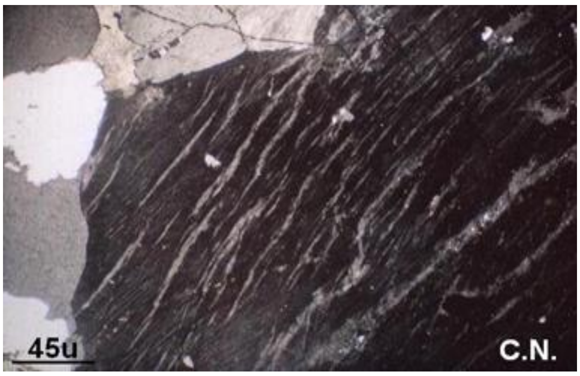

Figure 7 Flame perthit in orthoclase perthit C.N.

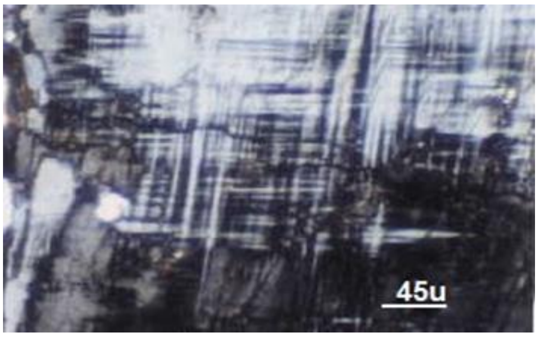

Figure 8 Cross hatching in microcline C.N.

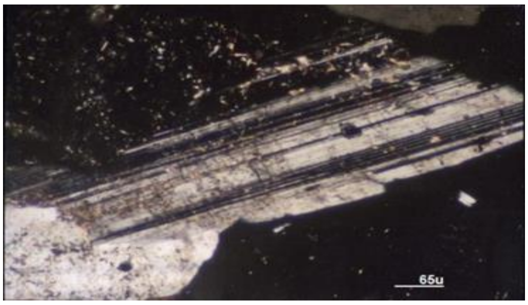

Figure 9 lamellar twining in plagioclase C.N.

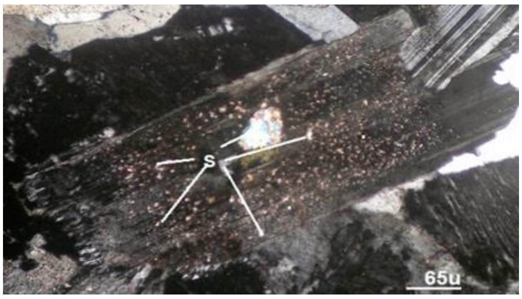

Figure 10 Saussuritization (S) plagioclase C.N.

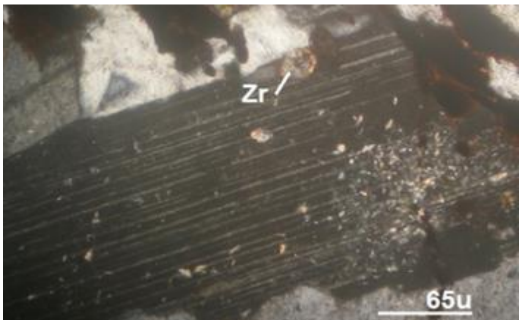

Figure 11 Plagioclase crystals enclose zircon (Zr) C.N.

Figure 12 Biotite altered to chlorite PPL.

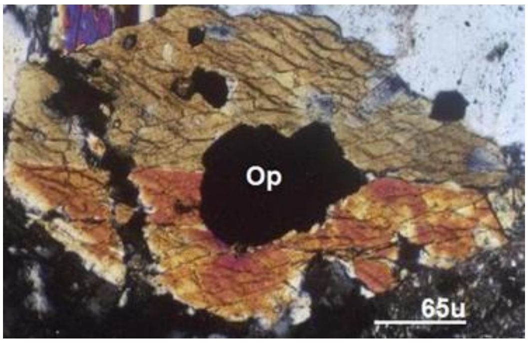

Figure 13 Hornblende crystals enclose opaque (Op) C.N.

Radioactive minerals of Hammamat

Sediments and Gattarian granite

The minerals detected by using Olympus microscope in Nuclear Materials Authority (NMA) Cairo, Egypt and Quanta FEG-250 ESEM attached by Energy Dispersive X-ray(EDX) in the national central research (NCR), Geza, Egypt.

The FEG column in Quanta 250 allows beam deceleration, which permits to achieve a resolution of 1.4 nm even at 1 kV electron landing voltage. The Quanta equipment can work under three different pressure ranges, the maximum pressure being 2600 Pa. This permits observation of life-sciences samples without previous metallic coating, i.e., studies in environmental conditions (ESEM).

This microscope allows the use of a Wet-STEM, which permits to analyze samples with controlled humidity and temperature, which is crucial in life-science samples. The SEM-Quanta can also use a heater to perform observations on samples heated up to 1000 ºC and detect changes in the morphology of the material. In addition, with this microscope de-acceleration of the electron beam over non-conductive samples can be performed leading to 1.4 nm resolution even at 1 kV.

The mineralogy and radioactive minerals of Hammamat sediments and Gattarian granite are:

Hammamate Sediments

Uranophane: (calcium uranium silicate hydrated), $Ca(UO_2)_2(SiO_3OH)_2 \cdot 5H_2O$, yellow color Figure 16, showing radial crystal under FEG microscope Figure 17. The uranophane contains 53.25% SiO_2, 38.15% UO_2 and 6.8% CaO.

Kasolite:$Pb(UO_2)[SiO_4] \cdot H_2O$, it contains 3.03 PbO_2, 18.23 SiO2, 9.96 CaO and 34.06 UO2 Figure 19, it is monoclinic system Figure 20.

Schroeckingerite: $NaCa_3(UO_2)(CO3)_3(SO_4)F \bullet 10(H_2O)$, the EDX Figure 18 shows that the schroeckingerite contains 5.54% Na_2O, 7.18% SiO_2 and 49.11% UO_2.

Gattar Granite

Coffinite: Uranium bearing silicate $U(SiO_4)_{0.9}(OH)_{0.4}$ dark brown in color Figure 14, Coffinit contains 53% UO_2 and 27% SiO_2. Figure 15 shows ESEM image for coffinite and there EDX.

Columbite: $(Fe,Mn)(Nb,Ta)_2O_6$ Figure 21, it contain 6.59% SiO_2, 12.89% Nb2O5, 49.23% UO_2, 7.07% CaO and 5.9% TiO_2. Samaan (200--) mentioned that the colombite of high niobium is high in carrying uranium while the colombite of high tantalum is very low in carrying uranium.

Figure 14 Brown coffinite grain.

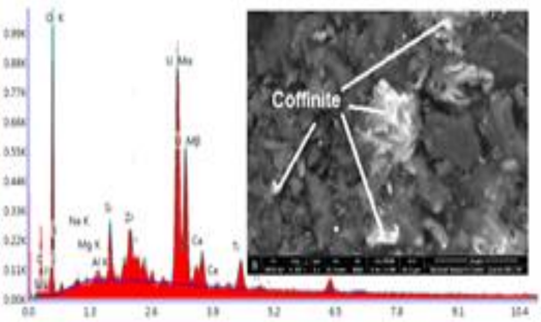

Figure 15 ESEM image and EDX chart for coffinite.

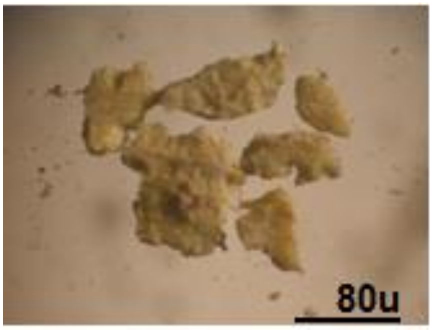

Figure 16 Yellow uranophane grain.

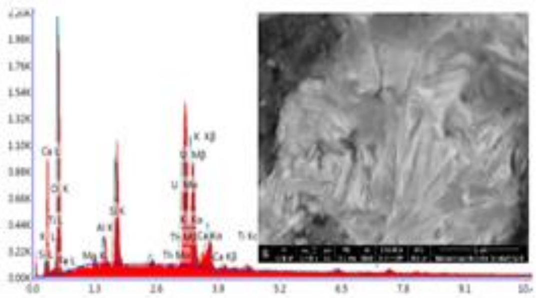

Figure 17 ESEM image and EDX chart for uranophan grain.

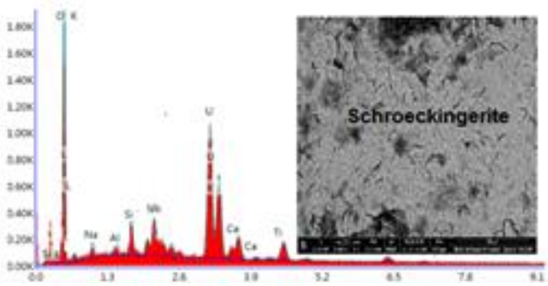

Figure 18 ESEM image and EDX for Schroeckingerite grain.

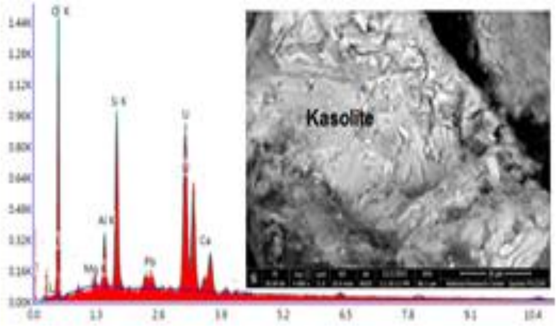

Figure 19 ESEM image and EDX for kasolite grain.

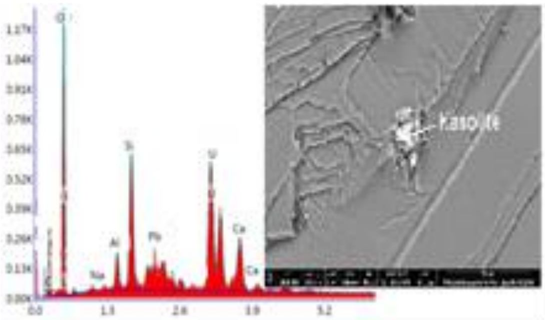

Figure 20 ESEM image and EDX for kasolite.

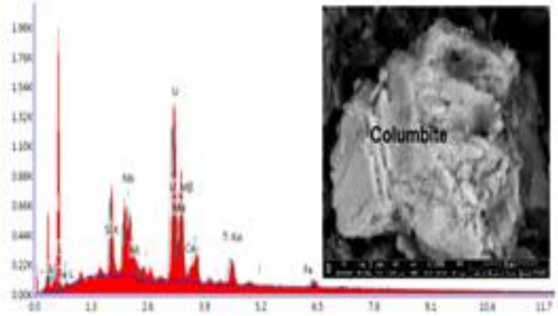

Figure 21 ESEM image and EDX for columbite grain.

Conclusions

- The Hammamat sediments crop in the central part of the study area. They are unconformably overly all the pre- existing older rocks.
- It composed mainly of two rock types: greywacke and siltstone. The greywackes consist mainly of quartz, feldspar and rock fragments. In greywakes the Ca-feldspars are altered to saussurite (saussuritization). Saussurite is not however recognized as a true mineral because it is a microscopic mixture of several other minerals. The complete or partial alteration of calcium-rich plagioclase to a fine-grained aggregate of secondary, sodic-rich plagioclase, epidote, muscovite, calcite, scapolite, and zeolites. The process commonly takes place during the low-grade regional metamorphism). Siltstones consist of quartz, feldspar, microcrystalline chlorite, sericite, mica and epidote. The Hammamat sediments contain Uranophane, Kasolite and Schroeckingwhierite. The Uranophane also known as uranotile, is a rare mineral that forms from the oxidation of uranium-bearing minerals. It is closely related to the two other uranium bearing minerals. The major constituents of kasolite are; uranium, lead and silicon. Lead does not exist as a radiogenic

product and not even as a substitute for uranium in the mineral structure. Alternatively, galena mineralization could be considered as a source for lead. Schroeckingeriteis one of the few uranyl carbonate minerals that is found on the mineral markets. Other uranyl carbonates include and ersonite, rutherfordine, sharpite, liebigite, swartzite and bayleyite. Schrockingerite, in addition to having a uranyl (UO_2) group in its chemistry, has a sulfate ion.

- The younger granites form high mountainous relief. The Gattar granite is holocrystalline and coarse grained, pink to red in color. Microscopically, it is composed mainly of quartz which characterized by undulos extinction due to oriented pressure (Dynamic effect), potash feldspars and plagioclase as essential minerals, biotite which partially chloritized due to chemical alteration (thermal effect), hornblende, zircon, apatite, and opaque as accessory minerals, epidote, chlorite and sericite are secondary minerals.

- The younger granites contain Coffinite and Columbite. Coffinite, $USiO_4$, is the second most abundant U(IV) mineral on Earth, and its formation is by the alteration of the UO_2. Columbite forms a series with the mineral tantalite. In fact the two are often grouped together as a semi-singular mineral called columbite-tantalite in many mineral guides, where they are compose a series of two or more elements which occupy the same places within a crystal structure and their respective percentages can then vary. Columbite is the more niobium than tantalite rich in uranium content.

References

[1] **Amin, N. F., 2010:** Surface and subsurface structural features controlling uranium mineralizations at granitic-hammamat contact, WadiBelieh, Northern Eastern Desert, Egypt. Ph.D. Thesis, Faculty of Science, Ain Shams University, 98p.

[2] **Attawiya, M. Y., 1990:** Petrochemical and geochemical studies of granitic rocks from GabalQattar area, Eastern Desert, Egypt. Arab. J. Nucl. Sci. App. Cairo, Vol. 23, No. 2, pp. 13-30.

[3] **Ayoub, R. R., 2003:** Geology and radioactivity of Gabal Um Tweir area, North Eastern Desert, Egypt. Unpublished Ph.D. Thesis, Faculty of Science, Cairo Univ., Cairo, Egypt.

[4] **Barthoux, J. C., 1922:** Chronologieet description des rochesignees du Desert Arabique. Men. Inst. Egypte, Le Caire, V. 5, 262p.

[5] **El-Kammar, A. M., Salman, A.E., Shalaby, M.H., Mahdy, A.I., (2001):** Geochemical and genetical constraints on rare metals mineralizations at the central Eastern Desert of Egypt. Chemical Journal 35, pp.117–135.

[6] **El Ramly, M. F. and Akaad, M. K., 1960:** The basement complex in the central Eastern Desert of Egypt, between Lat 240 30' and 250 40' N. Geol. Surv. Cairo, v. 8, 35 p.

[7] **Ghobrial, M. G. and Lotfi, M., 1967:** The geology of GabalGattar and GabalDokhan areas, Eastern Desert. Geol. Surv. Egypt,paper No. pp. 40, 26.

[8] **Greenberg, J. K., 1981:** Characteristics and origin of Egyptian younger granitess. Geol. Soc. American Bull., part II, V.92, pp. 749-840.

[9] **Khalaf, M. A., 1995:** Petrological and mineralogical characteristics of some uranium-bearing younger granites, north Estern Desert, Egypt. M.Sc., Thesis. Geology Dept., Faculty of Science, Cairo University, 60 p.

[10] **Kroner, A. M., Greiling, R. O., Reischmann, T., Hussein, I. M., Stern, R. J., Durr, S., Druger, J. and Zimmer, M., 1987:** Pan- African crustal evolution in the Nubian segment of northeast Africa. In Kroner, A. (ed), Proterozoic Lithospheric evolution. American Geophysical Union, Washington D. C, pp. 235-257.

[11] **Mahdy, A. A., (1999):** Petrological and geochemical studies on the younger granites and Hammamat sediments at Gabal Gattar-5 uranium occurrence, wadiBalih, North Easter Desert, Egypt. Ph.D.Thesis, Geology, Dept., Faculty of science, Ain shams Univ., 198 P.

[12] **Mahdy, M. A., Salman, A. B. and Mahmoud, A. H., (1990):** "Leaching studies on the uraniferousHammamat sediments, Wadi Bali, Northern Eastern Desert, Egypt, 14th Congress of Mining and Metallurgy, Edinburgh Scotland, pp.229-235.

[13] **Mahdy, N. M, Shalaby, M. H., Helmy, H. M., Osman, A. F., El-Sawy, E. H., Abu Zeid, E. K., (2013):** Trace and REE element geochemistry of fluorite and its relation to uranium mineralizations, GabalGattar Area, Northern Eastern Desert, Egypt.Arab Journal of Geoscience: DOI 10.1007/s12517-013-0933–2

[14] **Mahmoud, H. M., 1995:** Studies of the distribution and recovery of uranium/molybdenum from their minerals from Gebel Gattar area, Eastern Desert, Egypt. M.Sc. Thesis, Geology Dept., Faculty of Science, Cairo University, 126 p.

[15] **Rasmy, A., 1969:** Report of the petrographic and mineralogic study of twenty samples from GabalGattar. Int. Rep. Egypt.Geol. Survy, 14 p.

[16] **Roz, M. E., 1994:** Geology and uranium mineralization of GabalGattar, north Eastern Desert, Egypt. MSc. Thesis, Faculty of Science, Cairo Univ., 175 p.

[17] **Salman, A. B., El Aassy, I. E. and Shalaby, M. H., 1986**: New occurrence of uranium mineralization in Gabal Gattar, north Eastern Desert, Egypt. Ann. Egypt. Geol. Surv., XVI, pp. 31-34.

[18] **Salman, A. B., Ali, M. M. and Shalaby, M. H., 1990:** Stream sediments survey in GabalGattar, Gabal Umm Dissi granites, north Eastern Desert, Egypt. Phanerozoic and Development, El Azhar Univ.

[19] **Samaan, J. M. (2000):** Geology, petrology and radioactivity of the basement rocks of Gebel Uqab El Nugum-Gebel Seiga area, south wadiGarara, South Eastern Desert, Egypt. Ph. D. Thesis, Cairo. Univ., 247p.

[20] **SAMAAN, J. M., (2004):** The Lanthanide tetrad effects and its correlation with K/Rb, Y/Ho, Zr/Hf, Sr/Eu, Eu/Eu* AND Th/U Involving granitoid rocks of Gabal Hadyb area, south Eastern Desert, Egypt. 6th Internat. Conf. On Geochem., Alexandria Univ.

[21] **Sayyah, T. A. and Attawiya, M. Y., 1990:** Contribution of mineralogy of uranium occurrence of Gabal Gattar

granites, Eastern Desert, Egypt. Arab. J. Nucl. Sci. App. Cairo, V.23, No. 1, pp. 171-184.

[22] **Schurman, H. M., 1966:** The Precambrian along the Gulf of Suez and the Red Sea, Leiden E.J. Brill. 404P.

[23] **Shalaby, M. H. 1990:** Uranium mineralizations in northern Gabal Qattar locality, northern Eastern Desert, 7th Conf. Phanerozoic and Develop., Al Azhar Univ., Cairo. 3: 19 P.

[24] **Shalaby, M. H. (1995):** New occurrence of uranium mineralizations, G-VII, Gabal Qattar Uranium prospect, north Eastern Desert, Egypt. Bull .faculty of science, Alex. Univ., 35 (2): 447 – 460

[25] **Shalaby, M.H., 1996:** Structural controls of uranium mineralizations at Gabal Gattar, north Eastern Desert, Egypt. Proc. Egypt. Acad Sci., V. 46, pp. 521-536.

[26] **Stern, R. J., Gottfried, D. G. and Hedge, C. E., 1984:** Late Precambrian rifting and crustal evolution in the North Eastern Desert of Egypt. Geology, Vol. 12, pp. 168-172.

[27] **Takla, M. A., 2002:** Classification and Characterization of the Shield rocks of Egypt. The 6th International Conference on the Geology of Arab World, Cairo University, Abstracts. p. 32.

[28] **Waheeb, A. G. and EL Sundoly, H. I., 2016:** Structure roles for the localization of metasomatite uranium deposit type at WadiBelih area, Northern Easter Desert, Egypt. The Geology of Tethys Realm

[29] Willis, K. M., Stern, R. J. and Clauer, N., 1988: Age and geochemistry of late Precambrian sediments of Hammamat series from the north of Eastern Desert of Egypt. Precamb. Res., V. 42, pp. 173-187.

[30] **Yossief, T. F., 1996:** Correlative studies on some uraniferous radioactive granitic rocks in Qattar, El Missikat, El Eradiya and Um Ara areas, Eastern Desert, Egypt. M.Sc. Thesis, Geology Dept., Faculty of Science, Ain Shams University.